Hort Innovation

Final Report

Developing Technical Guidelines National Construction Code 2019 Proposals for Change

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Project code:

VG16004

Project:

VG16004 – Developing Technical Guidelines National Construction Code 2019 Proposals for Change

Disclaimer:

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Revision List:

Table 1 Revision Table

Date	Revision	Author	Description
June 12, 2017	Issue A	M Olivotto	Issued to Horticulture Innovation Australia Limited via electronic transfer.

Funding Organisation

Horticulture Innovation Australia Limited

Project Partners

Osborn Consulting Engineers Pty Ltd

FERM Engineering

Doyles Construction Lawyers

RM Consulting Group

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Glossary of Abbreviations

ABCB	Australian Building Codes Board
AIBS	Australian Institute of Building Surveyors
AS	Australian Standards
ASTM	American Society of Testing and Materials
BA	Building Approval
BCA	Building Code of Australia
CBA	Cost-Benefit Analysis
CFA	Country Fire Authority
CPM	Compartmentalised Plastic Membrane
DA	Development Application
FPM	Film Plastic Membrane
FRP	Fibre Reinforced Plastic
IHB	Greenhouse and Grow Structures
HDPE	High-density Polyethylene
HIA	Horticultural Innovation Australia
IBC	International Building Code
ICC	International Code Council
IHB	Intensive Horticultural Building
IFC	International Fire Code
IPM	Integrated Pest Management
NCC	National Construction Code
NOSHC	National Code of Practice for the Storage and Handling of Workplace Dangerous Goods
PCA	Protected Cropping Australia
PFC	Proposal for Change
PM	Plastic Membrane
SOP	Summary of Process
SPM	Sheet Plastic Membrane

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1.0 Executive Summary

The Current Problem

The Protected Cropping Industry is the fastest growing food producing sector in Australia, valued at around $1.8 billion at the farm gate per annum. This is equivalent to 20% of the value of total vegetable and cut flower production in Australia[1] (RIRDC, 2015). It is estimated that more than 10,000 people are employed directly in greenhouse horticulture throughout Australia, with the industry expanding at between 4-6% per annum. The average return on investment is between 5% and 10%. The potential return on investment for high technology greenhouse vegetable enterprises is around 20-25% per annum[2] (PCA, 2017).

An economic burden currently experienced by protected cropping growers (Non-Referenced Source: VG16004 Grower Survey) is the cost associated with the development and maintenance of new protective cropping structures. This burden may be attributed to:

- Project delays due to building classification uncertainty;
- Delays due to resolving design complications of non-relevant regulatory restrictions;
- Upfront costs of fire and egress infrastructure; and
- Ongoing costs of maintaining fire and egress infrastructure.

These burdens are present as, in Australia, protected cropping structures such as greenhouses and grow structures do not currently have a defined relevance to the current construction code, Building Code of Australia 2016. Therefore, the structures are forced to comply with general design and construction practices specified in the Australian Standards (AS) and the Building Code of Australia, which encapsulates the National Construction Code Volume One and Volume Two. A key concern for the protected cropping sector is that the current building codes applied to greenhouse construction are not relevant to today's operations.

The Proposal

The general concept of this proposal is as follows - the proposal consists of eleven steps, identifying specific changes to the classification and Provisional Framework to include Intensive Horticultural Buildings into the NCC. Steps one to three are associated with the NCC Volume One while steps four through to nine are associated with changes made to the NCC Volume Two. Steps ten and eleven are made to the NCC Guide.

[1] RIRDC, 2015. *HSA-9A,* s.l.: Australian Government - Rural Industries Research and Development Corporation.

[2] PCA, 2017. *Our Industry.* [Online]
Available at: http://www.protectedcroppingaustralia.com/?page_id=94
[Accessed 22 March 2017].

National Construction Code Volume One (Change Numbers One to Four)

- **ChNo1 – Redefine Farm Building** – To begin the change in classification/definition framework the project team has altered the current farm building definition within the NCC to include intensive horticultural buildings (defined in ChNo2). The intensive horticultural buildings are classified as Group A, Group B and Group C – these groups allow for efficient and effective classification of the analysed building, reducing compliance of unnecessary; and provisions not relevant to; the specific form and use of building.
- **ChNo2 – Provide Definition for Intensive Horticulture Building** – This proposed change adds a definition into the NCC for intensive horticulture buildings which specifies the building's primary usage for horticultural means.
- **ChNo3 – Alteration to NCC Volume One Part H3 Farm Buildings and Farm Sheds** – It is proposed to revise Part H3 to include intensive horticultural buildings and their application of Parts.

National Construction Code Volume Two (Change Numbers Five to Nine)

- **ChNo4 – Redefine Farm Building** – To begin the change in classification/definition framework the project team has altered the current farm building definition within the NCC to include intensive horticultural buildings (defined in ChNo5). The intensive horticultural buildings are classified as Group A, Group B and Group C – these groups allow for efficient and effective classification of the analysed building, reducing compliance of unnecessary; and provisions not relevant to; the specific form and use of building.
- **ChNo5 – Provide Definition for Group C Intensive Horticulture Building** – This proposed change adds a definition into the NCC for intensive horticulture buildings which specifies the building's primary usage for horticultural means.
- **ChNo6 – Group C Intensive Horticultural Building Classification as Class 10** – An addition shall be made to Class 10 at Part 1.3 Section 1.3.2 Classification whereby a subclass 10d shall be added. This allows for inclusion of the Group C Intensive Horticultural Building into Volume Two of the NCC. An explanatory information note has also been included in this part.
- **ChNo7 – Group C Intensive Horticultural Buildings Classification as Multiple** – An addition shall be made to Class 10 at Part 1.3 Section 1.3.3 Multiple classifications whereby a subclass 10d shall be added. This allows for inclusion of the Group C Intensive Horticultural Building into Volume Two of the NCC for multiple classification applications.
- **ChNo8 – Group C Intensive Horticultural Buildings Protection from Spread of Fire** – An alteration shall be made to Part 2.3 Fire Safety to ensure a Class 10d building does not significantly increase the risk of fire spread between Class 2 to 9 buildings.
- **ChNo9 – Group C Intensive Horticultural Buildings Explanatory Information** – An explanatory information note has been included in Part 2.3 Fire Safety which outlines specification for Class 10d structures.

Proposals Ten and Eleven have not been included in this summary but can be found in Section 6 of this document.

Consultation and Justification

Justification of the NCC Proposal for Changes is vital to the successful implementation of the project's recommendations. This project is utilising a five-part justification process to ensure the Proposals are defensible and of net-benefit to industry and society. A brief description of each of the justification parts are provided below:

- **Social** – Provides justification on how the proposed changes would provide a net-benefit to Australian society. For example: local food security etc.
- **Technical** – Provides justification on how the proposed changes are defensible in a technical environment. For example, fire models, literary review of international regulation etc.
- **Industry** – Provides justification that the proposed changes have had draft industry review and industry have provided feedback. Industry here relates to Building Certifiers and Fire Authorities, the industries who would implement proposed changes.
- **Growers and Grower Industry** – Provides justification that the proposed changes meet the needs of growers to encourage industry growth, food security and lower approval costs.
- **Economic** – Provides justification that the proposed changes are of economic benefit to the grower, local communities and Australia's national economy.

A summary of justification applied to each of the change initiatives documented in Section 6.2 of this report has been provided. For a detailed outline of justification refer to Sections 6.3.1 to 6.3.3 and referenced appendix documents.

2.0 Introduction

2.1 Scope and Objectives

It is the objective of this project to develop technical guidelines in relation to previous Horticultural Innovations Australia project VG13055 (refer to Appendix D) for inclusion in the National Construction Code. Utilising the findings of the VG13055 Code of Practice, and consultation with relevant industry and technical experts, the Project Team advises the submission of the Proposals for Changes made within this report and its associated Australian Building and Construction Board (ABCB) Proposal for Change document/s. It was the Project Team's objective to develop technical guidelines that meet the regulatory principals described by the National Construction Code (NCC); these principals are[3] (ABCB, 2016):

- There is a rigorously tested rationale for the regulation;
- The regulation would generate benefits to society greater than the cost (that is, net benefit);
- There is no regulation or non-regulatory alternative that would generate higher net benefits; and
- The competitive effects of the regulation have been considered and the regulation is no more restrictive than necessary in the public interest.

Once preliminary guidelines were developed, the relevant Project Team stakeholders (Osborn Consulting, FERM, Doyle's Construction Lawyers and RMCG) undertook investigatory consultation meetings with members of relevant industry bodies who would be affected and/or need to apply the proposed NCC changes. From there it was our objective, together with our team of construction lawyers, manufacturers, engineers and certifiers to develop full technical guidelines which are compliant with the regulatory principles (defined above), ideal grower requirements (determined through grower consultation and completed surveys), and Greenhouse / Grow Structure (IHB) stakeholder pressures.

The all-inclusive objective of this project is to develop a Proposal for Change that is accepted by the ABCB and achieves significant net benefit to vegetable growers throughout the application, design and approval stages of new IHB development.

2.2 Industry Background

The Australian vegetable industry is one of Australia's largest horticultural industries with an estimated annual gross value of production of $3.7 billion in 2013-14 with around 5,300 agricultural businesses that produce vegetables for human consumption.[4] (AUSVEG, 2017)

> *Note: In relation to the above figures, a minimum cut-off value of $5,000 was used to determine whether an agricultural business operation was in scope.*

The vegetable industry operates on a national scale, with production areas located all around the country. Most production is located close to capital and regional centres, however there are also significant production regions all over the country. The key states for production are Queensland and Victoria, whilst

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[3] ABCB, 2016. *Guidelines Preparing PFC,* s.l.: Australian Building Codes Board.

[4] AUSVEG, 2017. *Vegetable Industry Financials.* [Online]
Available at: http://ausveg.businesscatalyst.com/resources/industrystatistics.htm
[Accessed 10 January 2017].

Western Australia is also a significant state for vegetable exports. Vegetable production remains a key industry in Tasmania and South Australia[5] (AUSVEG, 2017).

In the domestic market, Australian vegetable growers have limited opportunities to increase their revenue stream which takes up approximately 93% of production. However, the level of exports of Australian vegetables, particularly to the Asian and Middle Eastern markets, have increased demand. Export values increased to over $270 million in 2014-15, up from $265 million in 2013-14 (AUSVEG, 2017). Increased international demand for Australian vegetables is partially due to the strong reputation of clean, green and safe vegetables awarded to Australian growers.

The supplier landscape is continuing to consolidate and adjust as many growers seek greater economies of scale in order to remain competitive. Some smaller businesses continue to remain profitable by focusing on niche market opportunities or specialising as suppliers to other larger growers who have direct supply contracts.

Despite the contraction in grower numbers the industry is steadily growing. This is evidenced by levy receipts which have shown continued steady growth over the past decade, rising to $8.1 million in 2014-15 from $5 million in 2004-5 (AUSVEG, 2017).

2.3 General Project Background

An economic burden currently experienced by protected cropping growers (Non-Referenced Source: VG16004 Grower Survey) is the cost associated with the development and maintenance of new protective cropping structures. This burden may be attributed to:

- Project delays due to building classification uncertainty;
- Delays due to resolving design complications of non-relevant regulatory restrictions;
- Upfront costs of fire and egress infrastructure; and
- Ongoing costs of maintaining fire and egress infrastructure.

These burdens are present as, in Australia, protected cropping structures such as greenhouses and grow structures do not currently have a defined relevance to the current construction code, Building Code of Australia 2016. Therefore, the structures are forced to comply with general design and construction practices specified in the Australian Standards (AS) and the Building Code of Australia, which encapsulates the National Construction Code Volume One and Volume Two. A key concern for the protected cropping sector is that the current building codes applied to greenhouse construction are not relevant to today's operations.

As protective cropping structures do not have their own code or exemptions they are usually, at the discretion of a private certifier or local council, required to conform to a code that applies to commercial/storage structures. These structures are typically defined as a Class 8 building in Section A3.3 of the NCC Volume One. Achieving Class 8 compliance of an intensive horticultural building can become a

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[5] AUSVEG, 2017. *Vegetable Industry Financials.* [Online]
Available at: http://ausveg.businesscatalyst.com/resources/industrystatistics.htm
[Accessed 10 January 2017].

large economic burden especially when adhering to, for example, the current NCC Volume One Class 8 egress and fire regulatory requirements.

Within the current version of the BCA (specifically NCC Volume One 2016) the ABCB has included Part H3 Farm Buildings and Farm Sheds to assist in providing deemed-to-satisfy provisions for farm related buildings. Though a step in a positive direction, many growers and members of the protected cropping industry consider this Part not to be applicable to intensive horticultural buildings due to their size, construction materials, occupancy ratios and use. Further discussion and justification for changing the BCA is provided throughout this 'Summary of Process' document and the associated 'ABCB Proposal for Change' document.

The Project Team briefly provide below outlines of the types of intensive horticultural buildings that are currently within Australia's protective cropping landscape.

A protective cropping structure is a structural building usually constructed from masonry, timber, steel, FRP or aluminium with glass, fibreglass, rigid or thermal plastic used as a covering material; coverings can be permeable or impermeable, retractable or permanent. These buildings are used for horticultural applications to control specific environmental conditions to facilitate high quality, high quantity production of a defined fruit, vegetable, plants or flower.

Profile identification of a greenhouse is generally according to its basic roof profile shape; most commonly these profiles are flat, arch, raised dome, sawtooth, gable, skillion and tunnel. Being a technology-based investment, the higher the level of technology used, the greater the potential for achieving tighter and more accurately controlled growing conditions. Technology levels in IHB can be categorised as 'Low', 'Medium' and 'High'.

> *Note: These categories are not used within the NCC Proposal for Change and are merely provided as a general IHB category definition used by growers and their associated industries. Technical classifications suited for inclusion into the National Constructions Code are defined in Section 6 of this Report and the associated National Construction Code Series Proposal for Change documents.*

Low technology IHB – these structures are very common in Australia. The greenhouses are usually less than 3 metres in height and have a tunnel or 'igloo' profile shape. These structures are popular because they are relatively inexpensive and easy to erect. Large span, cable supported net structures covering large areas usually up to 6.0 m high can also be included in this category. Refer to Figure 1 for an example of a low technology structure.

Figure 1 Example of a Low Technology Structure (Source: Purchased Stock Image)

Medium technology IHB – characterised by vertical walls (between 2 and 4 metres) and commonly has roof or side ventilation, or both. Medium technology greenhouses are seen as a compromise between low and high technology and are cost relative to increased environmental control (compared to low technology greenhouses). Refer to Figure 2 for an example of a medium technology structure.

Figure 2 Example of a Medium Technology Structure (Source: Purchased Stock Image)

High technology IHB – achieving the highest level of environmental control and automation to offer potential for higher quality and quantity of produce. These structures are usually constructed with walls at least 4 metres high and with the roof peak being up to 8 metres. Refer to Figure 3 for an example of a high technology structure.

Figure 3 Example of a High Technology Structure (Source: Purchased Stock Image)

The term ‘intensive horticultural building’ (see Section 2.8 for definition) has been used throughout this document and the associated changes proposed for the NCC. The term incorporates all structures and their categories discussed in Section 2.3 (this section) of this document.

The Proposal for Change (**PFC**) process is used to consider technical proposals to change the NCC, which could relate to either the BCA (Volumes One, Two and Guide), or the PCA (Volume Three). Technical proposals do not include those which address matters of public policy or for which direction from government is required before a change to the NCC can be considered. The following information is a direct source from the ABCB[6] (ABCB, 2017).

The PFC process is consistent with the Council of Australian Governments (**COAG**) best practice regulatory principles to ensure appropriate rigour is used in the assessment of proposals. The below has been directly sourced from relevant PFC change documents provided by the ABCB.

[6] ABCB, 2017. *Propose a Change.* [Online]
Available at: http://www.abcb.gov.au/NCC/Propose-a-Change
[Accessed 23 February 2017].

Proposal

Those seeking to propose a change are required to provide justification to support their proposal. This justification should be proportionate to the size of the proposed change or its potential impacts.

Justification should include:

- a description of the proposal;
- an explanation of the problem it is designed to resolve;
- evidence of the existence of the problem;
- how the proposal is expected to solve the problem;
- what alternatives to regulation have been considered, and why they are not preferred;
- who will be affected and how they will be affected; and
- any consultation that has taken place.

Consideration

Submitted proposals are reviewed and considered for tabling at a meeting of the relevant building or plumbing technical Committee.

If the proposal is considered to have merit, the Committees may recommend that changes be included in the next public comment draft of the relevant volume. For a proposal to be considered it must be submitted by 1 September 2017 in order to allow sufficient time for consideration prior to the release of the NCC 2019 public comment draft. Proposals received after this date will be considered for inclusion in the public comment draft for the following NCC edition i.e. NCC 2022.

In order to make the most effective use of resources, reduce unnecessary churn and focus on priorities, PFCs that address matters of public policy, repeat previous submissions, involve matters outside the purview of the NCC or the purpose of which would make no material change to a provision are discouraged.

Information submitted will not be released unless required by law, but may be made available to the ABCB and its Committees if required. Information collected may be subject to requests made under the Freedom of Information Act 1982.

Submission

A PFC must be developed using the prescribed PFC Template, in Microsoft Word format only. A Guideline to Preparing a PFC has been developed to provide further assistance in your preparation of a PFC. The completed PFC must be submitted using the PFC upload form.

2.4 Document Utilisation

2.4.1 General Background to Utilisation

This NCC PFC recommendation document sets out the practical guidelines for the design, approval and management of IHB buildings while providing justifiably appropriate additions or alternatives to the current 2016 BCA for inclusion into the 2019 BCA. This Summary of Process document presents design data, approval guidelines, grower consultation, industry consultation, economic benefit and building management information that affirms the change recommendations made within the associated ABCB Proposal for Change document.

The information, procedures and change recommendations provided within these documents (Summary of Process and ABCB Proposal for Change documents) are based on literary review of national and international codes and guidelines with considerable consultation with the following professional and interested stakeholders:

- Fire Engineers [Professional Stakeholder];
- Building Certifiers [Professional Stakeholder];
- Construction Lawyers [Professional Stakeholder];
- Structural Engineers [Professional Stakeholder];
- Horticultural Management and Extension Consultants [Professional Stakeholder];
- IHB Manufacturers [Interested Stakeholder]; and
- IHB Growers [Interested Stakeholder].

Table 2, below, provides a description of each of the documents utilised within this project.

Table 2 Utilised Documents Description

Summary of Process (SOP)	ABCB Proposal for Change (PFC)
The Summary of Process document provides supporting and background information for the proposed PFC. This document also includes the means of justification for the change initiatives documented with the PFC.	The completed Proposal for Change form will assist the Australian Building Codes Board (**ABCB**) and its technical advisers in assessing the proposal and its potential impact. The PFC form outlines all recommended changes to the 2019 BCA.

The approach utilised to link both the Summary of Process and ABCB Proposal for Change is described in the following way: Generally, the ABCB PFC should be read as primary while the SOP is utilised as a supporting document to the recommended changes made. Within the PFC, each proposed change will be afforded a unique number to assist in ensuring ease of navigation throughout the documents. These unique numbered changes within the PFC link to their associated change section within SOP **Section 6.2 Summary of each Proposal**, their supporting information can be found for each specific change proposal.

2.4.2 Submission to the ABCB and Associated Timeframes

As per VG16004's executed contract, Osborn Consulting Engineers Pty. Ltd. may be formally engaged by Horticulture Innovations Australia to submit the Proposal for Change to the ABCB on the Company's behalf, refer to Section 7.1 for further information. Horticulture Innovations may choose to contact Osborn Consulting to discuss submission and consultation requirements during the ABCB amendment cycle not covered within this Contract's scope of works. Osborn Consulting will be contactable to discuss financial and engagement terms of this if the need arises.

The following table (refer to Table 3) describes key NCC 2019 dates:

Table 3 Key Dates for PFC[7] (ABCB, 2017)

Date	Title	Description
1 September 2017	Proposal for Change Submission period closes	Proposals to change the NCC for 2019 may be submitted at any time, however must be received by 1 September 2017.
1 February 2018	Public Comment Draft Consultation period	The public comment period commences on 1 February 2018 when the NCC 2019 Public Comment Draft is released.
13 April 2018		Closing date for comments on NCC 2019 is 13 April 2018.
February 2019	NCC 2019 preview available	The preview of NCC 2019 is available for download from the ABCB website from February 2019.
1 May 2019	NCC 2019 adopted	NCC 2019 will be adopted by States and Territories on 1 May 2019

Note: The dates documented in Table 2 are subject to change, the reader is advised to confirm these dates are accurate at the time of reading by visiting http://www.abcb.gov.au/NCC/Propose-a-Change

Submission of the PFC must be completed using the online ABCB 'PFC unload form'.

Important Note on Submission and ABCB Adoption:

Though the Project Team has undertaken thorough review, analysis and consultation with relevant industries there are associated risks in submission and adoption of the Proposal for Change within the National Construction Code. The Australian Building Code Board has the prerogative to reject in part or whole of a Proposal that is submitted for inclusion. As outlined in this Project's Milestone Reports, there is an underlying risk that the ABCB may not accept the suggested Proposals due to the relative newness of the NCC Volume One Part H3 and the classification verification methods proposed. Throughout the project, it has been the Project Team's objective to meet the expectations of Hort Innovations, vegetable levy growers and relevant industry consultation requests. The Project Team has strived for genuinely acceptable outcomes which are considered to meet the ABCB PFC guidelines and industry needs to effectively reduce burden on protected cropping growers and the industry they support. Due to the nature of the ABCB amendment cycle the Project Team makes no guarantee on the adoption of the Proposal documented.

2.5 The Project Team

Osborn Consulting Engineers Pty. Ltd.

Osborn Consulting Engineers were the primary research provider for the Hort Innovation project VG16004 'Developing technical guidelines and best practice extension toolbox for greenhouse construction and safe operation'. Osborn Consulting (previously Osborn Lane) is an engineering consulting firm that have

[7] ABCB, 2017. *Propose a Change.* [Online]
Available at: http://www.abcb.gov.au/NCC/Propose-a-Change
[Accessed 23 February 2017].

been providing professional engineering services in the disciplines of Structural and Civil Engineering Design since 1983. The Company has a particular interest and a wealth of experience in greenhouses, grow structures, protective canopies and fabric structure design, which it has applied to this particular project.

FERM Engineering

FERM Engineering are one of the primary sub-consultants for the Hort Innovation project VG16004. They offered professional services in Fire Engineering including fire safety audits and assessments, dynamic modelling, and various fire and egress assessments and reports. Under the scope of this project, FERM Engineering addressed fire related elements of a building, fire equipment and egress research, smoke and fire spread and intervention assessments and information requirements for proposals of change to a revised NCC.

Doyle's Construction Lawyers

As one of the primary sub-consultants for the VG16004 Project, Doyle's Construction Lawyers specialise in Construction Law. Due to their experience in the building and construction industry, Doyle's contributed to the project by providing project planning and legal advice, as well as conducting valuable research in regard to local government approval processes. In addition, Doyle's provided proposals for reform of the legislation and approval process and contributed to the strategic recommendation contained in the final report.

RMCG

RMCG are a major sub-consultant for the VG16004 project, using their experience in horticulture, extension and rural industry development to provide a range of valuable advice and support. In particular, RMCG undertook the development of technical guidelines, literature review, grower and industry consultation, as well as the development of the best practice extension toolbox and also assisted with project management.

2.6 Project Outputs

The Project Team has developed the following outputs for the Project, these are documented in list form below:

- **Summary of Process Document (this document)** – This document provides literary review findings, justification and consultation throughout the Project. This document is considered the foundation document and shall be read in conjunction with the Proposal for Change document.
- **Proposal for Change Document (Appendix A)** – This document outlines, in the format prescribed by the Australian Building Codes Board, the Proposals for Change proposed by this Project and provides an overview of the justification used to validate the Proposals. This document shall be read in conjunction with the Summary of Process document as it provides detailed research methodology and documentation.
- **Fire Models and Report by FERM (Appendix B)** – This document provides methodology, analysis and results obtained from fire models produced as part of the technical justification of this Project and is referenced in the Summary of Process and Proposal for Change documents.
- **Grower Toolbox (Appendix C)** – This set of documents provide growers and their associated industries with a valuable educational source of information regarding the development,

application process, design and operation of intensive horticulture buildings. The toolbox has also been developed as a website and can be found at www.greenhousetoolbox.com

- **Letters of support and associated information (Appendix E)** – Letters of support have been provided from relevant stakeholders.
- **Industry Consultation Webinar (link provided)** – A recording of the industry consultation webinar undertaken in May 2017 has been provided. The recording can be found at https://attendee.gotowebinar.com/register/412247973284797953
- **A booth at the APEX-Brinkman Future Growing Conference in July 2017** – Members of the Project Team will attend and manage a booth at the Future Growing Conference in July 2017. The conference will be an ideal situation for project outreach, education and dissemination.

2.7 Reference Documents

The following list of technical references have been utilised throughout the development of this project:

- National Construction Code of Australia (NCC, BCA), Volume One & Volume Two, 2016
- International Building Code (IBC) 2015, International Code Council INC.
- International Fire Code (IFC) 2015, International Code Council INC.
- National Code of Practice for the Storage and Handling of Workplace Dangerous Goods (NOHSC: 2017)
- AS 1670 Fire detection, warning, control and intercom systems — Systems design, installation and commissioning
- AS 2419 Fire hydrant installations - System design, installation and commissioning
- AS 2441 Installation of fire hose reels
- AS 2444 Portable fire extinguishers and fire blankets – Selection and location
- AS 1288 Glass in Buildings
- AS 2047 Windows in Buildings
- AS/NZS 1170 Structural Design Actions
- AS 4100 Steel Structures
- AS 1720 Timber Structures
- AS 3600 Concrete Structures
- AS 1664 Aluminium Structures
- AS 1530.2 Methods for fire testing on building materials
- EN 13031-1 Greenhouses – Design and Construction
- BS 5502-23 Building and structures for agriculture – Part 23: Fire Precautions

2.8 Terms and Definitions

For the purposes of this Document, the following terms and definitions apply. Where applicable, sources of the below definitions have been taken from the NCC, IBC and relevant Australian Standards.

Area:

<any part of a roof> area normal to the slope

Area:

<storey of a building> total area bounded by the inner finished surfaces of the enclosed wall or, on any side where there is no enclosing wall, by the outermost edge of the floor on the side.

Boundary:
Border edge of a lease or lot boundary.

Building:
A permanent structure that has a roof and support systems and is used for housing of people or work processes or goods or possessions.

Certifier:
Private and Local Government certifiers shall henceforth be referred to as certifier/s.

Element of structure:
Any loadbearing element of a structure.

Fire hazard:
Physical situation that could catch fire or cause a fire and thereby be harmful to persons, or damage to property, or both.

Fire risk:
Probability that a fire will occur as a result of the existence of a fire hazard.

Fire consequence:
The effect, result, or outcome of a fire. Consequence relates to damage to or loss of life and/or property.

Greenhouse (see grow structure):
Greenhouse refers to intensive horticultural structures growing or propagation of plants, flowers and vegetables and excludes retail and wholesale nurseries and conservatories.

Grow structure (see greenhouse):
Grow structure refers to intensive horticultural structures growing or propagation of plants, flowers and vegetables and excludes retail and wholesale nurseries and conservatories.

Grower:
Greenhouse or grow structure owners, greenhouse or grow structure developers and farm operators shall henceforth be referred to as grower/s.

Height:
<of a building, for the propose of fire considerations> vertical height from ground level to half the height of the roof in a pitched building, or to the top of the roof or parapet (whichever is the higher) in a flat roof building.

Intensive Horticultural Building:
A farm building or part thereof, used for environmentally controlled farming, propagation or growing of plants or fungi but is not used for the packing, display, trade or sale of the products or parts produced.

Occupant:
Is a person, family, group that lives in, regularly occupies, works in or has quarters or has an activity that takes space inside the Building. It does not include animals, livestock or items of property.

Protected area:
Part of the external wall constructed to achieve the required period of fire resistance.

3.0 Summary of Literary Review and Consultation

3.1 Literary Review Methodology

Research methodology for this report was conducted in consultation with knowledgeable and expert parties, including consultation with construction lawyers, private certifiers, rural management specialists, fire engineers, regulators, growers, manufacturers and other industry members. A literary review of the existing standards and supporting documentation is the basis of all research methodology completed for this project. All of the consultants contributing to the project utilised a VG16004 Project Dropbox account to facilitate collaboration and development of the literature review, recommendations, technical guidelines and toolboxes. All references, either direct or indirect within this project are in the style of Harvard Referencing within text references, footnote references and an end of document reference list.

Several utilised avenues of research methodology for this project were:

1. Research existing theories and concepts to help identify proposed improvements to the approval process through a literary review process.
2. Complete research on the needs and desires of the industry (including growers, manufacturers and regulatory/certification bodies) including on the provision of general information and on technical guidelines and associated compliance.
3. Mathematical and logistical research on industry and business to determine cost of compliance and potential reductions.
4. The analysis and development of strategic leadership tool sets to ensure efficient and effective engagement with growers, stakeholders, experts and regulators (where required).
5. Undertake effective legal framework analysis to determine legal outcomes of the objectives and outputs.
6. Carry out social and communicational research to find answers to questions not discovered in the mathematical and logistical research (social research being the easiest means to determine industry perception of a specific issue).

Other avenues of methodology may be introduced during the project however the above six processes underpin all research and documentation.

Social and communicational research with the grower community consisted of the development of a grower survey.

3.2 Literary Review Findings

Section 3.2 of this document outlines the literary review findings of this Project. A literature review is a critical analysis of published sources, or literature, on a particular topic. It is an assessment of the literature and provides a summary, classification, comparison and evaluation.

3.2.1 Intensive Horticultural Building Classification in Australia

Reducing cost of compliance for structures, be it through regulation or design parameters, is not a new idea; the exponentially increasing availability of new technology and growth in design experience has led to greater design efficiency. Growers have benefited greatly from the progress made in structural efficiency by the design of lighter and stronger IHB systems. National, State and Local Council regulation however, may be seen to lack efficiency, decisiveness and relevance to the expanding IHB industry.

Issues streamlining the process of government approval for IHB originate largely from the interpretation of the National Construction Code (NCC) - Building Code of Australia (BCA) and its classification of IHB. Further reference to the Building Code of Australia (BCA) in this project means Volume One of the National Construction Code Series (NCC) unless noted otherwise. Construction requirements for every building type are primarily associated with their classification in accordance with clauses A3.2 and 1.3.2 of the BCA. A3.2 of the BCA stipulates[8] (NCC Vol One, 2016) "The classification of a building or part of a building is determined by the purpose for which it is designed, constructed or adapted to be used."

The below Table 4 outlines existing building classes used within the NCC.

Table 4 NCC Classifications[9] (QBCC, 2017)

Classes of Building		
Class 1	**Class 1a**	A single dwelling being a detached house, or one or more attached dwellings, each being a building, separated by a fire-resisting wall, including a row house, terrace house, town house or villa unit.
	Class 1b	A boarding house, guest house, hostel or the like with a total area of all floors not exceeding 300m2, and where not more than 12 reside, and is not located above or below another dwelling or another Class of building other than a private garage.
Class 2	A building containing 2 or more sole-occupancy units each being a separate dwelling.	
Class 3	A residential building, other than a Class 1 or 2 building, which is a common place of long term or transient living for a number of unrelated persons. Example: boarding-house, hostel, backpackers accommodation or residential part of a hotel, motel, school or detention centre.	
Class 4	A dwelling in a building that is Class 5, 6, 7, 8 or 9 if it is the only dwelling in the building.	
Class 5	An office building used for professional or commercial purposes, excluding buildings of Class 6, 7, 8 or 9.	
Class 6	A shop or other building for the sale of goods by retail or the supply of services direct to the public. Example: café, restaurant, kiosk, hairdressers, showroom or service station.	
Class 7	**Class 7a**	A building which is a car park.
	Class 7b	A building which is for storage or display of goods or produce for sale by wholesale.
Class 8	A laboratory, or a building in which a handicraft or process for the production, assembling, altering, repairing, packing, finishing, or cleaning of goods or produce is carried on for trade, sale or gain.	
Class 9	A building of a public nature.	
	Class 9a	A health care building, including those parts of the building set aside as a laboratory.
	Class 9b	An assembly building, including a trade workshop, laboratory or the like, in a primary or secondary school, but excluding any other parts of the building that are of another class.
	Class 9c	An aged care building.
Class 10	A non-habitable building or structure.	
	Class 10a	A private garage, carport, shed or the like.
	Class 10b	A structure being a fence, mast, antenna, retaining or free standing wall, swimming pool or the like.
	Class 10c	A private bushfire shelter.

In the individual States and Territories, appropriate authorities (such as local councils) may classify IHB or other 'farm buildings' as Class 10a, which covers non-habitable buildings. A classification of 10a would

[8] NCC Vol One, 2016. Part A3 Classifications of Buildings and Structures. In: *NCC 2016 BCA Guide to Volume One.* s.l.:ABCB, p. 56.

[9] QBCC, 2017. *NCC Classification Fact Sheet.* [Online]
Available at: https://www.qbcc.qld.gov.au/sites/default/files/BCA%20Classes%20of%20Building.pdf
[Accessed 01 5 2017].

only be made if Class 7 and Class 8 within the BCA were not appropriate[10] (NCC Vol One, 2016). When making the decision a certifier considers the buildings size, operations, purpose and occupation/utilization by people.

There are three basic types of Class 7 buildings. The first is Class 7a a carpark, the second, Class 7b, a building for storage and thirdly Class 7c, a building for the sale of wholesale goods. 'Wholesale' is the business of selling goods in large quantities and at low prices, typically to be sold on by retailers at a profit[11] (NCC Guide, 2016). An IHB structure would not fit into these categories easily without considerable interpretation of the word 'wholesale' and 'storage.' The primary use of IHB is for growing produce. Once the produce is ready for sale, the product is picked (collected) and transported to another storage facility for wholesale. Hence, Class 7 is inappropriate for IHB. Though common farm IHBs would not meet the classification of 'wholesale', the nursery segment of the industry is affected.

Though initially considered by the Project Team, inclusion of nursery structures within the definition of IHB has identified several risks to the successful implementation of the proposal for Change for inclusion into the National Construction Code by the Australian Building Code Board. Through literary review the Project Team identified three typical forms of nurseries, these being retail, wholesale and production. Production structures are defined as IHBs used solely for the purpose for growth of plants and not for sale or trade. Retail nurseries were dismissed from the farm IHB category due to their public nature and current classification as a building used for the sale of goods – analysis found these structures were required to conform to the existing provisions due to their higher risk/consequence profile. Wholesale nurseries were not initially dismissed from the farm IHB category however their inclusion into the proposed IHB classification proved difficult and hazardous – further detail has been provided below regarding this.

As mentioned above, the current NCC Guide Part A3 describes wholesale activity as "wholesale means sale to people in the trades or in the business of 'on-selling' goods and services to another party (including the public)." As such, a wholesale nursery currently falls within the Class 7b of the NCC. As there is little ambiguity surrounding the current Class 7b building (for storage, or display of goods or produce for sale by wholesale) it may therefore prove difficult for the Proposal to pass regulatory standards imposed by the ABCB. Reasons for this are if ABCB allows specific wholesale buildings to have their own classification then the code becomes convoluted and ambiguous through a precedence set by this Proposal. Analysis and models also show that if the Project Team were to include wholesale nurseries into the farming IHB definition it would be forced to reduce the impact on the NCC Provision exclusions. A building for wholesale purposes would need to be accessible to those with a disability, alternative exits (as documented within the PFC) would not be allowed, egress distances would be the same as current NCC distances and hydrant/sprinkler systems would be imposed. It is considered that these findings are of no significant benefit to industry especially the vegetable levy paying growers.

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[10] NCC Vol One, 2016. Part A3.1 Classification of Buildings and Structures. In: *NCC 2016 Building Code of Australia - Volume One.* s.l.:Australian Building Code Board, pp. 45-47.

[11] NCC Guide, 2016. National Construction Code 2016. In: *Part A3 Classifications of Buildings and Structures.* s.l.:ABCB, p. 60.

Class 8 buildings are commonly described as a 'factory.' More specifically, this class includes buildings used as a "laboratory, or building in which a handicraft or process for the production, assembling, altering, repairing, packing, finishing, or cleaning of goods or produce is carried on for trade, sale, or gain."[12] (NCC Vol One, 2016) Use of the word 'production' has been problematic when decisively classifying IHB structures in a unified category around Australia. If a certifier does not classify an IHB as Class 10a, he/she would usually classify the structure as Class 8 as people are likely to be employed to feed, clean or collect produce from animals or plants within a building. However, this can be seen as an inaccurate classification. Practice Note 2015-67 by the Victoria Building Commission (issued January 2015) gives information on the process that animal shelter buildings are required to comply with the BCA[13] (Victoria Building Authority, 2015).

Part H3 of the NCC 2016 Volume One titled 'Farm Buildings and Farm Sheds' has attempted to clarify buildings used for farming, though a positive direction, these recommendations do not aptly apply to the specific design and safety parameters suited to an intensive horticultural building. For example, it is common for protected cropping structures to have an area greater than 1 hectare (10,000 m^2); compliance with egress requirements stipulated within the NCC can therefore prove difficult if the building is to comply with Part D1 'Provision of Escape', particularly Part D1.4 whereby 20 m travel distance is prescribed unless alternative exits are constructed the 40 m travel distance is permitted[14] (NCC Vol One, 2016). Exits are also not permitted to be more than 60 m apart as per provisions documented in NCC Part D1.5. Therefore, a protected cropping structure with a large area would have difficulty complying with the egress provisions if the lengths or widths of the building exceeds 40 to 60 m. Growers with larger buildings are typically required to seek alternative solutions to this egress issue that meets safe operations practices determined by a professional engineer – this solution applies additional cost and time to the project, reducing development incentive.

Literary review of Part B of the NCC Volume One investigates the prescription of provisions in relation to the structure through performance requirements such as actions and loading, reliability, structural resistance, glass installation and construction methods. The requirements stipulated within Part B were assessed against the criteria of rigorous testing rationale for the regulation as defined by the ABCB; the regulation would generate benefits to society greater than the cost (that is, net benefit); there is no regulation or non-regulatory alternative that would generate higher net benefits; and the competitive effects of the regulation have been considered and the regulation is no more restrictive than necessary in the public interest[15] (ABCB, 2016).

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[12] NCC Vol One, 2016. Part A3.1 Classification of Buildings and Structures. In: *NCC 2016 Building Code of Australia - Volume One.* s.l.:Australian Building Code Board, pp. 45-47.

[13] Victoria Building Authority, 2015. *Practice Note 2015-67 Application of the Building Code of Australia to Farm Buildings,* s.l.: Victoria Building Authority.

[14] NCC Vol One, 2016. Part D1.4 Exit travel distances. In: *National Construction Code Volume One.* s.l.:Australian Building Codes Board, pp. 193-194.

[15] ABCB, 2016. *Guidelines Preparing PFC,* s.l.: Australian Building Codes Board.

It was found through this assessment that recommended change to the Part B Structural Provisions may be seen to be unnecessary, and if they were enacted, may cause ambiguity of requirements. Consequences could include improper design of structures resulting in reduced public safety and increased economic burden on the grower and society. This report does however recommend that proprietors of the Australian Standards AS 2047, AS 1288, AS/NZS 1562.3 and AS/NZS 4256 assess these standards against the proposed changes made to the NCC by this project. The aforementioned Australian Standards provide regulation on structural design and construction of both rigid and non-rigid glazing.

3.2.2 Intensive Horticultural Building Classification Internationally

Europe, Canada and the United States of America have codes and standards that can either be specifically used for IHB structures or can be adapted for the unique function and occupancy of a particular IHB. The International Building Code includes exceptions and specific requirements for agricultural buildings, such as, greenhouses or grow structures. Several international codes that provide inclusions of intensive horticultural buildings are:

- International Building Code (**IBC**) – International Codes Council;
- International Fire Code (**IFC**) – International Codes Council;
- EN 13031-1 Greenhouses – Design and Construction; and
- BS 5502-23 Building and Structures for Agriculture – Part 23: Fire Precautions

Note that the above-mentioned list does not provide all international reference sources which include intensive horticultural buildings or the like.

The International Building Code is published by the International Code Council in the United States of America. The IBC is a comprehensive building code which establishes the minimum regulations for building systems using prescriptive and performance-related provisions. The document is founded on broad-based principles that make possible the use of new materials and new building designs[16] (International Code Council , 2015).

Agricultural buildings, which include IHB, are classified as Group U buildings under the IBC (International Code Council, 2015). Group U (Utility and Miscellaneous) buildings and structures are of an accessory nature or miscellaneous structures. The IBC specifies structures not classified in any specific occupancy shall be constructed, equipped and maintained to conform to requirements of this code commensurate with the fire and live hazard incidental to their occupancy.

Appendix C of the IBC provides exceptions and provisions for Group U buildings. These exceptions and provisions include allowances for Group U building heights and areas, distances between other buildings and exits.

Exceptions for exits are as follows (International Code Council, 2015):

1. The maximum travel distance from any point in the building to an approved exit shall not exceed 91,440 mm; and
2. One exit is required for each 1,393.5 m2 of area or a fraction thereof.

[16] International Code Council, 2015. Appendix C Group U - Agricultural Buildings. In: *International Building Code.* s.l.:International Code Council, p. 615.

3.2.3 Fire and Egress

Growing produce in greenhouses and grow structures often takes place in rural, remote locations zoned for agricultural use; due to this remoteness, the buildings are almost always far from firefighting assets/stations. This means longer reaction time that gives an advantage to the spread of the fire. IHB fires usually start in a discrete point and can quickly spread through the combustible materials. Although there have been relatively few documented serious greenhouse fires, each occurrence has taken place where there was high potential fire risk. This high fire risk leads to a high fire consequence, consequences including loss of life and serious property damage. Risk factors commonly associated with IHB fires are as follows:

- Size of the operation;
- Structural materials used;
- Glazing/covering materials used;
- Machinery and equipment maintenance;
- The use of automation including production;
- Lighting, and
- Environmental control systems.

Material Use and IHB Fires

Materials used within greenhouses are chosen for their useful growing properties and features, however, the same materials may have unforeseen risks associated with fire susceptibility and/or exacerbation. Combustible materials commonly used in IHB include, but is not limited to plastic glazing materials, shade cloth, energy curtains, containers, packaging products, stored chemicals and fertilizers, and plant materials.

It is a common misconception that metal-framed buildings, a common greenhouse construction method, are “fireproof”[17] (Jones, 2011). Unlike timber, metal has a negligible fire spread rating. It is however common for an unprotected metal framed building to fail much sooner than its hardwood timber counterpart in the event of a fire. Strength of steel decreases rapidly when a structural element becomes hot; this can result in a complete structural collapse long before actual flames spread through the building[18] (Burton, 2017).

Consultation with fire engineers has determined that a solid hardwood timber column/post will typically remain structurally sound for a longer period of time in the event of a fire than its steel counterpart[19] (FERM, 2016).

All plastic materials used as greenhouse glazing or shade cloth are combustible and need to be protected from high heat sources and open flames. Edges of glazing tend to be more susceptible to ignition than a flat surface (Burton, 2017). As such, the edges should be protected with a non-combustible material.

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[17] Jones, E., 2011. Preventing Greenhouse Fires. *Greenhouse Management,* July 2011(58), pp. 78-81.

[18] Burton, S., 2017. *Fire's Effect on Steel* [Interview] (February 2017).

[19] FERM, 2016. *Discussion on Timber and Fire* [Interview] (7 December 2016).

When shade cloth or glazing is ignited, or exposed to flame the polymers melt and drip. Dripping polymers cause damage to protected crops and can have the serious potential of igniting other flammable materials.

Fire-retardant glazing and shade cloth has market availability and several manufacturers have had Australian testing complying with AS 1530.2.1993 and USA Standards. Manufacturers, such as Polyfab Australia, use new generation technology that enables flame resistant additives to work with ultraviolet stabilisers to ensure maximum flame resistance while still offering long-term UV protection[20] (Polyfab Australia, 2017). Fire-retardant shade cloth is generally more costly than standard shade cloth. As such, several IHB designs within the USA have taken to effectively creating greenhouse divisions by installing wall and roof panels of flame-resistant glazing, acting as firebreaks and compartmentalisation[21] (NGMA, 2010). These fire-resistant panels discourage fire spreading throughout the entire IHB, through compartmentalisation. This compartmentalisation has been seen to reduce the severity of the fire and losses. It should be noted that there were no identified laboratory tests to verify the effectiveness of this procedure, but field tests indicate that it can be an effective fire precautionary measure.

Fire Extinguisher and IHB Fires

Fires start small and grow larger with the availability of time and fuel; an appropriate fire extinguisher in the hands of an experienced person can often prevent a small fire from becoming a major loss. Each workplace building (including IHB) should have the appropriate types of fire extinguishers for all possible fire hazards. Extinguisher placement is stipulated within the relevant Australian Standard or by the instruction of a Professional Fire Engineer.

Fires can be categorised into the following four (4) groups. These are:

- **CLASS A:** Paper, Wood, Cardboard
- **CLASS B:** Solvents, Paint, Petroleum, Methylated Spirits
- **CLASS E:** Electric fires
- **CLASS F:** Cooling oils and fats

Extinguishers can be categorised into the following five (5) main groups[22] (QFES, 2016). These are:

- **Carbon dioxide fire extinguisher**
  Carbon Dioxide fire extinguishers are recommended for Class 'E' electrical hazard fires, but also have limited capabilities for extinguishing small, indoor Class 'A' paper and Class 'B' flammable liquid fires.

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[20] Polyfab Australia, 2017. *Polyfab Australia Products.* [Online]
Available at: http://polyfab.com.au/
[Accessed 22 November 2016].

[21] NGMA, 2010. *Fire Safety,* Harrisburg PA: National Greenhouse Manufacturers Association USA.

[22] QFES, 2016. *Fire Extinguishers.* [Online]
Available at: https://www.qfes.qld.gov.au/community-safety/home/documents/QFES-InfoSheet-Extinguishers.pdf
[Accessed 6 March 2017].

- **Water fire extinguisher**
  Air/Water Fire Extinguisher contains water under pressure and is to be used in an upright position. It is designed for use on solids such as wood, paper, rubbish or textiles, and has a discharge period of 60 - 100 seconds. Water extinguishers are unsuitable for flammable liquid fires.
- **Foam fire extinguisher**
  Air/Foam Fire Extinguisher contains an aqueous film-forming foam additive and is to be used in an upright position. It is designed for use on flammable liquid fires such as petrol, oils and paint. This extinguisher must not be used on fires involving live electrical equipment.
- **Dry chemical fire extinguisher**
  A 'BE' dry chemical fire extinguisher can be effectively used on fires involving live electrical equipment or flammable liquids and cooking oil. The 'ABE' fire extinguisher is recommended for fires where wood, paper, flammable liquid or live electrical equipment are involved.
- **Wet chemical fire extinguisher**
  Wet Chemical Fire Extinguisher contains a liquid alkaline extinguishing agent and is specifically designed for use in commercial kitchens on deep fryer fires involving fat and cooking oil. These extinguishers must never be used on fires involving live electrical equipment

Determining the most effective extinguisher location is important; it is a general rule to locate extinguishers close to the potential hazards (be it greenhouse CO_2 generator, fans and motors and areas of stored combustibles and accelerants), in the middle of long aisles and near external doorways.

Water Storage for Fire Fighting Purposes

State/Local Government applies policy in relation to above ground water storage tanks for firefighting purposes. Policies are in addition to the requirements found in the relevant Australian Standards for water storage tanks for firefighting purposes. Currently, the services of a Professional Fire Engineer may need to be sought to determine appropriate water storage for each particular IHB.

Egress

The concept of occupant egress implemented through building regulations involves the provision of a designed and designated means of egress for a building. Egress should be an unobstructed path from any point in the building to the outside. Proper design includes the width of the spaces and doors, direction of door swing, lighting and marking, protection from the fire and its effects, and also the geometry of stairs or ramps. Limiting travel distances to reach a means of egress or common paths of travel, dead ends, and the provision of alternate means of egress, if the primary path is blocked by fire, are basic concepts of egress design; these requirements have been sourced directly from Section D of the NCC. Part D of the NCC 2013 Building Code of Australia – Volume One provides Provisions for the aforementioned.

Assuming a IHB is classified as a Class 10 building the following Deem-to-Satisfy Provisions are imposed when referring to Part D1 ‘Provision for Escape’ within the BCA. These are:

- All buildings (any Class) – Every building must have at least one exit from each story.[23] (NCC Vol One, 2016);

[23] NCC Vol One, 2016. Part D1.2 Number of exits required. In: *National Construction Code Volume One.* s.l.:Australian Building Codes Board, p. 191.

- Minimum exit travel distances are not specified[24] (NCC Vol One, 2016).

However, if the IHB is classified as Class 8 the following Deem-to-Satisfy Provisions are imposed when referring to Part D1 'Provision for Escape' within the BCA:

- Every building must have at least one exit from each story; a minimum of two (2) exits must be provided if the building has an effective height of more than 25 m[25] (NCC Vol One, 2016).
- No point on the floor must be more than 20 m from an exit, or a point from which travel in different directions to two exits is available, in which case the maximum distance to one of those exits must not exceed 40 m[26] (NCC Vol One, 2016).

The International Building Code provides the following egress provisions. These egress provisions are specifically for agricultural buildings that are of a compliant building type; IHB are a compliant building type.

The means of egress for a IHB building shall comply with the applicable provisions of Chapter 10 of the IBC, based on an occupant loading factor of 1 person per 30 m^2 of the gross floor area. Both statements below must be adhered to:

- The maximum travel distance from any point in the building to an approved exit shall not exceed 91,440 mm.
- One exit is required for each 1390 m^2 of area or a fraction thereof.[27] (International Code Council, 2015)

[24] NCC Vol One, 2016. Part D1.4 Exit travel distances. In: *National Construction Code Volume One.* s.l.:Australian Building Codes Board, pp. 193-194.

[25] NCC Vol One, 2016. Part D1.2 Number of exits required. In: *National Construction Code Volume One.* s.l.:Australian Building Codes Board, p. 191.

[26] NCC Vol One, 2016. Part D1.4 Exit travel distances. In: *National Construction Code Volume One.* s.l.:Australian Building Codes Board, pp. 193-194.

[27] International Code Council , 2015. Preface. In: *International Building Code.* s.l.:International Code Council , p. iii.

3.3 Consultation Findings

The Protected Cropping Industry is the fastest growing food producing sector in Australia, valued at around $1.8 billion at the farm gate per annum. This is equivalent to 20% of the value of total vegetable and cut flower production in Australia[28] (RIRDC, 2015). It is estimated that more than 10,000 people are employed directly in greenhouse horticulture throughout Australia, with the industry expanding at between 4-6% per annum. The average return on investment is between 5% and 10%. The potential return on investment for high technology greenhouse vegetable enterprises is around 20-25% per annum[29] (PCA, 2017).

3.3.1 Project Justification Summary

Justification of the NCC Proposals for Change is vital to the successful implementation of the project's recommendations. This project is utilising a five-part justification process (refer to Figure 4) to ensure the Proposals are defensible and of net-benefit to industry and society. Justification of the Proposals for Change are provided in Section 6.3 of this document.

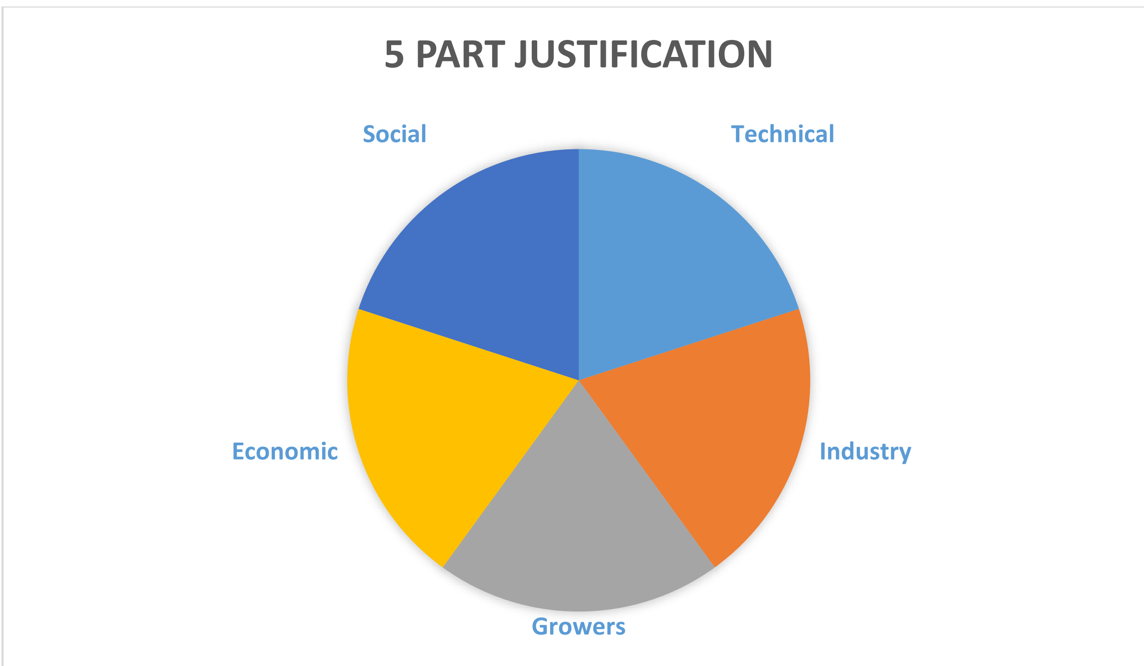

Figure 4 Project Justification using a 5 Part Approach

[28] RIRDC, 2015. *HSA-9A,* s.l.: Australian Government - Rural Industries Research and Development Corporation.

[29] PCA, 2017. *Our Industry.* [Online]
Available at: http://www.protectedcroppingaustralia.com/?page_id=94
[Accessed 22 March 2017].

A brief description of each of the justification parts are provided below:

Social – Provides justification on how the proposed changes would provide a net-benefit to Australian society. For example: local food security etc.

Technical – Provides justification on how the proposed changes are defensible in a technical environment. For example, fire models, literary review of international regulation etc.

Industry – Provides justification that the proposed changes have had draft industry review and industry have provided feedback. Industry here relates to Building Certifiers and Fire Authorities, the industries who would implement proposed changes.

Growers and Grower Industry – Provides justification that the proposed changes meet the needs of growers to encourage industry growth, food security and lower approval costs.

Economic – Provides justification that the proposed changes are of economic benefit to the grower, local communities and Australia's national economy.

3.3.2 Grower Consultation Survey

A survey completed for this project of greenhouse growers in Australia was undertaken. This investigated the information needs of growers and where they source information, their preference for receiving information, as well as the strengths and weaknesses of the current regulatory system for greenhouse construction and safe operation. The survey was distributed through AUSVEG and Protected Cropping Australia e-news which reached 800+ email addresses; hardcopies of the survey were also distributed in the Volume 3 2016 Soilless Magazine. The survey received twenty-nine (29) responses from members within the IHB industry with a majority of the responses being from protected cropping vegetable growers. Below are several survey questions that have provided particularly pertinent information in understanding growers concerns, needs and their expectations and vision of the IHB industry in the future.

Survey Highlight One

Question: What category best describes your business?
Answer Choice: Expanding, consolidating, stable or downsizing.

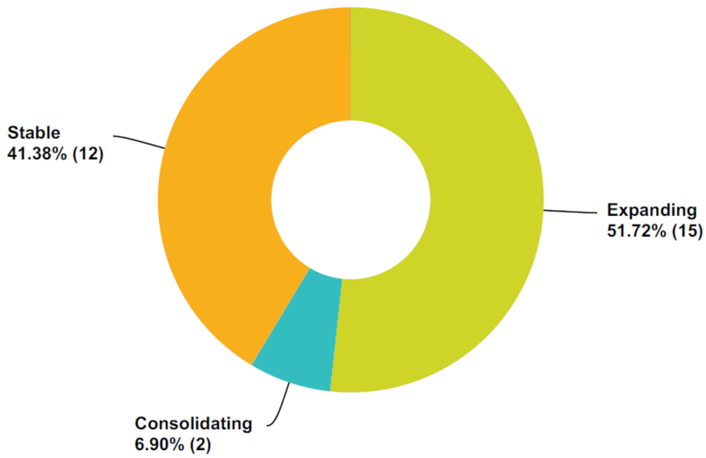

Figure 5 Survey Question: What category best describes your business?

51.72% of survey participants said their businesses were expanding, 41.38% said their businesses were stable and 6.9% said they were consolidating. These findings provide quantifiable support towards the Proposal for Change. With approximately 52% of responding growers identifying their businesses as expanding it is important for the Australian regulation industry to encourage and not hinder future IHB development that has a considerable net-benefit for Australian society. Refer to Section 6.3.1 for cost-benefit analysis and discussion.

Survey Highlight Two

Question: What is the primary type of structure present?
Answer Choice: Low technology, medium technology or high technology.

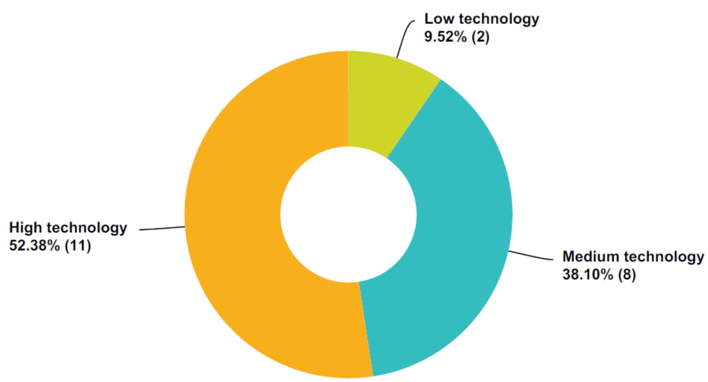

Figure 6 Survey Question Answers: What is the primary type of structure present?

52.38% of survey participants said the primary IHB structures on their sites were high technology, typically Group A structures. 38.10% have medium technology structures, typically Group B structures, while only 9.52% have low technology, typically Group C. These findings provide insight into the innovation and future-planning of Australia's typical protective cropping grower. With higher technology structures, growers are able to produce higher yields of a greater quality and crop security. These initiatives assist in ensuring sustained vegetable production growth to meet growing national and international demands.

Survey Highlight Three

Question: What are the IHB construction materials?
Answer Choice: Steel glass, steel and impervious membrane, steel and pervious membrane or other.

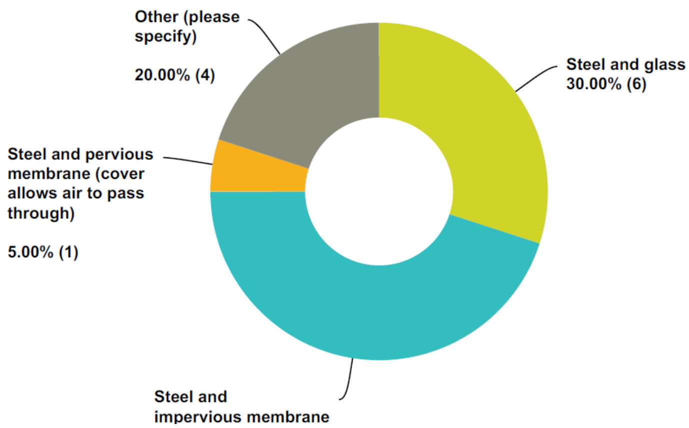

Figure 7 Survey Question Answers: What are the IHB construction materials?

A majority of responses were steel and impervious membrane at 45%, 30% were steel and glass while the remaining 25% were pervious structures.

Survey Highlight Four

Question: What is the total area of all IHB on the property?

Approximately 50% of responses had an area greater than 10,000 m^2 (1 hectare) with several responding to having 35 hectare to 80 hectare of crop protection structures. The remaining 50% of respondents had between 700 m^2 and 9,000 m^2.

Survey Highlight Five

Question: What is the roof profile of the IHB frames?
Answer Choice: Flat arch, raised dome, sawtooth, skillion, tunnel or other.

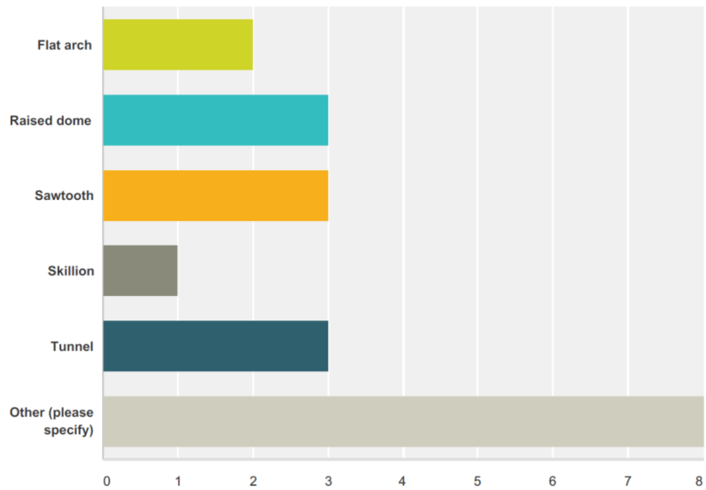

Figure 8 Survey Question Answers: What is the roof profile of the IHB frames?

The Venlo system, raised dome, sawtooth and tunnel roof profiles were the most popular responses. These results assisted technical fire modelling and analysis, refer to Appendix B for further information of the effects of roof profiles in Intensive Horticultural Buildings.

Survey Highlight Six

Question: How could greenhouse construction and safe operation be improved? Note: select all that are relevant.

Survey analysis identified that 'Understanding the preparation, lodgement, assessment and approval process with local government' and 'cost of compliance' as the two most significant threats to growth that the protected cropping industry faces, 64.29% of survey responses indicated as such. The second most popular issues were 'Determining if a development application is required', 'Understanding the compliance process', and 'Requirements for work place health and safety'.

3.3.3 Grower Consultation Case Studies

Grower Case One

Grower Identification: Grower VIC
Typical crops being produced: Hydroponic seedlings, tomatoes and capsicums

Type of IHB: Glass and steel Dutch Venlo

Technology level: High, Group A

Total area under IHB: 26 ha

Site visit undertaken: Yes

Field Investigation Findings:

Grower VIC has identified that they are Hort Innovation levy paying growers. Glasshouses are imported from Netherlands through the Dutch Venlo company. The greenhouses are provided with frameworks, fastening elements, glazing and steel zinc-coated metalware. Frameworks and gutters are made of aluminium, metalware for fixings and aluminium construction. Construction meet European standard EN 13031[30] (Venlo , 2017).

Grower VIC's history with development approvals (**DA**) and council compliancy is as follows. The first Dutch Venlo greenhouse constructed onsite required fire and egress requirements; these requirements were hydrant booster pumps, a fire ring suppression system and illuminated exit signs. Before construction of successive glasshouse structures Grower VIC approached a building surveyor and a fire engineer to investigate and engage in reducing cost of compliance. The fire engineer completed a risk assessment in relation to the possible outcomes in the event of a fire – this risk assessment was presented to local council and Country Fire Authority (**CFA**) officials which delivered an outcome that was acceptable to the grower.

DA concessions are directly related to fire and egress requirements applicable to all future glasshouse structures constructed on the growers property. Some practical fire and egress requirements were still imposed on new developments after the concession was implemented. One such requirement was the installation of fire hose reels at locations specified by the fire engineer. Other imposed requirements were the construction of concrete fire rated walls (60 minutes rating) between the plant equipment room and the growing areas. The installation of break-glass sensors that activate the H_20 misting/fog system, which remains active till disengaged, is an alternative to the fire ring suppression system that has been approved by CFA and local Council. Misting/fog fire suppression systems utilise existing infrastructure used during daily operation of the glasshouse and therefore do not require outlay for dedicated fire suppression systems that may never be used. Fire extinguishers are also located at each exit and control panels.

[30] Venlo , 2017. *Venlo Greenhouses: Economical Quality.* [Online]
Available at: http://www.venloinc.com/greenhouses/venlo
[Accessed 13 November 2016].

Exits and egress in all glasshouses are approved by Council and CFA; exits are at the end of each row and provide a maximum escape path of 126 meters. Glass wall panes could also be shattered in the event of a fire if alternative escape is required. Emergency evacuation plans and procedures are conveyed to all staff and site visitors.

Grower VIC has not experienced structural failure due to extreme natural events nor has there been documentation of fire in any of the glasshouses onsite. The Project Team has been informed that the greenhouses are maintained meticulously and are kept clear of combustible materials.

Grower Case Two

Grower Identification: Grower QLD

Typical crops being produced: Cucumbers

Type of IHB: Impermeable plastic membrane on hooped steel structure

Technology level: Low, Group B

Total area under IHB: 5.4 ha

Site visit undertaken: Yes

Field Investigation Findings:

Grower QLD has identified that they are Hort Innovation levy paying growers.

Greenhouses are imported from Adelaide, SA and constructed from steel hoops, timber/steel column supports and are covered with an impermeable plastic membrane. The greenhouses have been in operation for 20+ years and mainly produce cucumbers year round. All sides of the greenhouses remain openable throughout the growing season. There has been no extreme natural event (storm/hail etc.) that has caused structural failure documented on Grower QLD's property, nor has a fire occurred.

The property is in a semi-rural area with residences all around. Grower QLD has had issue with residential complaints regarding noise pollution from tractors and other farming machinery, spraying and visual pollution.

Grower QLD has recently had to apply for a DA through the local Council for the existing greenhouses. The process of obtaining building approval (**BA**) has been a problematic, protracted occurrence which has caused the grower economic and emotional hardship. Grower QLD accepted that DA would have to be completed however it was the uncertainty and professional inexperience throughout the process which caused issues. These issues were:

- Local Council was unable to provide the grower with a uniform response to what process was required to complete the DA efficiently. Council was also unable to provide estimated council fees associated with the DA process. After meeting with Grower QLD, an engineer from Osborn Consulting contacted a member of the Council's Planning Department to request further information regarding the process of DA for greenhouse structures. The response from Council received was "DA requirements are a case-by-case issue and are dependent on the council certifier. Council does not have documented guidelines that outline what is required [for the completion of greenhouse DA]."

- To obtain structural certification of the existing greenhouses a large Brisbane based engineering firm was engaged – This resulted in the apparent noncompliance of the existing structural columns [presumably for wind loading], the only remediation measure that was offered to the grower was to replace all existing columns with a larger size. Grower QLD was displeased with this result and acquired a second opinion through an alternative engineering firm. The second firm was much more experienced in the design of low technology greenhouses and found the greenhouses were structurally adequate for both strength and service loading and as such no additional work was needed. Through experience it is evident that applying prescribed wind loading to low technology greenhouses, specified in AS/NZS 1170.2 Wind Loading Code can be unnecessarily conservative if the entire structural system is not understood.

Fire and egress regulation was not imposed during the DA process though Grower QLD has identified that several other growers in the area were required to comply with fire and egress during DA and BA of new and existing greenhouses.

Grower Case Three

Grower Identification: Grower NSW

Typical crops being produced: Fresh culinary herbs

Type of IHB: Venlo double gable

Technology level: Mixed

Total area under IHB: 1.0 ha

Site visit undertaken: No

Findings:

Grower NSW has identified that they are Hort Innovation levy paying growers.

Grower NSW has IHB constructed of both steel and glass and steel and impermeable membrane on his site. Structural engineering certification was obtained for the IHB through Faber Greenhouses and the building was required to be inspected independently by the City Council as part of the final certification of occupancy. The development application required the following:

1. A certificate from a consulting engineer, certifying the footings and structural steel framework;
2. A copy of the geotechnical report, certifying the bearing capacity and compaction of the glasshouse pad with attention to the bearing pressure of the footings;
3. Certificates to be provided from the glazing provider, certifying that the glazing complies with Australian Standards;
4. Additional exit points, as indicated from a Fire Service Engineer;
5. A copy of a fire safety statement, certifying the following is in place:
    a. Emergency evacuation plan;
    b. Emergency exit operation;
    c. Portable fire extinguishers.
6. Adequate staff toilet amenities required to be provided prior to occupation of the Glasshouse.

The structure(s) have not previously failed due to winds, fire or other extreme environmental events.

Fire and egress requirements were imposed on the IHB during the design and approval stage; escape doors/kick-out panels were required on walls at 25 meters apart. Evacuation plans, staff education and procedures were also required. Evacuation plan was a minimal cost and an invaluable asset to the safety of staff and protection of the IHB.

Certification of IHB glass was a major issue when completing the local council development application information request. Roof glass needed to be toughened so that it shatters into small pieces. Wall glass is typically ‘float glass’ which is dangerous if broken, especially if broken by a person jumping or falling through it.

Grower NSW was happy with the development application approach taken by the local Council.

<u>Grower Case Four</u>

Grower Identification: Grower NSW

Typical crops being produced: Future grower

Type of IHB: Non-rigid hooped

Technology level: Low

Total area under IHB: 1.0 ha

Site visit undertaken: No

Findings:

Acquaro v Great Lakes Council [2006] NSWLEC 574

An appeal was lodged in the NSW Land and Environment Court against the council’s refusal of a development application for the construction of a shed for the storage of farm related equipment, required in connection with the keeping of bees on a Rural 1(a) allotment. This case is a convenient fit to our research at is also involves ‘agriculture’ or:

a) the production of crops or fodder; or
b) the keeping or breeding of livestock, bees, poultry or other birds; or
c) horticultural purposes including fruit, vegetables and flower crop production, and wholesale plant nursery; or
d) the grazing of livestock, …

For a number of reasons, the development application was refused. The NSW Land and Environment Court was tasked with resolving the below issues (as provided by the Court):

- Whether the development will enhance the environmental qualities of the area;
- Whether the development represents the orderly and economic development of land;
- The suitability of the site for the development;
- The impact on the scenic qualities of the area;
- Compliance with council's outbuildings policy;

- Precedence and public interest; and
- Weight to be given to the Draft Great Lakes LEP 1996 (Amendment 55).

When deciding whether or not to allow the Appeal, Hussey C stated, “The associated criteria also requires the development to be undertaken on an economic and orderly basis.... The proposed shed presents as a relatively large structure, even with the awning removed. The evidence presented does not satisfy me that a shed of this magnitude is required as an ancillary part of the low scale "hobby" beekeeping activity.” This is of considerable interest to a prospective Greenhouse grower, whether they be partaking in a hobby or a commercial business. The development must be undertaken on an economic and orderly basis, and this is something that will require considerable contemplation.

Hussey C concluding statements included, “The proliferation of similar sheds on the small Rural 1(a) allotments would not, in my opinion protect and enhance the environmental qualities of the area. My conclusion is that the approval of the shed would be contrary to the strategic planning controls and therefore not in the public interest” and the Appeal was not allowed.
See more here: https://www.caselaw.nsw.gov.au/decision/549f88f83004262463acfd75

Grower Case Five

Grower Identification: Grower NSW

Typical crops being produced: Future grower

Type of IHB: Non-rigid hooped

Technology level: Temporary Structure

Total area under IHB: More than 200 m^2

Site visit undertaken: No

Findings:

The complexities with NSW and National Planning Laws continues. Temporary structures face extensive regulations surrounding fire safety (among many other regulations). As the proposed structure will be roofed (with a plastic fabric type material) and have walls with a similar type material and over 200 m^2, there is a possibility that it could be treated as a temporary structure.

Regulations of Temporary Structures

Temporary Structures are regulated by the Australian Building Codes Board 2015 Standard for Temporary Structures. The Code provides a great deal of regulatory procedures that must be complied with when constructing a Temporary Structure.

The safe use of temporary structures requires judgement based on experience and careful evaluation of relevant factors and each case should be evaluated on its individual circumstances. The application of on-site risk management or risk monitoring is a critical consideration in the planning, implementation and use of temporary structures.

Per the Environmental Planning and Assessment Act 1979 (NSW) a "temporary structure" includes a booth, tent or other temporary enclosure (whether or not part of the booth, tent or enclosure is permanent), and also includes a mobile structure. As the greenhouse was not intended to be permanently founded into the ground, is it possible that it will be a temporary enclosure despite being permanent. The fire safety provisions as mentioned previously are a part of vigorous regulations surrounding Temporary Structures. The code covers fire resistance, firefighting equipment, egress provisions and emergency lighting and exit signs. In a response to the above mentioned the grower stated, "I am unsure of the relevance of such extreme measures to my residential greenhouse and are doubting their application."

Jambrecina v Blacktown City Council [2008] NSWLEC 1505

The Jambrecina v Blacktown City Council [2008] NSWLEC 1505 ('Jambrecina') case represents an interesting precedent for many proposed greenhouses. In Jambrecina, the landowner made an appeal against the council's refusal of a development application to use six sheds in the rear yard. The land is in a typical low-density residential area, with an area of 1,214 m^2. The total area of the problematic sheds is 76m^2. Importantly, one of the existing sheds is being used as a greenhouse.

The Blacktown Local Environmental Plan permits sheds in the rear yards of allotments in the Residential 2A zone with consent. The Land Environment Plan requires that structures should be capable of 'visual integration with the surrounding environment'. Further to this, the Development Control Plan for Residential Zones specifies that 'garages, carports, awnings and sheds should not be designed in isolation, but should be designed as part of a holistic approach to the property.' The Council Planner advocated for the four sheds to be demolished as they were prefabricated and were suitable only for temporary use.

Dr John Roseth, Senior Commissioner in the Land and Environment Court of New South Wales concluded that the removal of the sheds was not justified for the following reasons:

a) The site is very large. The total area of house and six sheds is less than 20% of the site. The general appearance of the rear yard is spacious.
b) The sheds cannot be seen from the street and are only slightly visible from the neighbouring rear yards. If they are moved 3m from the rear boundary, they will not be visible from the rear neighbour's property. The owner of that property is the main objector.
c) There are other large structures in neighbouring rear yards, in particular at 31 Knox Road. While those structures are purpose-built rather than prefabricated, the visual bulk is just as large or larger.

The Senior Commissioner gave the following opinion before upholding the Appeal:

"In my opinion, in the scale of environmental negatives, these four small sheds in the rear corner of a large residential allotment are of extremely minor importance. They seem to suit the applicant's lifestyle. The benefit of removing them would be so small that it would not compensate for the disappointment caused to the applicant."

Grower Case Six

Grower Identification: Grower NSW

Typical crops being produced: Vegetables

Type of IHB: Existing medium technology greenhouses

Technology level: Existing medium technology greenhouses

Site visit undertaken: No

Findings:

Compliance with fire access and egress requirements in the Sydney Basin, NSW

A couple of growers in a cluster of medium technology and older polyhouse designed greenhouses decided to expand their area of production. This was so that they could better supply the Sydney markets, which are just down the road. Unbeknown to them, some of the conditions placed on the planning permit for fire compliance would prevent them achieving their business vision.

The group of growers had discussed the expansion opportunity for a while, but eventually decided to put their plans into action. They first met with the local Council, and the economic development officers were enthusiastic about the positive impact on the local economy.

After their development application was submitted, there were a number of changes requested by the local Council planning department and Fire Authority. Firstly, this included a height restriction below 3.5 metres because of the close proximity to a residential area. But the growers claimed they needed the additional height and ventilation to create a stable and homogenous climate for plant growth.

“Creating the right environment for plant growth is what it’s all about, that’s our business. We need to do this using the best technology available, not the old stuff we already had” said one of the growers.

Secondly, there were numerous fire safety matters to address. This mainly related to fire pumps and hydrants, however the existing greenhouses didn’t have these installed to the density the new development required. With the assistance of a fire engineer, the growers outlined the planned irrigation system and fire loading of the new structures. The Fire Authority still had concerns with the risk profile due to the existing structures on the farms. The planning officer at the local Council hadn’t seen a development like this before, so was unsure how to weigh-up the different information.

“We just kept meeting these road blocks. The compliance delays were really difficult to deal with” mentioned another grower.

Identifying who the local Council planning contact and main referral authorities are, in a prescribed area, is an integral first step. Often the Fire Authority, in this case metropolitan, will want to understand the site layout, existing structures and risk profile to better inform their requirements for the new development. Making sure access to the right experts is also important.

<u>Grower Case Seven</u>

Grower Identification: Grower NSW

Typical crops being produced: Vegetables

Type of IHB: Existing high technology greenhouses

Technology level: High technology

Site visit undertaken: No

Findings:

High technology greenhouse development in Carisbrook, Victoria

An up-and-coming greenhouse business near Maryborough in western Victoria was looking to modernise and expand their operation. The location was ideal, as it was 10km from the edge of town, with access to natural gas right to the property. However, the process involved in progressing the development came with its challenges.

The business started under small plastic houses in 1999 and covered approximately 1,500 m^2, following the transition out of sheep grazing on the family farm. They now grow tomatoes and baby cucumbers entirely under glass as a result of two 1.5 hectare developments, with plans for an on-site packing shed in the pipeline.

"We weren't aware of the situation we were jumping into. We just wanted to start growing, and the Country Fire Authority were telling us we had all these other issues to take care of. It was pretty difficult to understand", stated the grower.

The grower, along with their father and brother, embarked on the development application process with the local Council. This hit a few hurdles early, especially when it came to objections from the neighbours relating to sunlight reflection and noise. They then met with the neighbours and planners to talk through their plans and came up with some agreed solutions. But it didn't stop there.

"We had some inexperienced local builders, they hadn't done this type of thing before. But it seems that everything's done slightly differently everywhere."

There were also issues with the CO_2 enrichment in the greenhouses and fire loading from the Country Fire Authority's perspective, as one of the main referral agencies. However, because there is no Australian Standard the American Standard was used instead.

The main impacts to the grower from the uncertainty during the development application process were:

- Time delays, with lots of back-and-forth with fire engineers, building surveyors and Country Fire Authority with reporting, approval and recommendations
- Increased cost, both in employing additional expertise and paying for reports and infrastructure, but also lost production.

These challenges were addressed by:

- Installing reasonable treatments in the boiler rooms that were low pressure (1 bar), but had a very low risk profile.
- Appointing a certified engineer to introduce sensible treatments and avoid costly ones, like ring mains.
- Strategically locating static water sources around the property in above ground tanks with firefighting fittings, which has been a good compromise compared to network fire hydrants.
- Replacing fire exit doors with push-out doors, which has also satisfied the local Council and Country Fire Authority, in combination with compliant stairs.
- Minimising waste streams to reduce truck traffic to and from the property. The grower now uses coia that can be composted and sold locally. There is also a closed loop water and nutrient system, and the small amount of wastewater is used to irrigate the lawn around the greenhouses.

So what were some of the lessons? “Second time around we got a building surveyor and fire engineer from Melbourne. Getting the right people in early is critical. We did spend a bit more, but we saved so much more at the back end of the project with time and infrastructure”, said the grower.

3.3.4 General End of Project Industry Consultation

A draft version of the Proposal for Change document was released for public consultation and comments on May 1st, 2017 and closed on May 19th, 2017. The document was released to all survey participants via email, to PCA and AUSVEG for e-news inclusion (reaching over 800+ people) and to other engaged stakeholders. A copy of the consultation article has been provided in Appendix F. The Project Team received the following general industry feedback and comments, these were assessed for validity and were included in this document and the Proposal for Change where deemed appropriate.

During the end of project consultation period the Project Team received several emails regarding the inclusion of retractable greenhouse structures within the definitions. Though these structures were characteristically already included within the definitions the Project Team decided for clarity of inclusion that the industry comment would be adopted without reserve. The Proposal for Change document now includes the term ‘retractable IHB’ within the relevant definitions.

Several industry stakeholders also provided the Project Team with feedback on the then exclusion of flower production structures. These structures were initially excluded from the definition clauses due to the project's crop scope and that it is being funded by the vegetable levy. Through email consultation with Anthony Kachenko of Hort Innovations on May 12th, 2017 it was decided that flower production structures should be included within the prescribed definitions. Assessments were undertaken on these buildings and it was found they generally comply with the structural attributes of a vegetable IHB. The Proposal for Change document has now included flower production structures within the IHB grouping.

Though initially considered by the Project Team, inclusion of nursery structures within the definition of IHB has identified several risks to the successful implementation of the Proposal for Change (PFC) for inclusion into the National Construction Code (NCC) by the Australian Building Codes Board (ABCB). Through literary review we identified three typical forms of nurseries, these being retail, wholesale and production. Retail nurseries were dismissed from the farm IHB category due to their public nature and classification as a building used for the sale of goods – analysis found these structures were required to conform to the existing provisions due to their higher risk/consequence profile. Wholesale nurseries were not initially dismissed from the farm IHB category, however their inclusion into the proposed IHB classification proved difficult and risky – further detail has been provided below.

The current NCC describes wholesale activity as "Wholesale means sale to people in the trades or in the business of 'on-selling' goods and services to another party (including the public)". As such, a wholesale nursery currently falls within the Class 7b of the NCC. As there is little ambiguity surrounding current Class 7b buildings (for storage, or display of goods or produce for sale by wholesale) it may therefore be difficult for the Project Team to get the Proposal, with the inclusion of 'wholesale' nurseries, approved by the ABCB. Reasons for this are somewhat political for the ABCB, if they allow specific wholesale buildings to have their own classification then the code becomes convoluted and ambiguous. The National Technical Manager of The Australian Institute of Building Surveyors (AIBS) was consulted and informed that AIBS supports the NCC's derivation of standardised means of identification of relevant technical requirements for specific building types – adjusting 'wholesale' unfortunately does not support this.

Analysis and models show that if the Project Team was to include wholesale nurseries into the farming IHB it would be forced to reduce our impact on NCC Provision exclusions. A building for wholesale purposes would need to be accessible to those with a disability, alternative exits (as documented in the PFC) would not be allowed, egress distances would be the same as current NCC distances and hydrant/sprinkler systems imposed. It is considered that these findings are of no significant benefit to industry, especially the vegetable levy paying growers.

Through email correspondence by Anthony Kachenko of Hort Innovations on May 26th, 2017 the Project Team was provided with approval to include growth/rearing production nurseries into the proposed IHB definition.

Feedback provided by Local Government during this consultation period can be found in Section 3.3.6 of this document.

A webinar was delivered on May 12th, 2017 to provide an overview of the project findings, recommendations and resources for growers and industry stakeholders. This included the technical guidelines for greenhouses and grow structures for inclusion in the National Construction Code (NCC) developed under Part 1 of the project. While Part 2 developed a toolbox containing vital information and resources relating to the design, approvals, construction and safe operation of greenhouses in Australia; a tool specifically designed for growers and the protected vegetable cropping industry.

The webinar was hosted by RM Consulting Group, chaired by Carl Larson from the same organisation and included the panellist Marcel Olivotto. Eight (8) individuals registered for the webinar initially while five (5) attended the webinar. The webinar was recorded and distributed to Protected Cropping Australia (PCA), AUSVEG and other industry stakeholders during the week of May 15th, 2017.

The recording of the webinar can be found through the below link:
https://attendee.gotowebinar.com/register/412247973284797953

3.3.5 Fire Industry Consultation

To be provided by relevant authorities before ABCB submission.

3.3.6 Local Council and Certification Industry Consultation

Local Council Consultation

Throughout the consultation period the Project Team received feedback on the Proposal for Change from local Councils. The Project received feedback from several Councils, this feedback has been documented below.

Building Certifiers from the Lockyer Valley Regional Council provided detailed feedback on the Proposal. The Lockyer Valley Region (located in South East Queensland) is heavily invested in horticulture and considers that the Proposal will provide a greater degree of clarity to the building industry over the correct classification of IHBs. Council Building Certifiers provided the following general comment about the Proposal:

"In regards to overall comments – this proposal will provide a greater degree of clarity to the building industry over the correct classification and decrease the time required for design and certification as it provides a uniform set of requirements across the country and certainty over the correct classification of the building (IHBs). This should reduce the current variation between different certifiers and reduce economic burden on owners. It will decrease the overall time from conception of a project to finalisation particularly in the design process and in reduction of costly alternative solutions for fire safety and to achieve final certification of the structure. This in turn should increase the rate of compliant buildings as growers feel more confident to obtain development approvals for their buildings and final certification documentation prior to the use of the building. This will reduce the cost to Councils in compliance action as the number of unapproved structures is reduced. Having compliant approved buildings also has positive implication for the owners of these structures in regards to insurance (both in the event of a building destruction and worker injury) – in some cases insurances won't cover when the building does not have final certification of the building."[31] (Martin & Shum, 2017)

The Lockyer Valley Certifiers also provided direct feedback on specific items of the Proposal. These items were assessed by the Project Team and were incorporated into the final Proposal after consideration of inclusion consequences were determined.

Australian Institute of Building Surveyors Consultation

The Project Team engaged the technical consultation services of the Australian Institute of Building Surveyors (AIBS) throughout this project. In late May of 2017 the Project Team were informed via email from the National Technical Manager of AIBS that the then proposed building verification method (no longer included within the PFC) would not be supported by the Institute. The Institute outlined that they support a prescriptive method of classification rather than a method reliant on a building surveyor's assessment (verification method).

[31] Martin, G. & Shum, G., 2017. *Proposal for Change National Construction Cose Series - Intennsive Horticultural Building Inclusion Farm Buildings,* s.l.: Lockyer Valley Regional Council.

Further information in regards to the classification options considered can be found in Section 5.0 of this document.

The Project Team recognises the importance of AIBS's feedback and has endeavoured to meet their requests while maintaining the project's key outcomes of reducing burden on protected cropping growers.

4.0 Summary of Technical Review

This document provides a summary of the objectives, findings and recommendations of the Project Team Technical Review Programme conducted throughout the Project.

4.1 Fire and Egress Engineering

Technical review of IHB structures in relation to fire and egress was undertaken by FERM Engineering. The technical review of associated elements has been documented in the FERM Engineering report titled “Fire Safety Review” which has been provided in the Appendix B of this document.

4.1.1 Identification of Hazards

Hazards in a IHB Environment

Growing vegetables under an IHB is an extension and the next evolutionary stage of field farming, which is often located in areas void of a prompt firefighting response. It is common knowledge that the longer a fire is left unattended, the more difficult it is to contain. Fires commonly start at a discreet point within a building and can quickly spread through combustible materials. Due to farm expansion and development, it is common for IHB facilities to be open and inter-connected. Although there have been relatively few documented serious greenhouse fires, each occurrence has taken place where there was high potential fire risk. This high fire risk leads to a high fire consequence, consequences including loss of life and serious property damage. The various high risks that may be present are the increased size of the installation due to add-on growth, high value of the protected crop, the use of highly combustible modern plastics and the use of automation including production, lighting and environmental controls.

Materials used within an IHB are usually chosen for their useful structural properties and features. It is, however, common for these materials to have unwanted or unexpected risks especially in the area of fire and egress.

Though able to transmit light, plastic glazing materials are not as energy efficient as other building materials that can be insulated. Modern plastic glazing and woven fabrics have been engineered to transmit light, resist wind, hail and chemical attack while at the same time improving energy efficiency. Electronic automation of a typical IHB is also increasing, computer controlled open vents, lamps and fans are all environment control systems commonly installed in an Australian Greenhouse. These advancements assist in increased crop yield, stability and quality. It is, therefore, reasonable to assume that modern plastics and automation offer appropriate compromise between efficiency and risk.

An increase of electronic automation in an IHB encourages an additional risk of fire, being electrical components. A faulty electronic component can short circuit and emit sparks. Sparks can ignite combustible materials, such as plastic membrane. Growers, certifiers and designers recognise these undesirable risks, however accept the compromise because the value of these properties exceeds the alternative of designing and certifying a IHB that is truly fireproof and useless for growing plants. It is, therefore, important to determine the appropriate balance between risk management and benefits.

In addition to the structural aspects and contents of a greenhouse, its environment is unique to all other buildings. A typical greenhouse environment includes high levels of temperature, moisture, and sometimes UV light to achieve the highest yield and crop quality. Chemicals used on plants within an IHB can aggressively attack structural elements and membrane. All equipment, especially mechanical and electrical, is subject to wear and degradation.

Depending on construction and material types used within an IHB, fires have been observed to move quickly throughout smaller, Group C type facilities. Growers have witnessed fires in plastic membrane structures, particularly woven netting, rapidly engulf an entire IHB building. Crops, property and structures are often severely damaged if a fire occurs. Fires also interrupt the business that supports and impacts the lives of many, including owners, employees and customers for weeks, months and sometimes years.

Fortunately, steps can be taken in farm planning and management that assist in minimising fire risks, and provide procedures that result in a cleaner, safer and more efficient IHB operation. Many correlations exist between good fire risk management and good IHB farm operation management. It is not reasonable to assume the risk of an IHB fire will reach zero; however, risk and associated consequences can be managed to a level that will minimise threats to human life and loss of property.

IHB Fire Risk Assessment

Managing fire risk and associated consequences appropriately is becoming increasingly important to the financial viability of the greenhouse and grow-structure industry in Australia. There are three major risk management tools that are commonly considered. These are:

- Risk control;
- Risk sharing; and
- Risk communication.

Risk control consists of risk assessment procedure, fire prevention, fire contingency plans and employee training. Insurance is considered a risk-sharing tool. Risk communication is usually between an employer and employees and is documented in Section 5 Farm Management and General Principals of VG13055.

4.1.2 Fabric Flame Retardancy

The two Australian Standards relating to fabric fire retardancy are AS1530.2 and AS1530.3. Test descriptions have been provided below.

Test Descriptions:

AS1530.2 Flammability of materials

The test fabric is hung vertically. The fabric is then ignited at the bottom using a pilot flame. The spread of the flame is then measured up and across the fabric. From this, a Flammability Index is produced being a number between 0 (least hazardous) and 100 (most hazardous). The test shows how quickly flame can spread from the floor to the ceiling using blinds as a carrier.

AS1530.3 Simultaneous determination of ignitability, flame propagation, heat release and smoke release.

The test fabric is put into a frame for support. The heat source is a gas fired ceramic panel. This panel begins 850mm in front of the fabric and is moved closer every 30 seconds. The closest the ceramic panel gets to the fabric is 175mm. This test is a measure of the fabric's performance under radiated heat only, such as when a heater is placed close to a blind/curtain - not with direct exposure to flame.

Main Indices from AS1350.3:

- Ignitability Index 0(best)-20(worst) Explanation: Only given if fabric ignites.
- Spread of Flame 0 -10 Explanation: Did ignite but went out.
- Heat Evolved Index 0 -10 Explanation: Heat given off.
- Smoke Developed Index 0 -10 Explanation: Amount of smoke released.

Requirements under BCA AS1530.2 are not required for select fabrics under the BCA. In some parts of the country the BCA is overridden by specific state requirements or local government by-laws. The requirements may vary from area to area and generally a Flammability Index of 6 is sufficient but specific requirements should be checked with the local building authority.

AS1530.3 The BCA only makes reference to the Spread of Flame Index and the Smoke Developed Index. General Requirements: Spread of Flame Index: 9 Smoke Developed Index: 8.

4.2 Structural Engineering

Technical review of structural engineering elements in relation to intensive horticultural buildings built upon the literary review completed by Osborn Lane Consulting Engineers for Horticulture Australia Limited reference number: VG13055.

4.2.1 Existing Construction Materials

There are two types of greenhouses commonly used around Australia. These are:

- Steel frame with glass or rigid plastic cladding, these are also known as glasshouses, and
- Steel frame with polycarbonate (impermeable non-rigid plastic membrane)

Greenhouse frames (support structure) may be constructed of timber, steel, aluminium or concrete. Modern greenhouses are usually constructed of steel or aluminium. Aluminium generally provides a stronger, rust resistant, lightweight frame but can be significantly more expensive than steel and timber. Timber is typically used for low technology IHB. Timber can be difficult and expensive to maintain as it needs to be treated with a preservative and may require periodic painting to prevent rotting.

Floors may be constructed of porous concrete, reinforced concrete, gravel or compacted clay covered with a strong polypropylene fabric. Porous concrete is typically strong enough to bear most loads encountered in greenhouse situations and allows for drainage through the surface. Reinforced concrete is more expensive and does not allow drainage through the surface.

However, reinforced concrete might be desirable in traffic areas where heavy loads occur. Concrete floors (unless used as part of the irrigation system) should have a slight grade to promote drainage and prevent ponding of water. Gravel is low cost and allows drainage, but can allow the growth of weeds and may not accommodate all types of equipment.

Polypropylene fabric (weed mat) can be a low-cost alternative and can be combined with gravel, but the floor can become uneven over time, can cause ponding and algae growth.

As shown above there are three cladding systems commonly used on IHB in Australia, these are glass panes, polycarbonate panels and poly-films or netting.

Polycarbonate panels are made from clear, rigid plastic that transmits light almost as well as glass. Panels are typically available as flat twin-wall panels, these contain two flat polycarbonate panes separated by an air space. The air space between panes improves the insulation properties of the panels.

Though more expensive than poly films, polycarbonate panels are cheaper than glass within a greenhouse application. The benefit of polycarbonate is that it is almost as durable as glass while its weight is considerably less. This makes it much easier to handle and install. However, polycarbonate panels have a tendency to yellow over time which can reduce the light transmitting efficiency of the panel.

Twin-wall polycarbonate panels include a rating, in millimetres, that indicates the size of the separation between the individual polycarbonate panels (e.g. 4mm twin-wall panels have a 4mm air space between the panels). A larger gap between the panels provides better heat insulation properties. The lowest-price option, poly film can be a good option for IHB where budgets are small and long-term useful life is not as important. Poly films are easy to work with, but they are the least permanent option for IHB.

Poly films are often rated in terms of the number of useful growing seasons (e.g. 1 year useful life, 4-year useful life), this is the films life expectancy.

The useful life of poly film is determined by a number of factors. These may include:

- Climate;
- Film thickness;
- UV treated/stabilised;
- Installation quality; and
- Chemical attack from horticultural spray.

If a UV stabilizer has been applied to the film, it is important to check if the stabilising agent has been applied to both sides of the film. If treatment has only been applied on one side it is important to install the treated side facing the sun.

Glass is the highest-quality, highest-price cladding option for IHB. It is the heaviest material and so can be the most difficult to install. If installed correctly and protected from shattering, glass outlasts any other plastic option in terms of useful life. It must be noted that not all glass is the same. Annealed glass can be dangerous for greenhouse applications. When it breaks, annealed glass shatters into long, sharp shards which may cause injury. Tempered glass is four to six times more shatter-resistant than annealed glass and when it breaks, it breaks into small square pieces, making it unlikely to cause injury. There are different varieties of tempered glass (single tempered, double tempered, and more) with various tensile strengths.

4.2.2 New/Innovative Materials and Methods

Composite Materials

New and innovative construction materials show promise as future structural and glazing materials in the greenhouse and grow structure industry, fibre composites are a prime example of this. Fibre composites are materials made from two or more constituent materials with significantly different physical and chemical properties that, when combined, produce a material with different characteristics from the individual components[32] (Durand, 2008).

Composite materials are not a new discovery, nor do they remain a costly and unrealistic alternative to existing construction materials. Concrete, for example, is one of the oldest and most commonly used composites which is reinforced by particles. More recent developments in composites include:

- Composites reinforced by chopped strands;
- Unidirectional composites;
- Laminates, timber ply sheeting is one such example;
- Fabric-reinforced plastics;
- Honeycomb composite structure.

Fibre-reinforced plastic (**FRP**) has become a notable material in structural engineering application over the past decades. Studies by academic institutions are continuing to document the potential benefits of FRP in construction. Cost-effectiveness has also been modelled against traditional concrete, masonry, steel, cast iron, and timber structures and found to be encouraging in future predictions. The fibres are usually glass, basalt, carbon or aramid while the polymer usually consists of epoxy, polyester thermosetting plastic or vinylester[33] (Hult & Rammerstorfer, 1994).

Though promising, fibre-reinforced plastics are not currently being produced at a rate, consistency and controlled quality to be applicable as an alternative to steel, aluminium or timber within an IHB.

Light Diffusion

Growers can control the greenhouse climate including light levels, temperature and humidity. These variables can impact plant quality, yield and the efficiency of heating and cooling systems. Diffuse light through cladding and membranes plays an important role in increased and uniform productivity.

Light from the sun is composed of a diffuse and direct component. Diffuse light is light scattered by particles, which can be found in clouds, in whitewash, various types of glazing or shades. Diffuse light comes from all directions so shadows are only cast directly underneath objects, while direct light will cause high contrast between dark shadows and brightly illuminated surfaces.

Most plants can benefit from diffuse light as they use it more efficiently. This is because diffuse light:

- Stimulates greater photosynthesis due to less shading by upper leaves and greater penetration into the canopy; and
- Promotes better growth due to more even distribution of light horizontally, with less hot and shady areas.

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[32] Durand, L., 2008. *Composite Materials Research Progress.* s.l.:Nova Publishers.

[33] Hult, J. & Rammerstorfer, F., 1994. *Engineering Mechanics of Fibre Reinforced Polymers and Composite Structures.* 1 ed. s.l.:Springer-Verlag Wien GMBH.

Research has shown that the benefits of diffuse light to the grower can include:

- Improved crop yield;
- Higher leaf count;
- Lower crop temperature;
- Shorter crop time;
- Improved quality; and
- Increased uniformity of vegetables.

These results have been demonstrated in commercial fruit and vegetable crops with a high plant canopy, as well as ornamentals with a small plant canopy. The benefits are greater during the summer.

For example, research in The Netherlands conducted by Hemming et al. (2007) found that cucumber yield and number increased by 4.3% and 7.8% respectively with a diffuse light cover compared to a clear cover protected environment. This was despite the fact that the diffuse cover reduced the total light transmission by 4%[34] (Hemming, et al., 2007).

These benefits have the potential to be much larger in sunnier climates like Australia, compared to cloudier locations like The Netherlands. This is because it's important that the crop still receives the same amount of light, just scattered, rather than reducing absolute light transmission.

Diffuse light can be provided by installing cladding and membranes in your greenhouse. These can include curtains, glazing, whitewash, screens and more recently Svensson's white strips, for example. Cladding and membranes can convert direct sunlight into diffuse light without decreasing light transmission to the crop.

However, there are some important considerations when introducing diffuse light. These include, but are not limited to:

- Fixed or semi-permanent cladding or membrane will generally be cheaper, easier to install and operate, but risk losing light transmission, therefore crop growth, when conditions are too dark. For semi-permanent covers like whitewash there is also a significant amount of uncertainty about when is the best time to apply during the season (e.g. spring); and
- Moveable cladding or membrane are usually more expensive, more complex to install and operate, but have the benefit of customising the amount of diffuse and direct light in response to the conditions. This means you can maximise crop growth year-round[35] (Cockshull, et al., 1991).

The general 'rule of thumb' is to only apply diffuse light to the crop when needed. This will usually be during the warmer months when direct light could slow growth or damage the crop.

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[34] Hemming, S., Dueck, T., Janse, J. & Noort, F., 2007. Teh effect of diffuse light on crops. *International Symposium on High Technology for Greenhouse System Management,* 801(2007), pp. 1293-1300.

[35] Cockshull, K., Graves, C. & Cave, R., 1991. The influence of shading on yeild of greenhouse tomatoes. *Journal of Horticultural Science,* 67(1).

While the concept of diffuse light is well understood, there are still many areas for further research to better understand its impact on commercial crop growth in a protected cropping environment. This includes:

- Effect of diffuse light on crops during different seasons;
- Methods for measuring leaf photosynthesis;
- Orientation and spacing of crop rows to maximise light reflection;
- Crop architecture and the influence on light distribution and absorption; and
- Correlation between pre-harvest growth conditions and fruit and vegetable quality[36] (Li & Yang, 2015).

4.2.3 Structural Design: Wind Loading

Existing Loading as per AS/NZS 1170.2

AS/NZS 1170.2:2011 Wind Actions (incorporating amendment numbers 1, 2 and 3) set out procedures for determining wind speeds and resulting wind actions to be used in the structural design of structures subjected to wind actions. The processes of determining wind actions on structures as per AS/NZS 1170.2 are as follows:

a) Determine site wind speed (AS/NZS 1170.2 Clause 2.2).
b) Determine design wind speed from the site wind speeds (AS/NZS 1170.2 Clause 2.3).
c) Determine design wind pressures and distributed forces (AS/NZS 1170.2 Clause 2.4).
d) Calculate wind actions (AS/NZS 1170.2 Clause 2.5).

Determining the correct/most appropriate annual probability of exceedance for each structure is also very important for structural safety and economic viability. Obtaining annual probability of exceedance is a two-step process.

Firstly, the importance levels of a structure shall be determined in accordance with Table F1 of AS/NZS 1170.0, refer to Table 5. Importance levels for IHB are defined by the proposed use of each structure. It's common for low technology, Group C IHB (steel hooped frames with plastic membrane) to have an Importance Level of 1 'LOW' consequence of failure; this low importance level is associated with a low consequence for loss of human life, or small or moderate economic, social or environmental consequences. Medium to high technology, Group A and B IHBs tend to have an Importance Level of 2 'ORDINARY' consequence of failure; definition of this is medium consequence for loss of human life, or considerable economic, social or environmental consequences.

[36] Li, T. & Yang, Q., 2015. Advantages of diffuse light for horticultural production and perspectives for further research. *Frontiers in Plant Science,* 6(704).

Table 5 Structure Types for Importance Levels[37] (Standards Australia, 2011)			
Consequence of failure	**Description**	**Importance Level**	**Comment**
Low	Low consequence for loss of human life, or small or moderate economic, social or environmental consequences	1	Minor structures (failure not likely to endanger human life)
Ordinary	Medium consequence for loss of human life, or considerable economic, social or environmental consequences	2	Normal structures and structures not falling into other levels
High	High consequence for loss of human life, or very great economic, social or environmental consequences	3	Major structures (affecting crowds)
		4	Post-disaster structures (post disaster functions or dangerous activities)
Exceptional	Circumstances where reliability must be set on a case by case basis	5	Exceptional structures

Once the importance levels have been identified the annual probability of exceedance can be found through Table F2 in AS/NZS 1170.0 (Standards Australia, 2011). The BCA requires that regional wind speeds of specific probability be used for building design. The more important the building (as per Table 5), the less the allowable risk that the design speed will be exceeded in any one year and the higher the speed required in the design. Regardless of their importance level or classification, buildings should not fail when subjected to the wind event for which they are certified to withstand. Common engineering design working life of wind loading for low technology, typically Group C IHB's is 25 years while high technology, Group A IHB's tend to have a design working life of 50 years as per AS 1170.0.

Potential for Loading Reductions

AS/NZS 1170.2:2011 Wind Actions (Incorporating Amendment Nos 1, 2 and 3) notes in 1.1 SCOPE that: "The standard is a stand-alone document for structures within specified criteria. It may be used, in general, for all structures but other information may be necessary." And "Further advice, which may include wind-tunnel testing, should be sought for geometries not covered in this Standard, such as unusual roof geometries or support systems, very large roofs, or the roofs of podium at the base of tall buildings."[38] (Standards Australia, 2001)

Where appropriate, engineers have the option to utilise AS 1170.2 in conjunction with European Standard numbered EN 13031-1 Greenhouses – Design and Consideration. EN 13031-1 provides an engineer with

[37] Standards Australia, 2011. Appendix F - Annual Probability of Exceedance. In: *AS 1170.0 Structural Design Actions.* s.l.:Standards Australia, p. 31.

[38] Standards Australia, 2001. Section 1 General 1.1 Scope. In: *AS 1170.2 Structural Design Actions Wind Actions.* s.l.:Standards Australia, p. 6.

external pressure coefficients c_{pe} for common greenhouse structural geometries which are not documented within the current AS 1170.2[39] (European Standard, 2001).

4.2.4 Background to Structural Adequacy

Group A and Group B IHBs are usually designed by an experienced engineering firm that works closely with the protective cropping industry, whereas Group C IHBs are often certified by the geographically closest engineering service that may not have ample experience in designing IHB.

It is common practice for engineers to utilise the following Structural Design Actions Australian Standards while designing an IHB located within Australia. These are -

- AS/NZS 1170.0:2002 Structural Design Actions – General Principles
- AS/NZS 1170.1:2002 Structural Design Actions – Permanent, Imposed and Other Actions
- AS/NZS 1170.2:2011 Structural Design Actions – Wind Actions

It is however important to note that the abovementioned Standards provide design loading actions and regulation upon structures that are most commonly designed in Australia/New Zealand; it is therefore common for an IHB to require special consideration during the design process. Special consideration is provided in Section 4.2.5, below.

4.2.5 Special Consideration for Design Loading

Special consideration is required where Structural Design Actions specified in the AS/NZS 1170 set are not relevant to the structure being designed. This occurs most when designing a structure to comply with AS/NZS 1170.2 Structural Design Actions – Wind Actions. If wind loadings on structures cannot be appropriately estimated through the use of AS/NZS 1170.2, due to geometries not covered in the standard, it is appropriate to utilise the below options. These are:

- European Standards; and
- Further research, which may include wind-tunnel testing.

European Standards

Where appropriate, engineers have the option to utilise AS 1170.2 in conjunction with European Standard numbered EN 13031-1 Greenhouses – Design and Consideration. EN 13031-1 provides an engineer with external pressure coefficients c_{pe} for common greenhouse structural geometries which are not documented within AS 1170.2.

Australian Research

Research is continually being completed to increase the inclusivity of AS/NZS 1170.2 to include actions upon all relevant structures to Australia and its industries. An example of current research is the work having been completed at James Cook University to determine characteristic wind loads on large flat roofed porous canopies. Osborn (2016) found that large porous protection canopy construction has evolved in Australia over the past 30 years from modest small orchard canopies to large canopies over essential water storages to reduce evaporation and pollution, canopies over large numbers of vehicles for car importers and exporters, and horticultural canopies of over 40 hectares in area. The canopies have

[39] European Standard, 2001. *EN 13031-1.* s.l.:European Committee for Standardization.

proved to be an effective economical method to protect increasing numbers and types of assets from exposure to sun, hail, wind, birds and insects.

Canopy design and construction has evolved from the grass roots with initially no structural engineering design input. As the value of assets protected has increased, the request for structural engineering certification of the canopies has become common. To be able to certify the canopy's structure, the certifying engineer needs to confidently be able to predict the wind actions that may occur. In the past, there has been limited structural engineering research undertaken into wind loads on porous structures. The aim of the study was to research the characteristic wind actions normal to large flat roof porous canopies and derive design pressure coefficients. Surface friction actions from wind drag across the surfaces are not researched in this thesis and remain a subject for future research.

Osborn (2016) completed four scale models of a typical porous protection canopy which were constructed for testing in the wind tunnel at the Cyclone Testing Station (CTS), James Cook University, Townsville. The models are of identical geometry, but each of different porosity, 0%, 19%, 38% and 58%. The Models were placed in the CTS boundary layer wind tunnel and rotated through 360° at increments of 15°. At each 15° increment, three sets of pressure readings, each for 30 seconds, were taken at a series of pressure taps located on the Model externally and internally. The pressure readings were processed by the wind tunnel transducer into non-dimensional pressure coefficients and then adjusted for the boundary layer speed at the height of the Model.

Pressure coefficient results were imported into the analysis software Matlab and Excel and then plotted against the geometry of the canopy. The research presented the results graphically with pressure coefficients being plotted against distance. The distance is shown non-dimensional as ratios of model width and length to model height. It is evident from the external pressure results, that the introduction of porosity into the canopy's roof surface causes significant reduction in the magnitude of the wind actions acting on the roof when compared to the solid canopy. In contrast, the introduced porosity does not modify the magnitude of the wind actions on the walls greatly, but does alter the coefficient distribution. Internal pressure coefficients were found to decrease in magnitude across the model away from the windward edge.

To predict the resultant wind actions on the canopy surfaces, the simultaneous external and internal pressure coefficients were summed and adjusted using a gust factor in accordance with the Standard AS/NZS 1170.2. The net surface pressure coefficient was then plotted for four wind direction increments of 15° from 0° to 45° as contour plots for the roof and graphically for the four walls. The results were then combined to find the peak maximum and minimum pressure coefficients for a $\pm 45°$ wind direction sector orthogonal to the structure as required in AS/NZS1170.2.

Osborn (2016) found that the introduction of porosity to the models caused significant reduction in the magnitude of resultant roof wind actions. Roof normal actions are less by a factor of 10 than the actions for solid flat roofs. Increasing the magnitude of the porosity caused only minor further reduction in the roof wind actions. The wall actions do not decrease significantly from the magnitudes of the solid coefficients, but are distributed differently due to the flow of the wind in and out of the canopy interior through the porous wall and roof surfaces. The derived net pressure coefficient results are summarised in tabular form and provide values for the design of large porous flat roofed canopies under wind load[40] (Osborn, 2016).

4.3 Project Ethics and Risk Review

4.3.1 Ethics in data Collection

In preparing the guidelines and toolbox documents, which were specifically designed for growers and the protected vegetable cropping industry, the core Project Team have ensured each of their ethical obligations toward data collection have been met and further upheld to a standard as expected by Australian society.

When undertaking the collection of data, the Project Team maintained meticulous standards relating to the privacy of individuals and copyright of corporations and individuals alike. Any data contained in this project which was not collected by the Project Team and rather another corporation has been clearly referenced to ensure the reader is aware of the origin of the information.

4.3.2 Ethics in documentation

There has been a steady increase in the awareness of ethical standards and principles that organizations, as well as individuals, must ensure are taken into consideration in documentation and alike processes.

There is a heightened awareness of the nature of the extensive ethical issues which have arisen and directly relate to documentation and the various processes. As such, the Project Team remains aware of the significance of the accuracy of any documentation provided in the report and operated to ensure that all information provided was precise, so as to avoid causing harm if relied upon by others.

The Project Team has designed the guidelines and toolboxes so as to provide the necessary information for others to make well-informed decisions. Those involved in the project were required to provide the highest quality documentation to ensure consumer protection throughout the project.

4.3.3 Ethical decision-making framework

The purpose of the implementation of an ethical framework by the Project Team is to ensure those involved in the development of this project are provided with:

1. A coherent structure that may be referred to when important issues are considered throughout the life of the project. This structure was implemented to provide a practiced method for those involved so that the exploration of the ethical aspects of a decision and in turn the weighing of considerations which may affect our decisions were naturally instilled throughout the process;
2. Awareness of their responsibility to promote fairness and consistency in their decision-making process;
3. A concept that the decisions made throughout the project may directly or indirectly affect individuals and organisations and are to be taken into consideration in the conceptualization and implementation of the project;
4. The duties and obligations that are required in particular situations and decision-making aspects of the project; and

[40] Osborn, E. P., 2016. *Characteristic Wind Actions on Large Flat Roofed Porous Canopies,* s.l.: James Cook University.

5. To provide reason to our decisions that align with our ethical obligations.

The Project Team understands that whilst there is no infallible or decisively objective structure by which ethical decisions are made, the framework as provided above was implemented to provide consistency in the project and a structure to guide those involved. It is well versed that public bodies are to be accountable for their actions and decisions and should therefore be able to provide evidence to demonstrate that the same are reasonable and well considered.

4.3.4 The project's social responsibility

As organisations, we (the Project Team) are steadfastly aware of our social responsibility and our obligation to act for the benefit of our greater society.

The implementation and development of the project was created in such a way as to incorporate the needs of many and aims to accommodate the vast majority of those currently in the industry and those looking to enter. This diversification of the information and guidelines will hopefully allow a greater number of individuals and corporations to become involved in greenhouse construction and development.

Sustainability has been a core element to the project strategy. As a socially responsible corporation, environmental impacts and community support is at the forefront of strategic design. We recognize that the introduction of additional greenhouses in Australia may assist in contributing to our overall sustainability and may contribute to more sustainable farming measures and promote sustainable agriculture.

The wealth of knowledge found within the technical guidelines and extension toolboxes were designed to benefit those who are unable to readily access advice regarding the same and to create efficiencies where they may have been lacking previously. We believe allowing widespread access to simple and effective information should be pioneered to be the expected standard of corporations and as such have created easily understood toolboxes to complement our guidelines.

The Project Team is dedicated to continuing to operate sustainably and for the benefit of all Australians.

4.3.5 Outline of risk review parameters

Risk management is integral in the development of any project and in particular throughout the Project Team's development of technical guidelines and a best practice extension toolbox for greenhouse construction and safe operation.

The parameters considered by the Project Team throughout the development of the project included considering the following:

1. Possibility of the risk occurring;
2. Prevention of any possible risks occurring;
3. Consequences if the risk does occur;
4. Structured response to risks when required; and
5. Recovery if an incident occurs.

It was viewed as critical to assess the possible risks associated with the project, determine the possible outcome of such a risk arising and providing those involved with a clear response technique to ensure any potential risk is minimized to prevent further, if any, consequential effects on the project.

The Project Team accessed various consultants and legal advisors to ensure a great percentage of the risks the project may have been susceptible to were minimized. By testing the steps as provided above, the Project Team regularly evaluated the reliability of the risk minimization plan and adopted improved strategies to ensure the success of the project.

5.0 Researching and Developing Classification of Structures

Through utilisation of the below lists, sources and references the Project Team developed several alternative intensive horticultural building classification structures for developing the Proposal for Change. Diverse structures of development were considered to assist in ensuring that the most desirable outcome was achieved for project stakeholders. Sources and references used include:

- Grower consultation;
- Protected cropping industry consultation;
- Fire authority industry consultation;
- Building surveyor industry consultation;
- Local council consultation;
- Literary review of existing international methods;
- Literary review of alternative methods; and
- Technical structural and fire review.

The following information provided in Section 5 (this section) of this document outlines methods analysed and the criteria used to assess each. Refer to Section 2.4.2 of this document for important information on submission to the ABCB.

Through consultation with professional technical industry bodies the Project Team was requested to investigate the inclusion of animal rearing facilities into a broader 'low-occupancy intensive agricultural building' classification rather than a specific intensive horticultural building classification. When considered, it was found that the inclusion of intensive animal facilities and other agricultural buildings significantly retards the ability for the protected cropping industry vegetable growers to achieve burden reducing benefit as animal facilities differ in the following ways (not all listed):

- Intensive animal buildings are typically devoid of transparent or semi-transparent cladding – making egress in an emergency difficult without emergency lighting and illuminated exit signs;
- Intensive animal buildings do not use fogging, misting or spray infrastructure for general day-to-day operational use nor do these structures typically have roof vents but rather rely on wall-mounted fans for ventilation – these variations impose significantly different fire characteristics when assessing the interactions of a fire on its host building environment;
- General structural variations between animal and horticultural buildings;
- Animal welfare considerations; and
- Environmental, noise, smell and dust pollution variations between animal and horticultural buildings.

Due to these discrepancies between buildings documented above, it was decided that intensive animal buildings would be excluded from the Proposal as these buildings apply significant negative action when assessing and prescribing adjustments in required regulatory requirements; the inclusion of intensive animal buildings significantly reduces the Project Team's ability to provide meaningful burden reduction for protected cropping growers. Another reason for excluding intensive animal buildings by the Project was that funding was provided by the Hort Innovations Vegetable Levy Growers and extended only to vegetable growers, flower and berry's and production nurseries.

Though combining intensive horticultural and animal buildings into one classification called 'low-occupancy intensive agricultural buildings' may have a higher success of obtaining acceptance through the ABCB assessment framework the provisional changes recommended in the Proposal would be significantly diluted, creating a low, potentially unsuitable return on investment for Hort Innovations and its levy paying members.

5.1 Assessable Criteria for Classification Structure

The following assessable criteria were applied to each of the methods provided in Section 5.2.1 and Section 5.2.2 of this document.

Assessable Criteria One – The regulation would generate benefits to society greater than the cost (that is, net benefit). The economic burden on protected cropping growers is potentially reduced by the Proposal for Change. The Provisions provided in the Proposal are generally accepted by the grower stakeholders.

Assessable Criteria Two – The Provisions provided in the Proposal are generally accepted by the wider protected cropping industry.

Assessable Criteria Three – The Provisions and classification means provided in the Proposal are generally accepted by technical authorities. These authorities include but are not limited to fire authorities, local council and building surveyor authorities. These criteria also include the perceived requirements expected by the Australian Building and Construction Board.

Assessable Criteria Four – There is a rigorously tested rationale for the regulation. The Proposal complies with technical literary review and technical analysis and findings of this Project.

Assessable Criteria Five – The competitive effects of the regulation have been considered and the regulation is no more restrictive than necessary in the public interest.

5.2 Proposal for Change Classification Structure Proposed

Through analysis of the sources listed in Section 5.0 of this document the Project Team developed two distinct structures which were then assessed against the criteria outlined in Section 5.1 of this document. Both structures have been provided below.

5.2.1 Classification Structure One (Prescriptive Method)

The prescriptive method of certification provides a rigid framework for intensive horticultural building classification. This approach supports the derivation of standardised means of identification of relevant technical requirements of specific building types. Classification of buildings, as a means of identification of suitable technical provisions to be applied, has been <u>based on the use of the building</u> for several decades in most jurisdictions.

Through several of the sources defined in Section 5.0 the Project Team identified three categories of IHB structures, these being Group A, Group B and Group C. Each Group has specific characteristics, particularly size and construction variation, which perform uniquely to structural and fire models and associated analysis. Below defines each of the IHB Groups.

Intensive Horticultural Building Group A – These farm buildings are of a higher-risk nature (in regard to construction, investment costs and operation), typically a building with rigid covering materials and a total area exceeding 5,000 m^2. This Group typically achieves the highest level of environmental control and automation to offer potential for higher quality and quantity of produce. With detailed automation programming these structures require lower ratios of occupancy in comparison to Group B and C buildings. These structures are usually constructed with rigid walls at least 4 metres high with the roof peak being up to 8 metres.

Intensive Horticultural Building Group B – These farm buildings are of a medium-risk nature (in regard to construction, investment costs and operation), typically a building with retractable or permanent non-rigid, plastic or fabric covering materials and a total area exceeding 500 m^2. Group B IHBs are typically characterised by vertical, non-rigid walls (between 2 and 5 metres) and commonly have roof or side ventilation, or both. Group B structures are seen as a compromise between the Group C and Group A and have cost and risk relativity for increased environmental control and overall areas (compared to typical Group C technology greenhouses).

Intensive Horticultural Building Group C – These farm buildings are of a low-risk nature (in regard to construction, investment costs and operation) and/or are typically constructed with non-rigid, plastic or fabric covering materials with a total area not exceeding 500 m^2. These structures shall be classified as Class 10d buildings and are regulated within the NCC Volume Two. These structures are very common in Australia. Construction is typically low cost and domestic in nature. The greenhouses are usually less than 3 metres in height and have a tunnel or 'igloo' profile shape. These structures are popular because they may be considered relatively inexpensive and further conceived as easy to erect. Large span, cable supported net structures covering large areas and up to 6.0 m high can also be included in this category.

It was therefore proposed to develop a classification framework around these classification groups and the specific characteristics of each. Below provides an excerpt from the Proposal for Change where the IHB structures are defined as being either Group A, Group B or Group C structures.

Farm building means a Class 7, ~~or~~ 8 or 10 building located on land primarily used for *farming* -

(a) that is either -

(i) used in connection with *farming*; or

(ii) used primarily to store one or more farm vehicles; or

(iii) that is an *Intensive Horticultural Building* belonging to one or a combination of the following groups -

(A) GROUP A *Intensive Horticulture Buildings – Intensive Horticultural Buildings* built with an average roof height of 5 to 9 m and a total floor area exceeding 500 m^2;

(B) GROUP B *Intensive Horticulture Buildings – Intensive Horticulture Buildings* built with an average roof height of 2 to 5 m and a total floor area exceeding 500 m^2;

(C) GROUP C *Intensive Horticulture Buildings – Intensive Horticulture Buildings* constructed with a total floor area no greater than 500 m^2 shall be classified as

Class 10d; Fabric canopy cable structures with no limitation on roof height and total floor area shall be classified as Class 10d or

(iv) any combination of (i), (ii) and (iii) and

(b) in which the total number of persons accommodated at any time does not exceed –

(i) one person per 200 m^2 of floor area or part thereof, up to a maximum of 8 persons for general farm buildings;

(ii) one person per 600 m^2 of floor area or part thereof for Group A *Intensive Horticultural Buildings;*

(iii) one person per 400 m^2 of floor area or part thereof for Group B *Intensive Horticultural Buildings; and*

(iv) one person per 100 m^2 of floor area of part thereof, up to a maximum of 5 persons for Group C *Intensive Horticultural Buildings*; and

(c) with a total floor area of not more than 3500 m^2 for general farm buildings. There are no maximum floor areas prescribed for Group A and B intensive horticultural buildings.

This method does not develop classification solely on the building's use, it also includes floor area, average roof height and building materials used within the classification; this differs from the established classification style (developed on a building's use) used by the NCC. Justification for this diversion from the established NCC classification method is as follows – If the Project Team were to develop a classification method based on the building's use then there would be only one, all encapsulating IHB group. Recognising the vast differences in IHBs in the industry, the Project Team deems the single classification of IHB as counterproductive and would impose more restrictive than necessary regulation on smaller Group C type (as documented above) structure, a regulatory principal that the NCC is opposed to. A single IHB classification group would also prevent the protected cropping growers from obtaining significant reductions in economic burden as the Project would have had to reduce the impact of the provisional changes to meet the IHB structure environment/marketplace. Utilising three classification groups (Group A, B and C) it was found that the Project Team could provide significant burden reduction in the form of provision adjustment specific to a particular building type. Refer to Section 6 of this document for further information on the regulatory provision changes proposed by this project.

5.2.2 Classification Structure Two (Verification Method)

Utilising the same Group classifications as defined in Section 5.2.1 of this document the verification method provides increased versatility of classifying IHBs. This approach looks at the risk posed by a structure and assigns a classification on that basis, somewhat independently of the use.

It was proposed to develop a classification framework around the Group A, B and C classification groups and the specific characteristics of each while including a building verification method to increase the rate of correct building classification. Below provides an excerpt from the Proposal for Change where the IHB structures are defined as being either Group A, Group B or Group C structures with the building verification method provided.

Though initially quite similar to the prescriptive method the verification method provides an open definition of each group (using the word ‘typically’) and requests that the group is verified through a building verification method, see (a) (iii) below where BV3 is requested.

Farm building means a Class 7, ~~or~~ 8 or 10 building located on land primarily used for *farming* -

(a) that is either -

(i) used in connection with *farming*; or

(ii) used primarily to store one or more farm vehicles; or

(iii) that is an *Intensive Horticultural Building* - a greenhouse, grow structure, canopy or the like belonging to one or a combination of the following groups which are verified through BV3 -

(A) GROUP A – Buildings typically built with rigid covering materials, average roof height of 5 to 9 m, and a total floor area exceeding 10,000 m^2

(B) GROUP B – Buildings typically built with non-rigid plastic or fabric covering materials, average roof height of 2 to 5 m, and a total floor area exceeding 1,000 m^2

(C) GROUP C – Buildings typically constructed with non-rigid plastic covering materials with a total floor area no greater than 500 m^2 shall be classified as Class 10d. Fabric and netted canopy structures with areas exceeding 500 m^2 are also included within this category; or

(iv) a combination of (i), (ii) and (iii) and

(b) in which the total number of persons accommodated at any time does not exceed one person per 200 m^2 of floor area or part thereof, up to a maximum of 8 persons for general farm buildings and up to a maximum of 1 person per 500 m^2 for *Intensive Horticultural Buildings*; and

(c) with a total floor area of not more than 3500 m^2 for general farm buildings. There are no maximum floor areas prescribed for Group A and B intensive horticultural buildings.

It is recommended that a classification-point verification method be provided in as NCC Volume One > Part B > BV3. This process will encourage correct group classification of Intensive Horticultural Buildings.

It is proposed that a classification-point assessment be the basis of determining classification of the Intensive Horticultural Building. To determine the classification, it is proposed that the following assessment be undertaken. The assessment determines risk associated with the assessable Intensive Horticultural Building and allocates the Intensive Horticultural Building into one of the following three classifications.

The assessable elements, shown from numbers 1 to 10 in the below Figure 9, are then analysed within a Classification-Point Matrix to identify the associated holistic risks and consequences of the proposed structure. Once a result is obtained a classification is determined as being a Group A, B or C intensive horticultural building.

There are ten input elements which shall be used to determine risks and consequences related to the development, see below.

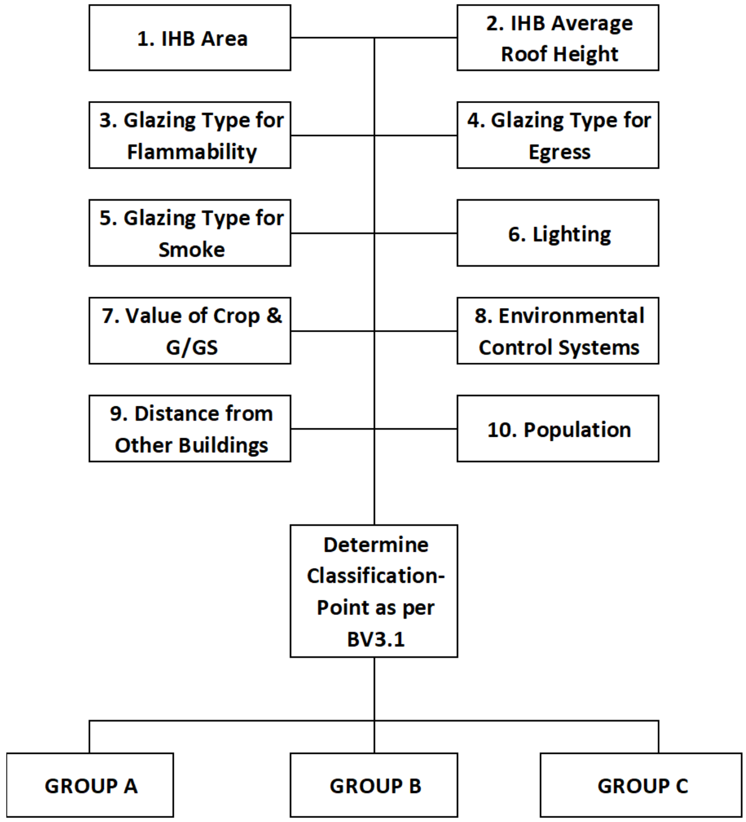

Figure 9 Building Verification Method Structure

The determination of Classification-Point Assessment Result for a site using pertinent elements shall be determined in accordance with the following steps:

- Make note of the relevant input findings, from BV3 (a) No. 1 to No. 10.
- Use the relevant tables and information to determine the Classification-Points for each of the elements using Table BV3.1 Matrix.
- Tally, through addition, the Classification-Points for each element to give the Total Classification-Point using Table BV3.1 Matrix.
- Determine classification of structure using the Total Classification-Point value as per Table BV3.9.

The verification method is provided below:

BV3 Intensive Horticultural Building Classification

Classification compliance of *intensive horticultural buildings* is verified for Grouping Categories A, B and C by –

a) Determining the building's classification-point value associated to the assessable building as per Table BV3.1; then

Table 6
Table BV3.1 – Classification-Point Matrix

No.	Element	Classification-Points					
		0	1	2	3	4	5
1	IHB Area	*	Band 1	*	Band 2	*	Band 3
2	IHB Average Roof Height	*	Band 1	*	Band 2	*	Band 3
3	Glazing Type For Flammability	*	Glass	CPM	*	*	PM
4	Glazing Type For Egress	No Sides	*	*	*	FPM	SPM & Glass
5	Glazing Type for Smoke	*	No Sides	FPM	*	*	SPM & Glass
6	Lighting	No Assimilated Lighting	*	*	*	*	Assimilated Lighting
7	Value of Crop & IHB	*	Low	Average	High	*	*
8	Environmental Control Systems	Low Tech	*	Medium Tech	*	High Tech	*
9	Distance from Other Buildings	*	Distance 1	*	Distance 2	*	Distance 3
10	Population	*	Band 1	*	Band 2	*	Band 3

Where –

No. 1 – Intensive Horticultural Building Area

The appropriate area band should be selected in accordance with the below table. The area of the intensive horticultural building should be taken as the footprint, in metres squared, of the new development as per Table BV3.2. The building footprint is any area covered by permeable or impermeable wall and/or roof cladding.

Important Note: If a new building development is attached, or has covered access/walkway, to an existing building, the total combined area of the new and existing buildings must be considered as the total building area.

Table BV3.2 – Area Bands for Intensive Horticultural Buildings

Building Area (m2)	**Band 1**	**Band 2**	**Band 3**
Area (m^2)	< 500 m^2 *(Less than 500 m^2)*	500 m^2 to 10,000 m^2	> 10,000 m^2 *(Greater than 10,000 m^2)*

NOTE: 10,000 m^2 = 1 hectares.

No. 2 – Intensive Horticultural Building Average Roof or Covering Height

The appropriate average roof or covering height should be selected in accordance with the below table. The average roof heights of the intensive horticultural building should be taken as the average height between the roof eave and roof apex, in metres, of the new development as per Table BV3.3.

Table BV3.3 – Averaged Roof Height Bands for Intensive Horticultural Buildings

Averaged Height (m)	**Band 1**	**Band 2**	**Band 3**
Averaged Height (m)	Less than 2 m	Between 2 m and 5 m	Greater than 5 m

No. 3 - Glazing/Covering Type: (Flammability)

All common intensive horticultural building materials and framing respond uniquely in the event of a fire. It is therefore important to identify which of the following three (3) typical materials shall be used. Common materials utilised are provided below. Flammability is considered both how easily something will burn/ignite and the degree of difficulty required to cause combustion of a substrate.

Glazing types for intensive horticultural building flammability are provided below:

- Glass;
- PM (Plastic Membrane); and
- CPM (Compartmentalized Plastic Membrane).

No. 4 – Glazing/Covering Type: (Egress)

Glazing types have considerable influence over the means and ease of egress during a fire event.

The following three (3) materials may exhibit different characteristics when exposed to a fire event and therefore have specific egress characteristics:

- FPM (Non-rigid Film Plastic Membrane)
- SPM (Rigid Sheet Plastic Membrane) & Glass
- No sides

No. 5 – Glazing/Covering Type: (Smoke)

Build-up of smoke within an intensive horticultural building is a crucial concern during a fire event. In the event of a fire it is vital for occupants to escape before inhalation occurs. Glazing characteristics in relation to the production and retention of smoke are as follows:

- FPM (Non-rigid Film Plastic Membrane)
- SPM (Rigid Sheet Plastic Membrane)

- Glass
- No sides

No. 6 – Lighting

Lighting refers to assimilation lighting and does not apply to general illumination. Assimilation lighting, also known as grow lamps or supplementary lighting, has an increased risk of being the origin of a fire, and as such a higher Classification-Point Assessment shall be awarded if this type of lighting is installed.

No. 7 - Value of Crop & Intensive Horticultural Building

Determine the predicted value of the crop per year and value of the intensive horticultural building as per Table BV3.4. Growers should be consulted by the assessor to correctly determine value of both the crop and intensive horticultural building.

Table BV3.4 – Predicted Value of Intensive Horticultural Crop per Year

Value of Crop & Building	**Low**	**Average**	**High**
Predicted Value of Crop per Year	< $100,000 *(less than $100,000)*	$100,000 to $5,000,000	> $5,000,000 *(greater than $5,000,000)*
Value of intensive horticultural building	< $40,000 *(less than $40,000)*	$40,000 to $2,000,000	> $2,000,000 *(greater than $2,000,000)*

NOTES: If value of crop and value of intensive horticultural building *are not within the same 'value column' it is important to interpolate results within Classification-Point Matrix.*

No. 8 - Environmental Control Systems

Select which of the following environmental control systems are proposed to be implemented into the new intensive horticultural building as per Table BV3.5:

Table BV3.5 – Intensive Horticultural Building Environmental Control Systems

Environmental Control Systems	**Low Control**	**Medium Control**	**High Control**
Control	No mechanical or electrical environmental control.	Mechanical ventilation and fan motors for air movement.	Boilers, fan motors, mechanical vents, electronic environmental control systems, etc.

No. 9 - Distance from other Buildings

Determining the distance between a proposed intensive horticultural building and existing buildings is vital to determine the risk of fire spreading. The distances shown in Table BV3.6 and BV3.7 are based on surrounding combustible buildings with a height no greater than 6 metres. For buildings with a height over 6 metres reference should be made to the second table. The below figures should be taken as minimum distances, and it should be understood that the further away from other buildings an intensive horticultural building is the better.

Table BV3.6 – Distance from Other Buildings, Equal to or Less than 6m High

Distance from other buildings (surrounding buildings height < 5 m high)	**Distance 1**	**Distance 2**	**Distance 3**
Distance (m)	> 10 m *(greater than 10 m)*	10 m to 3 m	< 3 m *(less than 3 m)*

Table BV3.7 – Distance from Other Buildings, Greater than 6m High

Distance from other buildings (surrounding buildings height > 5 m high)	**Distance 1**	**Distance 2**	**Distance 3**
Distance (m)	> 18 m *(greater than 18 m)*	18 m to 6 m	< 6 m *(less than 6 m)*

NOTE: Term 'height' shall be defined in text.

No. 10 – Population

Determine the maximum number of persons within the intensive horticultural building at any one time as per Table BV3.8.

Table BV3.8 – Number of Persons in the Intensive Horticultural Building

Number of Persons	**Band 1**	**Band 2**	**Band 3**
Persons	1 to 5 with an occupancy ratio of no greater than 1 person to 100 m^2	6 to 25 with an occupancy ratio of no greater than 1 person to 400 m^2	26 to 50 with an occupancy ratio of no greater than 1 person to 600 m^2

b) Determine the total Risk-Point Value, tally elements defined in BV3 (a) together and identify their appropriate grouping using Table BV3.9.

Table BV3.9 – Intensive Horticultural Building Grouping Classification and Associated Classification-Point Ranges

	GROUP A	**GROUP B**	**GROUP C**
Total Classification-Point	31 to 47	21 to 30	Less than 20
Explanation	These structures have the highest risk and associated consequences.	These structures have medium risk and associated consequences.	These structures have the lowest combined risk and associated consequences and may be considered as Class 10d buildings

NOTE: If the resulting Total Classification-Point exceeds the prescribed as per the above table a special solution must be obtained by a suitably qualified Engineer.

An example verification assessment has been provided for each Group below.

Group A Classification Example

A proposed intensive horticultural building with a total floor area of 25,000 m^2, rigid plastic cladding, high climate control and an average roof height of 6 m is to be assessed. Reference to Part A1.1 farm buildings definition suggests a Grouping of Group A, to verify this the assessor completes the verification method prescribed as BV3. The following classification-points were found for each assessable element, of which there are ten.

For No. 1 – Intensive Horticultural Building Area, Band 3 was selected from Table BV3.2 as the building shall have a total floor area greater than 10,000 m^2. This provides a **Classification-Point of 5** as per BV3.1.

For No. 2 – Intensive Horticultural Building Average Roof of Covered Height, Band 3 was selected from Table BV3.3 as the building shall have an average roof height of 6m. This provides a **Classification-Point of 5** as per BV3.1.

For No. 3 – Glazing/Covering Type: (Flammability), plastic membrane (PM) was selected as the building shall have plastic membrane cladding. This provides a **Classification-Point of 5** as per BV3.1.

For No. 4 – Glazing/Covering Type: (Egress), rigid sheet plastic membrane (SPM) was selected as the building shall have rigid plastic cladding. This provides a **Classification-Point of 5** as per BV3.1.

For No. 5 – Glazing/Covering Type: (Smoke), rigid sheet plastic membrane (SPM) was selected as the building shall have rigid plastic cladding. This provides a **Classification-Point of 5** as per BV3.1.

For No. 6 – Lighting, through discussion with the development applicant no assimilation lighting is proposed. This provides a **Classification-Point of 0** as per BV3.1.

For No. 7 – Value of Crop & Intensive Horticultural Building, through discussion with the development applicant is was determined that the value of the crop per year be $3,000,000 and the value of the building be $2,500,000. Using Table BV3.4 it is determined that the crop value is ‘Average’ and the building value as ‘High’. This provides a **Classification-Point of 2.5** as per BV3.1. Note: interpolation between ‘Average’ and ‘High’ has occurred.

For No. 8 – Environmental Control System, through discussion with the development applicant a high level of environmental control is proposed as per Table BV3.5. This provides a **Classification-Point of 4** as per BV3.1.

For No. 9 – Distance from other Buildings, through discussion with the development applicant 6 m is proposed between the new development and existing buildings as providing ‘Distance 2’ per Table BV3.6. This provides a **Classification-Point of 3** as per BV3.1.

For No. 10 – Population, through discussion with the development applicant they propose to have maximum occupation of 41 persons in the building at any one time with a ratio of 1 person to 609 m^2. As per Table BV3.8 ‘Band 3’ shall be selected. This provides a **Classification-Point of 5** as per BV3.1.

All verification elements have now been obtained. Tallying, through addition it is found that **the total classification-point is 39.5**. Referring to Table BV3.9 it is found that 39.5 results in a Group A classified structure, verifying the classification of Part A1.1.

Group B Classification Example

A proposed intensive horticultural building with a total floor area of 15,000 m^2, non-rigid plastic cladding, low climate control, and an average roof height of 5 m is to be assessed. Reference to Part A1.1 farm buildings definition suggests a Grouping of Group B, to verify this the assessor completes the verification method prescribed as BV3. The following classification-points were found for each assessable element, of which there are ten.

For No. 1 – Intensive Horticultural Building Area, Band 3 was selected from Table BV3.2 as the building shall have a total floor area greater than 10,000 m^2. This provides a **Classification-Point of 5** as per BV3.1.

For No. 2 – Intensive Horticultural Building Average Roof of Covered Height, Band 2 was selected from Table BV3.3 as the building shall have an average roof height of 5m. This provides a **Classification-Point of 3** as per BV3.1.

For No. 3 – Glazing/Covering Type: (Flammability), plastic membrane (PM) was selected as the building shall have plastic membrane cladding. This provides a **Classification-Point of 5** as per BV3.1.

For No. 4 – Glazing/Covering Type: (Egress), non-rigid film plastic membrane (FMP) was selected as the building shall have non-rigid plastic cladding. This provides a **Classification-Point of 4** as per BV3.1.

For No. 5 – Glazing/Covering Type: (Smoke), non-rigid film plastic membrane (FMP) was selected as the building shall have non-rigid plastic cladding. This provides a **Classification-Point of 2** as per BV3.1.

For No. 6 – Lighting, through discussion with the development applicant no assimilation lighting is proposed. This provides a **Classification-Point of 0** as per BV3.1.

For No. 7 – Value of Crop & Intensive Horticultural Building, through discussion with the development applicant is was determined that the value of the crop per year be $500,000 and the value of the building be $900,000. Using Table BV3.4 it is determined that the crop value is ‘Average’ and the building value as ‘Average’. This provides a **Classification-Point of 2** as per BV3.1.

For No. 8 – Environmental Control System, through discussion with the development applicant a medium level of environmental control is proposed as per Table BV3.5. This provides a **Classification-Point of 0** as per BV3.1.

For No. 9 – Distance from other Buildings, through discussion with the development applicant 6 m is proposed between the new development and existing buildings as providing ‘Distance 2’ per Table BV3.6. This provides a **Classification-Point of 3** as per BV3.1.

For No. 10 – Population, through discussion with the development applicant they propose to have maximum occupation of 20 persons in the building at any one time with an occupancy ratio of 1 person to 750 m^2. As per Table BV3.8 ‘Band 2’ shall be selected. This provides a **Classification-Point of 3** as per BV3.1.

All verification elements have now been obtained. Tallying, through addition it is found that **the total classification-point is 27**. Referring to Table BV3.9 it is found that 27 results in a Group B classified structure, verifying the classification of Part A1.1.

Group C Classification Example

A proposed intensive horticultural building with a total floor area of 400 m^2, non-rigid plastic cladding, low climate control, and an average roof height of 2.5 m is to be assessed. Reference to Part A1.1 farm buildings definition suggests a Grouping of Group C, to verify this the assessor completes the verification method prescribed as BV3. The following classification-points were found for each assessable element, of which there are ten.

For No. 1 – Intensive Horticultural Building Area, Band 1 was selected from Table BV3.2 as the building shall have a total floor area less than 500 m^2. This provides a **Classification-Point of 1** as per BV3.1.

For No. 2 – Intensive Horticultural Building Average Roof of Covered Height, Band 2 was selected from Table BV3.3 as the building shall have an average roof height of 2.5m. This provides a **Classification-Point of 3** as per BV3.1.

For No. 3 – Glazing/Covering Type: (Flammability), plastic membrane (PM) was selected as the building shall have plastic membrane cladding. This provides a **Classification-Point of 5** as per BV3.1.

For No. 4 – Glazing/Covering Type: (Egress), non-rigid film plastic membrane (FMP) was selected as the building shall have non-rigid plastic cladding. This provides a **Classification-Point of 4** as per BV3.1.

For No. 5 – Glazing/Covering Type: (Smoke), non-rigid film plastic membrane (FMP) was selected as the building shall have non-rigid plastic cladding. This provides a **Classification-Point of 2** as per BV3.1.

For No. 6 – Lighting, through discussion with the development applicant no assimilation lighting is proposed. This provides a **Classification-Point of 0** as per BV3.1.

For No. 7 – Value of Crop & Intensive Horticultural Building, through discussion with the development applicant is was determined that the value of the crop per year be $16,000 and the value of the building be $35,000. Using Table BV3.4 it is determined that the crop value is ‘Low’ and the building value as ‘Low’. This provides a **Classification-Point of 1** as per BV3.1.

For No. 8 – Environmental Control System, through discussion with the development applicant a medium level of environmental control is proposed as per Table BV3.5. This provides a **Classification-Point of 0** as per BV3.1.

For No. 9 – Distance from other Buildings, through discussion with the development applicant 6 m is proposed between the new development and existing buildings as providing ‘Distance 2’ per Table BV3.6. This provides a **Classification-Point of 3** as per BV3.1.

For No. 10 – Population, through discussion with the development applicant they propose to have maximum occupation of 2 persons in the building at any one time with an occupancy ratio of 1 person to 200 m^2. As per Table BV3.8 ‘Band 1’ shall be selected. This provides a **Classification-Point of 1** as per BV3.1.

All verification elements have now been obtained. Tallying, through addition it is found that **the total classification-point is 20**. Referring to Table BV3.9 it is found that 20 results in a Group C classified structure, verifying the classification of Part A1.1. As Group C has been selected it is appropriate to use NCC Volume Two and class the structure as 10d.

Though this method provides increased flexibility to the IHB classification process, the Project Team was informed, through consultation with the Australian Institute of Building Surveyors, that the Project may struggle obtaining support for this approach as it does not conform to the current NCC classification methodology, based on building use.

5.3 Classification Structure Selected

Both methods described above in Section 5.2.1 and Section 5.2.2 of this document have been assessed against the assessable criteria for classification defined in Section 5.1. Assessment results of the criteria are summarised below in Table 7 through to 9:

Table 7 Assessment of Classification Structure One

Criteria	Assessment
1	No negative feedback has been received.
2	Feedback was received and minor alterations to the method were made.
3	Feedback was received and minor alterations to the method were made.
4	The method complies with the literary review and technical analysis and findings.
5	The proposed three group classification minimises restrictiveness of the classification method.

Table 8 Assessment of Classification Structure Two

Criteria	Assessment
1	No negative feedback has been received.
2	Feedback was received. One feedback participant found the verification method overly complex.
3	The AIBS provided feedback where they recommended that a prescriptive method would be more agreeable to their institute and the Australian Building Codes Board.
4	The method complies with the literary review and technical analysis and findings.
5	The proposed three group classification minimises restrictiveness of the classification method.

A pro et contra analysis was then undertaken for each classification method, this is summarised below.

Table 9 Pro et Contra Analysis of Classification Structures

	Pro	Con
The method is flexible and can adjust to changes in the industry	Verification Method	Prescriptive Method
The method allows for little ambiguity in classification	Prescriptive Method	Verification Method
The method provides reduction in burden to growers	Prescriptive Method Verification Method	-
The method minimises liability placed on building surveyors	Prescriptive Method	Verification Method

The method generally meets the NCC classification framework	Prescriptive Method	Verification Method
The method reduces incorrect classification through a check system	Verification Method	Prescriptive Method

After deliberation and consultation, it was determined that the 'Classification Structure One (Prescriptive Method)' shall be adopted as the proposed method of classification for the Proposal for Change. Section 6 of this document outlines the proposal based on the prescriptive classification method. The verification method shall be included within the NCC Guide as a supporting mechanism to classify IHBs.

6.0 Summary of Proposal for Change (NCC 2019)

6.1 Structure of Proposal for Change

The general concept of this proposal is as follows - the proposal consists of eleven steps, identifying specific changes to the classification and Provisional Framework to include Intensive Horticultural Buildings into the NCC. Steps one to three are associated with the NCC Volume One while steps four through to nine are associated with changes made to the NCC Volume Two. Steps ten and eleven are made to the NCC Guide.

National Construction Code Volume One (Change Numbers One to Three)

ChNo1 – Redefine Farm Building

NCC Change Location: NCC Vol 1 2016 > A1 Interpretation > Part A1.1 Definition > Farm building (REVISED)

To begin the change in classification/definition framework the project team has altered the current farm building definition within the NCC to include intensive horticultural buildings (defined in ChNo2). The intensive horticultural buildings are defined as Group A, Group B and Group C – these groups allow for efficient and effective classification of the analysed building, reducing compliance of unnecessary; and provisions not relevant to; the specific form and use of building.

ChNo2 – Provide Definition for Intensive Horticulture Building

NCC Change Location: NCC Vol 1 2016 > A1 Interpretation > Part A1.1 Definition > Intensive Horticulture building (NEW)

This proposed change adds a definition into the NCC for intensive horticulture buildings which specifies the building's primary usage for horticultural means.

ChNo3 – Alteration to NCC Volume One Part H3 Farm Buildings and Farm Sheds

NCC Change Location: NCC Vol 1 2016 > Part H3 Farm Buildings and Farm Sheds > Part H3.1 Application of parts (REVISED)

It is proposed to revise Part H3 to include intensive horticultural buildings and their application of Parts.

National Construction Code Volume Two (Change Numbers Four to Nine)

ChNo4 – Redefine Farm Building

NCC Change Location: NCC Vol 2 2016 > Part 1.1 Interpretation > Part 1.1.7 Language (REVISED)

To begin the change in classification/definition framework the project team has altered the current farm building definition within the NCC to include intensive horticultural buildings (defined in ChNo5). The intensive horticultural buildings are defined as Group A, Group B and Group C – these groups allow for efficient and effective classification of the analysed building, reducing compliance of unnecessary; and provisions not relevant to; the specific form and use of building.

ChNo5 – Provide Definition for Group C Intensive Horticulture Building

NCC Change Location: NCC Vol 2 2016 > Part 1.1 Interpretation > Part 1.1.1 Definitions > Intensive horticulture building (new)

This proposed change adds a definition into the NCC for intensive horticulture buildings which specifies the building's primary usage for horticultural means.

ChNo6 – Group C Intensive Horticultural Building Classification as Class 10

NCC Change Location: NCC Vol 2 2016 > Part 1.3 Classification > Part 1.3.2 Classification > Class 10 (REVISED/ADDITION)

An addition shall be made to Class 10 at Part 1.3 Section 1.3.2 Classification whereby a subclass 10d shall be added. This allows for inclusion of the Group C Intensive Horticultural Building into Volume Two of the NCC. An explanatory information note has also been included in this part.

ChNo7 – Group C Intensive Horticultural Buildings Classification as Multiple

NCC Change Location: NCC Vol 2 2016 > Part 1.3 Classification > Part 1.3.3 Multiple Classifications (REVISED)

An addition shall be made to Class 10 at Part 1.3 Section 1.3.3 Multiple classifications whereby a subclass 10d shall be added. This allows for inclusion of the Group C Intensive Horticultural Building into Volume Two of the NCC for multiple classification applications.

ChNo8 – Group C Intensive Horticultural Buildings Protection from Spread of Fire

NCC Change Location: NCC Vol 2 2016 > Part 2.3 Fire Safety > Part 2.3.1 Protection from the spread of fire (REVISED)

An alteration shall be made to Part 2.3 Fire Safety to ensure a Class 10d building does not significantly increase the risk of fire spread between Class 2 to 9 buildings.

ChNo9 – Group C Intensive Horticultural Buildings Explanatory Information

NCC Change Location: NCC Vol 2 2016 > Part 2.3 Fire Safety > Explanatory information (REVISED/ADDITION)

An explanatory information note has been included in Part 2.3 Fire Safety which outlines specification for Class 10d structures.

National Construction Code Guide (Change Numbers Ten to Eleven)

ChNo10 – NCC Guide Interpretation Inclusion

NCC Change Location: NCC Guide 2016 > Part A1 Interpretation (REVISED)

Criteria have been included for a building to be considered an intensive horticultural building.

ChNo11 – NCC Guide Interpretation Inclusion and BV Additions

NCC Change Location: NCC Guide 2016 > Part B Structure > Part B1 Structural Provisions > BV3 Intensive Horticultural Building Verification Method (NEW)

The following shall be added to the NCC Guide 2019 as further explanation for Building Verification Method (BV).

6.2 Summary of Each Proposal

The below sections outline each of the individual Proposals for Change to the 2019 National Construction Code. This section provides an overview of each change element and the supporting justification for the change is provided in Section 6.3. For an explanation of the justification methodology implemented within this Proposal for Change refer to Section 3.3.1.

Proposed additions into the NCC documents are shown in green underlined text. An example has been provided below:

This is an example of NCC addition text.

Proposed removal of text within the NCC are shown in red and have a strikethrough. An example has been provided below:

~~This is an example of NCC removal text.~~

The following NCC changes are for the inclusion of Intensive Horticultural Building classification definitions within the existing Farm Buildings definition.

There are 11 (eleven) integrated proposals for NCC changes in Volumes One, Volume Two and NCC Guide, which are presented. To help understand the definition background the Project Team has listed the following series of definitions and photographic examples of each of the Groups, these have been provided below.

Classification Definitions

Intensive Horticultural Building Group A – These farm buildings are of a higher-risk nature (in regard to construction, investment costs and operation), typically a building with rigid covering materials and a total area exceeding 500 m^2. This Group typically achieves the highest level of environmental control and automation to offer potential for higher quality and quantity of produce. With detailed automation programming these structures require lower ratios of occupancy in comparison to Group B and C buildings. These structures are usually constructed with rigid walls at least 4 metres high with the roof peak being up to 10 metres. Refer to Figure 10 for an example of a typical Group A structure.

Figure 10 Typical Group A Structure (Source: Stock Image)

Intensive Horticultural Building Group B – These farm buildings are of a medium-risk nature (in regard to construction, investment costs and operation), typically a building with rigid or retractable or permanent non-rigid plastic covering materials and a total area exceeding 500 m^2. Group B IHBs are typically characterised by vertical, non-rigid walls (between 2 and 4 metres) and commonly have roof or side ventilation, or both. Group B structures are seen as a compromise between the Group C and Group A and have cost and risk relativity for increased environmental control and overall areas (compared to typical Group C technology greenhouses). Refer to Figure 11 for an example of a Group B structure.

Figure 11 Typical Group B Structures (Source: Stock Image)

Intensive Horticultural Building Group C – These farm buildings are of a low-risk nature (in regard to construction, investment costs and operation) and/or are typically constructed with non-rigid, plastic or fabric covering materials with a total area not exceeding 500 m^2. These structures shall be classified as Class 10d buildings and are regulated within the NCC Volume Two - refer to ChNo4 to ChNo9. These structures are very common in Australia. Large span, cable supported net structures covering large areas (exceeding 500 m^2) and up to 6.0 m high can also be included in this category. Construction is typically low cost and domestic in nature. The greenhouses are usually less than 3 metres in height and have a tunnel or 'igloo' profile shape. These structures are popular because they may be considered relatively inexpensive and further conceived as easy to erect. Refer to Figure 12 for an example of a greenhouse style Group C structures and Figure 13 for a fabric Group C structure.

Figure 12 Typical Greenhouse Group C Structure (Source: Stock Image)

Figure 13 Typical Cable Canopy Group C Structure (Source: Stock Image)

The following sections outline all 11 of the Proposals for Change for the farm buildings in the NCC Volume One, NCC Volume Two and the NCC Guide. All 11 form an integrated set of changes in order to have a comprehensive set of methodologies for the NCC Volume One and Two, to implement the new definitions for Intensive Horticultural Buildings.

PROPOSAL FOR CHANGE SUMMARY FOR NCC VOLUME 1 2019 EDITION

6.2.1 Change Number One (ChNo1)

Brief: It is proposed that farm building definitions shall be revised to include Intensive Horticultural Buildings (**IHB**) as is provided within the Classification Definitions category on pages 4-6 of this document. This option retains the farm building definitions and incorporates the IHB definitions. An IHB shall be classified as either a Group A, B or C structure.

Change Location: NCC Vol 1 2016 > A1 Interpretation > Part A1.1 Definition > Farm building **(REVISED)**

Proposal for Change Element One Commencement

Farm building means a Class 7, ~~or~~ 8 or 10 building located on land primarily used for *farming* -

(a) that is either -

(i) used in connection with *farming*; or

(ii) used primarily to store one or more farm vehicles; or

(iii) that is an *Intensive Horticultural Building* belonging to one or a combination of the following groups -

(A) GROUP A *Intensive Horticulture Buildings – Intensive Horticultural Buildings* built with an average roof height of 5 to 9 m and a total floor area exceeding 500 m^2;

(B) GROUP B *Intensive Horticulture Buildings – Intensive Horticulture Buildings* built with an average roof height of 2 to 5 m and a total floor area exceeding 500 m^2;

(C) GROUP C *Intensive Horticulture Buildings – Intensive Horticulture Buildings* constructed with a total floor area no greater than 500 m^2 shall be classified as Class 10d; Fabric canopy cable structures with no limitation on roof height and total floor area shall be classified as Class 10d or

(iv) any combination of (i), (ii) and (iii) and

(b) in which the total number of persons accommodated at any time does not exceed –

(i) one person per 200 m^2 of floor area or part thereof, up to a maximum of 8 persons for general farm buildings;

(ii) one person per 600 m^2 of floor area or part thereof for Group A *Intensive Horticultural Buildings;*

(iii) one person per 400 m^2 of floor area or part thereof for Group B *Intensive Horticultural Buildings; and*

(iv) one person per 100 m^2 of floor area of part thereof, up to a maximum of 5 persons for Group C *Intensive Horticultural Buildings*; and

(c) with a total floor area of not more than 3500 m^2 for general farm buildings. There are no maximum floor areas prescribed for Group A and B intensive horticultural buildings.

Proposal for Change Element One End

6.2.2 Change Number Two (ChNo2)

Brief: This proposed change adds a definition into the NCC Volumes One and Two for intensive horticulture buildings which specifies the building's primary usage for horticultural means. An IHB is a greenhouse, grow structure, canopy or the like belonging to one or a combination of the aforementioned in NCC Volume One, Part A1.1, Farm Buildings (ChNo1).

Change Location: NCC Vol 1 2016 > A1 Interpretation > Part A1.1 Definition > Intensive horticulture building **(NEW)**

Proposal for Change Element Two Commencement

Intensive Horticultural Building means a farm building or part thereof, used for environmentally controlled farming, propagation or growing of plants, flowers or fungi but which is not used for the packing, display, trade or sale of the products or parts produced. An intensive horticultural building shall belong to one or a combination of group defined by Part A1.1 farm building.

Proposal for Change Element Two End

6.2.3 Change Number Three (ChNo3)

Brief: To be added to NCC Vol 1 Part H3. This allows for inclusion of the Intensive Horticultural Building into Part H3 of the NCC – here specific deemed-to-satisfy provisions for each identified classification of Intensive Horticultural Building will be documented.

Change Location: NCC Vol 1 2016 > Part H3 Farm Buildings and Farm Sheds > Part H3.1 Application of parts **(REVISED)**

Proposal for Change Element Three Commencement

H3.1 Application of Part

(a) The Deemed-to-Satisfy Provisions of this Part apply to *farm buildings*, ~~and~~ *farm sheds* and *intensive horticultural buildings*.
(b) The Deemed-to-Satisfy Provisions of this Part take precedence where there is a difference to the Deemed-to-Satisfy Provisions of Sections C, D, E and F.
(c) H3.1 to H3.5, H3.8 and H3.11 to H3.18 apply to *farm sheds*.
(d) H3.1, H3.3, H3.5 to H3.7, H3.9 to H3.12, H3.14, H3.15 and H3.18 apply to a *farm building* but excludes *intensive horticultural buildings*.
(e) H3.1, H3.3 to H3.12, H3.14 to H3.19 apply to a Group A *intensive horticultural building*.
(f) H3.1, H3.3 to H3.19 apply to a Group B *intensive horticultural building*.

H3.2 Fire resistance and separation

A farm shed need not comply with the provision of Parts C1, C2, and C3, except for C1.11 if it is separated from any other building or allotment boundary by a distance of not less than 6 m.

H3.3 Provision for escape

(a) Except for D1.2, D1.4 to D1.6, D1.9, D1.10(a), D1.13(c), D1.14 and D1.15, the Deemed-to-Satisfy Provisions of D1 do not apply to a farm shed or intensive horticultural buildings.
Where –
  a. Group A intensive horticultural building shall have no point on a floor more than 60 m from an exit, or a point from which travel in different directions to 2 exits is available, in which case the maximum distance to one of those exits must not exceed 120 m. Exits that are required as alternative means of egress must be no greater than 140 m apart.
  b. Group B intensive horticultural building shall have no point on a floor more than 40 m from an exit, or a point from which travel in different directions to 2 exits is available, in which case the maximum distance to one of those exits must not exceed 80 m. Exits that are required as alternative means of egress must be no greater than 100 m apart.
  c. Farm shed buildings and Group C intensive horticultural buildings shall comply will H3.3 (a).

(b) An open space adjacent to a farm building, intensive horticultural building or a farm shed need not be directly connected with a public road.

H3.4 Construction of exits

Except for D2.13, D2.14, D2.16, D2.17 and D2.24, the Deemed-to-Satisfy Provisions of Part D2 do not apply to farm sheds.

Alternative exits for intensive horticultural buildings are -

(a) Single-use or sacrificial exits may be installed in intensive horticultural buildings if the building is deemed not *accessible*; these exits shall not exceed 1 to every 4 conventional exits.

Explanatory Note: A single-use or sacrificial exit is an exit which is used in an emergency. The means of alternative exit depend on construction materials used. For example, a non-rigid plastic film structure may allow for a cutting implement to be used to create a single-use exit; in which case a cutting implement shall be provided at every single-use exit location.

In a rigid structure 'kick-out' panels may be installed at each single-use exit location. These panels shall be constructed to allow a person to unlatch a holding device or kick out the panel with appropriate force (less than 250 N impact) in an emergency while ensuring structural stability during normal operations as per Part B. Egress kick-out panels and their supports require design from a suitably qualified and registered engineer.

H3.5 Fixed platforms, walkways, stairways and ladders

A fixed platform, stairway, ladder and any going and riser, landing, handrail or barrier may comply with AS 1657 in lieu of D2.13, D2.14, D2.16 and D2.17 where it serves a farm building, intensive horticultural building or a farm shed.

H3.6 Thresholds

The threshold of a doorway that services an area not required to be accessible by D3.1 in a farm building or intensive horticultural building need not comply with D2.15 where the door sill is not more than 700 mm above the finished surface of the ground, floor or the like, to which the doorway opens.

H3.7 Swing doors

A swing door in a required exit or forming part of a required exit need not swing in the direction of egress if it serves a farm building or intensive horticultural building.

H3.8 Fire fighting equipment

The Deemed-to-Satisfy Provisions of E1 do not apply to a farm shed. The Deemed-to-Satisfy Provisions of E1.5 and E1.8 do not apply to an intensive horticultural building.

A Group A and Group B intensive horticultural building over 80 m long or a floor area over 5,000 m^2 shall have an integrated firefighting service and initiation devices within 6 m of hydrant points as defined in Part H3.9 and no less than 2 per building with additional devices as necessary for zone control of the water irrigation system.

Where -

(a) The firefighting and fire initiation system shall include the integration of any mechanical ventilation, water spray, mist and/or fogging system, if they are installed within the building and utilised as part of the normal intensive horticultural building operation. In addition, any services as listed below shall be integrated to operate in a fire affected zone, with the fire initiating system. These include:
   i. Electrical Control System to operate the irrigation water pumps for the building
   ii. Water irrigation zone controls and valves to operate areas within the building
   iii. Mechanically controlled vents or louvers to open position in an activation zone
   iv. Retractable roof covers that can be opened in an activation zone

(b) One or more of the above building services are available, then the irrigation and pump systems shall be made part of the firefighting systems for activation by occupants with a local fire initiation device, located within 6 m of hydrant points and signed and labelled accordingly. Zoning will be designed to match the normal irrigation or spray zones normally utilised by the building's operator. Zoning provisions include:
   i. Initiation devices shall be zoned to match those operational zones with no less than one device per zone. Devices include, break glass, mushroom control buttons, lever pull handled devices or suitable single action switch
   ii. Where the affected activation zone is the floor area in which the integrated firefighting system was activated, floor areas shall be distributed equally between hydrant points.

H3.9 Fire hydrants and water supply

(a) An intensive horticultural building–
   i. With a total floor area greater than 5000 m^2; and
   ii. Located where a rural fire brigade is available to attend a building fire,

   Must be –

   i. Provided with Connection points no more than 90m apart
   ii. Provided with local fire water storage tanks suitable for access within 18m of the building with '1 hour' reserve and suction points for local fire services vehicle; or
   iii. Provided with other water supply suitable for access near the building with drought based reserve and suction points for local fire services vehicle; and
   iv. Located on the same allotment as an access point to water supply which –
      A. Has a minimum total capacity of 72 000 litres; and
      B. Is situated so as to enable emergency services vehicles access to within 4 m; and
      C. Is located within 60 m of the building

D. Can be part of the irrigation network to the building

E. Have signage and valve locations clearly marked, visible from 100m away

F. Have a hydrant outlet connection from the irrigation system to cover the known worst hazard part within the building that may include the Main Power Supply, Generator unit, combustible or flammable goods storage bays, or the like, identified with the rural fire service locally as a fire hazard.

(b) A farm building –

i. With a total floor area greater than 1000 m^2; and

ii. Located where a fire brigade is available to attend a building fire,

Must be –

iii. Provided with a fire hydrant system installed in accordance with AS 2419.1, except reference to '4 hours' water supply in clause 4.2 is replaced with '2 hours'; or

iv. Located on the same allotment as an access point to water supply which –

A. Has a minimum total capacity of 14 400 litres; and

B. Is situated so as to enable emergency services vehicles access to within 4 m ; and

C. Is located within 60 m of the building and not more than 90 m from any part of the building.

(c) For purposes of (a)(iv) or (b)(iv), water supply for a farm building or intensive horticultural building must consist of one or any number of the following

i. A water storage tank.

ii. A dam.

iii. A reservoir.

iv. A river.

v. A lake.

vi. A bore.

vii. A sea.

(d) If the whole or part of the water supply referred to in (a)(iv) or (b)(iv), is contained in a water storage tank, it must be –

i. Located not ~~less~~ more than ~~10~~ 60 m from the building; and

ii. Fitted with at least one small bore suction connection and one large bore suction connection where –

A. Each suction connection is located in a position so as to enable emergency service vehicles access to within 4 m; and

B. The suction connections are located not less than ~~10~~ 30 m from the building or the hazard part; and

C. 'small bore suction connection' and 'large bore suction connection' have the meanings contained in AS 2419.1.

H3.10 Fire hose reels

A fire hose reel system need not be provided to serve a farm building or intensive horticultural building where portable fire extinguishers are installed in accordance with H3.11.

H3.11 Portable fire extinguishers

(a) A farm building or intensive horticultural building not provided with a fire hose reel system in accordance with E1.4 must be provided with –

i. One portable fire extinguisher rated at not less than 5ABE in each room or area containing a generator, flammable materials or electrical equipment ~~containing flammable materials or electrical equipment~~; and
ii. One portable fire extinguisher as per (b) ~~rated at not less than 4A60BE~~ adjacent to every required exit door; and
iii. Location signs complying with clauses 3.3 to 3.9 of AS 2444 above each required portable fire extinguisher.

~~(b) A farm shed must be provided with not less than one portable fire extinguisher for every 500 m^2 of floor area or part thereof, distributed as evenly as practicable throughout the building.~~

(b) A portable fire extinguisher required by (b) must be –

i. Of ABE or CO_2 type; and
ii. Not less than 4.5 kg in size; and
iii. Installed in accordance with Section 3 of AS 2444.

H3.12 Emergency lighting requirements

(a) An emergency lighting system need not be installed in a farm building or intensive horticultural buildings –
  a. With no artificial lighting as permitted by H3.18; or
  b. With artificial lighting where, if that lighting fails due to an emergency, automatic power supply to the building is provided by a fuel-driven generator.

(b) An emergency lighting system need not be installed in a farm shed.

H3.13 Exit signs

An exit serving a farm shed, Group B or Group C intensive horticultural building need not be provided with an exit sign where the exit is a permanent opening not less than 2 m wide.

H3.14 Direction signs

In a farm building, intensive horticultural building or a farm shed, if an exit is not readily apparent to persons occupying or visiting the building, exit signs complying with H3.15 must be installed in appropriate positions in corridors, hallways, lobbies, and the like, indicating the direction to a required exit.

H3.15 Design and operation of exit signs

(a) In a farm building or intensive horticultural building, each required exit sign provided under E4.5 and H3.14 need not comply with E4.8 if –
   a. The use of illuminated exit signs may adversely impact the behaviour or welfare of animals being kept in the building; and
   b. Non-illuminated exit signs are installed in accordance with clauses 6.5, 6.6, 6.8 and 6.9 of AS 2293.1.

(b) In a farm shed or Group C intensive horticultural building, each required exit sign provided under E4.5 and H3.14 need not comply with E4.8 if exit signs complying with Section 6 and Appendix D of AS 2293.1 and provided except –
   a. The exit sign need not be illuminated; and
   b. The maximum viewing distance in clause 6.6 of AS 2293.1 must be not more than 24 m; and
   c. Clauses 6.3 and 6.7 of AS 2293.1 do not apply.

H3.16 Sanitary facilities

F2.3 does not apply to a farm shed or intensive horticultural buildings.

H3.17 Height of rooms and other spaces

F3.1 does not apply to a farm shed or intensive horticultural building which has ceiling heights not less than –

(a) In a room, corridor, passageway or the like – 2.1 m; and
(b) In a room or space with a sloping ceiling or projections – a height of not less than 2.1 m for at least two-thirds of the floor area of the room or space, and when calculating the floor area of the room or space, any part that has a ceiling height or less than 1.5 m is not included; and
(c) In a stairway, ramp, landing or the like – 2.0 m measured vertically above the nosing line of stairway treads or the floor surface of the ramp, landing or the like.

H3.18 Artificial lighting

(a) An artificial lighting system need not be provided in a farm building or intensive horticultural building where –
   i. Occupants are provided with visibility sufficient for safe movement through suitable alternative means; and
   ii. The use of artificial lighting could adversely affect the function of the building including, but not limited to –
      A. The behaviour or welfare of animals being kept in the building; or
      B. The cultivating or propagating of plants or fungi.

(b) An artificial lighting system need not be provided in a farm shed.

H3.19 Compartmentation and Separation

Deemed-to-Satisfy Provisions of C2.2 and C2.3 do not apply to intensive horticultural buildings where –

(a) Provided with a perimeter vehicular access complying with C2.4(b);
(b) The building is separated from any other building or allotment boundary by a distance not less than 6 m; and
(c) The building contains not more than 1 *storey*.

Proposal for Change Element Three End

PROPOSAL FOR CHANGE SUMMARY FOR NCC VOLUME 2 2019 EDITION

6.2.4 Change Number Four (ChNo4)

Brief: An addition shall be made to Part 1.1.7 Language of Volume Two to include the classification Class 10d.

Change Location: NCC Vol 2 2016 > Part 1.1 Interpretation > Part 1.1.7 Language **(REVISED)**

Proposal for Change Element Four Commencement

a) A reference to Class 1a, 1b, 7a, 7b, 9a, 9b, 9c, 10a, 10b ~~and~~, 10c and 10d is a reference to the separate classification.
b) A reference to –
   a. Class 1 – is reference to a Class 1a and 1b; and
   b. Class 7 – is a reference to a Class 7a and 7b; and
   c. Class 9 – is a reference to a Class 9a, 9b and 9c; and
   d. Class 10 – is a reference to a Class 10a, 10b ~~and~~, 10c and 10d.

Proposal for Change Element Four End

6.2.5 Change Number Five (ChNo5)

Brief: This proposed change adds a definition into the NCC for intensive horticulture buildings which specifies the building's primary usage for horticultural means.

Change Location: NCC Vol 2 2016 > Part 1.1 Interpretation > Part 1.1.1 Definitions > Intensive horticulture building **(NEW)**

Proposal for Change Element Five Commencement

Intensive Horticultural Building means a farm building or part thereof, used for environmentally controlled farming, propagation or growing of plants, flowers or fungi but which is not used for the packing, display, trade or sale of the products or parts produced. An intensive horticultural building shall belong to one or a combination of group defined by Part A1.1 farm building.

Proposal for Change Element Five End

6.2.6 Change Number Six (ChNo6)

Brief: An addition shall be made to Class 10 at Part 1.3 Section 1.3.2 Classification whereby a subclass 10d shall be added. This allows for inclusion of the Group C Intensive Horticultural Building into Volume Two of the NCC. An explanatory information note has also been included in this part.

Change Location: NCC Vol 2 2016 > Part 1.3 Classification > Part 1.3.2 Classification > Class 10 **(REVISED/ADDITION)**

Proposal for Change Element Six Commencement

Class 10 – a non-habitable building or structure being –

(a) Class 10a – a non-habitable building being a private garage, carport, shed, or the like; or
(b) Class 10b – a structure being a fence, mast, antenna, retaining or free-standing wall, swimming pool, or the like; or
(c) Class 10c – a private bushfire shelter~~.~~; or
(d) Class 10d – a structure being a Group C intensive horticultural building.

Explanatory information:

The Class 10d for use as defined for horticulture shall be limited in the classification as defined under Farm Building of NCC Volume One for this use. Where a structure exceeds the Group C limits and is determined as another Class, 10d shall not be used.

Proposal for Change Element Six End

6.2.7 Change Number Seven (ChNo7)

Brief: An addition shall be made to Class 10 at Part 1.3 Section 1.3.3 Multiple classifications whereby a subclass 10d shall be added. This allows for inclusion of the Group C Intensive Horticultural Building into Volume Two of the NCC for multiple classification applications.

Change Location: NCC Vol 2 2016 > Part 1.3 Classification > Part 1.3.3 Multiple Classifications **(REVISED)**

Proposal for Change Element Seven Commencement

Each part of a building must be classified separately, and –

(a) Class 1a, 1b, 10a, 10b ~~and~~, 10c and 10d are separate classifications; and
(b) A reference to –
  i. Class 1 – is a Class 1a and 1b; and
  ii. Class 10 – is to Class 10a, 10b ~~and~~, 10c and 10d; and
(c) Where parts have different purposes – if not more than 10% of the floor area of a Class 1 building is used for the purpose which is a different classification, the classification of Class 1 may apply to the whole building.

Proposal for Change Element Seven End

6.2.8 Change Number Eight (ChNo8)

Brief: An alteration shall be made to Part 2.3 Fire Safety to ensure a Class 10d building does not significantly increase the risk of fire spread between Class 2 to 9 buildings.

Change Location: NCC Vol 2 2016 > Part 2.3 Fire Safety > Part 2.3.1 Protection from the spread of fire **(REVISED)**

Proposal for Change Element Eight Commencement

(b) A class 10a and 10d building must not significantly increase the risk of fire spread between Class 1 to 9 buildings.

Proposal for Change Element Eight End

6.2.9 Change Number Nine (ChNo9)

Brief: An explanatory information note has been included in Part 2.3 Fire Safety which outlines specification for Class 10d structures.

Change Location: NCC Vol 2 2016 > Part 2.3 Fire Safety > Explanatory information **(REVISED/ADDITION)**

Proposal for Change Element Nine Commencement

Fire provisions applied to Class 10d are not required to be any different than those for a Class 10a and shall follow requirements of 3.7.1.5 to 3.7.1.8.

Proposal for Change Element Nine End

PROPOSAL FOR CHANGE SUMMARY FOR NCC GUIDE 2019 EDITION

6.2.10 Change Number Ten (ChNo10)

Brief: An alteration shall be made to 'Farm building' Part A1 Interpretation to include intensive horticultural buildings.

Change Location: NCC Guide 2016 > Part A1 Interpretation **(REVISED)**

Proposal for Change Element Ten Commencement

Farm building

Buildings used for farming-type purposes are often very diverse in nature, occupancy and use. There are a number of conditions in this definition to outline the specific instances where a Class 7 or Class 8 building can be considered a farm building for the purposes of the NCC. This is to ensure that the Deemed-to-Satisfy Provisions for farm buildings are appropriate for a particular building in question.

The definition sets out three main criteria that a general farm building must meet for it to be considered a farm building. These criteria can be described as:

- the use and location of the building;
- the maximum number of occupants and occupant density in the building; and
- a maximum floor area of the building.

The definition sets out four main criteria that an intensive horticultural farm building must meet for it to be considered an intensive horticultural building. These criteria can be described as:

- the use and location of the building;
- a range of allowable floor areas;
- the maximum number of occupants and occupant density in the building; and
- the maximum average roof height of the building.

It is recommended that this definition be read in conjunction with the definition of 'farming'.

Refer to **Part H3** for specific requirements for farm buildings.

Proposal for Change Element Ten End

6.2.11 Change Number Eleven (ChNo11)

Brief: An addition shall be made to Part A1 Interpretation to include intensive horticultural buildings.

It is proposed that a classification-point assessment be the basis of determining classification of the Intensive Horticultural Building. To determine the classification, it is proposed that the following assessment be undertaken. The assessment determines risk associated with the assessable Intensive Horticultural Building and allocates the Intensive Horticultural Building into one of the following three classifications.

The assessable elements, shown from numbers 1 to 10 in the below Figure 5, are then analysed within a Classification-Point Matrix to identify the associated holistic risks and consequences of the proposed structure. Once a result is obtained a classification is determined as being a Group A, B or C intensive horticultural building.

There are ten input elements which shall be used to determine risks and consequences related to the development, as provided below.

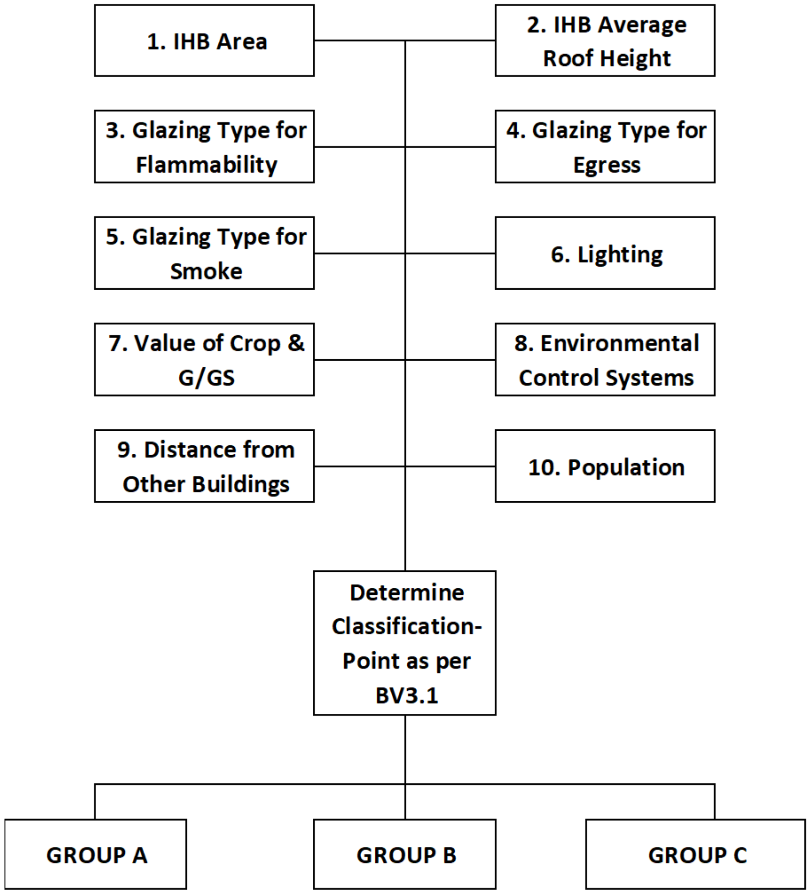

Figure 14 Building Verification Method Structure

For photographic examples of typical Group A, B and C structures refer to Classification Definitions within this report on pages 4-6.

The determination of Classification-Point Assessment Result for a site using pertinent elements shall be determined in accordance with the following steps:

- Make note of the relevant input findings, from BV3 (a) No. 1 to No. 10.
- Use the relevant tables and information to determine the Classification-Points for each of the elements using Table A1.1 (BV Matrix).
- Tally, through addition, the Classification-Points for each element to give the Total Classification-Point using Table A1.1 (BV Matrix).
- Determine classification of structure using the Total Classification-Point value as per Table A1.1 (Classification-Point).

Assessment examples have been provided in ChNo11 as part of the Proposal for Change to the NCC Guide.

Change Location: NCC Vol 1 2016 > Part B1 Structural

Change Location: NCC Guide 2016 > Part A1 Interpretation **(ADDITION)**

Proposal for Change Element Eleven Commencement

Intensive horticultural building

Buildings used for environmentally controlled farming, propagation or growing of plants, flowers or fungi but which is not used for the packing, display, trade or sale of the products or parts produced. These structures are commonly described as, but are not limited to, greenhouses, glasshouses, protected cropping structures and production nurseries (not for retail or wholesale access). The following generalisations may be considered as guidelines for intensive horticultural building groupings:

Group A intensive horticultural buildings are typically buildings built with rigid covering materials, average roof heights of 5 to 9 m, and/or a total floor area exceeding 500 m^2. It is common for these buildings to have a high level of environmental control.

Group B intensive horticultural buildings are typically built with permanent or retractable non-rigid plastic or fabric covering materials, average roof height of 2 to 5 m, and/or a total floor area exceeding 500 m^2. It is common for these buildings to have a low to medium level of environmental control.

Group C intensive horticultural buildings are typically constructed with rigid, non-rigid plastic or fabric covering materials with a total floor area no greater than 500 m^2. Fabric canopy cable structures with total areas exceeding 500 m^2 may be considered in this classification. These structures are classified as Class 10d structures. It is common for these buildings to have low, medium or high environmental control.

Environmental control refers to equipment used to monitor and control a building's environment; this may include ventilation, fogging, misting, spraying and shading systems.

It is recommended that this definition be read in conjunction with the definition of 'farming' and 'farm building'.

Refer to Part H3 for specific requirements for intensive horticultural buildings.

The following building verification method has been provided below. This can be utilised to verify classifications determined in NCC Volume One in relation to Group A, B or C intensive horticultural buildings.

A1.1 BV1 Intensive Horticultural Building Classification

Classification compliance of *intensive horticultural buildings* is verified for Grouping Categories A, B and C by –

(a) Determining the building's classification-point value associated to the assessable building as per Table A1.1 (BV Matrix); then

Table 10
Table A1.1 (BV1.1 Matrix) – Classification-Point Matrix

No.	Element	Classification-Points					
		0	1	2	3	4	5
1	IHB Area	*	Band 1	*	Band 2	*	Band 3
2	IHB Average Roof Height	*	Band 1	*	Band 2	*	Band 3
3	Glazing Type For Flammability	*	Glass	CPM	*	*	PM
4	Glazing Type For Egress	No Sides	*	*	*	FPM	SPM & Glass
5	Glazing Type for Smoke	*	No Sides	FPM	*	*	SPM & Glass
6	Lighting	No Assimilated Lighting	*	*	*	*	Assimilated Lighting
7	Value of Crop & IHB	*	Low	Average	High	*	*
8	Environmental Control Systems	Low Tech	*	Medium Tech	*	High Tech	*
9	Distance from Other Buildings	*	Distance 1	*	Distance 2	*	Distance 3
10	Population	*	Band 1	*	Band 2	*	Band 3

Where –

No. 1 – Intensive Horticultural Building Area

The appropriate area band should be selected in accordance with the below table. The area of the intensive horticultural building should be taken as the footprint, in metres squared, of the new development as per Table BV1.2. The building footprint is any area covered by permeable or impermeable wall and/or roof cladding.

Important Note: If a new building development is attached, or has covered access/walkway, to an existing building, the total combined area of the new and existing buildings must be considered as the total building area.

Table 11 Table A1.1 (BV1.2) - Area Bands for Intensive Horticultural Buildings

Building Area (m2)	**Band 1**	**Band 2**	**Band 3**
Area (m^2)	< 500 m^2 *(Less than 500 m^2)*	500 m^2 to 10,000 m^2	> 10,000 m^2 *(Greater than 10,000 m^2)*

NOTE: 1 m^2 = 0.0001 hectares.

No. 2 – Intensive Horticultural Building Average Roof or Covering Height

The appropriate average roof or covering height should be selected in accordance with the below table. The average roof heights of the intensive horticultural building should be taken as the average height between the roof eave and roof apex, in metres, of the new development as per Table BV1.3.

Table 12 Table BV1.3 - Averaged Roof Height for Intensive Horticultural Buildings

Averaged Height (m)	**Band 1**	**Band 2**	**Band 3**
Averaged Height (m)	Less than 2 m	Between 2 m and 5 m	Greater than 5 m

No. 3 - Glazing/Covering Type: (Flammability)

All common intensive horticultural building materials and framing respond uniquely in the event of a fire. It is therefore important to identify which of the following three (3) typical materials shall be used. Common materials utilised are provided below. Flammability is considered as both how easily something will burn/ignite and the degree of difficulty required to cause combustion of a substrate.

Glazing types for intensive horticultural building flammability are provided below:

- Glass;
- PM (Plastic Membrane); and
- CPM (Compartmentalized Plastic Membrane).

No. 4 – Glazing/Covering Type: (Egress)

Glazing types have considerable influence over the means and ease of egress during a fire event.

The following three (3) materials may exhibit different characteristics when exposed to a fire event and therefore have specific egress characteristics:

- FPM (Non-rigid Film Plastic Membrane)
- SPM (Rigid Sheet Plastic Membrane) & Glass
- No sides

No. 5 – Glazing/Covering Type: (Smoke)

Build-up of smoke within an intensive horticultural building is a crucial concern during a fire event. In the event of a fire it is vital for occupants to escape before inhalation occurs. Glazing characteristics in relation to the production and retention of smoke are as follows:

- FPM (Non-rigid Film Plastic Membrane)
- SPM (Rigid Sheet Plastic Membrane)
- Glass
- No sides

No. 6 – Lighting

Lighting refers to assimilation lighting and does not apply to general illumination. Assimilation lighting, also known as grow lamps or supplementary lighting, has an increased risk of being the origin of a fire, and as such a higher Classification-Point Assessment shall be awarded if this type of lighting is installed.

No. 7 - Value of Crop & Intensive Horticultural Building

Determine the predicted value of the crop per year and value of the intensive horticultural building as per Table BV1.4. Growers should be consulted by the assessor to correctly determine value of both the crop and intensive horticultural building.

Table 13 Table BV1.4 - Predicted Value of Intensive Horticultural Crop per Year & Value of Intensive Horticultural Building

Value of Crop & Building	**Low**	**Average**	**High**
Predicted Value of Crop per Year	< $100,000 *(less than $100,000)*	$100,000 to $5,000,000	> $5,000,000 *(greater than $5,000,000)*
Value of intensive horticultural building	< $40,000 *(less than $40,000)*	$40,000 to $2,000,000	> $2,000,000 *(greater than $2,000,000)*

NOTE: If value of crop and value of intensive horticultural building *are not within the same 'value column' it is important to interpolate results within Classification-Point Matrix.*

No. 8 - Environmental Control Systems

Select which of the following environmental control systems are proposed to be implemented into the new intensive horticultural building as per Table BV1.5:

Table 14 Table BV1.5 - Intensive Horticultural Building Environmental Control Systems

Environmental Control Systems	**Low Control**	**Medium Control**	**High Control**
Control	No mechanical or electrical environmental control.	Mechanical ventilation and fan motors for air movement.	Boilers, fan motors, mechanical vents, electronic environmental control systems, etc.

No. 9 - Distance from other Buildings

Determining the distance between a proposed intensive horticultural building and existing buildings is vital to determine the risk of fire spreading. The distances shown in Table BV1.6 and BV1.7 are based on surrounding combustible buildings with a height no greater than 6 metres. For buildings with a height over 6 metres reference should be made to the second table. The below figures should be taken as minimum distances, and it should be understood that the further away from other buildings an intensive horticultural building is the better.

Table 15 Table BV1.6 - Distance from Other Buildings, Equal to or Less than 6m High

Distance from other buildings (surrounding buildings height < 5 m high)	**Distance 1**	**Distance 2**	**Distance 3**
Distance (m)	> 10 m *(greater than 10 m)*	10 m to 3 m	< 3 m *(less than 3 m)*

Table 16 Table BV1.7 - Distance from Other Buildings, Greater than 6m High

Distance from other buildings (surrounding buildings height > 5 m high)	**Distance 1**	**Distance 2**	**Distance 3**
Distance (m)	> 18 m *(greater than 18 m)*	18 m to 6 m	< 6 m *(less than 6 m)*

NOTE: Term 'height' shall be defined in text.

No. 10 – Population

Determine the maximum number of persons within the intensive horticultural building at any one time as per Table BV1.8.

Table 17 Table BV1.8 - Number of Persons in the Intensive Horticultural Building

Number of Persons	**Band 1**	**Band 2**	**Band 3**
Persons	1 to 5 with an occupancy ratio of no greater than 1 person to 100 m^2	Occupancy ratio of no greater than 1 person to 400 m^2	Occupancy ratio of no greater than 1 person to 600 m^2

(b) Determine the total Classification-Point Value, tally elements defined in BV1 (a) together and identify their appropriate grouping using Table BV1.9.

Table 18 Table BV1.9 - Intensive Horticultural Building Grouping Classification and Associated Classification-Point Ranges

	GROUP A	**GROUP B**	**GROUP C**
Total Classification-Point	31 to 47	21 to 30	20 or less
Explanation	These structures have the highest risk and associated consequences.	These structures have medium risk and associated consequences.	These structures have the lowest combined risk and associated consequences and may be considered as Class 10d buildings

NOTE: If the resulting Total Classification-Point exceeds the prescribed as per the above table a special solution must be obtained by a suitably qualified Engineer.

Example verification methods have been provided below.

Group A Classification Example

A proposed intensive horticultural building with a total floor area of 25,000 m^2, rigid plastic cladding, high climate control and an average roof height of 6 m is to be assessed. Reference to Part A1.1 farm buildings definition suggests a grouping of Group A, to verify this the assessor completes the verification method prescribed as BV. The following classification-points were found for each assessable element, of which there are ten.

For No. 1 – Intensive Horticultural Building Area, Band 3 was selected from Table BV1.2 as the building shall have a total floor area greater than 10,000 m^2. This provides a **Classification-Point of 5** as per BV1.1.

For No. 2 – Intensive Horticultural Building Average Roof of Covered Height, Band 3 was selected from Table BV3.3 as the building shall have an average roof height of 6m. This provides a **Classification-Point of 5** as per BV1.1.

For No. 3 – Glazing/Covering Type: (Flammability), plastic membrane (PM) was selected as the building shall have plastic membrane cladding. This provides a **Classification-Point of 5** as per BV1.1.

For No. 4 – Glazing/Covering Type: (Egress), rigid sheet plastic membrane (SPM) was selected as the building shall have rigid plastic cladding. This provides a **Classification-Point of 5** as per BV1.1.

For No. 5 – Glazing/Covering Type: (Smoke), rigid sheet plastic membrane (SPM) was selected as the building shall have rigid plastic cladding. This provides a **Classification-Point of 5** as per BV1.1.

For No. 6 – Lighting, through discussion with the development applicant no assimilation lighting is proposed. This provides a **Classification-Point of 0** as per BV1.1.

For No. 7 – Value of Crop & Intensive Horticultural Building, through discussion with the development applicant it was determined that the value of the crop per year to be $3,000,000 and the value of the building to be $2,500,000. Using Table BV1.4 it is determined that the crop value is 'Average' and the building value as 'High'. This provides a **Classification-Point of 2.5** as per BV1.1. Note: interpolation between 'Average' and 'High' has occurred.

For No. 8 – Environmental Control System, through discussion with the development applicant a high level of environmental control is proposed as per Table BV1.5. This provides a **Classification-Point of 4** as per BV1.1.

For No. 9 – Distance from other Buildings, through discussion with the development applicant 6 m is proposed between the new development and existing buildings as providing 'Distance 2' per Table BV1.6. This provides a **Classification-Point of 3** as per BV1.1.

For No. 10 – Population, through discussion with the development applicant they propose to have maximum occupation of 41 persons in the building at any one time with a ratio of 1 person to 609 m^2. As per Table BV1.8 'Band 3' shall be selected. This provides a **Classification-Point of 5** as per BV1.1.

All verification elements have now been obtained. Tallying, through addition it is found that **the total classification-point is 39.5**. Referring to Table BV1.9 it is found that 39.5 results in a Group A classified structure, verifying the classification of Part A1.1.

Group B Classification Example

A proposed intensive horticultural building with a total floor area of 15,000 m^2, non-rigid plastic cladding, low climate control, and an average roof height of 5 m is to be assessed. Reference to Part A1.1 farm buildings definition suggests a grouping of Group B, to verify this the assessor completes the verification method prescribed as BV. The following classification-points were found for each assessable element, of which there are ten.

For No. 1 – Intensive Horticultural Building Area, Band 3 was selected from Table BV1.2 as the building shall have a total floor area greater than 10,000 m^2. This provides a **Classification-Point of 5** as per BV1.1.

For No. 2 – Intensive Horticultural Building Average Roof of Covered Height, Band 2 was selected from Table BV1.3 as the building shall have an average roof height of 5m. This provides a **Classification-Point of 3** as per BV1.1.

For No. 3 – Glazing/Covering Type: (Flammability), plastic membrane (PM) was selected as the building shall have plastic membrane cladding. This provides a **Classification-Point of 5** as per BV1.1.

For No. 4 – Glazing/Covering Type: (Egress), non-rigid film plastic membrane (FMP) was selected as the building shall have non-rigid plastic cladding. This provides a **Classification-Point of 4** as per BV1.1.

For No. 5 – Glazing/Covering Type: (Smoke), non-rigid film plastic membrane (FMP) was selected as the building shall have non-rigid plastic cladding. This provides a **Classification-Point of 2** as per BV1.1.

For No. 6 – Lighting, through discussion with the development applicant no assimilation lighting is proposed. This provides a **Classification-Point of 0** as per BV1.1.

For No. 7 – Value of Crop & Intensive Horticultural Building, through discussion with the development applicant it was determined that the value of the crop per year to be $500,000 and the value of the building to be $900,000. Using Table BV1.4 it is determined that the crop value is 'Average' and the building value as 'Average'. This provides a **Classification-Point of 2** as per BV1.1.

For No. 8 – Environmental Control System, through discussion with the development applicant a medium level of environmental control is proposed as per Table BV1.5. This provides a **Classification-Point of 2** as per BV1.1.

For No. 9 – Distance from other Buildings, through discussion with the development applicant 6 m is proposed between the new development and existing buildings as providing 'Distance 2' per Table BV1.6. This provides a **Classification-Point of 3** as per BV1.1.

For No. 10 – Population, through discussion with the development applicant they propose to have maximum occupation of 20 persons in the building at any one time with an occupancy ratio of 1 person to 750 m^2. As per Table BV1.8 'Band 2' shall be selected. This provides a **Classification-Point of 3** as per BV1.1.

All verification elements have now been obtained. Tallying, through addition it is found that **the total classification-point is 29**. Referring to Table BV1.9 it is found that 27 results in a Group B classified structure, verifying the classification of Part A1.1.

Group C Classification Example

A proposed intensive horticultural building with a total floor area of 400 m^2, non-rigid plastic cladding, low climate control, and an average roof height of 2.5 m is to be assessed. Reference to Part A1.1 farm buildings definition suggests a grouping of Group C, to verify this the assessor completes the verification method prescribed as BV. The following classification-points were found for each assessable element, of which there are ten.

For No. 1 – Intensive Horticultural Building Area, Band 1 was selected from Table BV1.2 as the building shall have a total floor area less than 500 m^2. This provides a **Classification-Point of 1** as per BV1.1.

For No. 2 – Intensive Horticultural Building Average Roof of Covered Height, Band 2 was selected from Table BV1.3 as the building shall have an average roof height of 2.5m. This provides a **Classification-Point of 3** as per BV1.1.

For No. 3 – Glazing/Covering Type: (Flammability), plastic membrane (PM) was selected as the building shall have plastic membrane cladding. This provides a **Classification-Point of 5** as per BV1.1.

For No. 4 – Glazing/Covering Type: (Egress), non-rigid film plastic membrane (FMP) was selected as the building shall have non-rigid plastic cladding. This provides a **Classification-Point of 4** as per BV1.1.

For No. 5 – Glazing/Covering Type: (Smoke), non-rigid film plastic membrane (FMP) was selected as the building shall have non-rigid plastic cladding. This provides a **Classification-Point of 2** as per BV1.1.

For No. 6 – Lighting, through discussion with the development applicant no assimilation lighting is proposed. This provides a **Classification-Point of 0** as per BV1.1.

For No. 7 – Value of Crop & Intensive Horticultural Building, through discussion with the development applicant it was determined that the value of the crop per year to be $16,000 and the value of the building to be $35,000. Using Table BV1.4 it is determined that the crop value is 'Low' and the building value as 'Low'. This provides a **Classification-Point of 1** as per BV1.1.

For No. 8 – Environmental Control System, through discussion with the development applicant a low level of environmental control is proposed as per Table BV1.5. This provides a **Classification-Point of 0** as per BV1.1.

For No. 9 – Distance from other Buildings, through discussion with the development applicant 6 m is proposed between the new development and existing buildings as providing 'Distance 2' per Table BV1.6. This provides a **Classification-Point of 3** as per BV1.1.

For No. 10 – Population, through discussion with the development applicant they propose to have maximum occupation of 2 persons in the building at any one time with an occupancy ratio of 1 person to 200 m^2. As per Table BV1.8 'Band 1' shall be selected. This provides a **Classification-Point of 1** as per BV1.1.

All verification elements have now been obtained. Tallying, through addition it is found that **the total classification-point is 20**. Referring to Table BV1.9 it is found that 20 results in a Group C classified structure, verifying the classification of Part A1.1. As Group C has been selected it is appropriate to use NCC Volume Two and class the structure as 10d.

Proposal for Change Element Eleven End

6.3 Justification of the Proposal for Change

A summary of justification applied to each of the change initiatives documented in Section 6.2 of this report has been provided below. For a detailed outline of justification refer to Sections 6.3.1 to 6.3.3 and referenced appendix documents.

ChNo1 Wall Height Justification – Through grower consultation, discussions with manufacturers, and completed survey data it was determined that wall heights of intensive horticultural buildings can be categorised into three (3) groups, these being less than 2 metres, 2 to 5 metres and 5 to 9 metres. Technical research and analysis undertaken by FERM Engineering and Osborn Consulting Engineers has determined a direct correlation between wall heights and risk consequences in relation to fire and egress; this is discussed further in Section 6.3.2 Technical Justification. Briefly, fire models provided by FERM Engineering identify a reduction of risk to occupants, and therefore the associated consequences, as the building height increases due to the inherent nature of a IHB fire and its environment.

ChNo1 Total Floor Area Justification – Through grower consultation, discussion with manufacturers, and completed survey data it was determined that IHBs typically far exceeded 2,000 m^2. Several survey participants recorded total floor areas that exceeded 20,000 m^2 (2 hectares) per IHB structure. Total floor areas were banded and attributed to Group A, B and C structures. To comply with NCC Volume One Part 2, a 2 hectare IHB would require hydrant and sprinkler systems if classified as a Class 8 building. Social and economic justification shows that these onerous NCC Provisions apply economic pressures to growers without appropriate evidence to support the necessity of hydrant and sprinkler systems in an IHB. The Project Team was unable to identify cases whereby an IHB fire was prevented by the installation of hydrants and/or sprinklers or the like as risks of fire within such buildings are relatively low. Refer to cost benefit analysis provided in Section 6.3.1 and FERM Engineering report in this document's appendix.

ChNo1 Fabric and Netting Structure Justification – Through consultation with a leading Australian netting and canopy structure contractor, and fire engineering technical experience, it was determined that netted canopy structures in the horticultural industry shall be classified as Group C intensive horticultural buildings. This is due to their typically low fire risk, rural locality, material compositions and size. Through literary review it was found that common plastic material used in knitted mesh netting is high-density polyethylene (**HDPE**). Flammability testing completed by AWTA Product Testing for a canopy structure manufacturer has found knitted fabric netting to have a low flammability index of 1 Refer to Appendix G for test results. Testing was completed in accordance with AS 1530.2-1993. Observation of the tests includes smoking, melting and flaming debris of specimens with a spread factor of 0 length and 0 width.

ChNo2 Definition of Intensive Horticultural Building Justification – Through consultation with industry it has been determined that a lack of definition within the NCC has contributed to an impairment of the IHB being classified in a cost-effective manner, reasons for this are discussed throughout this document. The term 'horticulture' was used rather than 'agriculture' as horticulture relates directly to the cultivation of plants or part thereof while agriculture can be attributed to breeding of animals, fibre or biofuels. Due to the funding parameters of this project the term 'horticulture' has been used as it provides a higher level of applicability to Hort Innovations' vegetable levy paying members.

ChNo3 NCC Volume One Part H3.1 Justification – Justification is not deemed necessary for this part.

ChNo3 NCC Volume One Part H3.2 Justification – No additions or revisions were made to this part.

ChNo3 NCC Volume One Part H3.3 Justification – Group A and Group B buildings were included separately within H3.3 Provisions for escape. Through technical fire models, provided by FERM Engineering, the Project Team determined appropriate travel distances during an emergency event. Though Group A buildings are the largest in the prescribed IHB classification framework fire models determined that these structures performed safer in a fire event, as such increased travel distances were given. Technical justification has further been provided through Section 6.3.2 of this document and the FERM Engineering report in the appendix of this document.

ChNo3 NCC Volume One Part H3.4 Justification – Alternative exits have been included for intensive horticultural buildings. Single-use or sacrificial exits are deemed alternative exits as per Part H3.4. A single-use or sacrificial exit is an exit which is used in an emergency. The means of alternative exit depend on construction materials used. For example, a non-rigid plastic film structure may allow for a cutting implement to be used to create a single-use exit; in which case a cutting implement shall be provided at every single-use exit location. In a rigid structure 'kick-out' panels may be installed at each single-use exit location. These panels shall be constructed to allow a person to kick out the panel with appropriate force (less 250 N) in an emergency while ensuring structural stability during normal operations as per Part B. Egress kick-out panels and their supports require design from a suitably qualified and registered engineer. During industry consultation, it was found that many IHB growers already enact such exits to meet alternative solutions provided by Professional Fire Engineers.

ChNo3 NCC Volume One Part H3.5 Justification – Intensive horticultural buildings were included in this Part, justification is not deemed necessary.

ChNo3 NCC Volume One Part H3.6 Justification – Intensive horticultural buildings were included in this Part, justification is not deemed necessary.

ChNo3 NCC Volume One Part H3.7 Justification – Intensive horticultural buildings were included in this Part, justification is not deemed necessary.

ChNo3 NCC Volume One Part H3.8 Justification – Dedicated fire suppression 'E1.5 Sprinklers' and 'E1.8 Fire control centres' were deemed not necessary through technical models and industry consultation; rather it is proposed that where installed, sprinkler/fogging/misting systems and mechanically operated vents be included in the integrated firefighting service. Technical justification has further been provided through Section 6.3.2 of this document and the FERM Engineering report in the appendix of this document.

ChNo3 NCC Volume One Part H3.9 Justification – A new Part H3.9 (a) was developed for IHBs where less-onerous provisions are imposed relating to water supply for firefighting purposes. Hydrant systems are deemed not necessary for intensive horticultural buildings. Technical justification has further been provided through Section 6.3.2 of this document and the FERM Engineering report in the appendix of this document.

ChNo3 NCC Volume One Part H3.10 Justification – Intensive horticultural buildings were included in this Part, justification is not deemed necessary.

ChNo3 NCC Volume One Part H3.11 Justification – Intensive horticultural buildings were included in this Part and adjustments were made to portable fire extinguisher Provisions. Adjustments were made to better suit the operation of IHBs.

ChNo3 NCC Volume One Part H3.12 Justification – Intensive horticultural buildings were included in this Part, justification is not deemed necessary.

ChNo3 NCC Volume One Part H3.13 Justification – Group B and Group C intensive horticultural buildings were included in this Part, justification is not deemed necessary.

ChNo3 NCC Volume One Part H3.14 Justification – Intensive horticultural buildings were included in this Part, justification is not deemed necessary.

ChNo3 NCC Volume One Part H3.15 Justification – Intensive horticultural buildings were included in this Part, justification is not deemed necessary.

ChNo3 NCC Volume One Part H3.16 Justification – Intensive horticultural buildings were included in this Part, justification is not deemed necessary.

ChNo3 NCC Volume One Part H3.17 Justification – Intensive horticultural buildings were included in this Part, justification is not deemed necessary.

ChNo3 NCC Volume One Part H3.18 Justification – Intensive horticultural buildings were included in this Part, justification is not deemed necessary.

ChNo3 NCC Volume One Part H3.19 Justification – Through technical models it was determined that the Deemed-To-Satisfy Provisions of C2.2 and C2.3 do not apply to IHBs when provided with vehicle access complying with C2.4(b) and being not greater than 1 storey. C2.2 and C2.3 refer to general floor area and volume limitations and provides associated Provisions. Technical justification finds insufficient proof to associate a IHB's total floor area to a potential risk to human life. Technical justification has further been provided through Section 6.3.2 of this document and the FERM Engineering report in the appendix of this document.

ChNo4 NCC Volume Two Part 1.1.7 Justification – Group C intensive horticultural buildings were included in this Part as Class 10d structures, justification is not deemed necessary.

ChNo5 NCC Volume Two Part 1.1.1 Justification – Group C intensive horticultural buildings were included in this Part as Class 10d structures, justification is not deemed necessary. Through consultation with industry it has been determined that a lack of definition within the NCC has impaired an IHB to be classified in a cost-effective manner, reasons for this are discussed throughout this document. Refer also to justification for ChNo2.

ChNo6 NCC Volume Two Part 1.3.2 Justification – Group C intensive horticultural buildings were included in this Part as Class 10d structures. The Class 10d for use as defined for Horticulture shall be limited in the classification verification as defined under BV3 of NCC Volume One for this use. Where a structure exceeds the Group C limits and is determined as another Class, 10d shall not be used. Being less than 500 m^2 technical analysis deemed these structures to be within the Class 10 classification framework. Technical justification has further been provided through Section 6.3.2 of this document and the FERM Engineering report in the appendix of this document.

ChNo7 NCC Volume Two Part 1.3.3 Justification – Group C intensive horticultural buildings were included in this Part as Class 10d structures, justification is not deemed necessary.

ChNo8 NCC Volume Two Part 2.3.1 Justification – Group C intensive horticultural buildings were included in this Part as Class 10d structures, justification is not deemed necessary.

ChNo9 NCC Volume Two Part 2.3 Justification – Group C intensive horticultural buildings were included in this Part as Class 10d structures, justification is not deemed necessary.

ChNo10 NCC Guide Interpretation Justification – Includes IHB's in the existing interpretation of 'farm buildings' within the NCC Guide and associated criteria. Justification is not deemed necessary.

ChNo11 No. 1 Intensive Horticultural Building Area Justification – Through grower consultation, discussions with manufacturers, and completed survey data it was determined that areas of Intensive Horticultural Buildings can be categorised into three (3) groups, these being less than 500 m^2, 500 to 10,000 m^2 and more than 10,000 m^2. Technical research and analysis has determined a direct correlation between total areas and risk in relation to fire and egress; this is discussed further in Section 6.3.2 Technical Justification and report by FERM Engineering within this document's appendix.

ChNo11 No. 2 Intensive Horticultural Building Average Roof or Covering Height Justification – Similarly to the justification documented above for ChNo11 No. 1 this Proposal relied on consultation with growers, manufacturers and industry members. Findings identified three (3) groups in relation to the average roof height of IHBs, these were: less than 2 m, between 2 m and 5 m and greater than 5 m. These heights were used for fire modelling and proved useful when determining risk of fire to Groups A, B and C structures; this is discussed further in Section 6.3.2 Technical Justification and report by FERM Engineering within this document's appendix.

ChNo11 No.3 Glazing/Covering Type: (Flammability) Justification – Literary review and industry consultation determined the three (3) main, typically used, glazing covering groups for Provision assessment against flammability. Flammability relates to the ability for a material to burn or ignite, causing fire or combustion. Technical justification has been used to determine weighting against the classification-point matrix in Table A1.1 BV Matrix. Compartmentalised plastic membrane refers to HDPE which has fire retardant within its composition.

ChNo11 No. 4 Glazing/Covering Type: (Egress) Justification – Literary review and industry consultation determined the three (3) main, typically used, glazing covering groups for Provision assessment against egress. Egress is the means in which an occupant exits a building; the type of glazing used determines the ease of egress. For example, a non-rigid film plastic membrane can be cut to escape a building during an emergency event while glass glazing proves more difficult to escape due to its strength and rigidity. Technical justification has been used to determine weighting against the classification-point matrix in Table A1.1 BV Matrix. Technical justification has further been provided through Section 6.3.2 of this document and the FERM Engineering report in the appendix of this document.

ChNo11 No. 5 Glazing/Covering Type: (Smoke) Justification – Literary review and industry consultation determined the three (3) main, typically used, glazing covering groups for Provision assessment against smoke. Smoke is a product of a material in combustion. Technical justification has been used to determine weighting against the classification-point matrix in Table A1.1 BV Matrix. Technical justification has further been provided through Section 6.3.2 of this document and the FERM Engineering report in the appendix of this document.

ChNo11 No. 6 Lighting Justification – Industry consultation determined that IHBs either have lighting or they don't. Literary review determined assimilation lighting as being a potential source of fire in IHBs.

ChNo11 No. 7 Value of Crop & Intensive Horticultural Building Justification – It was determined through industry consultation, particularly fire and insurance services that there is typically a direct correlation between the Grouping of a IHB and the value of its structure and protected crop. For example, a Group A structure is expected to have a higher building cost value and crop value per year, providing association to a Group style classification model.

ChNo11 No. 8 Environmental Control System Justification – Similarly to ChNo11 No. 6 justification industry consultation determined that IHBs either have low control, medium control or high control. Literary review determined environmental control systems as being a potential source of fire in IHBs.

ChNo11 No. 9 Distance from other Buildings Justification – Through technical review and professional opinion of FERM Engineering the distances prescribed in Tables BV1.6 and BV1.7 were determined appropriate for IHBs. Technical justification has further been provided through Section 6.3.2 of this document and the FERM Engineering report in the appendix of this document.

ChNo11 No. 10 Population Justification – Utilising survey data from industry consultation and technical fire models it was appropriate to develop three (3) bands of occupancy, these being 1 to 5 with an occupancy ratio of no greater than 1 person to 100 m^2, 6 to 25 with an occupancy ratio of no greater than 1 person to 400 m^2 and 26 to 50 with an occupancy ratio of no greater than 1 person to 600 m^2. Occupancy ratios were included within Table BV3.8 to ensure the risk of overcrowding to IHBs was reduced. Larger buildings, such as the Group A structures, have a much lower occupancy ratio than Group C as their size and total floor area demands a less occupied structure in the event of a building fire or emergency which requires escape. Technical justification has further been provided through Section 6.3.2 of this document and the FERM Engineering report in the appendix of this document.

ChNo11 Table BV1.9 Justification – The classification-point ranges prescribed in Table BV1.9 were determined through mathematical and empirical testing means. Three (3) groups were identified with an associated classification-point range. An IHB which falls within any of the defined ranges may be assessed accordingly as per the group classification identified.

6.3.1 Social and Economic Justification

Social and economic justification for the aforementioned Proposals for Change provides strong support for the initiatives proposed. The Australian Government defines Australian Society as:

"Australia is one of the most ethnically diverse societies in the world today. Almost one in four Australian residents were born outside of Australia and many more are first or second generation Australians, the children and grandchildren of recently arrived migrants and refugees. This wide variety of backgrounds, together with the culture of Indigenous Australians who have lived on the Australian continent for more than 50,000 years, have helped create a uniquely Australian identity and spirit."[41] (Australian Government, 2017)

Australian farmers and the fresh, quality produce they deliver to domestic and international markets have assisted in developing our unique identity. Through the decades Australian Farmers have adapted to new technologies and environments to maintain and increase production demands while making concerted efforts in ensuring food security for a growing world population. Though efforts are made by the Australian Grower to secure food production by initiating innovative systems such as Intensive Horticultural Buildings it is Australia's collective imperative to develop and maintain a strong and versatile food production portfolio. The Prime Minister's Science, Engineering and Innovation Council released a report on 'Australia and Food Security in a Changing World' in 2010 whereby the findings suggested that:

> *For Australia, food security is inextricably linked to the political stability of our region and has the potential to affect our national security. Food security also affects our status as a premier food exporting nation and the health and wellbeing of our population. The likelihood of a food crisis directly affecting the Australian population may appear remote given that we have enjoyed cheap, safe and high quality food for many decades and we produce enough food today to feed 60 million people. However, if our population grows to 35-40 million and climate change constrains food production, we can expect to see years where we will import more food than we export. We are now facing a complex array of intersecting challenges which threaten the stability of our food production, consumption and trade. It is imperative that we continue to develop food-related science and technology to fuel a future food revolution that must exceed the achievements of the Green Revolution. Australia is uniquely positioned to help build a resilient food value chain and support programs aimed at addressing existing and emerging food security challenges, such as*[42] (PMSEIC, 2010)*:*
>
> - *Vulnerability to climate change and climate variability.*
> - *Slowing productivity growth in primary industries observed over the last decade.*
> - *Increasing land degradation and soil fertility decline coupled with loss of productive land in peri-urban regions due to urban encroachment.*
> - *Increasing reliance on imports of food and food production inputs (such as fertilisers) and the susceptibility of these supplies to pressures outside our control.*

[41] Australian Government, 2017. *Our people.* [Online]
Available at: http://www.australia.gov.au/about-australia/our-country/our-people
[Accessed 3 April 2017].

[42] PMSEIC, 2010. *Australia and Food Security in a Changing World,* s.l.: Australian Government.

- *A finely tuned and 'just in time' food transport and distribution system that presents risks of rapid spread of contaminated food and is vulnerable to events such as pandemics.*
- *Poor nutritional intake leading to an increasing burden of diet-related diseases in the population.*
- *Conflict in our region and elsewhere.*

The main messages of the report included, a national approach to food, investing in R&D to reverse declining agricultural productivity growth, building human capacity to meet the challenges and opportunities faced and raising the importance and awareness of food in the public consciousness. Food production and processing is a fundamental part of Australia's economy and the health and wellbeing of its citizens. Food, however, is not currently dealt with in a way which brings together food related policy, regulatory agencies and research organisations.

As food security continues to emerge as a challenge globally and domestically, there will be increasing demand for:

- Efficiency in food production, processing and distribution and responsibility in purchasing and consumption to reduce wastage and minimise costs.
- R&D and the delivery of innovations to underpin productivity growth in the food sector, to meet human health needs and bring improvements in food processing.
- Flexibility and responsiveness in regulation to ensure rapid delivery of innovations to the food value chain.

Different policy, regulatory and program areas related to food should be brought together to ensure that government takes a consistent approach to food and food security. A national approach would bring a high level of coordination, build a strategy for a resilient food value chain and emphasise the link between food and population health. This initiative funded by Hort Innovations and the Australian Government along with the practical solutions outlined in the National Construction Code's Proposal for Change encapsulates the tools for Regulators to assist growers in securing the nation's food supply through the economic incentives afforded by the free market and the social benefit at an individual, local community and national level.

Intensive Horticultural Buildings provide both social and economic benefit, these are discussed below.

The social and economic incentive of Intensive Horticultural Buildings on the environment are of noteworthy significance. For example, a closed system IHB can deliver near zero waste water all year round. Controlled environment allows better use of integrated pest management (IPM), benefiting the growers economic standing, marketing potential and the end-consumers' health[43] (Opdam, et al., 2005).

Table 19, below, documents estimated efficiency production gains obtained by greenhouse vegetables compared to field production. As can be seen, incomparable production gains are achieved in all assessed vegetables.

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[43] Opdam, J., Schoonderbeck, G. & Heller, E., 2005. Closed Greenhouse: a Starting Point for Sustainable Entrepreneurship in Horticulture. *Acta Horticulture,* Volume 691, pp. 517-524.

Table 19 Greenhouse vs Field Production Efficiency Gains[44] (Smith, 2007)

Crop	Tomatoes	Capsicum	Cucumber	Lettuce
Greenhouse (kg/m^2)	76	30	100	80
Field (kg/m^2)	18	12	20	10
Efficiency Gains (%)	422	250	500	800

Australia is the driest inhabited continent in the world; 70% of it is either arid or semi-arid land. The arid zone is defined as areas which receive an average rainfall of 250mm or less[45] (Australian Government Department of the Environment and Energy, 2017). The semi-arid zone is defined as areas which receive an average rainfall between 250-350mm (Australian Government Department of the Environment and Energy, 2017). Constructing, operating and maintaining intensive horticultural buildings on marginal (arid) land is generally not an issue, meaning land generally ill-suited for horticulture becomes available and suitable for use if a stable water, gas and electricity supply is achieved. With an increasing global demand for fresh, safe produce Australia has sufficient available land for increased horticultural output through the means of intensive production.

The below graphs, Figure 15 and Figure 16, show the estimated number of hectares that are required to feed one person. The graphs identify agricultural land area production concerns with a growing world population. To meet the expected population growth the agricultural and horticultural industry must develop means to increase production density in available land areas, intensive horticultural buildings are one such solution. Increases in estimated production density can be found in Table 19 of this report.

[44] Smith, G., 2007. Field Vs Glasshouse Tomatoes. *Practical Hydroponics and Greenhouses,* May/June - 2007(94).

[45] Australian Government Department of the Environment and Energy, 2017. *Outback Australia - the rangelands.* [Online]
Available at: http://www.environment.gov.au/land/rangelands
[Accessed 5 March 2017].

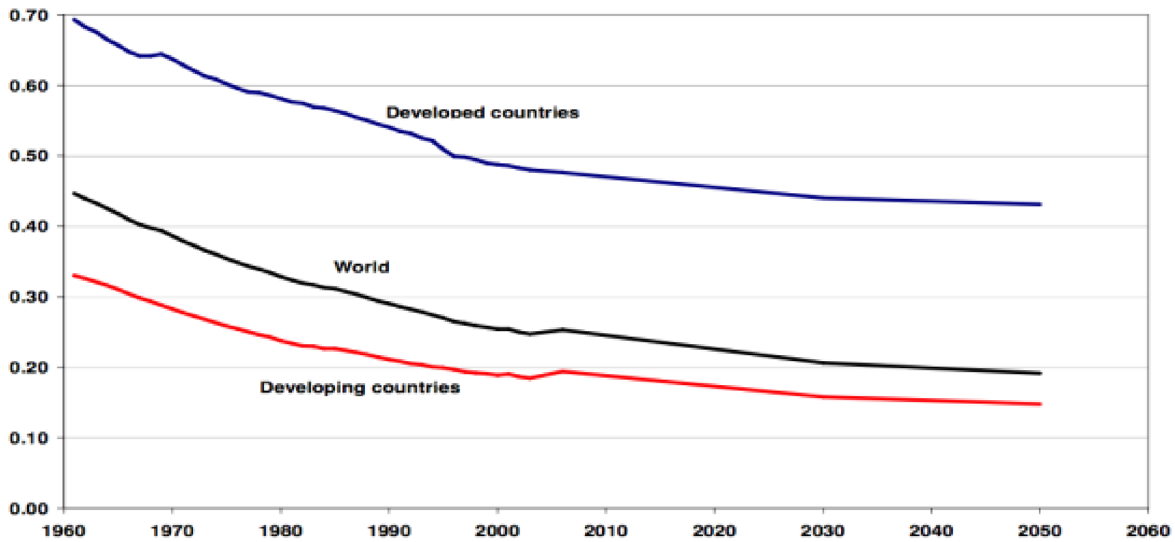

Figure 15 Arable land per capita (ha in use per person) (1961-2050) -[46] (Bruinsma, 2009)

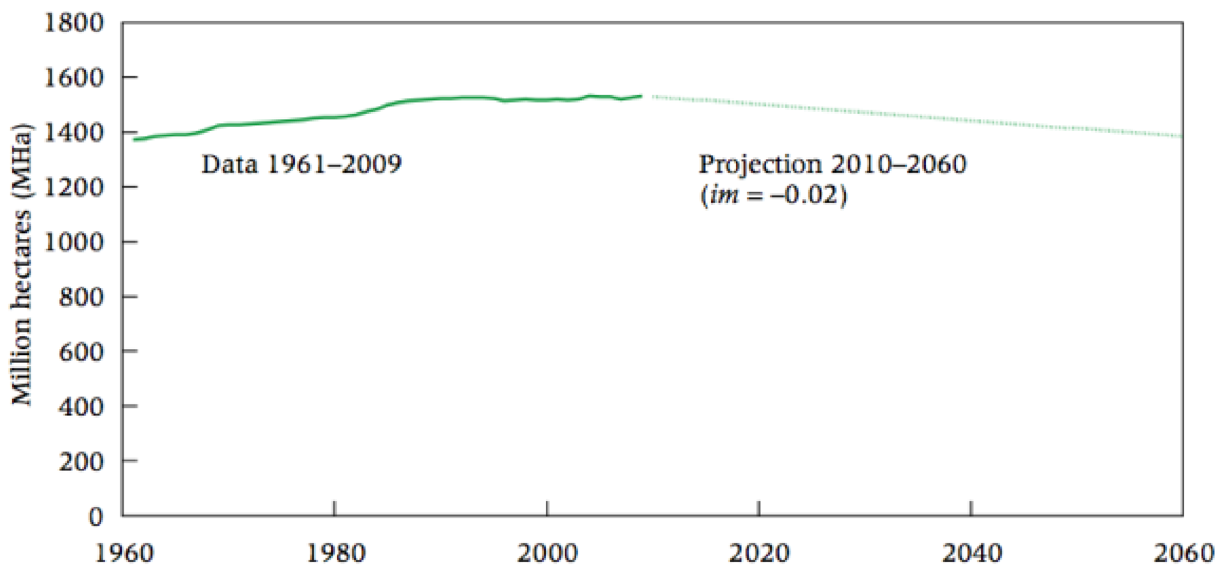

Figure 16 Peaking farmland: extent of global arable land and permanent crops, 1961-2009, and our (Our World in Data) projection for 2010-2060 -[47] (Ausubel, et al., February 2013)

Drought has long been an issue for rural and cosmopolitan Australians alike. The agricultural and horticultural industries rely on large stable water supplies to produce crops and animals and their products

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[46] Bruinsma, J., 2009. *The resource outlook to 2050: by how much do land, water and crop yields need to increase by 2050?.* [Online]
[Accessed Jan 2017].

[47] Ausubel, J., Wernick, I. & Waggoner, P., February 2013. Peak Farmland and the Prospect for Land Sparing.. *Population and Development Review,* 38(s1), pp. 221-242.

for consumption. Referring to Table 20 below estimates the quantity of water used for specific agricultural and horticultural outputs. Though water usage of hydroponic crops varies it can be stated with certainty that a hydroponic intensive horticultural building significantly reduces the water required to produce outputs in comparison to its field alternative.

Table 20 Water Usages per Agricultural Sector[48] (Smith, 2007)

Agricultural Sector	Litres of Water per $100 of Output
Rice	470,000
Cotton	160,00
Dairy – Milk	147,000
Sugar	123,900
Beef Cattle	81,200
Vegetables & Fruit	37,900
Wheat and Grains	24,500
Hydroponic Crops	As low as 600

Previous international research has identified protected cropping, especially high climate controlled intensive horticultural buildings, with higher °Brix (sugar) levels which delivers sweeter, more flavoursome fruits and vegetables with longer shelf life. Environmental conditions that most strongly influence crop quality and °Brix include sunlight, temperature, and moisture. Exposure to various combinations of these conditions due to planting and harvest schedules can influence elements of quality (including °Brix) and flavour in field and greenhouse-grown crops. These conditions influence the amount of soluble solids (mostly sugars) that are in marketable leaves, stems, fruits, tubers, roots, etc., at any one time. These factors influence °Brix levels alone and in combination. For example, temperature and light interact to set the rate of sugar production, but temperature may have a stronger influence on tomato fruit soluble solids content than sunlight[49] (Kleinhenz & Bumgarner, 2013). Controlled-environment greenhouse production involves a greater amount of control over factors that influence crop growth, yield, and certain aspects of quality than field production. Overall, the greenhouse industry continues to pay close attention to the effects of variety selection and crop management on °Brix. Also, adjustments in management regimes to optimize °Brix and other characteristics are generally more feasible in greenhouse than field settings. Farmers working with soils in more dynamic and unpredictable open field and high tunnel settings have an opportunity to gain from what is discovered in greenhouse production and research. More important, field and high tunnel vegetable growers can learn from their own tests of the relationships between management and °Brix and other aspects of crop quality. It is of social and economic benefit for fruit and vegetables to have high, consistent levels of °Brix; higher quality, more flavoursome produce will encourage increased consumption of fruit and vegetables for a healthier Australia.

Intensive Horticultural Buildings allow for year-round supply of consistent quality and quantity of produce to meet consumer demands through the means of environmentally sound and responsible growing systems. Though suited to rural areas, Intensive Horticultural Buildings can be constructed and operated

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[48] Smith, G., 2007. Field Vs Glasshouse Tomatoes. *Practical Hydroponics and Greenhouses,* May/June - 2007(94).

[49] Kleinhenz, M. & Bumgarner, N., 2013. Brix Values in Vegetable Crops. *Ohioline*, 18 January.

close to urban environments, keeping food miles low. Food miles are a way of attempting to measure how far food has travelled before it reaches the consumer[50] (FoodMiles, 2017). Reducing produce's food miles results in a fresher more environmentally conscious food life cycle.

Intensive Horticultural Buildings commonly provide higher, more stable, economic returns for a grower's efforts compared to traditional annual vegetable production (field). Growers with access to these higher and more stable returns not only benefit themselves but also the local and national communities as a whole. This is the result of a reduction of the grower's perceived risk in the cost of further development, allowing for increased capital and operational expenditure assisting the growth of local economies and national economies as well as assisting to meet food produce demand of rapidly expanding local, national and global populations.

The below Case Study, Table 21, provides further comparative data between field and greenhouse vegetable production, in this case tomatoes.

Table 21 Tomato Growing Case Study[51] (Smith, 2007)

	Field	Greenhouse	% Increase
Size	1 ha	1 ha	0%
Plant Density (average/m²)	1.1	2.2	100%
Total Plants	11,000	22,000	100%
Annual Production (kg)	69,231	585,000	845%
% 1st Grade	80 + %	95 + %	12%
Effective Production (1st grade kg)	58,846	555,750	944%
Effective Production (kg per m²)	5.9	55.6	944%
Effective Production (kg per plant)	5.3	25.3	472%
Water Use	8 M/L	14.5 M/L	182%
Conversion Rate (grams of fruit per litre water)	7.4	38.2	519%
Production per M/L (tonnes)	8.7	40.2	465%
Market Returns (gross)	$82,385 ($1.40/kg)	$1,667,250 (3/kg)	2,024%
Crop Length (months)	± 7	11.5	164%
Equivalent Field Production (ha)	1	9.4	944%

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50 FoodMiles, 2017. *Food Miles Calculator.* [Online]
Available at: http://www.foodmiles.com/
[Accessed 28 March 2017].

51 Smith, G., 2007. Field Vs Glasshouse Tomatoes. *Practical Hydroponics and Greenhouses,* May/June - 2007(94).

When reviewing the production figures, it appears on the surface that greenhouse production uses more water than field production, however it's worth noting greenhouse production occurs over 11.5 months compared to ± 7 months for field production. It should also be stated that the greenhouse water usage figures include all water used, not just that used for watering crops (i.e. fogging, roof sprinklers, hand washing, staff facilities, etc.). It is important to note the conversion rate of water used for tomato production per one litre of water in a greenhouse facility can produce 38.2 grams of fruit compared to only 7.4 grams in the field, this justifies the larger water usage figures within a typical greenhouse. Additional water usage justification comes in the form of production of fruit per megalitre (M/L) of water, a greenhouse can produce 40.2 tonnes per M/L while the field only produces 8.7 tonnes.

Additional social and economic justification for the increased usage of intensive horticultural buildings includes:

- Safe Foods – controlled production systems are able to more reliably offer products that meet both food security guidelines and the ever-increasing demands of discerning consumers.
- High Quality – Greenhouse produce are reliably 95 % first grade compared to field product of between 50 and 80%. High quality also delivers alternative packaging and presentation options with enhanced shelf-life and marketing potential.
- Reliable Supply – 12 month supply is available as climate variations are largely removed in protected cropping and this is highly prized by retailers and wholesale customers.

A cost-benefit analysis has been completed on the subject of 'hydrant and sprinklers vs fires' in Australian IHBs. Cost benefit analysis (**CBA**), sometimes called benefit cost analysis (**BCA**), is a systematic approach to estimating the strengths and weaknesses of alternatives (for example in transactions, activities, functional business requirements or project investments); it is used to determine options that provide the best approach to achieve benefits while preserving savings. The CBA is also defined as a systematic process for calculating and comparing benefits and costs of a decision, policy (with particular regard to government policy) or (in general) project.

Broadly, a CBA has two main purposes:

1. To determine if an investment/decision is sound (justification/feasibility) – verifying whether its benefits outweigh the costs, and by how much; and
2. To provide a basis for comparing projects – which involves comparing the total expected cost of each option against its total expected benefits.

CBA is related to (but distinct from) cost-effectiveness analysis. In CBA, benefits and costs are expressed in monetary terms, and are adjusted for the time value of money, so that all flows of benefits and flows of project costs over time (which tend to occur at different points in time) are expressed on a common basis in terms of their net present value.

The following cost-benefit analysis has been completed using data provided by a protected cropping grower with IHB buildings within the Group A and Group B classification. Evidence other than that shown in the below analysis has not been provided to protect the growers identify. The identity of the grower shall not be disclosed by this Document or the Project Team.

General information and figures provided by an anonymous grower (in today's money):

- Cost of IHB = $13,200,000 AUD
- Size of IHB = 8 ha
- Group Classification of IHB = Group A
- Revenue from the IHB per year = $10,000,000 AUD
- Design and installation cost of fire system (hydrants and sprinklers) = $325,000 AUD
- Maintenance of fire system over 50-year building design life = $750,000 AUD ($15,000 per year)

Analysis Part One: Approximate costs associated with the installation of hydrants and dedicated fire suppression sprinklers for the grower's newest 8 ha Group A IHB are as follows:

- Design and installation of the hydrant and suppression sprinklers = $325,000 AUD
- Maintenance of fire system over 50-year building design life = $750,000 AUD ($15,000 per year)

Therefore, the total estimated cost of the fire system for the structure's 50-year design life is approximately $1,075,000 in today's money. If a fire was to develop in the structure it is predicted, through fire models, that the structure would lose approximately 20% of a year's produce due to smoke and heat damage, the cost of this is estimated to be $2,000,000 of lost revenue for a year – it is predicted that the fire system would prevent a majority of structural failures however $1,200,000 in maintenance and localised repair/replacement would be expected. The general cost to benefit(loss) ratio is 3.0 for an installed fire system and estimated loss in the event of a fire.

Analysis Part Two: An analysis was then undertaken in the event that the Provisions documented within the Proposal for Change were applied to the 8 ha Group A structure. Estimated costs have been provided below:

- Cost of the storage tanks and other specified equipment = $140,000 AUD
- Maintenance of the equipment over 50-year building design life = $100,000 AUD ($2,000 per year)

Therefore, the estimated cost of the equipment (as specified in the PCF) for a structure's 50-year design life is approximately $240,000 in today's money. If a fire was to develop in the structure it is predicted, through fire models, that the structure would lose approximately 70% of a year's produce due to smoke and heat damage, the cost of this is estimated to be $8,400,000 of lost revenue for a year – it is predicted that the fire system would prevent total structural failure however $8,250,000 in maintenance and repair would be expected. The general cost to benefit(loss) ratio is 87.6 for an installed fire system and estimated loss in the event of a fire.

Comparing the two ratios it is found that the second case, where provision of the PFC is imposed, has a lower cost benefit in the event of a fire. However, through consultation which included grower surveys and insurance industry discussions, it was found that the likelihood of a moderate fire (refer to FERM report for associated kW) is unlikely. The Project Team was unable to identify enough cases of a fire in an Australian IHB to determine an accurate annual probability of occurrence. To develop the analysis a deemed conservative annual probability of occurrence of a fire in a Group A IHB was taken as 1 moderate fire every 50 years of operations, 1.00 times within the building's working life of 50 years.

Assuming that financial cost savings in fire related Provisions, estimated at $835,000 (Part One $1,075,000 – Part Two $240,000) were invested in a larger facility the facility would be approximately 0.5 ha larger (8.5 ha). Assuming the additional 0.5 ha has a similar production to the remaining 8 ha it is expected that the facility will make an additional $625,000 in revenue per year due to the additional building area of 0.5 ha. Forwarding this revenue over the building's 50-year design life an additional $31,250,000 would be expected in today's money. Now, assessing the potential additional revenue against the increased potential losses in the event of a 1:40 year fire it is found that the cost-benefit analysis greatly favours the outcome and Provisions within the Proposal for Change.

Note One: The annual probability of occurrence provided above can not be justified and is taken as a conservative estimate due to a lack of data around IHB fires in Australia. The Project Team does not standby nor guarantee this figure as it is subject to data currently unavailable.

Note Two: Though the economic losses have been shown as greater when the Proposal for Change is imposed it is important to note that the risk to occupants through egress times have been analysed and found to be suitable. For further information, refer to report by FERM Engineering in Appendix B.

6.3.2 Technical Justification

The recommendations made within the Proposal for Change have been developed around technical analytical models, international literary review and relevant engineering theory. Growing vegetables within an IHB is an extension and the next evolutionary stage of field farming, which are often located in areas void of a prompt fire fighting response. It is common knowledge that the longer a fire is left unattended, the more difficult it is to contain. Fires commonly start at a discreet point within a building and can quickly spread through combustible materials. Due to farm expansion and development, it is common for IHB facilities to be open and inter-connected. Although there have been relatively few documented serious greenhouse fires, each occurrence has taken place where there was high potential fire risk. This high fire risk leads to a high fire consequence, consequences including loss of life and serious property damage. The various high risks that may be present are the increased size of the installation due to add-on growth, high value of the protected crop, the use of highly combustible modern plastics and the use of automation including production, lighting and environmental controls.

To determine actual fire risks, the Project Team has developed fire models of each of the IHB group classifications (Group A, Group B, Group C) using the program CFAST, version 7.2.1. This program was developed by the National Institute of Standards and Technology and is used to simulate the impact of fires in building environments. CFAST is a two-zone model, which means that it simulates the environment in terms of a hot upper smoke layer and a cooler non-smoke lower layer and produces outputs accordingly. Refer to Technical Report titled 'Fire Safety Review' by Ferm Engineering which can be found within the appendix of the VG16004 Summary of Process document.

The following excerpt has been taken from the aforementioned Ferm Engineering report. It is advised that the Fire Safety Review report be read in its entirety and the content below as an executive summary of findings.

> ***7.0 RESULTS DISCUSSION***
>
> *The results shown identify a number of critical points arguing that these greenhouses are inherently safe for use. These are:*
>
> - *Evacuation*
> - *Room temperature*
> - *Smoke inhalation*

There is a smoke phenomenon called ceiling jet flow. In the event of a fire, hot plume gases rise to the ceiling. These hot gases fill empty space in a small layer underneath the ceiling. In a small compartment, this only exists briefly at the start before the compartment fills with smoke and this layer thickens to the floor. This can explain the smoke layer height figure shown above. The smaller structures are more irregular due to a smaller area for the ceiling jets to reach.

Similarities can be seen between the group B greenhouses and the group A greenhouses. Fire heat and buoyancy pressure in the fire compartment causes smoke to jet outwards resulting in extending very hot thin smoke layer radiating from the fire. Roof shape dictates how far this goes.

Separation distance

From the models, if these buildings are on fire then the impact of heat radiation on the adjoining area is shown to be low, radiant heat less than other forms of Type C construction, with the low fire loads. The separation distances studied were 3m, 6m, 10m and 18m. Justification for the selection of the distances is as follows:

- *Separation distance of 3m is selected because the BCA already specifies a minimum distance of 3m from a fire source feature, so the impact of a minimum 3m setback from a boundary is acceptable.*
- *Separation distance of 6m is selected since it's the BCA clause C3.2 specified distance between buildings on the same allotment to minimise the risk of fire spread for access by fire vehicles.*

These will be recommended in the H3 revision.

Group A

The introduction of natural ventilation in Group A drastically decreases the effects of the fire in the greenhouse. This can be seen throughout the graphs as the closed situation is significantly hotter than its counterpart natural ventilation scenario. It should be noted that the smoke layer exhibits strange characteristics, which is due to the ratio of opening area to surface area of the greenhouse. The openings cause a pressure drop, allowing smoke to escape after the initial stages. This causes the apparent drop and flat profile shown. Each revision demonstrates that in no case does the smoke layer reach below the 7m mark. This provides adequate time and space for evacuation before structural failure.

Appendix A shows the remaining graphs and visual output from the CFAST simulation.

Group B

The smoke layer height and upper layer temperature graphs show the effect of the melting of PMMA in the smallest three structures. For the smallest structure (500m^2), as the fire grows, the smoke layer begins to thicken simply because the whole room is beginning to heat up. This can be seen from the similarities between upper and lower layer temperatures. However, once the fire peaks, ceiling jets begin to appear and push smoke to the edges (outer compartments not shown in graphs) and pressurize the centre compartment where the fire is located. This cause the smoke layer of the centre compartment to drastically reduce and become very hot very rapidly.

Once the opening is introduced for the PMMA melting, smoke is released. Temperature and pressure decreases causing ceiling jets to disappear and a thickened uniform hot upper layer across all compartments to replace the dangerous hot smoke layer. These effects can be seen in all revisions, however, the added area for each structure results in a less pronounced effect of this phenomenon.

The introduction of the PMMA melting allows the fire to explode due to a breath of fresh oxygen. This vent however, provides constant relief to the rest of the structure by decreasing the layer of hot smoke and localizes damage to directly above the fire.

Each revision has an increasingly longer evacuation distance and at some point, will need 2 fire exits. The large areas modelled are very safe as the smoke layer is only dangerous for the 500m2 revision. Worst case scenario is that an evacuee will have to travel 30m in 200 seconds, or travel at 0.15m/s. Since the smoke layer does not reach below 2m, this travel can be easily attained in a fire situation.

Appendix B shows remaining graphs and Group B sensitivity analysis which includes 4m tall structures and double the fire load to 12MW. The 12MW increases the temperature of the smoke layer from 240°C to approximately 300°C, a relatively small change for the change in fire load. The same can be seen from a 4m structure, a smoke layer of 250°C is recorded, however, this increases to 350°C with a 12MW fire.

Group C

The impact of the polycarbonate bursting is very evident in this figure and almost becomes a precautionary measure. Once a ceiling vent is introduced, smoke starts to billow out of it, reducing the hot smoke layer and allowing a safe environment for someone to crawl. The polycarbonate bursting turns out to have a pronounced effect on smoke inhalation and temperatures at crawling levels. The introduction of the polycarbonate bursting allows the fire to explode due to a breath of fresh oxygen.

This vent however, provides constant relief to the rest of the structure by decreasing the layer of hot smoke and localizes damage to directly above the fire.

Each revision has an increasingly longer evacuation distance and at some point, will need 2 fire exits. All figures show that at worst case, a person will have to travel approximately 15m in 210 seconds from when the fire starts to spread. This model assumes the worst case and the fire starts burning at time zero, it excludes any detection and suppression.

Appendix C shows Group C sensitivity analysis which includes 3m and 5m tall structures. An increase in height shows little changes to the temperature of the structure, but a decrease in the height results in a 50°C increase of internal temperatures.

Travel Distance Safety Review

*All the travel distance ASET time analyses for the different structures revealed how much time is actually available in these structures. The way the fail with roof venting by the materials and volumes of released smoke, means the smoke spread is low. Areas are **not** filled with smoke rapidly.*

It is taken as 60m as per concession in QDC Part 3.7. On this basis, a safety factor applied to the travel time is (T3+SF2), which is 120 seconds (i.e.60sec + 60sec) respectively. In comparison to this, safety factors are not applied in standard Deemed to satisfy design.

ASET Determination

Based on the IFEG, tenability for occupant life safety is assessed on the following conditions not endangering human life:

- *Temperature*
- *Level of visibility For the purpose of this project, the limits of acceptability will be as follows:*

- *Occupant Tenability Criteria 1 - Smoke Layer ≥ 2.0m*

- *Hot Layer exposure less than 80-100C*
- *Fire Engineering Design Guide [i] suggests that the acceptance radiant heat from the upper smoke layer at the head height (2.1m above the floor level) should not exceed 2.5kW/m^2 which corresponds to the average upper smoke temperature of 200°C).*

Therefore, the adopted acceptance criteria are:

- *When smoke layer height drops to ≥ 2.0m, radiant heat at head height (2.1m AFFL) shall be ≤ 2.5kW/m^2 (or ≤ 200°C)*

In all the cases listed above, these conditions prevailed to safely accommodation evacuation distances well above the 40m in the DtS and up 80m is of no additional risk to occupants.

Materials used within an IHB are usually chosen for their useful structural properties and features. It is, however, common for these materials to have unwanted or unexpected risks especially in the area of fire and egress.

Though able to transmit light, plastic glazing materials are not as energy efficient as other building materials that can be insulated. Modern plastic glazing and woven fabrics have been engineered to transmit light, resist wind, hail and chemical attack while at the same time improving energy efficiency[52] (Kinney, et al., 2012). Electronic automation of a typical IHB is also increasing, computer controlled open vents, lamps and fans are all environment control systems commonly installed in an Australian Greenhouse. These advancements assist in increased crop yield, stability and quality. It is, therefore, reasonable to assume that modern plastics and automation offer appropriate compromise between efficiency and risk.

An increase of electronic automation in an IHB encourages an additional risk of fire, being electrical components. A faulty electronic component can short circuit and emit sparks. Sparks can ignite combustible materials, such as plastic membrane. Growers, certifiers and designers recognise these undesirable risks, however accept the compromise because the value of these properties exceeds the

[52] Kinney, L., Hutson, J., Stiles, M. & Clute, G., 2012. Energy-Efficient Greenhouse Breakthrough. *ACEEE,* Summer Study on Energy Efficiency in Buildings(13), pp. 176-188.

alternative of designing and certifying an IHB that is truly fireproof and useless for growing plants. It is, therefore, important to determine the appropriate balance between risk management and benefits.

In addition to the structural aspects and contents of a greenhouse, its environment is unique to all other buildings. A typical greenhouse environment includes high levels of temperature, moisture, ventilation and sometimes UV light to achieve the highest yield and crop quality. Technical models completed by Ferm Engineering also identified that: "The addition of natural ventilation creates a safer environment for evacuees at walking and in the smallest enclosures, at a crawling level, drastically reducing the hot smoke layer and reducing temperatures in the lower layer. It allows relief for the rest of the structure, localizing damage until the fire brigade arrives. The light weight fabrication is able to show thermal performance due to the sheer open sizes of these structures. Structurally week roof or covering systems with polymer based products aids in the fire development, by burning away and allowing the heat to escape rapidly." Chemicals used on plants within an IHB can aggressively attack structural elements and membrane. All equipment, especially mechanical and electrical, is subject to wear and degradation.

Fortunately, steps can be taken in farm planning and management that assist in minimising fire risks, and provide procedures that result in a cleaner, safer and more efficient IHB operation. Many correlations exist between good fire risk management and good IHB farm operation management. It is not reasonable to assume the risk of an IHB fire will reach zero; however, risk and associated consequences can be managed to a level that will minimise threats to human life and loss of property.

6.3.3 Industry and Grower Justification

Statistics, figures and industry information discussed below have been sourced from Protected Cropping Australia and industry journal article by Graeme Smith. References have been provided at the of each at the end of each text block.

The protected cropping industry is one of the fastest growing food producing sectors in Australia. It is estimated that the farm-gate value of produce is $1.3 billion Australian Dollars per annum which is equivalent to approximately 20% of the total value of vegetable and flower production. If all sectors, including retail, service providers, research, manufacture and growers the protected cropping industry contributes approximately $1.8 billion to the national economy. The protected cropping industry currently employs over 10,000 people throughout Australia[53] (PCA, 2017).

The protected cropping industry is expanding at 4% to 6% per annum.

Current investment in greenhouse vegetable infrastructure is conservatively valued at $975 million which is estimated to be 1,300 hectares at $75 per m^2. Annual investment in new infrastructure is valued at $50 million over the next 12 months which is estimated to be 25 hectares at $200 per m^2.

Woolworths have doubled consumption of greenhouse capsicums every year since 2005[54] (Smith, 2007).

[53] PCA, 2017. *Our Industry.* [Online]
Available at: http://www.protectedcroppingaustralia.com/?page_id=94
[Accessed 22 March 2017].

[54] Smith, G., 2007. Field Vs Glasshouse Tomatoes. *Practical Hydroponics and Greenhouses,* May/June - 2007(94).

Through formal communications (grower survey) and informal communications (site visits, meetings and phone conversations) growers have identified a definitive classification method as the most important issue to encourage sector growth. 64.29% of growers responded that 'understanding the preparation, lodgement, assessment and approval process with local council (and private certifiers)' as the single most important improvement the Australian crop protection industry could make.

Industry estimates a return on investment of older technology greenhouses at 3 to 5 % while newer technology greenhouses have a higher return due to increased production and quality of produce.

7.0 Next Step, Recommendations and Conclusion

7.1 Next Step

Section 7.1 of this document provides recommendations made by the Project Team in regard to the 'next step' of this project after the relevant documents have been submitted to Horticulture Innovation Australia on June 12, 2017 as per the 'Final Report' milestone specified in the project's executed contract. The next step recommendations made may be considered by Hort Innovations. If in agreement with the recommendations made in Table 22, Hort Innovation shall confirm, in writing, to Marcel Olivotto of Osborn Consulting Engineers Pty. Ltd. within 1 calendar month from submission of the Final Report. Table 22 shows recommendations from the date of submission of the Final Report to Hort Innovations to the proposed date of submission to the Australian Building Codes Board.

Table 22 Next Step Dates (June 2017 to Sept 2017)

No.	Description	Participant	Completion Date
1	Submission of Final Report to meet the project's executed contract	Osborn Consulting to Hort Innovations	June 12, 2017
2	Hort Innovations to advise Project Team of next step recommendations in Table 22 are agreed.	Hort Innovations to Osborn Consulting	July 12, 2017
3	Hort Innovations to review the supplied documents submitted by the Project Team and provide feedback and changes before ABCB submission date.	Hort Innovations to Osborn Consulting	July 28, 2017
4*	Osborn Consulting to continue to obtain Building Surveyor and Fire Authority consultation on the Proposal. Recommendations made shall be assessed and implemented where deemed appropriate.	Osborn Consulting	August 25, 2017
5	Osborn Consulting to collate all Proposal documents and submit to the ABCB in accordance with its submission procedure	Osborn Consulting	August 30, 2017

*** Note:** Due to the nature of consultation with large multi-faceted organisations/authorities such as the Australian Institute of Building Surveyors and state or federal fire authorities it is expected that the Project Team will continue to receive feedback regarding the Proposal after the Hort Innovations submission date of June 12, 2017. Feedback received by the above-mentioned organisations will be assessed by the Project Team for validity; if found to be valid the Project Team will then consult with Hort Innovations, PCA and selected engaged stakeholders regarding the inclusion of said feedback and then revise the Proposal to include feedback before the ABCB submission date.

Refer to Table 3 of this report for important dates once the Proposal has been submitted to the ABCB. Though not included within the Project's executed contract Hort Innovations may engage Osborn Consulting's services after the Proposal's submission to the ABCB on August 30, 2017 to undertake the following tasks as possible variations:

- Respond to requests for information from the ABCB during the assessment period;
- Run or partake in ABCB meetings and discussions surrounding the Proposal;

- Grower and industry support extension in relation to the toolbox for a proposed three-year period; and/or
- Make changes to the Proposal during the ABCB assessment period where required.

Hort Innovations may formally request, through writing, that Osborn Consulting (and it's subconsultants, where required) complete any of the tasks listed above. Osborn Consulting will then provide Hort Innovations with a quoted fee for each requested task and a detailed program on how each would be proposed.

Hort Innovations may also consider implementing a lobbying strategy to further increase the Proposal's chances of a successful ABCB assessment. The lobbying strategy may focus on persuading key political stakeholders, ABCB and Members of Parliament on the benefits the Proposal will bring to Australian Society through the reduced burden experienced by protected cropping growers. This would not be completed by Osborn Consulting Engineers.

7.2 Consolidation of Notices

Below provides consolidation of all notices provided by the Project Team throughout this document.

Notice Regarding Submission to ABCB – Though the Project Team has undertaken thorough review, analysis and consultation with relevant industries there are associated risks in submission and adoption of the Proposal for Change within the National Construction Code. The Australian Building Code Board has the prerogative to reject in part or whole of a Proposal that is submitted for inclusion. As outlined in this Project's Milestone Reports, there is an underlying risk that the ABCB may not accept the suggested Proposals due to the relative newness of the NCC Volume One Part H3 and the classification verification methods proposed. Throughout the project, it has been the Project Team's objective to meet the expectations of Hort Innovations, vegetable levy growers and relevant industry consultation requests. The Project Team has strived for genuinely acceptable outcomes which are considered to meet the ABCB PFC guidelines and industry needs to effectively reduce burden on protected cropping growers and the industry they support. Due to the nature of the ABCB amendment cycle the Project Team makes no guarantee on the adoption of the Proposal documented.

Notice Regarding Animal Building Inclusion – Though combining intensive horticultural and animal buildings into one classification called 'low-occupancy intensive agricultural buildings' may have a higher success of obtaining acceptance through the ABCB assessment framework the provisional changes recommended in the Proposal would be significantly diluted, creating a low, potentially unsuitable return on investment for Hort Innovations and its levy paying members.

Notice Regarding Continued Consultation – Due to the nature of consultation with large multi-faceted organisations/authorities such as the Australian Institute of Building Surveyors and state or federal fire authorities it is expected that the Project Team will continue to receive feedback regarding the Proposal after the Hort Innovations submission date of June 12, 2017. Feedback received by the above-mentioned organisations will be assessed by the Project Team for validity; if found to be valid the Project Team will then consult with Hort Innovations, PCA and selected engaged stakeholders regarding the inclusion of said feedback and then revise the Proposal to include feedback before the ABCB submission date.

Notice Regarding Hort Innovation Review – The Project Team proposes that Hort Innovation shall review this document and its associated appendices and provide Osborn Consulting with feedback in accordance with the proposed timeframe provided in Table 22. Osborn Consulting and its subconsultants will then consider the feedback and make adjustments to relevant Project documents where required before the ABCB submission date.

7.3 Recommendations and Conclusion

It was the objective of Part 1 of the VG16004 'Greenhouse Technical Guidelines and Best Practice Extension Toolbox' to develop technical guidelines in relation to previous project VG13055 for inclusion in the National Construction Code. Utilising the findings of the VG13055 Code of Practice, and consultation with relevant experts, the Project Team have attempted to ensure that the regulatory principles defined by the National Construction Code's 'Guidelines for Preparation of a Proposal for Change' were met and compliant.

Once the preliminary guidelines were developed, relevant stakeholders (Osborn, FERM, Doyle's and RMCG) undertook investigatory review and analysis and met with industry stakeholders to determine the validity of the Proposal for Change. From there it was Osborn Consulting's objective, together with its team of construction lawyers, manufacturers, engineers and certifiers to develop full technical guidelines which are compliant with the regulatory principals (defined above), ideal grower requirements, and G/GS stakeholder pressures. Upon the completion of the full technical guidelines Osborn Consulting distributed the guidelines for industry member review (including growers, manufacturers, and expert authorities) through the use of the Hort Innovations, AUSVEG and Protected Cropping Australia networks. The final objective of this Project was to develop and submit the 'NCC Change Proposal' to ABCB which is proposed in August 2017 as per Table 3.

Upon review of the Project's executed contract, Osborn Consulting considers that all agreed deliverable outputs have been met by this document and its associated appendices and reference sources. Should Hort Innovations have any comments or recommendations in regards to the provision of deliverables correspondence with Osborn Consulting is strongly encouraged.

The project Team recommends that Hort Innovation reviews this document along with its appendices and provides feedback to Osborn Consulting as per the proposed timelines provided in Section 7.1 of this document.

It has been the Project Team's objective throughout this project to meet the expectations of Hort Innovations, vegetable levy growers and relevant industry. Though the content in this document and the current Proposal for Change may not meet the expectations of all stakeholders, the Project Team has continually strived for genuinely acceptable outcomes which we consider meet the ABCB Proposal for Change guidelines and industry needs to effectively reduce burden.

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9.0 Acknowledgements

We would like to take this opportunity to thank and acknowledge Horticulture Innovations Australia for the opportunity to lead this important project, as well as the Australian Federal Government for their crucial funding.

This project would not have been possible without Protected Cropping Australia and the growers, farmers and industry professionals whose input was crucial to the research component of this valuable resource. We would like to thank the Australian Institute of Building Surveyors and the Lockyer Valley Council for their input and all other relevant parties who took the time to take part in our surveys.

Finally, we wish to recognise our sub-consultants, Ferm Engineering Pty Ltd, RM Consulting Group and Doyles Construction Lawyers, without whose hard work and expertise this project would not have been a success.

Appendix A: ABCB Proposal for Change to NCC 2019

PROPOSAL FOR CHANGE
NATIONAL CONSTRUCTION CODE SERIES

SUBJECT	**Intensive Horticultural Building Inclusion Farm Buildings**
BCA Volume One:	**Vol. One A1.1 (Revised/Addition)** **Vol. One BV3 (Addition)** **Vol. One H3 (Revised)**
BCA Volume Two:	**Vol. Two 1.1.7 (Revised)** **Vol. Two 1.1.1 (Addition)** **Vol. Two 1.3.2 (Revised/Addition)** **Vol. Two 1.3.3 (Revised)** **Vol. Two 2.3.1 (Revised)** **Vol. Two 2.3 (Explanatory Information)**
Guide to Volume One:	**Guide Definitions (Revised/Addition)**
PCA Volume Three:	**N/A**

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Revision: Issue A – 12th June 2017

NOTE
Refer to VG16004 'Summary of Process' Document for supporting information, literary review, justification and detailed consultation.

Acronyms, Terms and Definitions Used

ABCB	Australian Building Codes Board
AS	Australian Standards
ASTM	American Society of Testing and Materials
BA	Building Approval
BCA	Building Code of Australia
CPM	Compartmentalised Plastic Membrane
DA	Development Application
FPM	Film Plastic Membrane
FRP	Fibre Reinforced Plastic
G/GS	Greenhouse and Grow Structures

HIA	Horticultural Innovation Australia
IBC	International Building Code
ICC	International Code Council
IHB	Intensive Horticultural Building
IFC	International Fire Code
IPM	Integrated Pest Management
NCC	National Construction Code
PCA	Protected Cropping Australia
PFC	Proposal for Change
PM	Plastic Membrane
SOP	Summary of Process
SPM	Sheet Plastic Membrane

Table of Figures

For the purposes of this Document, the following terms and definitions apply.

Area:
<any part of a roof> area normal to the slope

Area:
<storey of a building> total area bounded by the inner finished surfaces of the enclosed wall or, on any side where there is no enclosing wall, by the outermost edge of the floor on the side.

Boundary:
Border edge of a lease or lot boundary.

Building:
A permanent structure that has a roof and support systems and is used for housing of people or work processes or goods or possessions.

Certifier:
Private and Local Government certifiers shall henceforth be referred to as certifier/s.

Element of structure:
Any loadbearing element of a structure.

Fire hazard:
Physical situation that could catch fire or cause a fire and thereby be harmful to persons, or damage to property, or both.

Fire risk:
Probability that a fire will occur as a result of the existence of a fire hazard.

Fire consequence:
The effect, result, or outcome of a fire. Consequence relates to damage to or loss of life and/or property.

Greenhouse (see grow structure):
Greenhouse refers to intensive horticultural structures growing or propagation of plants, flowers and vegetables and excludes retail and wholesale nurseries and conservatories.

Grow structure (see greenhouse):
Grow structure refers to intensive horticultural structures growing or propagation of plants, flowers and vegetables and excludes retail and wholesale nurseries and conservatories.

Grower:
Greenhouse or grow structure owners, greenhouse or grow structure developers and farm operators shall henceforth be referred to as grower/s.

Height:
<of a building, for the propose of fire considerations> vertical height from ground level to half the height of the roof in a pitched building, or to the top of the roof or parapet (whichever is the higher) in a flat roof building.

Intensive Horticultural Building:
A farm building or part thereof, used for environmentally controlled farming, propagation or growing of plants or fungi but is not used for the packing, display, trade or sale of the products or parts produced.

Occupant:
Is a person, family, group that lives in, regularly occupies, works in or has quarters or has an activity that takes space inside the Building. It does not include animals, livestock or items of property.

Protected area:
Part of the external wall constructed to achieve the required period of fire resistance.

The Proposal

1. What is the proposal?

Below is the Proposal for Change to include intensive horticultural buildings (**IHB**) within the 2019 version of the National Construction Code (**NCC**). These Proposals are produced to achieve the all-inclusive objective to develop a Proposal for Change that is accepted by the Australian Building Codes Board (**ABCB**) and achieves significant net benefit to protected cropping growers throughout the application, design and approval stages of new IHB development.

The following NCC changes are for the inclusion of Intensive Horticultural Building classification definitions within the existing Farm Buildings definition.

There are 11 (eleven) integrated proposals for NCC changes in Volumes One, Volume Two and Guide, which are presented within this document. To help understand the definition background the Project Team has listed the following series of definitions and photographic examples of each of the IHB Groups, these have been provided below.

Classification Definitions

Intensive Horticultural Building Group A – These farm buildings are of a higher-risk nature (in regard to construction, investment costs and operation), typically a building with rigid covering materials and a total area exceeding 500 m^2. This Group typically achieves the highest level of environmental control and automation to offer potential for higher quality and quantity of produce. With detailed automation programming these structures require lower ratios of occupancy in comparison to Group B and C buildings. These structures are usually constructed with rigid walls at least 4 metres high with the roof peak being up to 10 metres. Refer to Figure 1 for an example of a typical Group A structure.

Figure 1 Typical Group A Structure (Source: Purchased Stock Image)

Intensive Horticultural Building Group B – These farm buildings are of a medium-risk nature (in regard to construction, investment costs and operation), typically a building with rigid or retractable or permanent non-rigid plastic covering materials and a total area exceeding 500 m^2. Group B IHBs are typically characterised by vertical, non-rigid walls (between 2 and 4 metres) and commonly have roof or side ventilation, or both. Group B structures are seen as a compromise between the Group C and Group A and have cost and risk relativity for increased environmental control and overall areas (compared to typical Group C technology greenhouses). Refer to Figure 2 for an example of a Group B structure.

Figure 2 Typical Group B Structures (Source: Purchased Stock Image)

Intensive Horticultural Building Group C – These farm buildings are of a low-risk nature (in regard to construction, investment costs and operation) and/or are typically constructed with non-rigid, plastic or fabric covering materials with a total area not exceeding 500 m^2. These structures shall be classified as Class 10d buildings and are regulated within the NCC Volume Two - refer to ChNo4 to ChNo9. These structures are very common in Australia. Large span, cable supported net structures covering large areas (exceeding 500 m^2) and up to 6.0 m high can also be included in this category. Construction is typically low cost and domestic in nature. The greenhouses are usually less than 3 metres in height and have a tunnel or ‘igloo’ profile shape. These structures are popular because they may be considered relatively inexpensive and further conceived as easy to erect. Refer to Figure 3 for an example of a greenhouse style Group C structures and Figure 4 for a fabric Group C structure.

Figure 3 Typical Greenhouse Group C Structure (Source: Purchased Stock Image)

Figure 4 Typical Cable Canopy Group C Structure (Source: Stock Image)

The following sections outline all 11 of the Proposals for Change for the farm buildings in the NCC Volume One, Volume Two and Guide. All 11 form an integrated set of changes in order to have a comprehensive set of amendments for the NCC Volume One and Two, to implement the new definitions for Intensive Horticultural Buildings.

Proposed additions into the NCC documents are shown in green underlined text. An example has been provided below:

This is an example of NCC addition text.

Proposed removal of text within the NCC are shown in red and have a strikethrough. An example has been provided below:

~~This is an example of NCC removal text.~~

PROPOSAL FOR CHANGE SUMMARY FOR NCC VOLUME 1 2019 EDITION

The following section outlines the Proposals for Change made to the NCC Volume One in relation to the Proposals made through ChNo1 to ChNo3.

Change Number One (ChNo1)

Brief: It is proposed that farm building definitions shall be revised to include Intensive Horticultural Buildings (**IHB**) as is provided within the Classification Definitions category on pages 4-6 of this document. This option retains the farm building definitions and incorporates the IHB definitions. An IHB shall be classified as either a Group A, B or C structure.

Change Location: NCC Vol 1 2016 > A1 Interpretation > Part A1.1 Definition > Farm building **(REVISED)**

Proposal for Change Element One Commencement

Farm building means a Class 7, ~~or~~ 8 or 10 building located on land primarily used for *farming* -

(a) that is either -

(i) used in connection with *farming*; or

(ii) used primarily to store one or more farm vehicles; or

(iii) that is an *Intensive Horticultural Building* belonging to one or a combination of the following groups -

(A) GROUP A *Intensive Horticulture Buildings – Intensive Horticultural Buildings* built with an average roof height of 5 to 9 m and a total floor area exceeding 500 m^2;

(B) GROUP B *Intensive Horticulture Buildings – Intensive Horticulture Buildings* built with an average roof height of 2 to 5 m and a total floor area exceeding 500 m^2;

(C) GROUP C *Intensive Horticulture Buildings – Intensive Horticulture Buildings* constructed with a total floor area no greater than 500 m^2 shall be classified as Class 10d; Fabric canopy cable structures with no limitation on roof height and total floor area shall be classified as Class 10d or

(iv) any combination of (i), (ii) and (iii) and

(b) in which the total number of persons accommodated at any time does not exceed –

(i) one person per 200 m^2 of floor area or part thereof, up to a maximum of 8 persons for general farm buildings;

(ii) one person per 600 m^2 of floor area or part thereof for Group A *Intensive Horticultural Buildings;*

(iii) one person per 400 m^2 of floor area or part thereof for Group B *Intensive Horticultural Buildings; and*

(iv) one person per 100 m^2 of floor area of part thereof, up to a maximum of 5 persons for Group C *Intensive Horticultural Buildings*; and

(c) with a total floor area of not more than 3500 m^2 for general farm buildings. There are no maximum floor areas prescribed for Group A and B intensive horticultural buildings.

Proposal for Change Element One End

Change Number Two (ChNo2)

Brief: This proposed change adds a definition into the NCC Volumes One and Two for intensive horticulture buildings which specifies the building's primary usage for horticultural means. An IHB is a greenhouse, grow structure, canopy or the like belonging to one or a combination of the aforementioned in NCC Volume One, Part A1.1, Farm Buildings (ChNo1).

Change Location: NCC Vol 1 2016 > A1 Interpretation > Part A1.1 Definition > Intensive horticulture building **(NEW)**

Proposal for Change Element Two Commencement

Intensive Horticultural Building means a farm building or part thereof, used for environmentally controlled farming, propagation or growing of plants, flowers or fungi but which is not used for the packing, display, trade or sale of the products or parts produced. An intensive horticultural building shall belong to one or a combination of group defined by Part A1.1 farm building.

Proposal for Change Element Two End

Change Number Three (ChNo3)

Brief: To be added to NCC Vol 1 Part H3. This allows for inclusion of the Intensive Horticultural Building into Part H3 of the NCC – here specific deemed-to-satisfy provisions for each identified classification of Intensive Horticultural Building will be documented.

Change Location: NCC Vol 1 2016 > Part H3 Farm Buildings and Farm Sheds > Part H3.1 Application of parts **(REVISED)**

Proposal for Change Element Three Commencement

H3.1 Application of Part

(a) The Deemed-to-Satisfy Provisions of this Part apply to *farm buildings*, ~~and~~ *farm sheds* and *intensive horticultural buildings*.

(b) The Deemed-to-Satisfy Provisions of this Part take precedence where there is a difference to the Deemed-to-Satisfy Provisions of Sections C, D, E and F.

(c) H3.1 to H3.5, H3.8 and H3.11 to H3.18 apply to *farm sheds*.

(d) H3.1, H3.3, H3.5 to H3.7, H3.9 to H3.12, H3.14, H3.15 and H3.18 apply to a *farm building* but excludes *intensive horticultural buildings*.

(e) H3.1, H3.3 to H3.12, H3.14 to H3.19 apply to a Group A *intensive horticultural building*.

(f) H3.1, H3.3 to H3.19 apply to a Group B *intensive horticultural building*.

H3.2 Fire resistance and separation

A farm shed need not comply with the provision of Parts C1, C2, and C3, except for C1.11 if it is separated from any other building or allotment boundary by a distance of not less than 6 m.

H3.3 Provision for escape

(a) Except for D1.2, D1.4 to D1.6, D1.9, D1.10(a), D1.13(c), D1.14 and D1.15, the Deemed-to-Satisfy Provisions of D1 do not apply to a farm shed or intensive horticultural buildings.

Where –

a. Group A intensive horticultural building shall have no point on a floor more than 60 m from an exit, or a point from which travel in different directions to 2 exits is available, in which case the maximum distance to one of those exits must not exceed 120 m. Exits that are required as alternative means of egress must be no greater than 140 m apart.

b. Group B intensive horticultural building shall have no point on a floor more than 40 m from an exit, or a point from which travel in different directions to 2 exits is available, in which case the maximum distance to one of those exits must not exceed 80 m. Exits that are required as alternative means of egress must be no greater than 100 m apart.

c. Farm shed buildings and Group C intensive horticultural buildings shall comply will H3.3 (a).

(b) An open space adjacent to a farm building, intensive horticultural building or a farm shed need not be directly connected with a public road.

H3.4 Construction of exits

Except for D2.13, D2.14, D2.16, D2.17 and D2.24, the Deemed-to-Satisfy Provisions of Part D2 do not apply to farm sheds.

Alternative exits for intensive horticultural buildings are -

(a) Single-use or sacrificial exits may be installed in intensive horticultural buildings if the building is deemed not *accessible*; these exits shall not exceed 1 to every 4 conventional exits.

Explanatory Note: A single-use or sacrificial exit is an exit which is used in an emergency. The means of alternative exit depend on construction materials used. For example, a non-rigid plastic film structure may allow for a cutting implement to be used to create a single-use exit; in which case a cutting implement shall be provided at every single-use exit location.

In a rigid structure 'kick-out' panels may be installed at each single-use exit location. These panels shall be constructed to allow a person to unlatch a holding device or kick out the panel with appropriate force (less than 250 N impact) in an emergency while ensuring structural stability during normal operations as per Part B. Egress kick-out panels and their supports require design from a suitably qualified and registered engineer.

H3.5 Fixed platforms, walkways, stairways and ladders

A fixed platform, stairway, ladder and any going and riser, landing, handrail or barrier may comply with AS 1657 in lieu of D2.13, D2.14, D2.16 and D2.17 where it serves a farm building, intensive horticultural building or a farm shed.

H3.6 Thresholds

The threshold of a doorway that services an area not required to be accessible by D3.1 in a farm building or intensive horticultural building need not comply with D2.15 where the door sill is not more than 700 mm above the finished surface of the ground, floor or the like, to which the doorway opens.

H3.7 Swing doors

A swing door in a required exit or forming part of a required exit need not swing in the direction of egress if it serves a farm building or intensive horticultural building.

H3.8 Fire fighting equipment

The Deemed-to-Satisfy Provisions of E1 do not apply to a farm shed. The Deemed-to-Satisfy Provisions of E1.5 and E1.8 do not apply to an intensive horticultural building.

A Group A and Group B intensive horticultural building over 80 m long or a floor area over 5,000 m^2 shall have an integrated firefighting service and initiation devices within 6 m of hydrant points as defined in Part H3.9 and no less than 2 per building with additional devices as necessary for zone control of the water irrigation system.

Where -

(a) The firefighting and fire initiation system shall include the integration of any mechanical ventilation, water spray, mist and/or fogging system, if they are installed within the building and utilised as part of the normal intensive horticultural building operation. In addition, any services as listed below shall be integrated to operate in a fire affected zone, with the fire initiating system. These include:

  i. Electrical Control System to operate the irrigation water pumps for the building
  ii. Water irrigation zone controls and valves to operate areas within the building
  iii. Mechanically controlled vents or louvers to open position in an activation zone
  iv. Retractable roof covers that can be opened in an activation zone

(b) One or more of the above building services are available, then the irrigation and pump systems shall be made part of the firefighting systems for activation by occupants with a local fire initiation device, located within 6 m of hydrant points and signed and labelled accordingly. Zoning will be designed to match the normal irrigation or spray zones normally utilised by the building's operator. Zoning provisions include:

  i. Initiation devices shall be zoned to match those operational zones with no less than one device per zone. Devices include, break glass, mushroom control buttons, lever pull handled devices or suitable single action switch
  ii. Where the affected activation zone is the floor area in which the integrated firefighting system was activated, floor areas shall be distributed equally between hydrant points.

H3.9 Fire hydrants and water supply

(a) An intensive horticultural building–

  i. With a total floor area greater than 5,000 m^2; and
  ii. Located where a rural fire brigade is available to attend a building fire,

  Must be –

  i. Provided with Connection points no more than 90m apart

ii. Provided with local fire water storage tanks suitable for access within 18m of the building with '1 hour' reserve and suction points for local fire services vehicle; or

iii. Provided with other water supply suitable for access near the building with drought based reserve and suction points for local fire services vehicle; and

iv. Located on the same allotment as an access point to water supply which –

    A. Has a minimum total capacity of 72 000 litres; and
    B. Is situated so as to enable emergency services vehicles access to within 4 m; and
    C. Is located within 60 m of the building
    D. Can be part of the irrigation network to the building
    E. Have signage and valve locations clearly marked, visible from 100m away
    F. Have a hydrant outlet connection from the irrigation system to cover the known worst hazard part within the building that may include the Main Power Supply, generator unit, combustible or flammable goods storage bays, or the like, identified with the rural fire service locally as a fire hazard.

(b) A farm building –

i. With a total floor area greater than 1000 m^2; and

ii. Located where a fire brigade is available to attend a building fire,

Must be –

iii. Provided with a fire hydrant system installed in accordance with AS 2419.1, except reference to '4 hours' water supply in clause 4.2 is replaced with '2 hours'; or

iv. Located on the same allotment as an access point to water supply which –

    A. Has a minimum total capacity of 144 00 litres; and
    B. Is situated so as to enable emergency services vehicles access to within 4 m ; and
    C. Is located within 60 m of the building and not more than 90 m from any part of the building.

(c) For purposes of (a)(iv) or (b)(iv), water supply for a farm building or intensive horticultural building must consist of one or any number of the following

i. A water storage tank.
ii. A dam.
iii. A reservoir.
iv. A river.
v. A lake.
vi. A bore.
vii. A sea.

(d) If the whole or part of the water supply referred to in (a)(iv) or (b)(iv), is contained in a water storage tank, it must be –

i. Located not ~~less~~ more than ~~10~~ 60 m from the building; and

ii. Fitted with at least one small bore suction connection and one large bore suction connection where –

A. Each suction connection is located in a position so as to enable emergency service vehicles access to within 4 m; and

B. The suction connections are located not less than ~~10~~ 30 m from the building or the hazard part; and

C. ‘small bore suction connection’ and ‘large bore suction connection’ have the meanings contained in AS 2419.1.

H3.10 Fire hose reels

A fire hose reel system need not be provided to serve a farm building or intensive horticultural building where portable fire extinguishers are installed in accordance with H3.11.

H3.11 Portable fire extinguishers

(a) A farm building or intensive horticultural building not provided with a fire hose reel system in accordance with E1.4 must be provided with –

i. One portable fire extinguisher rated at not less than 5ABE in each room or area containing a generator, flammable materials or electrical equipment ~~containing flammable materials or electrical equipment~~; and

ii. One portable fire extinguisher as per (b) ~~rated at not less than 4A60BE~~ adjacent to every required exit door; and

iii. Location signs complying with clauses 3.3 to 3.9 of AS 2444 above each required portable fire extinguisher.

~~(b) A farm shed must be provided with not less than one portable fire extinguisher for every 500 m^2 of floor area or part thereof, distributed as evenly as practicable throughout the building.~~

(b) A portable fire extinguisher required by (b) must be –

i. Of ABE or CO_2 type; and

ii. Not less than 4.5 kg in size; and

iii. Installed in accordance with Section 3 of AS 2444.

H3.12 Emergency lighting requirements

(a) An emergency lighting system need not be installed in a farm building or intensive horticultural buildings –

a. With no artificial lighting as permitted by H3.18; or

b. With artificial lighting where, if that lighting fails due to an emergency, automatic power supply to the building is provided by a fuel-driven generator.

(b) An emergency lighting system need not be installed in a farm shed.

H3.13 Exit signs

An exit serving a farm shed, Group B or Group C intensive horticultural building need not be provided with an exit sign where the exit is a permanent opening not less than 2 m wide.

H3.14 Direction signs

In a farm building, intensive horticultural building or a farm shed, if an exit is not readily apparent to persons occupying or visiting the building, exit signs complying with H3.15 must be installed in appropriate positions in corridors, hallways, lobbies, and the like, indicating the direction to a required exit.

H3.15 Design and operation of exit signs

(a) In a farm building or intensive horticultural building, each required exit sign provided under E4.5 and H3.14 need not comply with E4.8 if –
  a. The use of illuminated exit signs may adversely impact the behaviour or welfare of animals being kept in the building; and
  b. Non-illuminated exit signs are installed in accordance with clauses 6.5, 6.6, 6.8 and 6.9 of AS 2293.1.

(b) In a farm shed or Group C intensive horticultural building, each required exit sign provided under E4.5 and H3.14 need not comply with E4.8 if exit signs complying with Section 6 and Appendix D of AS 2293.1 and provided except –
  a. The exit sign need not be illuminated; and
  b. The maximum viewing distance in clause 6.6 of AS 2293.1 must be not more than 24 m; and
  c. Clauses 6.3 and 6.7 of AS 2293.1 do not apply.

H3.16 Sanitary facilities

F2.3 does not apply to a farm shed or intensive horticultural buildings.

H3.17 Height of rooms and other spaces

F3.1 does not apply to a farm shed or intensive horticultural building which has ceiling heights not less than –

(a) In a room, corridor, passageway or the like – 2.1 m; and
(b) In a room or space with a sloping ceiling or projections – a height of not less than 2.1 m for at least two-thirds of the floor area of the room or space, and when calculating the floor area of the room or space, any part that has a ceiling height or less than 1.5 m is not included; and
(c) In a stairway, ramp, landing or the like – 2.0 m measured vertically above the nosing line of stairway treads or the floor surface of the ramp, landing or the like.

H3.18 Artificial lighting

(a) An artificial lighting system need not be provided in a farm building or intensive horticultural building where –

i. Occupants are provided with visibility sufficient for safe movement through suitable alternative means; and

ii. The use of artificial lighting could adversely affect the function of the building including, but not limited to –

A. The behaviour or welfare of animals being kept in the building; or

B. The cultivating or propagating of plants or fungi.

(b) An artificial lighting system need not be provided in a farm shed.

H3.19 Compartmentation and Separation

Deemed-to-Satisfy Provisions of C2.2 and C2.3 do not apply to intensive horticultural buildings where –

(a) Provided with a perimeter vehicular access complying with C2.4(b);

(b) Is separated from any other building or allotment boundary by a distance not less than 6 m; and

(c) Contains not more than 1 *storey*.

Proposal for Change Element Three End

PROPOSAL FOR CHANGE SUMMARY FOR NCC VOLUME 2 2019 EDITION

The following section outlines the Proposals for Change made to the NCC Volume Two in relation to the Proposals made through ChNo4 to ChNo9.

Change Number Four (ChNo4)

Brief: An addition shall be made to Part 1.1.7 Language of Volume Two to include the classification Class 10d.

Change Location: NCC Vol 2 2016 > Part 1.1 Interpretation > Part 1.1.7 Language **(REVISED)**

Proposal for Change Element Four Commencement

(a) A reference to Class 1a, 1b, 7a, 7b, 9a, 9b, 9c, 10a, 10b ~~and~~, 10c and 10d is a reference to the separate classification.

(b) A reference to –

i. Class 1 – is reference to a Class 1a and 1b; and

ii. Class 7 – is a reference to a Class 7a and 7b; and

iii. Class 9 – is a reference to a Class 9a, 9b and 9c; and

iv. Class 10 – is a reference to a Class 10a, 10b ~~and~~, 10c and 10d.

Proposal for Change Element Four End

Change Number Five (ChNo5)

Brief: This proposed change adds a definition into the NCC for intensive horticulture buildings which specifies the building's primary usage for horticultural means.

Change Location: NCC Vol 2 2016 > Part 1.1 Interpretation > Part 1.1.1 Definitions > Intensive horticulture building **(NEW)**

Proposal for Change Element Five Commencement

Intensive Horticultural Building means a farm building or part thereof, used for environmentally controlled farming, propagation or growing of plants, flowers or fungi but which is not used for the packing, display, trade or sale of the products or parts produced. An intensive horticultural building shall belong to one or a combination of group defined by Part A1.1 farm building.

Proposal for Change Element Five End

Change Number Six (ChNo6)

Brief: An addition shall be made to Class 10 at Part 1.3 Section 1.3.2 Classification whereby a subclass 10d shall be added. This allows for inclusion of the Group C Intensive Horticultural Building into Volume Two of the NCC. An explanatory information note has also been included in this part.

Change Location: NCC Vol 2 2016 > Part 1.3 Classification > Part 1.3.2 Classification > Class 10 **(REVISED/ADDITION)**

Proposal for Change Element Six Commencement

Class 10 – a non-habitable building or structure being –

(a) Class 10a – a non-habitable building being a private garage, carport, shed, or the like; or

(b) Class 10b – a structure being a fence, mast, antenna, retaining or free-standing wall, swimming pool, or the like; or

(c) Class 10c – a private bushfire shelter~~.~~; or

(d) Class 10d – a structure being a Group C intensive horticultural building.

Explanatory information:

The Class 10d for use as defined for horticulture shall be limited in the classification as defined under Farm Building of NCC Volume One for this use. Where a structure exceeds the Group C limits and is determined as another Class, 10d shall not be used.

Proposal for Change Element Six End

Change Number Seven (ChNo7)

Brief: An addition shall be made to Class 10 at Part 1.3 Section 1.3.3 Multiple classifications whereby a subclass 10d shall be added. This allows for inclusion of the Group C Intensive Horticultural Building into Volume Two of the NCC for multiple classification applications.

Change Location: NCC Vol 2 2016 > Part 1.3 Classification > Part 1.3.3 Multiple Classifications **(REVISED)**

Proposal for Change Element Seven Commencement

Each part of a building must be classified separately, and –

(a) Class 1a, 1b, 10a, 10b ~~and~~, 10c and 10d are separate classifications; and

(b) A reference to –

i. Class 1 – is a Class 1a and 1b; and

ii. Class 10 – is to Class 10a, 10b ~~and~~, 10c and 10d; and

(c) Where parts have different purposes – if not more than 10% of the floor area of a Class 1 building is used for the purpose which is a different classification, the classification of Class 1 may apply to the whole building.

Proposal for Change Element Seven End

Change Number Eight (ChNo8)

Brief: An alteration shall be made to Part 2.3 Fire Safety to ensure a Class 10d building does not significantly increase the risk of fire spread between Class 2 to 9 buildings.

Change Location: NCC Vol 2 2016 > Part 2.3 Fire Safety > Part 2.3.1 Protection from the spread of fire **(REVISED)**

Proposal for Change Element Eight Commencement

(b) A class 10a and 10d building must not significantly increase the risk of fire spread between Class 1 to 9 buildings.

Proposal for Change Element Eight End

Change Number Nine (ChNo9)

Brief: An explanatory information note has been included in Part 2.3 Fire Safety which outlines specification for Class 10d structures.

Change Location: NCC Vol 2 2016 > Part 2.3 Fire Safety > Explanatory information **(REVISED/ADDITION)**

Proposal for Change Element Nine Commencement

Fire provisions applied to Class 10d are not required to be any different than those for a Class 10a and shall follow requirements of 3.7.1.5 to 3.7.1.8.

Proposal for Change Element Nine End

PROPOSAL FOR CHANGE SUMMARY FOR NCC GUIDE 2019 EDITION

The following section outlines the Proposals for Change made to the NCC Guide in relation to the Proposals made through ChNo1 to ChNo9, as per above.

Change Number Ten (ChNo10)

Brief: An alteration shall be made to 'Farm building' Part A1 Interpretation to include intensive horticultural buildings.

Change Location: NCC Guide 2016 > Part A1 Interpretation **(REVISED)**

Proposal for Change Element Ten Commencement

Farm building

Buildings used for farming-type purposes are often very diverse in nature, occupancy and use. There are a number of conditions in this definition to outline the specific instances where a Class 7 or Class 8 building can be considered a farm building for the purposes of the NCC. This is to ensure that the Deemed-to-Satisfy Provisions for farm buildings are appropriate for a particular building in question.

The definition sets out three main criteria that a general farm building must meet for it to be considered a farm building. These criteria can be described as:

- the use and location of the building;
- the maximum number of occupants and occupant density in the building; and
- a maximum floor area of the building.

The definition sets out four main criteria that an intensive horticultural farm building must meet for it to be considered an intensive horticultural building. These criteria can be described as:

- the use and location of the building;
- a range of allowable floor areas;
- the maximum number of occupants and occupant density in the building; and
- the maximum average roof height of the building.

It is recommended that this definition be read in conjunction with the definition of 'farming'.

Refer to **Part H3** for specific requirements for farm buildings.

Proposal for Change Element Ten End

Change Number Eleven (ChNo11)

Brief: An addition shall be made to Part A1 Interpretation to include intensive horticultural buildings.

It is proposed that a classification-point assessment be the basis of determining classification of the Intensive Horticultural Building. To determine the classification, it is proposed that the following assessment be undertaken. The assessment determines risk associated with the assessable Intensive Horticultural Building and allocates the Intensive Horticultural Building into one of the following three classifications.

The assessable elements, shown from numbers 1 to 10 in the below Figure 5, are then analysed within a Classification-Point Matrix to identify the associated holistic risks and consequences of the proposed structure. Once a result is obtained a classification is determined as being a Group A, B or C intensive horticultural building.

There are ten input elements which shall be used to determine risks and consequences related to the development, as provided below.

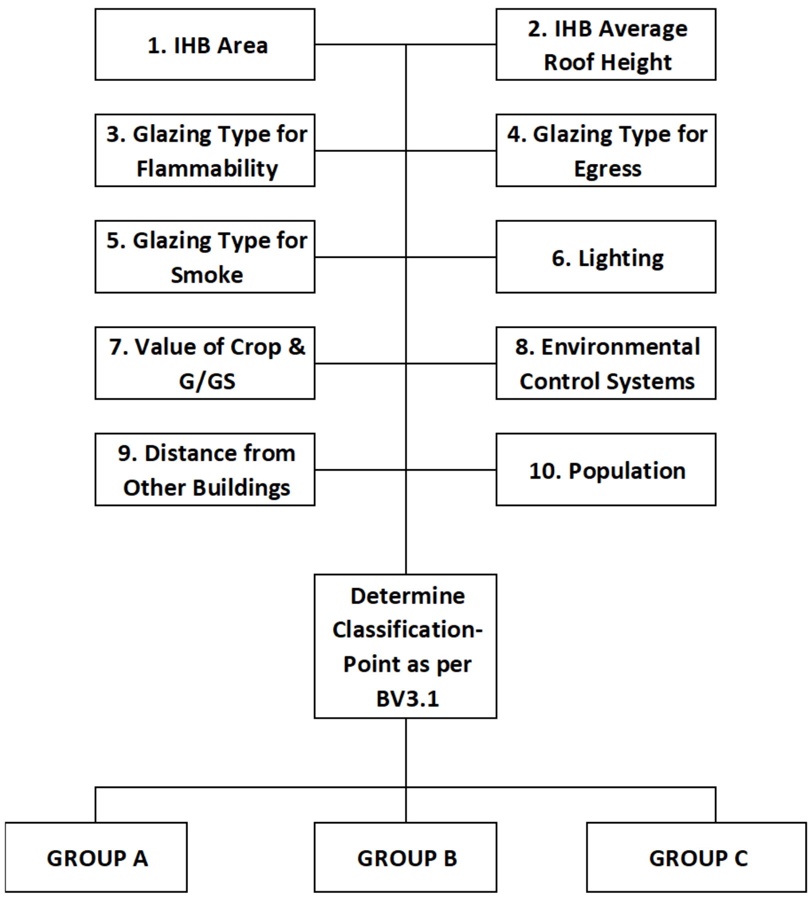


Figure 5 Building Verification Method Structure

For photographic examples of typical Group A, B and C structures refer to Classification Definitions within this report on pages 4-6.

The determination of Classification-Point Assessment Result for a site using pertinent elements shall be determined in accordance with the following steps:

- Make note of the relevant input findings, from BV3 (a) No. 1 to No. 10.
- Use the relevant tables and information to determine the Classification-Points for each of the elements using Table A1.1 (BV Matrix).
- Tally, through addition, the Classification-Points for each element to give the Total Classification-Point using Table A1.1 (BV Matrix).
- Determine classification of structure using the Total Classification-Point value as per Table A1.1 (Classification-Point).

Assessment examples have been provided in ChNo11 as part of the Proposal for Change to the NCC Guide.

Change Location: NCC Guide 2016 > Part A1 Interpretation **(ADDITION)**

Proposal for Change Element Eleven Commencement

Intensive horticultural building

Buildings used for environmentally controlled farming, propagation or growing of plants, flowers or fungi but which are not used for the packing, display, trade or sale of the products or parts produced. These structures are commonly described as, but are not limited to, greenhouses, glasshouses, protected cropping structures and production nurseries (not for retail or wholesale access). The following generalisations may be considered as guidelines for intensive horticultural building groupings:

Group A intensive horticultural buildings are typically buildings built with rigid covering materials, average roof heights of 5 to 9 m, and/or a total floor area exceeding 500 m^2. It is common for these buildings to have a high level of environmental control.

Group B intensive horticultural buildings are typically built with permanent or retractable non-rigid plastic or fabric covering materials, average roof height of 2 to 5 m, and/or a total floor area exceeding 500 m^2. It is common for these buildings to have a low to medium level of environmental control.

Group C intensive horticultural buildings are typically constructed with rigid, non-rigid plastic or fabric covering materials with a total floor area no greater than 500 m^2. Fabric canopy cable structures with total areas exceeding 500 m^2 may be considered in this classification. These structures are classified as Class 10d structures. It is common for these buildings to have low, medium or high environmental control.

Environmental control refers to equipment used to monitor and control a building's environment; this may include ventilation, fogging, misting, spraying and shading systems.

It is recommended that this definition be read in conjunction with the definition of 'farming' and 'farm building'.

Refer to Part H3 for specific requirements for intensive horticultural buildings.

The following building verification method has been provided below. This can be utilised to verify classifications determined in NCC Volume One in relation to Group A, B or C intensive horticultural buildings.

A1.1 BV1 Intensive Horticultural Building Classification

Classification compliance of *intensive horticultural buildings* is verified for Grouping Categories A, B and C by –

(a) Determining the building's classification-point value associated to the assessable building as per Table A1.1 (BV Matrix); then

Table 1
Table A1.1 (BV1.1 Matrix) – Classification-Point Matrix

No.	Element	Classification-Points					
		0	1	2	3	4	5
1	IHB Area	*	Band 1	*	Band 2	*	Band 3
2	IHB Average Roof Height	*	Band 1	*	Band 2	*	Band 3
3	Glazing Type For Flammability	*	Glass	CPM	*	*	PM
4	Glazing Type For Egress	No Sides	*	*	*	FPM	SPM & Glass
5	Glazing Type for Smoke	*	No Sides	FPM	*	*	SPM & Glass
6	Lighting	No Assimilated Lighting	*	*	*	*	Assimilated Lighting
7	Value of Crop & IHB	*	Low	Average	High	*	*
8	Environmental Control Systems	Low Tech	*	Medium Tech	*	High Tech	*
9	Distance from Other Buildings	*	Distance 1	*	Distance 2	*	Distance 3
10	Population	*	Band 1	*	Band 2	*	Band 3

Where –

No. 1 – Intensive Horticultural Building Area

The appropriate area band should be selected in accordance with the below table. The area of the intensive horticultural building should be taken as the footprint, in metres squared, of the new development as per Table BV1.2. The building footprint is any area covered by permeable or impermeable wall and/or roof cladding.

Important Note: If a new building development is attached, or has covered access/walkway, to an existing building, the total combined area of the new and existing buildings must be considered as the total building area.

Table 2 Table A1.1 (BV1.2) - Area Bands for Intensive Horticultural Buildings

Building Area (m2)	**Band 1**	**Band 2**	**Band 3**
Area (m^2)	< 500 m^2 *(Less than 500 m^2)*	500 m^2 to 10,000 m^2	> 10,000 m^2 *(Greater than 10,000 m^2)*

NOTE: 1 m^2 = 0.0001 hectares.

No. 2 – Intensive Horticultural Building Average Roof or Covering Height

The appropriate average roof or covering height should be selected in accordance with the below table. The average roof heights of the intensive horticultural building should be taken as the average height between the roof eave and roof apex, in metres, of the new development as per Table BV1.3.

Table 3 Table BV1.3 - Averaged Roof Height for Intensive Horticultural Buildings

Averaged Height (m)	**Band 1**	**Band 2**	**Band 3**
Averaged Height (m)	Less than 2 m	Between 2 m and 5 m	Greater than 5 m

No. 3 - Glazing/Covering Type: (Flammability)

All common intensive horticultural building materials and framing respond uniquely in the event of a fire. It is therefore important to identify which of the following three (3) typical materials shall be used. Common materials utilised are provided below. Flammability is considered as both how easily something will burn/ignite and the degree of difficulty required to cause combustion of a substrate.

Glazing types for intensive horticultural building flammability are provided below:

- Glass;
- PM (Plastic Membrane); and
- CPM (Compartmentalized Plastic Membrane).

No. 4 – Glazing/Covering Type: (Egress)

Glazing types have considerable influence over the means and ease of egress during a fire event.

The following three (3) materials may exhibit different characteristics when exposed to a fire event and therefore have specific egress characteristics:

- FPM (Non-rigid Film Plastic Membrane)
- SPM (Rigid Sheet Plastic Membrane) & Glass
- No sides

No. 5 – Glazing/Covering Type: (Smoke)

Build-up of smoke within an intensive horticultural building is a crucial concern during a fire event. In the event of a fire it is vital for occupants to escape before inhalation occurs. Glazing characteristics in relation to the production and retention of smoke are as follows:

- FPM (Non-rigid Film Plastic Membrane)
- SPM (Rigid Sheet Plastic Membrane)
- Glass
- No sides

No. 6 – Lighting

Lighting refers to assimilation lighting and does not apply to general illumination. Assimilation lighting, also known as grow lamps or supplementary lighting, has an increased risk of being the origin of a fire, and as such a higher Classification-Point Assessment shall be awarded if this type of lighting is installed.

No. 7 - Value of Crop & Intensive Horticultural Building

Determine the predicted value of the crop per year and value of the intensive horticultural building as per Table BV1.4. Growers should be consulted by the assessor to correctly determine value of both the crop and intensive horticultural building.

Table 4 Table BV1.4 - Predicted Value of Intensive Horticultural Crop per Year & Value of Intensive Horticultural Building

Value of Crop & Building	**Low**	**Average**	**High**
Predicted Value of Crop per Year	< $100,000 *(less than $100,000)*	$100,000 to $5,000,000	> $5,000,000 *(greater than $5,000,000)*
Value of intensive horticultural building	< $40,000 *(less than $40,000)*	$40,000 to $2,000,000	> $2,000,000 *(greater than $2,000,000)*

NOTE: If value of crop and value of intensive horticultural building *are not within the same 'value column' it is important to interpolate results within Classification-Point Matrix.*

No. 8 - Environmental Control Systems

Select which of the following environmental control systems are proposed to be implemented into the new intensive horticultural building as per Table BV1.5:

Table 5 Table BV1.5 - Intensive Horticultural Building Environmental Control Systems

Environmental Control Systems	Low Control	Medium Control	High Control
Control	No mechanical or electrical environmental control.	Mechanical ventilation and fan motors for air movement.	Boilers, fan motors, mechanical vents, electronic environmental control systems, etc.

No. 9 - Distance from other Buildings

Determining the distance between a proposed intensive horticultural building and existing buildings is vital to determine the risk of fire spreading. The distances shown in Table BV1.6 and BV1.7 are based on surrounding combustible buildings with a height no greater than 6 metres. For buildings with a height over 6 metres reference should be made to the second table. The below figures should be taken as minimum distances, and it should be understood that the further away from other buildings an intensive horticultural building is the better.

Table 6 Table BV1.6 - Distance from Other Buildings, Equal to or Less than 6m High

Distance from other buildings (surrounding buildings height < 5 m high)	Distance 1	Distance 2	Distance 3
Distance (m)	> 10 m *(greater than 10 m)*	10 m to 3 m	< 3 m *(less than 3 m)*

Table 7 Table BV1.7 - Distance from Other Buildings, Greater than 6m High

Distance from other buildings (surrounding buildings height > 5 m high)	Distance 1	Distance 2	Distance 3
Distance (m)	> 18 m *(greater than 18 m)*	18 m to 6 m	< 6 m *(less than 6 m)*

NOTE: Term 'height' shall be defined in text.

No. 10 – Population

Determine the maximum number of persons within the intensive horticultural building at any one time as per Table BV1.8.

Table 8 Table BV1.8 - Number of Persons in the Intensive Horticultural Building

Number of Persons	Band 1	Band 2	Band 3
Persons	1 to 5 with an occupancy ratio of no greater than 1 person to 100 m^2	Occupancy ratio of no greater than 1 person to 400 m^2	Occupancy ratio of no greater than 1 person to 600 m^2

(b) Determine the total Classification-Point Value, tally elements defined in BV1 (a) together and identify their appropriate grouping using Table BV1.9.

Table 9 Table BV1.9 - Intensive Horticultural Building Grouping Classification and Associated Classification-Point Ranges

	GROUP A	GROUP B	GROUP C
Total Classification-Point	31 to 47	21 to 30	20 or less
Explanation	These structures have the highest risk and associated consequences.	These structures have medium risk and associated consequences.	These structures have the lowest combined risk and associated consequences and may be considered as Class 10d buildings

NOTE: If the resulting Total Classification-Point exceeds the prescribed as per the above table a special solution must be obtained by a suitably qualified Engineer.

Example verification methods have been provided below.

Group A Classification Example

A proposed intensive horticultural building with a total floor area of 25,000 m^2, rigid plastic cladding, high climate control and an average roof height of 6 m is to be assessed. Reference to Part A1.1 farm buildings definition suggests a grouping of Group A, to verify this the assessor completes the verification method prescribed as BV. The following classification-points were found for each assessable element, of which there are ten.

For No. 1 – Intensive Horticultural Building Area, Band 3 was selected from Table BV1.2 as the building shall have a total floor area greater than 10,000 m^2. This provides a **Classification-Point of 5** as per BV1.1.

For No. 2 – Intensive Horticultural Building Average Roof of Covered Height, Band 3 was selected from Table BV3.3 as the building shall have an average roof height of 6m. This provides a **Classification-Point of 5** as per BV1.1.

For No. 3 – Glazing/Covering Type: (Flammability), plastic membrane (PM) was selected as the building shall have plastic membrane cladding. This provides a **Classification-Point of 5** as per BV1.1.

For No. 4 – Glazing/Covering Type: (Egress), rigid sheet plastic membrane (SPM) was selected as the building shall have rigid plastic cladding. This provides a **Classification-Point of 5** as per BV1.1.

For No. 5 – Glazing/Covering Type: (Smoke), rigid sheet plastic membrane (SPM) was selected as the building shall have rigid plastic cladding. This provides a **Classification-Point of 5** as per BV1.1.

For No. 6 – Lighting, through discussion with the development applicant no assimilation lighting is proposed. This provides a **Classification-Point of 0** as per BV1.1.

For No. 7 – Value of Crop & Intensive Horticultural Building, through discussion with the development applicant it was determined that the value of the crop per year to be $3,000,000 and the value of the building to be $2,500,000. Using Table BV1.4 it is determined that the crop value is ‘Average’ and the building value as ‘High’. This provides a **Classification-Point of 2.5** as per BV1.1. Note: interpolation between ‘Average’ and ‘High’ has occurred.

For No. 8 – Environmental Control System, through discussion with the development applicant a high level of environmental control is proposed as per Table BV1.5. This provides a **Classification-Point of 4** as per BV1.1.

For No. 9 – Distance from other Buildings, through discussion with the development applicant 6 m is proposed between the new development and existing buildings as providing ‘Distance 2’ per Table BV1.6. This provides a **Classification-Point of 3** as per BV1.1.

For No. 10 – Population, through discussion with the development applicant they propose to have maximum occupation of 41 persons in the building at any one time with a ratio of 1 person to 609 m^2. As per Table BV1.8 ‘Band 3’ shall be selected. This provides a **Classification-Point of 5** as per BV1.1.

All verification elements have now been obtained. Tallying, through addition it is found that **the total classification-point is 39.5**. Referring to Table BV1.9 it is found that 39.5 results in a Group A classified structure, verifying the classification of Part A1.1.

Group B Classification Example

A proposed intensive horticultural building with a total floor area of 15,000 m^2, non-rigid plastic cladding, low climate control, and an average roof height of 5 m is to be assessed. Reference to Part A1.1 farm buildings definition suggests a grouping of Group B, to verify this the assessor completes the verification method prescribed as BV. The following classification-points were found for each assessable element, of which there are ten.

For No. 1 – Intensive Horticultural Building Area, Band 3 was selected from Table BV1.2 as the building shall have a total floor area greater than 10,000 m^2. This provides a **Classification-Point of 5** as per BV1.1.

For No. 2 – Intensive Horticultural Building Average Roof of Covered Height, Band 2 was selected from Table BV1.3 as the building shall have an average roof height of 5m. This provides a **Classification-Point of 3** as per BV1.1.

For No. 3 – Glazing/Covering Type: (Flammability), plastic membrane (PM) was selected as the building shall have plastic membrane cladding. This provides a **Classification-Point of 5** as per BV1.1.

For No. 4 – Glazing/Covering Type: (Egress), non-rigid film plastic membrane (FMP) was selected as the building shall have non-rigid plastic cladding. This provides a **Classification-Point of 4** as per BV1.1.

For No. 5 – Glazing/Covering Type: (Smoke), non-rigid film plastic membrane (FMP) was selected as the building shall have non-rigid plastic cladding. This provides a **Classification-Point of 2** as per BV1.1.

For No. 6 – Lighting, through discussion with the development applicant no assimilation lighting is proposed. This provides a **Classification-Point of 0** as per BV1.1.

For No. 7 – Value of Crop & Intensive Horticultural Building, through discussion with the development applicant it was determined that the value of the crop per year to be $500,000 and the value of the building to be $900,000. Using Table BV1.4 it is determined that the crop value is 'Average' and the building value as 'Average'. This provides a **Classification-Point of 2** as per BV1.1.

For No. 8 – Environmental Control System, through discussion with the development applicant a medium level of environmental control is proposed as per Table BV1.5. This provides a **Classification-Point of 2** as per BV1.1.

For No. 9 – Distance from other Buildings, through discussion with the development applicant 6 m is proposed between the new development and existing buildings as providing 'Distance 2' per Table BV1.6. This provides a **Classification-Point of 3** as per BV1.1.

For No. 10 – Population, through discussion with the development applicant they propose to have maximum occupation of 20 persons in the building at any one time with an occupancy ratio of 1 person to 750 m^2. As per Table BV1.8 'Band 2' shall be selected. This provides a **Classification-Point of 3** as per BV1.1.

All verification elements have now been obtained. Tallying, through addition it is found that **the total classification-point is 29**. Referring to Table BV1.9 it is found that 27 results in a Group B classified structure, verifying the classification of Part A1.1.

Group C Classification Example

A proposed intensive horticultural building with a total floor area of 400 m^2, non-rigid plastic cladding, low climate control, and an average roof height of 2.5 m is to be assessed. Reference to Part A1.1 farm buildings definition suggests a grouping of Group C, to verify this the assessor completes the verification method prescribed as BV. The following classification-points were found for each assessable element, of which there are ten.

For No. 1 – Intensive Horticultural Building Area, Band 1 was selected from Table BV1.2 as the building shall have a total floor area less than 500 m^2. This provides a **Classification-Point of 1** as per BV1.1.

For No. 2 – Intensive Horticultural Building Average Roof of Covered Height, Band 2 was selected from Table BV1.3 as the building shall have an average roof height of 2.5m. This provides a **Classification-Point of 3** as per BV1.1.

For No. 3 – Glazing/Covering Type: (Flammability), plastic membrane (PM) was selected as the building shall have plastic membrane cladding. This provides a **Classification-Point of 5** as per BV1.1.

For No. 4 – Glazing/Covering Type: (Egress), non-rigid film plastic membrane (FMP) was selected as the building shall have non-rigid plastic cladding. This provides a **Classification-Point of 4** as per BV1.1.

For No. 5 – Glazing/Covering Type: (Smoke), non-rigid film plastic membrane (FMP) was selected as the building shall have non-rigid plastic cladding. This provides a **Classification-Point of 2** as per BV1.1.

For No. 6 – Lighting, through discussion with the development applicant no assimilation lighting is proposed. This provides a **Classification-Point of 0** as per BV1.1.

For No. 7 – Value of Crop & Intensive Horticultural Building, through discussion with the development applicant it was determined that the value of the crop per year to be $16,000 and the value of the building to be $35,000. Using Table BV1.4 it is determined that the crop value is ‘Low’ and the building value as ‘Low’. This provides a **Classification-Point of 1** as per BV1.1.

For No. 8 – Environmental Control System, through discussion with the development applicant a low level of environmental control is proposed as per Table BV1.5. This provides a **Classification-Point of 0** as per BV1.1.

For No. 9 – Distance from other Buildings, through discussion with the development applicant 6 m is proposed between the new development and existing buildings as providing ‘Distance 2’ per Table BV1.6. This provides a **Classification-Point of 3** as per BV1.1.

For No. 10 – Population, through discussion with the development applicant they propose to have maximum occupation of 2 persons in the building at any one time with an occupancy ratio of 1 person to 200 m^2. As per Table BV1.8 ‘Band 1’ shall be selected. This provides a **Classification-Point of 1** as per BV1.1.

All verification elements have now been obtained. Tallying, through addition it is found that **the total classification-point is 20**. Referring to Table BV1.9 it is found that 20 results in a Group C classified structure, verifying the classification of Part A1.1. As Group C has been selected it is appropriate to use NCC Volume Two and class the structure as 10d.

Proposal for Change Element Eleven End

THE PROBLEM, SOLVERS AND JUSTIFICATION

The Current Problem

2. What problem is the proposal designed to solve?

Grower and Industry Problem

Australia does not have a unified building classification of agricultural buildings (greenhouses/protective cropping structures) within the National Construction Code (**NCC**).

An economic burden currently experienced by protected cropping growers (Non-Referenced Source: VG16004 Grower Survey) is the cost associated with the development and maintenance of new protective cropping structures. This burden comes in, but is not exclusive to, the form of:

- Project delays due to building classification uncertainty;
- Delays due to resolving design complications of non-relevant regulatory restrictions;
- Upfront costs of fire and egress infrastructure; and
- Ongoing costs of maintaining fire and egress infrastructure.

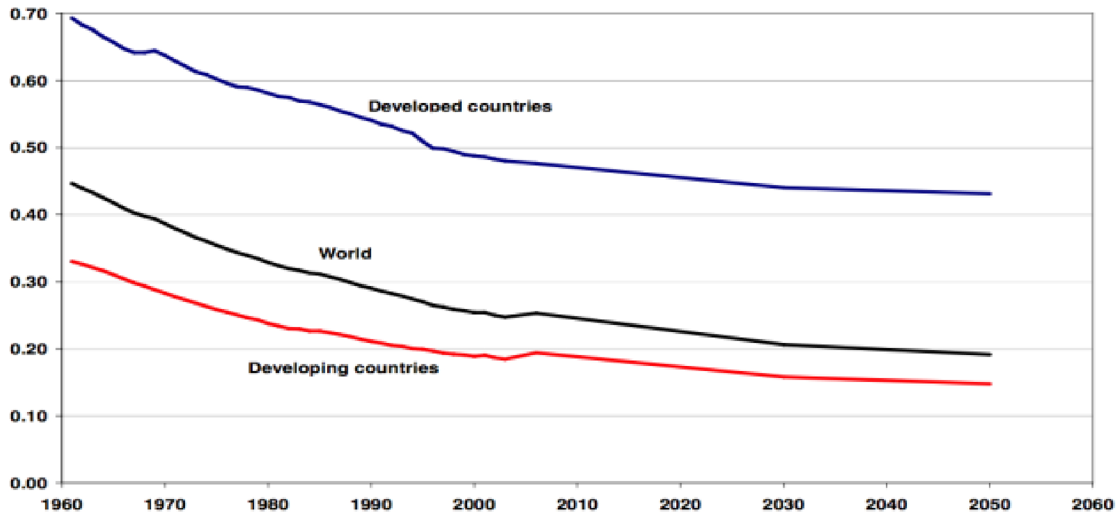
In Australia, burdens exist as protected cropping structures, such as greenhouses and grow structures, do not currently have accurate application to the current construction code, the Building Code of Australia 2016. Therefore, the IHB structures are forced to comply with general design and construction requirements specified in the Australian Standards (**AS**) and the Building Code of Australia (**BCA**), which encapsulates the National Construction Code Volume One and Volume Two. A key concern for the protected cropping sector is that the current building codes applied to greenhouse construction are not relevant to today's operations.

As protective cropping structures do not have their own code or exemptions they are usually, at the discretion of a private certifier or local council, required to conform to regulation that applies, and is suited to, commercial/production/storage structures. These structures are typically defined as a Class 8 building in Section A3.3 of the NCC Volume One. Achieving Class 8 compliance of an intensive horticultural building can become a large economic burden especially when adhering to, for example, the current NCC 2016 Volume One Class 8 egress and fire regulatory requirements.

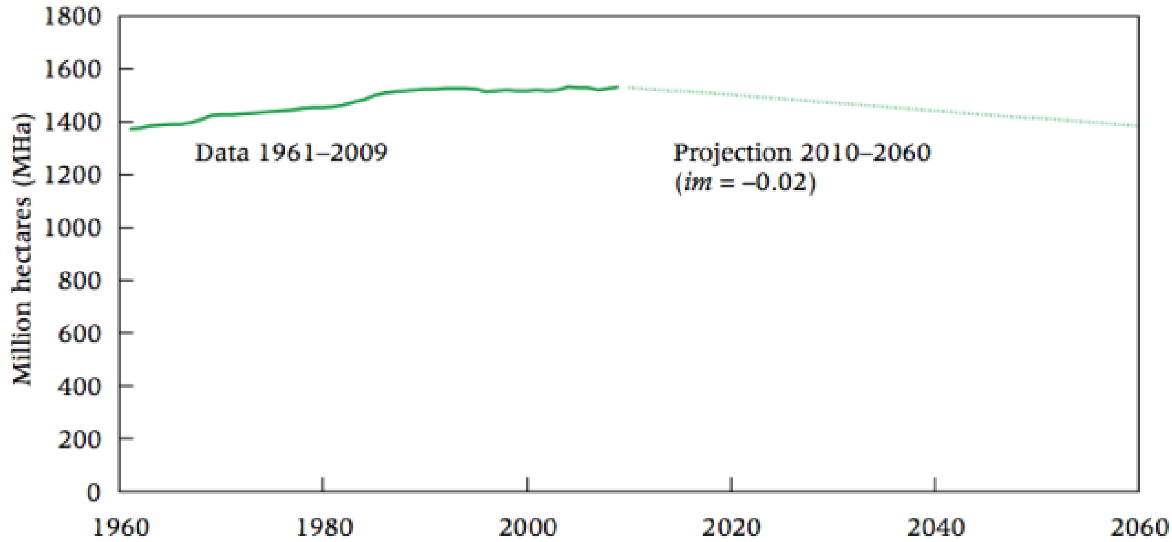
Within the current version of the BCA (specifically NCC Volume One 2016) the Australian Building Codes Board (**ABCB**) has included Part H3 Farm Buildings and Farm Sheds to assist in providing deemed-to-satisfy provisions for farm related buildings. Though a step in a positive direction, many growers and members of the protected cropping industry consider this Part not to be applicable to intensive horticultural buildings due to their size, construction materials, occupancy ratios and use. Further discussion and justification for changing the BCA is provided throughout this project's 'Summary of Process' document and the associated 'ABCB Proposal for Change' document.

Social and Economic Problem

The proposal also encourages security of food production in Australia. The below graphs show estimated hectares that are required to feed one person. The graphs identify agricultural land area production concerns with a growing world population. To meet the expected population growth the agricultural and horticultural industry must develop means to increase production density in available land areas, intensive horticultural buildings are one such solution.



Arable land per capita (ha in use per person) (1961-2050) –[1] (Bruinsma, 2009)



Peaking farmland: extent of global arable land and permanent crops, 1961-2009, and our (Our Word in Data) projection for 2010-2060 -[2] (Ausubel, et al., February 2013)

[1] Bruinsma, J., 2009. *The resource outlook to 2050: by how much do land, water and crop yields need to increase by 2050?.* [Online]
[Accessed Jan 2017].

[2] Ausubel, J., Wernick, I. & Waggoner, P., February 2013. Peak Farmland and the Prospect for Land Sparing.. *Population and Development Review,* 38(s1), pp. 221-242.

Australian farmers and the fresh, quality produce they deliver to domestic and international markets have assisted in developing our unique national identity. Through the decades Australian Farmers have adapted to new technologies and environments to maintain and increase production demands while making concerted efforts in ensuring food security for a growing world population. Though efforts are made by the Australian Grower to secure food production by initiating innovative systems such as Intensive Horticultural Buildings it is Australia's collective imperative to develop and maintain a strong and versatile food production portfolio.

3. What evidence exists to show there is a problem?

Justification and evidence of the NCC Proposals for Change is vital to the successful implementation of the project's recommendations. This project is utilising a five-part justification process, see Figure 6, to ensure the Proposals are defensible and of net-benefit to industry and society. Detailed justification of the Proposals for Change is provided in the Summary of Process document.

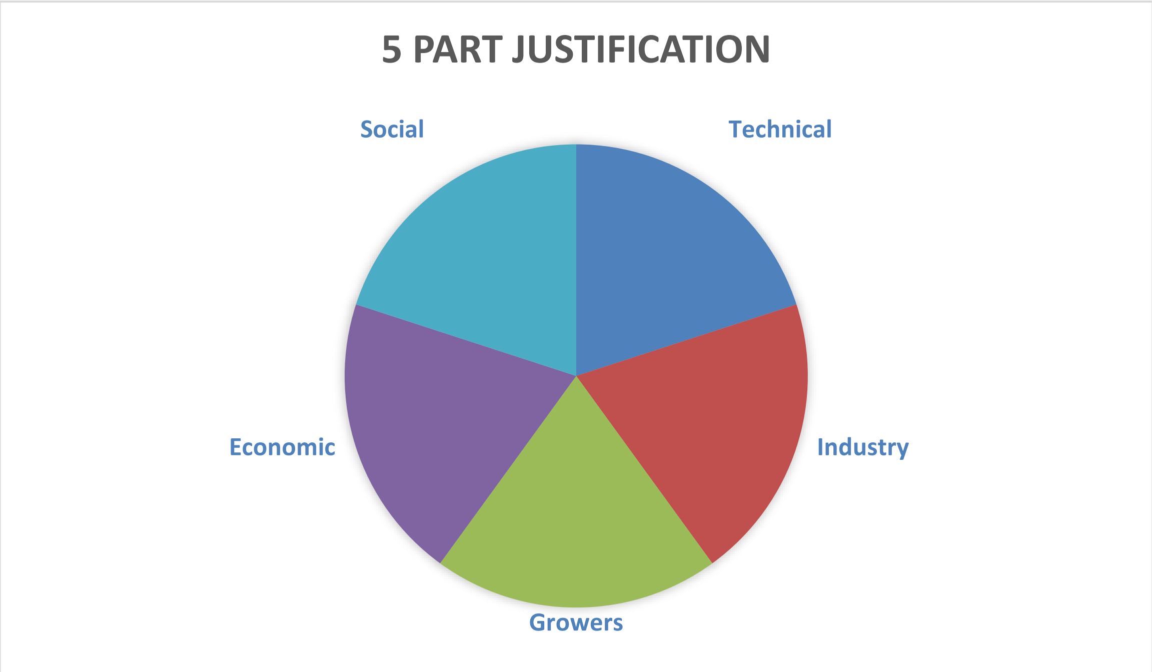


Figure 6 Project Justification using a 5 Part Approach

A brief description of each of the justification parts are provided below:

Social – Provides justification on how the proposed changes would provide a net-benefit to Australian society. For example: local food security etc.

Technical – Provides justification on how the proposed changes are defensible in a technical environment. For example, fire models, literary review of international regulation etc.

Industry – Provides justification that the proposed changes have had draft industry review and industry have provided feedback. Industry here relates to Building Certifiers and Fire Authorities, the industries who would implement proposed changes.

Growers and Grower Industry – Provides justification that the proposed changes meet the needs of growers to encourage industry growth, food security and lower approval costs.

Economic – Provides justification that the proposed changes are of economic benefit to the grower, local communities and Australia's national economy.

Evidence from Grower Consultation Surveys

A survey of greenhouse growers in Australia was undertaken for this project. This investigated the information needs of growers and where they source information, their preference for receiving information, as well as the strengths and weaknesses of the current regulatory system for greenhouse construction and safe operation. The survey received twenty-nine (29) responses from members within the IHB industry with a majority of the responses being from protected cropping vegetable growers. Below are several survey questions that have provided particularly pertinent information in understanding growers concerns, needs, expectations and vision of the IHB industry in the future.

<u>Survey Highlight One</u>

Question: What category best describes your business?
Answer Choice: Expanding, consolidating, stable or downsizing.

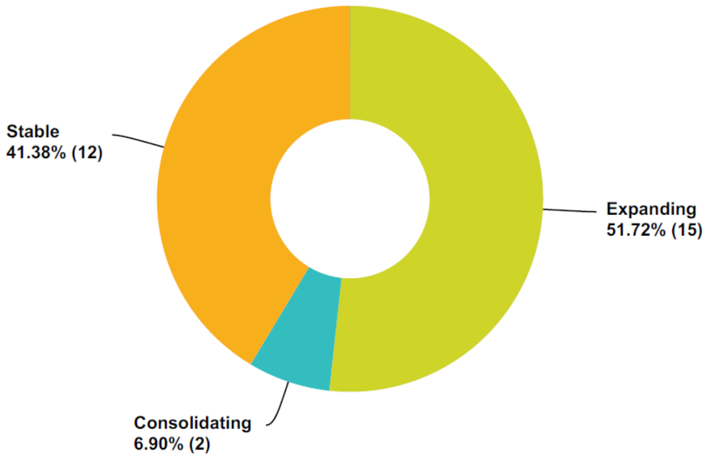


Figure 7 Survey Question: What category best describes your business?

51.72% of survey participants said their businesses were expanding, 41.38% said their businesses were stable and 6.9% said they were consolidating. These findings may be seen to provide quantifiable support towards the Proposal for Change. With approximately 52% of responding growers identifying their businesses as expanding it is important for the Australian regulation industry to encourage and not hinder future IHB development that has a considerable net-benefit for Australian society. Refer to the Summary of Process document for net/cost-benefit analysis and discussion.

Survey Highlight Two

Question: What is the primary type of structure present?
Answer Choice: Low technology, medium technology or high technology.

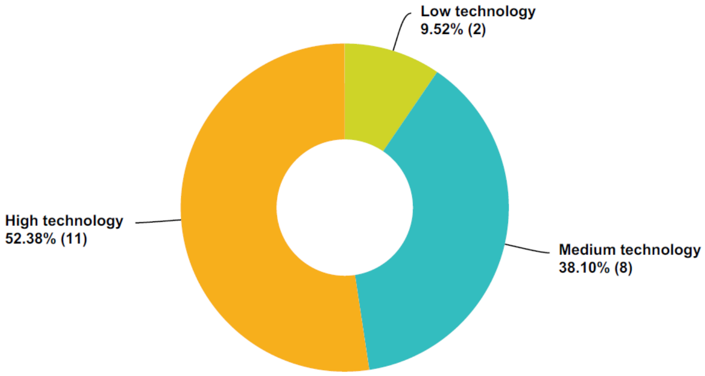


Figure 8 Survey Question Answers: What is the primary type of structure present?

52.38% of survey participants said the primary IHB structures on their sites were high technology, typically Group A structures. 38.10% have medium technology structures, typically Group B structures, while only 9.52% have low technology, typically Group C. These findings provide insight into the innovation and future-planning of Australia's typical protective cropping grower. With higher technology structures, growers are able to produce higher yields of a greater quality and crop security. These initiatives assist in ensuring sustained vegetable production growth to meet growing national and international demands.

Survey Highlight Three

Question: What is the total area of all G/GS on the property?

Approximately 50% of responses had an area greater than 10,000 m^2 (1 hectare) with several responding to having 35 hectares to 80 hectares of crop protection structures. The remaining 50% of respondents had between 700 m^2 and 9,000 m^2. These results show that growers are investing in large IHBs of more than 1 hectare, these areas far exceed the maximum size of fire compartments or atria as defined in Table C2.2 of NCC Volume One; buildings are permitted to exceed the prescribed area in Table C2.2 if it complies with provisions outlined in C2.3 large isolated buildings. These provisions allow for buildings with areas exceeding 18,000 m^2 if a sprinkler system is installed and a vehicle access path provided.

Vehicle access paths are commonly accepted by the grower as good farm management however growers are burdened by the installation of sprinkler systems which have little practicality in IHB type structures.

Survey Highlight Four

Question: How could greenhouse construction and safe operation be improved? Note: select all that are relevant.

Survey analysis identified that 'Understanding the preparation, lodgement, assessment and approval process with local government' and 'cost of compliance' as the two most significant threats to growth that the protected cropping industry faces, as 64.29% of survey responses indicated as such. The next most relevant issues were 'Determining if a development application is required', 'Understanding the compliance process', and 'Requirements for work place health and safety'.

Evidence from Case Studies

Several example case studies have been provided, additional cases can be found in the Summary of Process document.

Grower Case One

Grower Identification: Grower VIC
Typical crops being produced: Hydroponic seedlings, tomatoes and capsicums

Type of G/GS: Glass and steel Dutch Venlo

Technology level: High, Group A

Total area under G/GS: 26 ha

Site visit undertaken: Yes

Field Investigation Findings:

Grower VIC has identified that they are Hort Innovation levy paying growers. Glasshouses are imported from the Netherlands through the Dutch Venlo company. The greenhouses are provided with frameworks, fastening elements, glazing and steel zinc-coated metalware. Frameworks and gutters are made of aluminium, metalware for fixation and aluminium construction. Construction meets European standard EN 13031[3] (Venlo , 2017).

Grower VIC's history with development approval (**DA**) and council compliancy is as follows. The first Dutch Venlo greenhouse constructed onsite required fire and egress requirements; these requirements were hydrant booster pumps, a fire ring suppression system and illuminated exit signs. Before construction of successive glasshouse structures Grower VIC approached a building surveyor and a fire engineer to investigate and engage in reducing cost of compliance. The fire engineer completed a risk assessment in relation to the possible outcomes in the event of a fire – this risk assessment was presented to local council and Country Fire Authority (**CFA**) officials which delivered an outcome that was acceptable to the grower.

[3] Venlo , 2017. *Venlo Greenhouses: Economical Quality.* [Online]
Available at: http://www.venloinc.com/greenhouses/venlo
[Accessed 13 November 2016].

DA concessions are directly related to fire and egress requirements applicable to all future glasshouse structures constructed on the growers property. Some practical fire and egress requirements were still imposed on new developments after the concession was implemented. One such requirement was the installation of fire hose reels at locations specified by the fire engineer. Other imposed requirements were the construction of concrete fire rated walls (60 minutes fire resistance) between the plant equipment room and the growing areas. The installation of break-glass sensors that activate the H_2O misting/fog system which remains active until disengaged is an alternative to the fire ring suppression system that has been approved by CFA and local Council. Misting/fog fire suppression systems utilise existing infrastructure used during daily operation of the glasshouse and therefore do not require layout of dedicated fire suppression systems that may never be used. Fire extinguishers are also located at each exit and control panels.

Exits and egress in all glasshouses are approved by Council and CFA; exits are at the end of each row and provide a maximum escape path of 126 meters. Glass wall panes could also be shattered in the event of a fire if alternative escape is required. Emergency evacuation plans and procedures are conveyed to all staff and site visitors.

Grower VIC has not experienced structural failure due to extreme natural events nor has there been documentation of fire in any of the glasshouses onsite. The Project Team has been informed that the glasshouses are maintained meticulously and are kept clear of combustible materials.

Grower Case Two

Grower Identification: Grower QLD

Typical crops being produced: Cucumbers

Type of G/GS: Impermeable plastic membrane on hooped steel structure

Technology level: Low, Group B

Total area under G/GS: 5.4 ha

Site visit undertaken: Yes

Field Investigation Findings:

Grower QLD has identified that they are Hort Innovation levy paying growers.

Greenhouses are imported from Adelaide, SA and constructed from steel hoops, timber/steel column supports and are covered with an impermeable plastic membrane. The greenhouses have been in operation for 20+ years and mainly produce cucumbers year round. All sides of the greenhouses remain operable throughout the growing season. There has been no extreme natural event documented (storm/hail etc.) that has caused structural failure on Grower QLD's property, nor has a fire occurred.

The property is in a semi-rural area with houses surrounding the structure. Grower QLD has had issue with residential complaints regarding noise pollution from tractors and other farming machinery, spraying and visual pollution.

Grower QLD has recently had to apply for a Development Approval (**DA**) through the local Council for the existing greenhouses. Grower QLD describes the process of obtaining Building Approval (**BA**) as a problematic and protracted occurrence which has caused the grower economic and emotional hardship. Grower QLD accepted that DA would have to be completed however it was the unknowingness and professional inexperience throughout the process which caused issues. These issues were:

- Local Council was unable to provide the grower with a uniform response to what process was required to complete the DA efficiently. Council was also unable to provide listed council fees associated with the DA process. After meeting with Grower QLD, an engineer from Osborn Consulting contacted a member of local Council's Planning Department to request further information regarding the process of BA for greenhouse structures. The response from Council that was received was "DA requirements are a case-by-case issue and are dependent on the council certifier. Council does not have documented guidelines that outline what is required [for the completion of greenhouse DA]."
- To obtain structural certification of the existing greenhouses a large Brisbane based engineering firm was engaged – This resulted in the apparent noncompliance of the existing structural columns [presumably for wind loading], the only remediation measure that was offered to the grower was to replace all existing columns with a larger size. Grower QLD was displeased with this result and acquired a second opinion through an alternative engineering firm. The second firm was much more experienced in the design of low technology greenhouses and found the greenhouses were structurally adequate for both strength and service loading and as such no additional work was needed. Through experience it is evident that applying wind loading to low technology greenhouses, specified in AS/NZS 1170.2 Wind Loading Code can be unnecessarily conservative if the entire structural system is not understood.

Fire and egress regulation was not imposed during the DA process though Grower QLD has identified that several other growers in the area were required to comply with fire and egress during BA of new and existing greenhouses.

The Objective

4. How will the proposal solve the problem?

Question 4, above, has been answered by providing solvers in the areas of growers and industry, social, economic and technical solvers. These are provided below.

Grower and Industry Solvers

The proposal utilises the already existing framework of Part H3 'farm buildings and farm sheds' to incorporate IHB into the deemed-to-satisfy provisions and outlines succinct exceptions for the specific IHB groupings. The proposal is aimed to reduce ambiguity and miss-classification surrounding the classification of IHBs. A prescriptive approach to classifying these structures will reduce economic burden on growers (burdens documented in answer to Question 2). A reduced economic burden would encourage additional development in protected cropping which will increase Australia's produce output for the local and international market and also its food security and independence.

Social and Economic Solvers

For Australia, food security can be considered inextricably linked to the political stability of our region and has the potential to affect our national security. Food security also affects our status as a premier food exporting nation and the health and wellbeing of our population. The likelihood of a food crisis directly affecting the Australian population may appear remote given that we have enjoyed cheap, safe and high-quality food for many decades and we produce enough food today to feed millions of people. However, if our population grows to 35-40 million and climate change constrains food production, we may see years where we will import more food than we export. We are now facing a complex array of intersecting challenges which may threaten the stability of our food production, consumption and trade. It is imperative that we continue to develop food-related science and technology to fuel a future food revolution that must exceed the achievements of the Green Revolution. Australia is uniquely positioned to help build a resilient food value chain and support programs aimed at addressing existing and emerging food security challenges, such as:

- Vulnerability to climate change and climate variability.
- Slowing productivity growth in primary industries observed over the last decade.
- Increasing land degradation and soil fertility decline coupled with loss of productive land in peri-urban regions due to urban encroachment.
- Increasing reliance on imports of food and food production inputs (such as fertilisers) and the susceptibility of these supplies to pressures outside our control.
- A finely tuned and 'just in time' food transport and distribution system that presents risks of rapid spread of contaminated food and is vulnerable to events such as pandemics.

- Poor nutritional intake leading to an increasing burden of diet-related diseases in the population.
- Conflict in our region and elsewhere[4] (PMSEIC, 2010).

The main messages of the report included, a national approach to food, investing in R&D to reverse declining agricultural productivity growth, building human capacity to meet the challenges and opportunities faced and raising the importance and awareness of food in the public consciousness. Food production and processing is a fundamental part of Australia's economy and the health and wellbeing of its citizens. Food, however, is not currently dealt with in a way which brings together food related policy, regulatory agencies and research organisations.

The social and economic incentive of Intensive Horticultural Buildings on the environment are of noteworthy significance. For example, a closed system IHB can deliver near zero waste water all year round. Controlled environment allows better use of integrated pest management (IPM), benefiting the growers economic standing, marketing potential and the end-consumers' health.

The table, below, documents estimated efficiency of production gains obtained by greenhouse vegetables compared to field production. As can be seen, incomparable production gains are achieved in all assessed vegetables, assisting growers to meet the growing domestic and international demands for fresh, Australian grown vegetables.

Greenhouse vs Field Production Efficiency Gains[5] (Smith, 2007)

Crop	Tomatoes	Capsicum	Cucumber	Lettuce
Greenhouse (kg/m^2)	76	30	100	80
Field (kg/m^2)	18	12	20	10
Efficiency Gains (%)	422	250	500	800

Australia is one of the driest inhabited continent in the world; 70% of it is either arid or semi-arid land. The arid zone is defined as areas which receive an average rainfall of 250mm or less.

The semi-arid zone is defined as areas which receive an average rainfall between 250 to 350mm[6] (Australian Government Department of the Environment and Energy, 2017). Constructing, operating and maintaining intensive horticultural buildings on

[4] PMSEIC, 2010. *Australia and Food Security in a Changing World,* s.l.: Australian Government.

[5] Smith, G., 2007. Field Vs Glasshouse Tomatoes. *Practical Hydroponics and Greenhouses,* May/June - 2007(94).

[6] Australian Government Department of the Environment and Energy, 2017. *Outback Australia - the rangelands.* [Online]
Available at: http://www.environment.gov.au/land/rangelands
[Accessed 5 March 2017].

marginal (arid) land is generally not an issue, meaning land generally ill-suited for horticulture becomes available and suitable for use if a stable water, gas and electricity supply is achieved. With an increasing global demand for fresh, safe produce Australia has sufficient available land for increased horticultural output through the means of intensive production.

The Proposal solves the issue by reducing burden and increasing ease of protected cropping development which increases Australia's food security and independence.

Technical Solvers

The recommendations made within the Proposal for Change have been developed around technical analytical models, international literary review and relevant engineering theory. Growing vegetables within an IHB is an extension and the next evolutionary stage of field farming, which are often located in areas void of a prompt fire fighting response. It is common knowledge that the longer a fire is left unattended, the more difficult it is to contain. Fires commonly start at a discreet point within a building and can quickly spread through combustible materials. Due to farm expansion and development, it is common for IHB facilities to be open and inter-connected. Although there have been relatively few documented serious greenhouse fires, each occurrence has taken place where there was high potential fire risk. This high fire risk leads to a fire consequence, consequences including potential loss of life and serious property damage. The various high risks that may be present are the increased size of the installation due to add-on growth, high value of the protected crop, the use of highly combustible modern plastics and the use of automation including production, lighting and environmental controls.

To determine actual fire risks, the Project Team has developed fire models of each of the IHB group classifications (Group A, Group B, Group C) using the program CFAST, version 7.2.1. This program was developed by the National Institute of Standards and Technology and is used to simulate the impact of fires in building environments. CFAST is a two-zone model, which means that it simulates the environment in terms of a hot upper smoke layer and a cooler non-smoke lower layer and produces outputs accordingly. Refer to Technical Report titled 'Fire Safety Review' by Ferm Engineering which can be found within the appendix of the VG16004 Summary of Process document.

The following excerpt has been taken from the aforementioned Ferm Engineering report. It is advised that the Fire Safety Review report be read in its entirety and the content below as an executive summary of findings.

7.0 RESULTS DISCUSSION

The results shown identify a number of critical points arguing that these greenhouses are inherently safe for use. These are:

- *Evacuation*
- *Room temperature*
- *Smoke inhalation*

There is a smoke phenomenon called ceiling jet flow. In the event of a fire, hot plume gases rise to the ceiling. These hot gases fill empty space in a small layer underneath the ceiling. In a small compartment, this only exists briefly at the start before the compartment fills with smoke and this layer thickens to the floor. This can explain the smoke layer height figure shown above. The smaller structures are more irregular due to a smaller area for the ceiling jets to reach.

Similarities can be seen between the group B greenhouses and the group A greenhouses. Fire heat and buoyancy pressure in the fire compartment causes smoke to jet outwards resulting in extending very hot thin smoke layer radiating from the fire. Roof shape dictates how far this goes.

Separation distance

From the models, if these buildings are on fire then the impact of heat radiation on the adjoining area is shown to be low, radiant heat less than other forms of Type C construction, with the low fire loads. The separation distances studied were 3m, 6m, 10m and 18m. Justification for the selection of the distances is as follows:

- *Separation distance of 3m is selected because the BCA already specifies a minimum distance of 3m from a fire source feature, so the impact of a minimum 3m setback from a boundary is acceptable.*
- *Separation distance of 6m is selected since it's the BCA clause C3.2 specified distance between buildings on the same allotment to minimise the risk of fire spread for access by fire vehicles.*

These will be recommended in the H3 revision.

Group A

The introduction of natural ventilation in Group A drastically decreases the effects of the fire in the greenhouse. This can be seen throughout the graphs as the closed situation is significantly hotter than its counterpart natural ventilation scenario. It should be noted that the smoke layer exhibits strange characteristics, which is due to the ratio of opening area to surface area of the greenhouse. The openings cause a pressure drop, allowing smoke to escape after the initial stages. This causes the apparent drop and flat profile shown. Each revision demonstrates that in no case does the smoke layer reach below the 7m mark. This provides adequate time and space for evacuation before structural failure.

Appendix A shows the remaining graphs and visual output from the CFAST simulation.

Group B

The smoke layer height and upper layer temperature graphs show the effect of the melting of PMMA in the smallest three structures. For the smallest structure (500m^2), as the fire grows, the smoke layer begins to thicken simply because the whole room is beginning to heat up. This can be seen from the similarities between upper and lower layer temperatures. However, once the fire peaks, ceiling jets begin to appear and push smoke to the edges (outer compartments not shown in graphs) and pressurize the center compartment where the fire is *located. This cause the smoke layer of the center compartment to drastically reduce and become very hot very rapidly.*

Once the opening is introduced for the PMMA melting, smoke is released. Temperature and pressure decreases causing ceiling jets to disappear and a thickened uniform hot upper layer across all compartments to replace the dangerous hot smoke layer. These effects can be seen in all revisions, however, the added area for each structure results in a less pronounced effect of this phenomenon.

The introduction of the PMMA melting allows the fire to explode due to a breath of fresh oxygen. This vent however, provides constant relief to the rest of the structure by decreasing the layer of hot smoke and localizes damage to directly above the fire.

Each revision has an increasingly longer evacuation distance and at some point will need 2 fire exits. The large areas modelled are very safe as the smoke layer is only dangerous for the 500m2 revision. Worst case scenario is that an evacuee will have to travel 30m in 200 seconds, or travel at 0.15m/s. Since the smoke layer does not reach below 2m, this travel can be easily attained in a fire situation.

Appendix B shows remaining graphs and Group B sensitivity analysis which includes 4m tall structures and double the fire load to 12MW. The 12MW increases the temperature of the smoke layer from 240°C to approximately 300°C, a relatively small change for the change in fire load. The same can be seen from a 4m structure, a smoke layer of 250°C is recorded, however, this increases to 350°C with a 12MW fire.

Group C

The impact of the polycarbonate bursting is very evident in this figure and almost becomes a precautionary measure. Once a ceiling vent is introduced, smoke starts to billow out of it, reducing the hot smoke layer and allowing a safe environment for someone to crawl. The polycarbonate bursting turns out to have a pronounced effect on smoke inhalation and temperatures at crawling levels. The introduction of the polycarbonate bursting allows the fire to explode due to a breath of fresh oxygen.

This vent however, provides constant relief to the rest of the structure by decreasing the layer of hot smoke and localizes damage to directly above the fire.

Each revision has an increasingly longer evacuation distance and at some point will need 2 fire exits. All figures show that at worst case, a person will have to travel approximately 15m in 210 seconds from when the fire starts to spread. This model assumes the worst case and the fire starts burning at time zero, it excludes any detection and suppression.

Appendix C shows Group C sensitivity analysis which includes 3m and 5m tall structures. An increase in height shows little changes to the temperature of the structure, but a decrease in the height results in a 50°C increase of internal temperatures.

Travel Distance Safety Review

*All the travel distance ASET time analyses for the different structures revealed how much time is actually available in these structures. The way the fail with roof venting by the materials and volumes of released smoke, means the smoke spread is low. Areas are **not** filled with smoke rapidly.*

It is taken as 60m as per concession in QDC Part 3.7. On this basis, a safety factor applied to the travel time is (T3+SF2), which is 120 seconds (i.e.60sec + 60sec) respectively. In comparison to this, safety factors are not applied in standard Deemed to satisfy design.

ASET Determination

Based on the IFEG, tenability for occupant life safety is assessed on the following conditions not endangering human life:

- *Temperature*
- *Level of visibility For the purpose of this project, the limits of acceptability will be as follows:*

- *Occupant Tenability Criteria 1 - Smoke Layer ≥ 2.0m*

- *Hot Layer exposure less than 80-100C*
- *Fire Engineering Design Guide [i] suggests that the acceptance radiant heat from the upper smoke layer at the head height (2.1m above the floor level) should not exceed 2.5kW/m² which corresponds to the average upper smoke temperature of 200℃).*

Therefore, the adopted acceptance criteria are:

- *When smoke layer height drops to ≥ 2.0m, radiant heat at head height (2.1m AFFL) shall be ≤ 2.5kW/m² (or ≤ 200℃)*

In all the cases listed above, these conditions prevailed to safely accommodation evacuation distances well above the 40m in the DtS and up 80m is of no additional risk to occupants.

Materials used within an IHB are usually chosen for their useful structural properties and features. It is, however, common for these materials to have unwanted or unexpected risks especially in the area of fire and egress.

Though able to transmit light, plastic glazing materials are not as energy efficient as other building materials that can be insulated. Modern plastic glazing and woven fabrics have been engineered to transmit light, resist wind, hail and chemical attack while at the same time improving energy efficiency[7] (Kinney, et al., 2012). Electronic automation of a typical IHB is also increasing, computer controlled open vents, lamps and fans are all environment control systems commonly installed in an Australian

[7] Kinney, L., Hutson, J., Stiles, M. & Clute, G., 2012. Energy-Efficient Greenhouse Breakthrough. *ACEEE,* Summer Study on Energy Efficiency in Buildings(13), pp. 176-188.

Greenhouse. These advancements assist in increased crop yield, stability and quality. It is, therefore, reasonable to assume that modern plastics and automation offer appropriate compromise between efficiency and risk.

An increase of electronic automation in an IHB encourages an additional risk of fire, being electrical components. A faulty electronic component can short circuit and emit sparks. Sparks can ignite combustible materials, such as plastic membrane. Growers, certifiers and designers recognise these undesirable risks, however accept the compromise because the value of these properties exceeds the alternative of designing and certifying an IHB that is truly fireproof and useless for growing plants. It is, therefore, important to determine the appropriate balance between risk management and benefits.

In addition to the structural aspects and contents of a greenhouse, its environment is unique to all other building classifications. A typical greenhouse environment includes high levels of temperature, moisture, ventilation and sometimes UV light to achieve the highest yield and crop quality. Technical models completed by Ferm Engineering also identified that: "The addition of natural ventilation creates a safer environment for evacuees at walking and in the smallest enclosures, at a crawling level, drastically reducing the hot smoke layer and reducing temperatures in the lower layer. It allows relief for the rest of the structure, localizing damage until the fire brigade arrives. The light weight fabrication is able to show thermal performance due to the sheer open sizes of these structures. Structurally weak roof or covering systems with polymer based products aids in the fire development, by burning away and allowing the heat to escape rapidly." Chemicals used on plants within an IHB can aggressively attack structural elements and membrane. All equipment, especially mechanical and electrical, is subject to wear and degradation.

Fortunately, steps can be taken in farm planning and management that assist in minimising fire risks, and provide procedures that result in a cleaner, safer and more efficient IHB operation. Many correlations exist between good fire risk management and good IHB farm operation management. It is not reasonable to assume the risk of an IHB fire will reach zero and be negligible; however, risk and associated consequences can be managed to levels that will minimise threats to human life and loss of property.

5. What alternatives to the proposal (regulatory and non-regulatory) have been considered and why are they not recommended?

Research methodology for this report was conducted in consultation with knowledgeable and expert parties, including consultation with construction lawyers, private certifiers, rural management specialists, fire engineers, regulators, growers, manufacturers and other industry members. A literary review of the existing standards and supporting documentation is the basis of all research methodology completed for this project.

Though there are alternatives to a national regulatory approach to IHBs, such as State-by-State regulation or 'Ministers Specifications' no approach provides an effective, nation-wide provisions approach like the BCA. State-by-State regulation provides provisions within an individual state, this has been found to create regulatory disparity between States which may lead to over or under regulation of IHBs and may affect growth and stability of the protected cropping industry.

Other non-regulatory alternatives which were considered include the development of technical and information toolboxes for growers and the affected industry. This option assists growers in becoming more engaged in the structure's approval process however it does little to reduce a new development's costs of compliance. Though benefits of a toolbox are not particularly applicable to classification of IHBs they do provide growers with a valuable resource. As such, a toolbox has been developed through this project to provide pertinent information for growers in the areas of design, construction and management of a protected cropping building.

The Impacts

6. Who will be affected by the proposal?

This proposal has a broad reach in regard to affected persons and industries, the below list outlines these groups which may include, but are not limited to:

- Australian Vegetable Growers;
- The Australian Protected Cropping Industry;
- Protected Cropping Manufacturers;
- Building Certifiers and Local Councils;
- National, State, Local and Rural Fire Authorities; and
- Australian Society.

7. In what way and to what extent will they be affected by the proposal?

The below describes the affected groups, as listed above, and in what way and to what extent they are affected.

Australian Vegetable Growers

With reduced regulatory ambiguity and unnecessary Provisions the Australian protected cropping growers shall be in a position to better meet the exponential growth of national and international demands for fresh, quality Australian produce. With a more concrete approach to IHB development assessments and approvals growers shall be in a better economic position to plan for development, be it new or an expansion, as having a solid classification and Provisions Framework for IHBs allows for better and more accurate initial cost estimates of the development.

Though the initial economic benefit of reduced unnecessary Provisions is significant it is also important to recognise the cost benefit of reduced Provisions over the building's design life. Technical engineering models developed by this project identify unnecessary NCC Provisions for buildings of this specific nature, for example, installation of a dedicated fire-suppression sprinkler system has been deemed unnecessary (see justification) and as such savings in yearly maintenance costs of sprinklers can be achieved. This project has identified through a grower survey that yearly maintenance costs of sprinklers are between $5,000 and $20,000 depending on the complexity and scale.

Intensive Horticultural Buildings commonly provide higher, more stable, economic returns for a grower's efforts compared to traditional annual vegetable production (field). Growers with access to these higher and more stable returns not only benefit themselves but also the local and national communities as a whole. This is the result of a reduction of the grower's perceived risk in the cost of further development, allowing for increased capital and operational expenditure assisting the growth of local economies and national economies as well as assisting to meet food produce demand of rapidly expanding local, national and global populations.

The below Case Study provides further comparative data between field and greenhouse vegetable production, in the case of tomatoes.

Tomato Growing Case Study[8] (Smith, 2007)

	Field	Greenhouse	% Increase
Size	1 ha	1 ha	0%
Plant Density (average/m²)	1.1	2.2	100%
Total Plants	11,000	22,000	100%
Annual Production (kg)	69,231	585,000	845%
% 1st Grade	80 + %	95 + %	12%
Effective Production (1st grade kg)	58,846	555,750	944%
Effective Production (kg per m²)	5.9	55.6	944%
Effective Production (kg per plant)	5.3	25.3	472%
Water Use	8 M/L	14.5 M/L	182%
Conversion Rate (grams of fruit per litre water)	7.4	38.2	519%
Production per M/L (tonnes)	8.7	40.2	465%
Market Returns (gross)	$82,385 ($1.40/kg)	$1,667,250 ($3/kg)	2,024%
Crop Length (months)	± 7	11.5	164%
Equivalent Field Production (ha)	1	9.4	944%

When reviewing the production figures, it appears on the surface that greenhouse production uses more water than field production, however it's worth noting greenhouse production occurs over 11.5 months compared to ± 7 months for field production. It should also be stated that the greenhouse water usage figures include all water used, not just that used for irrigating crops (i.e. fogging, roof sprinklers, hand

[8] Smith, G., 2007. Field Vs Glasshouse Tomatoes. *Practical Hydroponics and Greenhouses,* May/June - 2007(94).

washing, staff facilities, etc.). It is important to note the conversion rate of water used for tomato production per one litre of water a greenhouse facility can produce 38.2 grams of fruit compared to only 7.4 grams in the field, this justifies the larger water usage figures within a typical greenhouse. Additional water usage justification comes in the form of production of fruit per megalitre (M/L) of water, a greenhouse can produce 40.2 tonnes per M/L while the field only produces 8.7 tonnes.

If implemented, this Proposal for Change will encourage non-protected cropping growers to investigate protected cropping as a viable alternative to field production and an investment in themselves, their business and their local community.

Australian Vegetable Growers Cost-Benefit Analysis

A cost-benefit analysis has been completed on the subject of 'hydrant and sprinklers vs fires' in Australian IHBs. Cost benefit analysis (**CBA**), sometimes called benefit cost analysis (**BCA**), is a systematic approach to estimating the strengths and weaknesses of alternatives (for example in transactions, activities, functional business requirements or projects investments); it is used to determine options that provide the best approach to achieve benefits while preserving savings. The CBA is also defined as a systematic process for calculating and comparing benefits and costs of a decision, policy (with particular regard to government policy) or (in general) project.

Broadly, CBA has two main purposes:

1. To determine if an investment/decision is sound (justification/feasibility) – verifying whether its benefits outweigh the costs, and by how much;
2. To provide a basis for comparing projects – which involves comparing the total expected cost of each option against its total expected benefits.

CBA is related to (but distinct from) cost-effectiveness analysis. In CBA, benefits and costs are expressed in monetary terms, and are adjusted for the time value of money, so that all flows of benefits and flows of project costs over time (which tend to occur at different points in time) are expressed on a common basis in terms of their net present value.

The following cost-benefit analysis has been completed using data provided by a protected cropping grower with IHB buildings within the Group A and Group B classification. Evidence other than that shown in the below analysis has not been provided to protect the growers identify. The identity of the grower shall not be disclosed by this Document or the Project Team.

General information and figures provided by a grower (in today's money):

- Cost of IHB = $13,200,000 AUD
- Size of IHB = 8 ha
- Group Classification of IHB = Group A
- Revenue from the IHB per year = $10,000,000 AUD
- Design and installation cost of fire system (hydrants and sprinklers) = $325,000 AUD
- Maintenance of fire system over 50-year building design life = $750,000 AUD ($15,000 per year)

Analysis Part One: Approximate costs associated with the installation of hydrants and dedicated fire suppression sprinklers for the grower's newest 8 ha Group A IHB are as follows:

- Design and installation of the hydrant and suppression sprinklers = $325,000 AUD
- Maintenance of fire system over 50-year building design life = $750,000 AUD ($15,000 per year)

Therefore, the total estimated cost of the fire system for the structure's 50-year design life is approximately $1,075,000 in today's money. If a fire was to develop in the structure it is predicted, through fire models, that the structure would lose approximately 20% of a year's produce due to smoke and heat damage, the cost of this is estimated to be $2,000,000 of lost revenue for a year – it is predicted that the fire system would prevent a majority of structural failure however $1,200,000 in maintenance and localised repair/replacement would be expected. The general cost to benefit(loss) ratio is 3.0 for an installed fire system and estimated loss in the event of a fire.

Analysis Part Two: An analysis was then undertaken in the event that the Provisions documented within the Proposal for Change were applied to the 8 ha Group A structure. Estimated costs have been provided below:

- Cost of the storage tanks and other specified equipment = $140,000 AUD
- Maintenance of the equipment over 50-year building design life = $100,000 AUD ($2,000 per year)

Therefore, the estimated cost of the equipment (as specified in the PCF) for a structure's 50-year design life is approximately $240,000 in today's money. If a fire was to develop in the structure it is predicted, through fire models, that the structure would lose approximately 70% of a year's produce due to smoke and heat damage, the cost of this is estimated to be $8,400,000 of lost revenue for a year – it is predicted that the fire system would prevent total structural failure however $8,250,000 in maintenance and repair would be expected. The general cost to benefit(loss) ratio is 87.6 for an installed fire system and estimated loss in the event of a fire.

Comparing the two ratios it is found that the second case, where provision of the PFC is imposed, has a lower cost benefit in the event of a fire. However, through consultation which included grower surveys and insurance industry discussions, it was found that the likelihood of a moderate fire (refer to FERM report for kW) is unlikely. The Project Team was unable to identify enough cases of a fire in an Australian IHB to determine an accurate annual probability of occurrence. To develop the analysis a deemed conservative annual probability of occurrence of a fire in a Group A IHB was taken as 1 moderate fire every 50 years of operations, 1.00 times within the building's working life of 50 years.

Assuming that financial cost savings in fire related Provisions, estimated at $835,000 (Part One $1,075,000 – Part Two $240,000) were invested in a larger facility the facility would be approximately 0.5 ha larger (total area of 8.5 ha). Assuming the additional 0.5 ha has a similar production to the remaining 8 ha it is expected that the facility will make an additional $625,000 in revenue per year due to the additional building area of 0.5 ha. Forwarding this revenue over the building's 50-year design life an additional $31,250,000 would be expected in today's money. Now, assessing the potential additional revenue against the increased potential losses in the event of a fire within the building's design life (1:50 years) it is found that the cost-benefit analysis greatly favours the outcome and Provisions within the Proposal for Change.

Note One: The annual probability of occurrence provided above can not be justified and is taken as a conservative estimate due to a lack of data around IHB fires in Australia. The Project Team does not standby nor guarantee this figure as it is subject to data currently unavailable.

Note Two: Though the economic losses have been shown as greater when the Proposal for Change is imposed it is important to note that the risk to occupants through egress times have been analysed and found to be suitable. For further information, refer to report by FERM Engineering.

The Australian Protected Cropping Industry

The protected cropping industry is one of the fastest growing food producing sectors in Australia. It is estimated that the farm-gate value of produce is $1.3 billion Australian Dollars per annum which is equivalent to approximately 20% of the total value of vegetable and flower production. If all sectors including retail, service providers, research, manufacture and growers are combined the protected cropping industry contributes approximately $1.8 billion to the national economy. The protected cropping industry currently employs over 10,000 people throughout Australia[9] (PCA, 2017).

The protected cropping industry is expanding at 4% to 6% per annum[10] (Smith, 2007).

Current investment in greenhouse vegetable infrastructure is conservatively valued at $975 million which is estimated to be 1,300 hectares at $75 per m^2. Annual investment in new infrastructure is valued at $50 million over the next 12 months which is estimated to be 25 hectares at $200 per m^2 (PCA, 2017).

Woolworths have doubled consumption of greenhouse capsicums every year since 2005[11] (Smith, 2007).

Through formal communications (grower survey) and informal communications (site visits, meetings and phone conversations) growers have identified a definitive classification method as the most important issue to encourage sector growth. 64.29% of growers responded that 'understanding the preparation, lodgement, assessment and approval process with local council (and private certifiers)' as the single most important improvement the Australian crop protection industry could make (Source: Osborn Consulting Survey).

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[9] PCA, 2017. *Our Industry.* [Online]
Available at: http://www.protectedcroppingaustralia.com/?page_id=94
[Accessed 22 March 2017].

[10] Smith, G., 2007. Field Vs Glasshouse Tomatoes. *Practical Hydroponics and Greenhouses,* May/June - 2007(94).

[11] Smith, G., 2007. Field Vs Glasshouse Tomatoes. *Practical Hydroponics and Greenhouses,* May/June - 2007(94).

If implemented, this Proposal for Change will further encourage growth and economic security in the industry which may, for example, translate to increased industry employment, industry turnover and the industry's contribution to Australia's economy.

Protected Cropping Manufacturers

Protected Cropping Manufacturers will benefit from not only increased sales but also increased assurance in knowing the structures they develop and sell meet the requirements stipulated within the BCA.

Manufacturer statement to be provided.

Building Certifiers and Local Councils

The Proposal for Change will make assessing IHBs more consistent for building certifiers and local councils.

Council statement to be provided.

National, State, Local and Rural Fire Authorities

Within the consultation process of this proposal, the rural fire services have been contacted in several states to assist in the review process. It is integral for the building application process to have a better understanding of the fire services provided in the rural environment.

Australian Society

Australian society may be positively affected by the Proposal in many direct and indirect ways. Australian society may benefit in the following ways by increasing the prevalence of IHBs:

- Increased food security – controlled production systems are able to more reliably offer products that meet both food security guidelines and the ever-increasing demands of discerning consumers;
- Fresh, flavoursome produce year-round – 12-month supply is available as climate variations are largely removed in protected cropping which is highly prized by retailers, wholesale and end customers;
- Reduction in pesticide on produce – reductions in pesticide use are generally considered good for public health and retailer marketing potential;
- Australian grown vegetables – Increasing quantity of vegetables grown in Australia which supports Australian growers and local industry. It also reduces food-miles and plant-to-plate times for environmental and health conscious consumers;
- High quality produce – greenhouse produce is reliably 95% first grade compared to field production of between 50% and 80%. High quality also delivers alternative packaging and presentation options with enhanced shelf-life and marketing potential; and

- Reduced horticultural water usage – Being a nation susceptible to drought, Australian society would benefit greatly from decreased ratio of water used to produce per kilogram of vegetables.

Previous international research has identified protected cropping, especially high climate controlled intensive horticultural buildings have higher °Brix (sugar) levels which delivers sweeter, more flavoursome fruits and vegetables with longer shelf life. Environmental conditions that most strongly influence crop quality and °Brix include sunlight, temperature, and moisture. Exposure to various combinations of these conditions due to planting and harvest schedules can influence elements of quality (including °Brix) and flavour in field and greenhouse-grown crops. These conditions influence the amount of soluble solids (mostly sugars) that are in marketable leaves, stems, fruits, tubers, roots, etc., at any one time. These factors influence °Brix levels alone and in combination. For example, temperature and light interact to set the rate of sugar production, but temperature may have a stronger influence on tomato fruit soluble solids content than sunlight[12] (Kleinhenz & Bumgarner, 2013).

Controlled-environment greenhouse production involves a greater amount of control over factors that influence crop growth, yield, and certain aspects of quality than field production. Overall, the greenhouse industry continues to pay close attention to the effects of variety selection and crop management on °Brix. Further, adjustments in management regimes to optimize °Brix and other characteristics are generally more feasible in greenhouse than field settings. Farmers working with soils in more dynamic and unpredictable open field and high tunnel settings have an opportunity to gain from what is discovered in greenhouse production and research. More importantly, field and high tunnel vegetable growers can learn from their own tests of the relationships between management and °Brix and other aspects of crop quality. It is of social and economic benefit for fruit and vegetables to have high, consistent levels of °Brix; higher quality, more flavoursome produce will encourage increased consumption of fruit and vegetables for a healthier Australia. These changes to the NCC allow for this to occur on a scaled and consistent basis for future development.

[12] Kleinhenz, M. & Bumgarner, N., 2013. Brix Values in Vegetable Crops. *Ohioline*, 18 January.

Consultation

8. Who has been consulted and what are their views?

Protected Cropping Growers and Associated Industry Bodies

A survey completed for this project of greenhouse growers in Australia was undertaken. This investigated the information needs of growers and where they source information, their preference for receiving information, as well as the strengths and weaknesses of the current regulatory system for greenhouse construction and safe operation. The survey was distributed through AUSVEG and Protected Cropping Australia e-news which reached 800+ email addresses; hardcopies of the survey were also distributed in the Volume 3 2016 Soilless Magazine. The survey received twenty-nine (29) responses from members within the IHB industry with a majority of the responses being from protected cropping vegetable growers. Survey responses can be found in this project's document titled 'Summary of Process'.

A draft version of the Proposal for Change document was released for public consultation and comments on May 1st, 2017 and closed on May 19th, 2017. The document was released to all survey participants via email, to PCA and AUSVEG for e-news inclusion (reaching over 800+ people) and to other engaged stakeholders. A copy of the consultation article has been provided in Appendix F of the Summary of Process document. The Project Team received general industry feedback and comments, these were assessed for validity and were included in this document and the Proposal for Change where deemed appropriate.

A webinar was delivered on May 12th, 2017 to provide an overview of the project findings, recommendations and resources for growers and industry stakeholders. This included the technical guidelines for greenhouses and grow structures for inclusion in the National Construction Code (NCC) developed under Part 1 of the project. While Part 2 developed a toolbox containing vital information and resources relating to the design, approvals, construction and safe operation of greenhouses in Australia; a tool specifically designed for growers and the protected vegetable cropping industry.

Throughout the project the Project Team has been in communication with Horticulture Innovations Australia Limited, engaged growers and protected cropping industry stakeholders to ensure their needs were assessed and included where appropriate.

Local Council Consultation

Throughout the consultation period the Project Team received feedback on the Proposal for Change from Local Councils. The Project received feedback from several Councils, this feedback has been documented below.

Building Certifiers from the Lockyer Valley Regional Council provided detailed feedback on the Proposal. The Lockyer Valley Region (located in South East Queensland) is heavily invested in horticulture and considers that the Proposal will provide a greater degree of clarity to the building industry over the correct classification of IHBs. Council Building Certifiers provided the following general comment about the Proposal:

"In regards to overall comments – this proposal will provide a greater degree of clarity to the building industry over the correct classification and decrease the time required

for design and certification as it provides a uniform set of requirements across the country and certainty over the correct classification of the building (IHBs). This should reduce the current variation between different certifiers and reduce economic burden on owners. It will decrease the overall time from conception of a project to finalisation particularly in the design process and in reduction of costly alternative solutions for fire safety and to achieve final certification of the structure. This in turn should increase the rate of compliant buildings as growers feel more confident to obtain development approvals for their buildings and final certification documentation prior to the use of the building. This will reduce the cost to Councils in compliance action as the number of unapproved structures is reduced. Having complaint approved buildings also has positive implication for the owners of these structures in regards to insurance (both in the event of a building destruction and worker injury) – in some cases insurances won't cover when the building does not have final certification of the building."[13] (Martin & Shum, 2017)

The Lockyer Valley Certifiers also provided direct feedback on specific items of the Proposal. These items were assessed by the Project Team and were incorporated into the final Proposal after consideration of inclusion consequences were determined.

Australian Institute of Building Surveyors Consultation

The Project Team engaged the technical consultation services of the Australian Institute of Building Surveyors (AIBS) throughout this project. In late May of 2017 the Project Team was informed via email from the National Technical Manager of AIBS that the then proposed building verification method (no longer included within the PFC NCC Volume One and Volume Two) would not be supported by the Institute. The Institute outlined that they support a prescriptive method of classification rather than a method reliant on a building surveyor's assessment (verification method).

Further information in regards to the classification options considered can be found in Section 5.0 of this project's document titled 'Summary of Process'.

The Project Team recognises the importance of AIBS's feedback and has endeavoured to meet their requests while maintaining the project's key outcomes of reducing burden on protected cropping growers.

Fire Authority Consulting

To be provided.

[13] Martin, G. & Shum, G., 2017. *Proposal for Change National Construction Cose Series - Intennsive Horticultural Building Inclusion Farm Buildings,* s.l.: Lockyer Valley Regional Council.

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Appendix B: FERM Engineering Report

ACN 097 535 996

FARM BUILDINGS
GREENHOUSE CLASSIFICATION AND DEFINITION
INTENSIVE HORTICULTURAL BUILDING (IBH)

FIRE SAFETY REVIEW

FARM BUILDINGS
CATEGORY GROUPS A, B AND C

FIRE AND EGRESS AND MODELLING

For

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FIGURES

ABBREVIATIONS USED

ABS	Alternative Building Solution – Building Code defines as a variance to prescriptive designs
ASET	Available Safe Egress Time – Used for tenability time evaluations
BCA	Building Code of Australia
DTS	Deemed to Satisfy provisions within the Building Code of Australia
FEB	Fire Engineering Brief – Briefing Document of Fire Safety Options
FER	Fire Engineering Report
FIP	Fire Indicator Panel
FRL	Fire Resistance Level- Defines Structural / Integrity / Insulation resistance times
IFEG	International Fire Engineering Guidelines – Referenced by Australian Building Codes Board
NIST	National Institute of Standards and Technology
NCC	National Construction Code
QFES	Queensland Fire and Emergency Service
RSET	Required Safe Egress Time – Used for egress evaluations

FARM BUILDINGS

GREENHOUSE CLASSIFICATION AND DEFINITION INTENSIVE HORTICULTURAL BUILDING (IBH)

FIRE SAFETY REVIEW

FIRE AND EGRESS

MODELLING ASSESSMENTS

8TH JUNE 2017

1. INTRODUCTION

Horticulture Innovation Australia, Osborn Consulting Engineers, FERM, RMCG and Doyle's Construction Lawyers are commissioned to undertake a Proposal for change to the NCC for Farm Buildings.

This project, titled: "*Developing technical guidelines and best practices extension toolbox for greenhouse construction and safe operations*" .

In Part 1 of this project the project team is developing technical guidelines for Greenhouse and Grow Structures (G/GS) for inclusion in the NCC .

In Part 2 develops and communicates relevant G/GS's information for growers in an accessible and practical format. This report forms the Fire Safety aspect of the greenhouse review in Part 2.

FERM Engineering, has consulted the ABCB methods of assessing the Classification of Buildings. The ABCB guide is attached in Appendix A for review. In there is a small section of Farm Buildings. The NCC has only defined terms 'farm building' and 'farm shed' as two different types of buildings used for 'farming'. This is not the case in the hobby and commercial farming community.

In this review Part 2, we look at the fire safety inclusion of a new group of farm buildings, not under the classification type 7 and 8. They are defined as Intensive Horticultural Buildings or (IHB).

These have been modeled as "Group" type greenhouse construction for which we have created three categories A, B, C.

The definition of these categories or "Group" of construction is based on the proposed redefined Farm Buildings as Intensive Horticultural Buildings or (IHB) and the proposal for change will include the following classification note:

Farm building means a Class 7, ~~or~~ 8 or 10 building located on land primarily used for *farming* -

(a) that is either -

(i) used in connection with *farming*; or

(ii) used primarily to store one or more farm vehicles; or

(iii) that is an *Intensive Horticultural Building* belonging to one or a combination of the following groups -

(A) GROUP A *Intensive Horticulture Buildings* – *Intensive Horticultural Buildings* built with an average roof height of 5 to 9 m and a total floor area exceeding 500 m^2;

(B) GROUP B *Intensive Horticulture Buildings* – *Intensive Horticulture Buildings* built with an average roof height of 2 to 5 m and a total floor area exceeding 500 m^2;

(C) GROUP C *Intensive Horticulture Buildings* – *Intensive Horticulture Buildings* constructed with a total floor area no greater than 500 m^2 shall be classified as Class 10d; Fabric canopy cable structures with no limitation on roof height and total floor area shall be classified as Class 10d or

(iv) any combination of (i), (ii) and (iii) and

(b) in which the total number of persons accommodated at any time does not exceed –

(i) one person per 200 m^2 of floor area or part thereof, up to a maximum of 8 persons for general farm buildings;

(ii) one person per 600 m^2 of floor area or part thereof for Group A *Intensive Horticultural Buildings;*

(iii) one person per 400 m^2 of floor area or part thereof for Group B *Intensive Horticultural Buildings; and*

(iv) one person per 100 m^2 of floor area of part thereof, up to a maximum of 5 persons for Group C *Intensive Horticultural Buildings*; and

(c) with a total floor area of not more than 3500 m^2 for general farm buildings. There are no maximum floor areas prescribed for Group A and B intensive horticultural buildings.

The purpose of this fire safety report is to assess the possible fire implications and offer recommendations of fire safety systems. These reviews are undertaken with the modeling of hazards and possible fires and the assessment of greenhouse construction materials found in these three Groups of use A, B, C and their fire behavior. There is also a need to understand any distinction between animal farm buildings and horticultural buildings as the hazards and uses are different, even though the size may not.

In the conclusion, we recommend a redefined set of guidelines for a NCC Proposal of Change, which modifies the current NCC Section H3 and compares these to the current guide for "Classification of Farm Buildings and Sheds" on the ABCB website issued in May 2017.

2. FARM BUILDING CLASSIFICATION AND MODEL OUTLINE

The total risk matrix for each category Group of IHB can be shown in the table below. A proposal to the NCC is to create a revised section **H3** based research to add group A, B and C greenhouse construction as a range of either class 7, 8 and a new class 10d building.

We outline the parameters assessed for each Group.

	GROUP A	GROUP B	GROUP C
Total Risk-Point	# to #	# to #	Less than #
Explanation	These structures have the highest risk and associated consequences.	These structures have medium risk and associated consequences.	These structures have the lowest combined risk and associated consequences and may be considered as Class 10a buildings

Group A construction is developed as a high cost and operated commercially and industrial in nature. Due to the expense of these structures, they are not used for domestic purposes and are very elaborately designed. These greenhouses can encompass areas for the better part of 25,000 square meters.

High level construction must occur with these structures. Designs assessed have included greenhouses with large ridge vents and multiple frame spans. As a result, an average height has been calculated. This height is fire modeled at averages of 9m. Sensitivity fire load models have been carried out with 6MW, 12MW and 18MW fire loads and lower 7m high buildings.

Illustrations and image

Fig 1. Group A - Intensive Horticultural Building Large Area and Volume

Fig 2. Group A - Intensive Horticultural Building – Rigid Span

Group B construction is medium cost and typically commercial in nature, however, they can be used for domestic purposes. Notwithstanding, they encompass a larger area and height.

We assess these for fire risk in this draft paper. Construction must occur with medium labor and equipment because of the commercial purposes. As a result, we have averaged the height of these greenhouses to a constant 7m with varying floor areas to compare the effects of fire on different building envelope sizes. Sensitivity has been carried out with a 4m high structure and 6MW and 12MW fire loads.

Illustrations and image

Fig 3. Group B Farm Greenhouse Shed – Large Light Weight Spans

Group C construction is low cost and domestic in nature. This means that construction can occur without excessive building equipment and labor.

As a result, we have averaged the height of these greenhouses to a constant 4m with varying floor areas to compare the effects of fire on different building envelope sizes. Sensitivity for this group includes 3m and 5m high structures.

Illustrations and image

Fig 4. Group C Farm Greenhouse Shed

Fig 5. Group C Farm Greenhouse Shed

Fig 6. Group C Farm Style Shed – Class 10d)

Fig 7. Group C Packaged Greenhouse – Small Scale 10 d)

3. STUDY OUTLINE

The study has been based on a building assessment research project by the Horticulture Innovation Australia who have commissioned this study. This has also been included in previous work by the Australia Building Codes board and the Queensland development code who have both produced studies on farm buildings.

These requirements have been published in the National Construction Code and in South Australia and Queensland the QDC MP3.7. This study is to take that information further to different types of rural construction to undertake a new proposal for these types of construction as the models presented would appear to be inadequate for the rural sectors requirements.

In the research of growers, in various state rural sectors they were not adequately consulted, as determined by a survey of growers and members of the rural sector indicated they could have been better served by better research, which is now being undertaken.

The research was to look at three major types of construction used on farms and growing sectors that have an impact on fire safety for workers or processes within these IHB structures. We hope to determine new structure classification by their use and define new forms of fire system criteria for assessments or the degree of necessary fire protection, evacuation and intervention strategies.

Additional research has been undertaken on the materials of use and potential flammability for fire scenarios on these different structures. These include a number of structural elements being aluminum, steel or composite materials and the fabrics of sales, heshons and curtains that are adopted for translucent sun light and shade for the growing cycles.

Greenhouse carbon dioxide enrichment [Ref 6, 7]

The potential use of carbon dioxide enrichment in greenhouse cultivation to enhance plant growth has been known for nearly 100 years. After the development of equipment for the controlled serial enrichment of carbon dioxide, the technique was established on a broad scale in the Netherlands. In Japan, trees of mandarin oranges are often grown in containers within plastic greenhouses which results in high yields of earlier, blemish-free fruit.

Similarly in Australia, Valencia orange trees grown in containers under CO_2 enrichment from time of flowering until fruit harvest yielded 70% more fruit.

Fig 8. Large Scale Greenhouse Rooms – Enrichment with CO_2

Leafy vegetables, fruit and ornamentals are commonly grown under CO_2 enrichment. Enrichment of lettuce and celery is very effective since most of the total plant weight contributes to marketable harvest weight. Two-to three-fold enrichment of CO_2 concentrations can result in midwinter lettuce that either is 25–40% heavier at harvest or takes 10–15 fewer days to attain a standard market weight. Celery responds similarly by producing a heavier 'stalk' or requiring reduced time to reach marketable size.

Commercial greenhouses can be located near appropriate industrial facilities for mutual benefit. For example, Cornerways Nursery in the UK is strategically placed near a major sugar refinery consuming both waste heat and CO_2 from the refinery, which would otherwise be vented to atmosphere. The refinery reduces its carbon emissions, whilst the nursery enjoys boosted tomato yields and does not need to provide its own greenhouse heating.

An issue of CO_2 consumption in these type of facilities will allow the potential to also reduce the fire potential with reduced O_2 levels to acceptable at human levels but reduced for fire development. NO_2 type has been already applied commercially as well, so these need to be considered in the future as well.

Farm Building Services

The potential use of internal farm building infrastructure for fire safety could be a useful a factor in many of these building situations. Most IHB have access to most of the following systems or services:

- irrigation sprays and drip feeders
- water reticulation,
- water storage,
- building ventilation with passive and motorised,
- the light weight materials are able to vent fires
- vehicle access points and driveways
- lighting or electrical / solar
- Seasonal use

The other important aspect is their location. Often in rural settings, long travel times for limited fire fighting appliances to attend. These long delays in the event of fire have shown to be potentially no chance of fire intervention and when a fire has occurred, low levels of damage by the way they are built.

So commercial costs and sustainable construction must be applied, as this will allow the industry to grow, and NCC provisions adjusted to prevent un-sustainable costs applied, given such low risks to both life and property.

4. FIRE MODEL OUTLINE

To model fires in these Groups of IHB constructions, we have used the program CFAST, version 7.2.1. This program was developed by NIST (National Institute of Standards and Technology) and is used to simulate the impact of fires in building environments.

CFAST is a two-zone model, which means that it simulates the environment in terms of a hot upper smoke layer and a cooler non-smoke lower layer and produces outputs accordingly.

The simplified fire and plume model was adopted due to the open nature of these buildings, as fires will be unconstrained. In some cases, the fire will behave as if in the complete open. This is illustrated below.

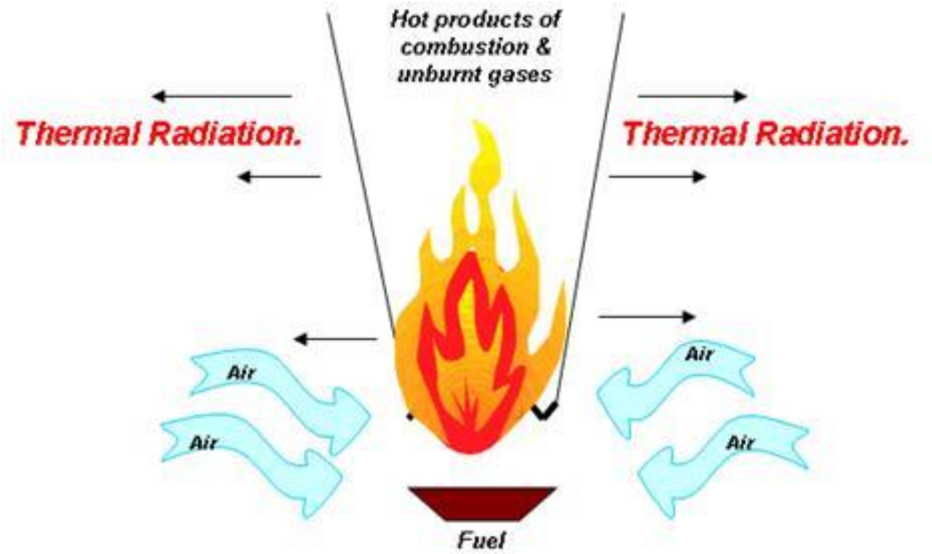


Fig 9. Fire Plume Schematic

Air is entrained adding volume to un-burnt gases. As a result, the plume has traits of an upside down cone, as the area of hot gases gets larger. Calculations of flame height can be found in The SFPE Handbook of Fire Safety Engineering.

The flame height was then put into an equation for a truncated cone for a simplified fire plume. The larger radius of the truncated cone was found to be approximately 20 square meters, which was the input area for the melted ceiling vent.

Although the ceiling vent was a constant area, each revision had a specific timing that the roof membrane (PVC, PMMA, Polycarbonate, etc) would melt. These results are shown in the Appendies of the report for all the second round of sensitivity modeling.

Group A Fire Scenario Models

As mentioned above, we have assumed a constant height of 9m due to the domestic nature of this greenhouse construction type. We then allocated 4 different floor areas and the height averaged at 9m.

- 2,000m² (70x30m),
- 5,000m² (110x45m),
- 10,000m² (170x60m) and
- 15,000m² (190x80m).

These structures are high scale commercial greenhouses. Therefore, glass has been chosen as the sheeting material with structural steel as the framing. Although it is preceded by polycarbonate and PMMA for strength, glass is still used very commonly in large commercial greenhouses. It can come in a range of thicknesses providing adequate impact resistance for day to day incidents. The main characteristics however, are longevity and light clarity which still makes it very contemporary.

The properties of glass do not allow it to be very suitable for high impact but it is heat resistant. Glass has no specific melting point, but a transformation range where it changes from solid state to a viscous plastic state. There is no true defined range, however, reports show that it is roughly 500-550°C.

Two models were ran as part of this assessment. The first was a simple enclosed model where no oxygen could leak in or escape. The second was a spin off with the introduction of large natural ventilation throughout the structure. Ventilation is very important in greenhouses for humidity and temperature control. These can also act as safety precautions during a fire.

It should be noted that netted structures are another form of greenhouse structure with similar sizes which are excluded in this report. There are options and alternatives where polyethylene does have fire retardant additives, however, these do not seem to suit large grow structures.

Normal netted structures will therefore have little impact on fire and smoke and will simply burn away. This net system will protect the contents inside from storm, however, it has little impact resistance structurally and light weight.

Sensitivity fire load models have been carried out with 6MW, 12MW and 18MW fire loads and lower 7m high buildings.

Group B Fire Scenario Models

We have assumed a constant height of 7m due to the domestic nature of this greenhouse construction type. We then allocated 6 different floor areas and the height averaged at 7m.

- 500m² (37.5x15m),
- 1,000m² (50x20m),
- 2,000m² (30x70m),

- 4,000m^2 (100x40m),
- 8,000m^2 (160x50m) and
- 10,000m^2 (170x60m).

Due to the low scale commercial nature of these structures, PMMA (polymethyl methacrylate) has been chosen for the sheeting material. PMMA is used regularly as a suitable replacement for glass because of its rigidness and light transparency.

Although it has been proven that polycarbonate is more durable than PMMA, is it roughly 3-4 times the cost of PMMA and has less ability to maintain clarity for light transparency, polycarbonate begins to form yellowness and loss of clarity from UV exposure. PMMA is often used in double or triple wall layers because of ease of it to be polished. This can increase the resistance to heat and impact.

It is difficult to pinpoint certain properties of PMMA since there are so many ranges of commercial compositions in the market. The glass transition temperature can range from 100-165°C and the crystalline melting temperature can range from 180-300°C. As mentioned previously, this also depends on the amount of wall layers used.

PMMA is also known to char, where up to 15% of the structure can undergo degradation in this way. This can act as a temporary barrier for heat impact in the direct vicinity of the fire.

Sensitivity has been carried out with 6MW and 12MW fire loads.

Group C Fire Scenario Models

We have assumed a constant height of 4m due to the domestic nature of this greenhouse construction type. We then allocated 7 different floor areas;

- 50m^2 (10x5m),
- 100m^2 (15x7m),
- 150m^2 (15x10m).
-

These structures are considered solely domestic in nature.

- 200m^2 (20x10m),
- 300m^2 (20x15m),
- 400m^2 (25x16m) and
- 500m^2 (25x20m).

These structures are considered both domestic and minor commercial structures.

In line with the domestic and low cost nature, we have used polycarbonate as the sheeting material. Polycarbonate is a thermoplastic; meaning that deformation due to elevated temperatures is reversible. Polycarbonate has two critical temperatures, the glass transition temperature (145-150˚C) and crystalline melting temperature (215-230˚C).

The glass transition temperature causes the material to reduce rigidity and become rubbery and soft. Thermal decomposition and pyrolysis occurs at 380-465˚C. Since the melting temperature is below thermal decomposition, the material will start to burn away, removing it from any immediate high heat source and creating a void where the fire is burning.

Polycarbonates are also capable of producing high amounts of char up to the thermal decomposition temperature, which can act as a temporary barrier between the heat and the material. This thermal barrier will help to stop the burn away to be even greater.

Sensitivity for this group C includes 3m and 5m high structures.

5. FIRE MODELS – CFAST RESULTS

Fires for each of these structures are quite different. For example, for Group A, it is largely commercial and profit making. Therefore, high level machinery and equipment is necessary within the structure, creating more risk of a larger fire. This is similar within Group B structures, however, the smaller scale prevents fire from becoming too large. For Group C, the scale of structure significantly prevents a large fire. Intervention is often done by the owners and no one else so this fire profile represents a quick growth but a slow decay.

Group A and B

The fire used was one supplied by CFAST and described as a "panel workstation" fire. Three different fire sizes were analyzed, 6MW, 12MW and 18MW for Group A and 6MW and 12MW for Group B. It is assumed that in a commercial greenhouse, there is enough rough for machinery and vehicles. Within a greenhouse are cellulose combustible items, in particular, plants, plant baskets and meshes, wooden shelves and benches, chemicals and shade cloths.

These flammable items can be amplified through the use of high amounts of ventilation, which is very common in this industry. The "panel workstation" fire profile was chosen because it imitates the traits of a greenhouse fire in a structure this size, that being a fire similar to a tractor fire with 300 seconds to peak, where it plateaus and oscillates as more objects catch fire and a decay of 300 seconds. The oscillation, for conservative purposes, was neglected and the fire assumes the peak heat release rate for 400-500 seconds. This is considered conservative.

For Group A structures, the next step in the process was to setup the CFAST models and the 4 revisions corresponding to each different floor area. This initial step assumed a closed building envelope with no ventilation whatsoever, simply to determine how hot it would get. The second round modelling involved high level ventilation, which is prominent in these structures.

For Group B, the next step was to introduce the PMMA failing and burning, and the structure to assume a void space for smoke to be relived through.

Group C

The fire used was one supplied by CFAST and described as a “bunk bed” fire. Within a greenhouse are cellulose combustible items, in particular, plants, plant baskets and meshes, wooden shelves and benches, chemicals and shade cloths.

The CFAST NIST fire model input called “bunk bed” fire profile was chosen because it imitates the traits of a possible small scale greenhouse fire of timber, plastic and foam elements. The Fire profile has a time to peak of 250 seconds, with a defined peak and a slow decay of 500-600 seconds. Fires in these small scale structures are often fought by owners with no other intervention, which is why it is such a long decay.

Similar to Group B, a first round of modelling was done to simply see how hot smoke would get. The next step was to introduce the polycarbonate bursting creating a void for smoke relief.

6. CFAST MODELLING OUTPUT SUMMARY

Below are the results of the first round of modeling for each Group category. These are the combined results of the sizes variation composited into single graphs. It should be noted that each group of structure has considerable size difference. Group C construction has only one compartment for each revision, however, to obtain a more accurate output, Group A and B have been separated into 10m long compartments which span the width of the structure. The output shown corresponds to the compartment with the fire, which is located in the middle of the structures for consistency purposes.

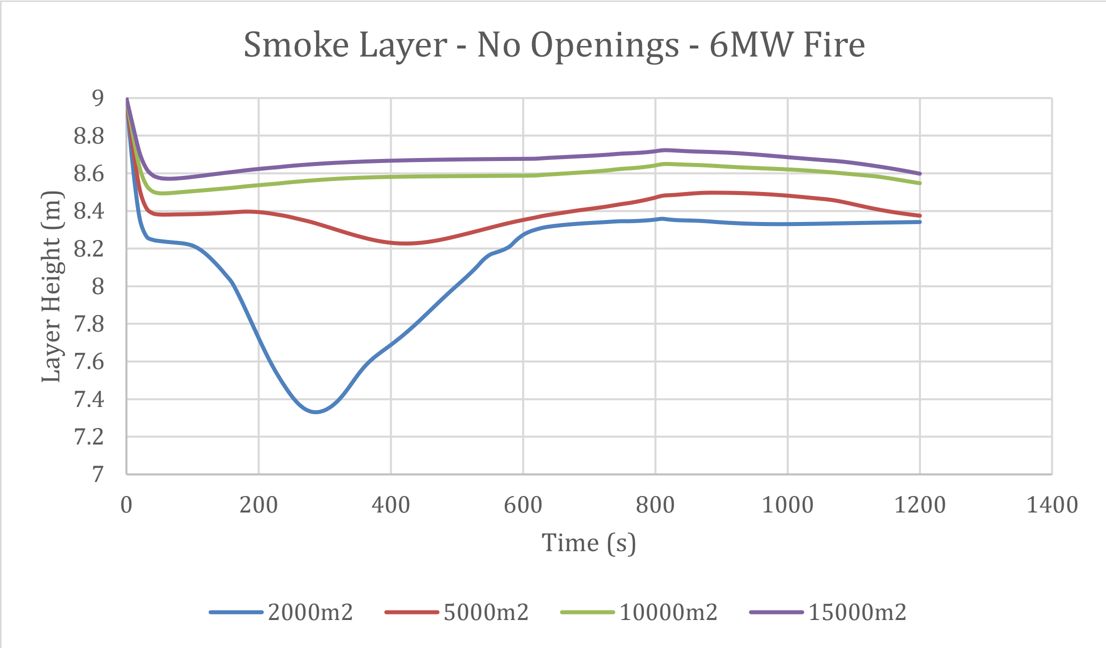
Group A

Area	No. of compartments	Width of compartment	Depth of compartment
200m^2	7	10m	30m
5000m^2	11	10m	45m
10000m^2	17	10m	60m
15000m^2	19	10m	80m

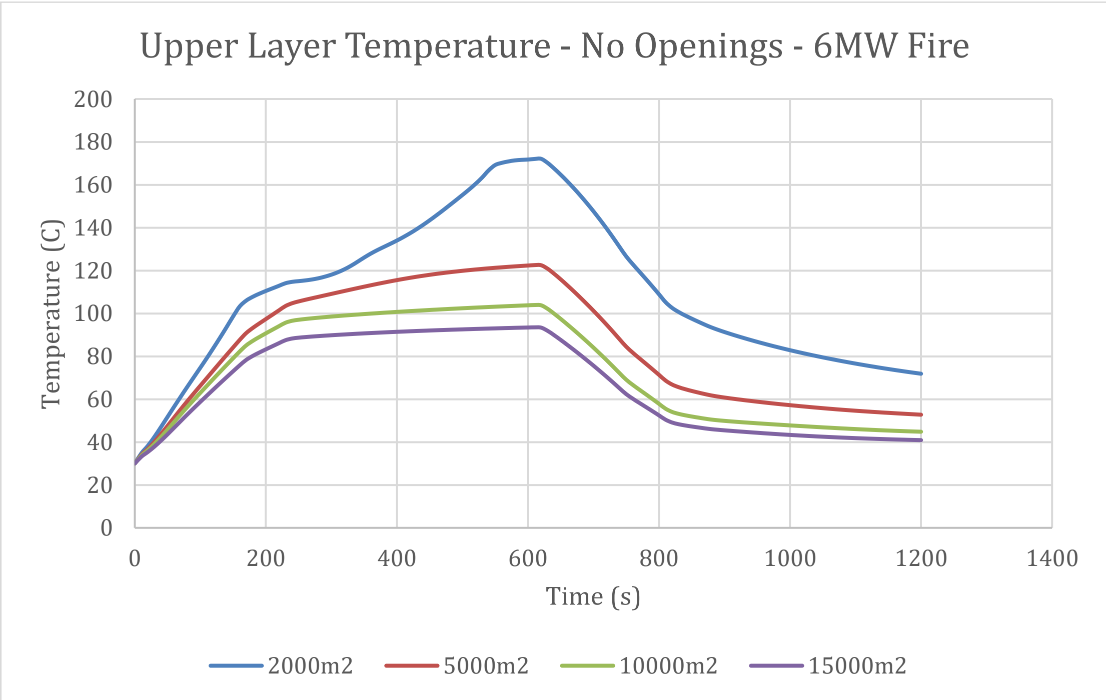
Group B

Area	No. of compartments	Width of compartment	Depth of compartment
500m^2	3	10m	37.5m
1000m^2	5	10m	20m
2000m^2	7	10m	30m
4000m^2	9	10m	40m
8000m^2	15	10m	50m
10000m^2	17	10m	60m

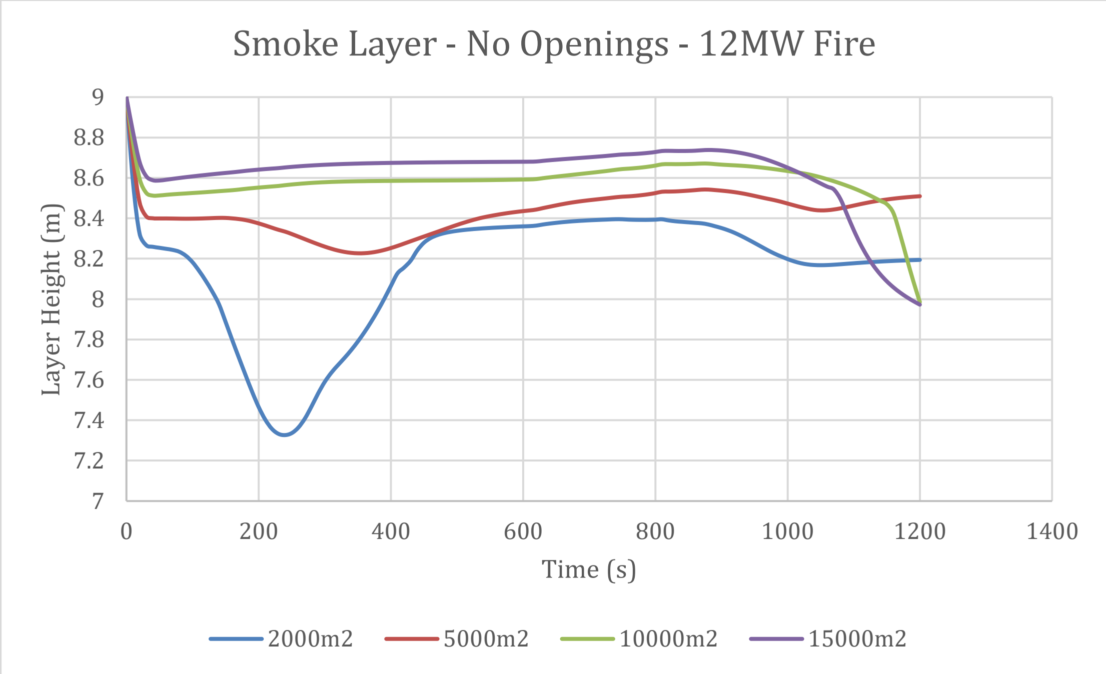
Group A



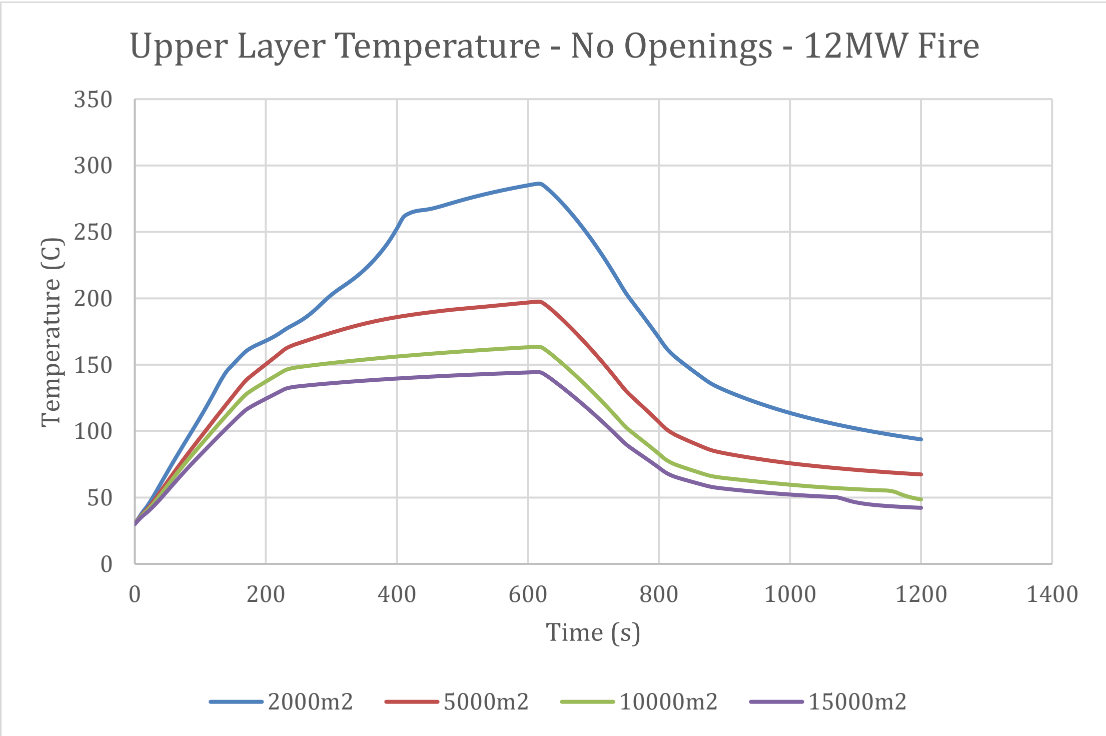
Height of Smoke Internally (6MW fire size)



Temperature of Smoke in upper layer

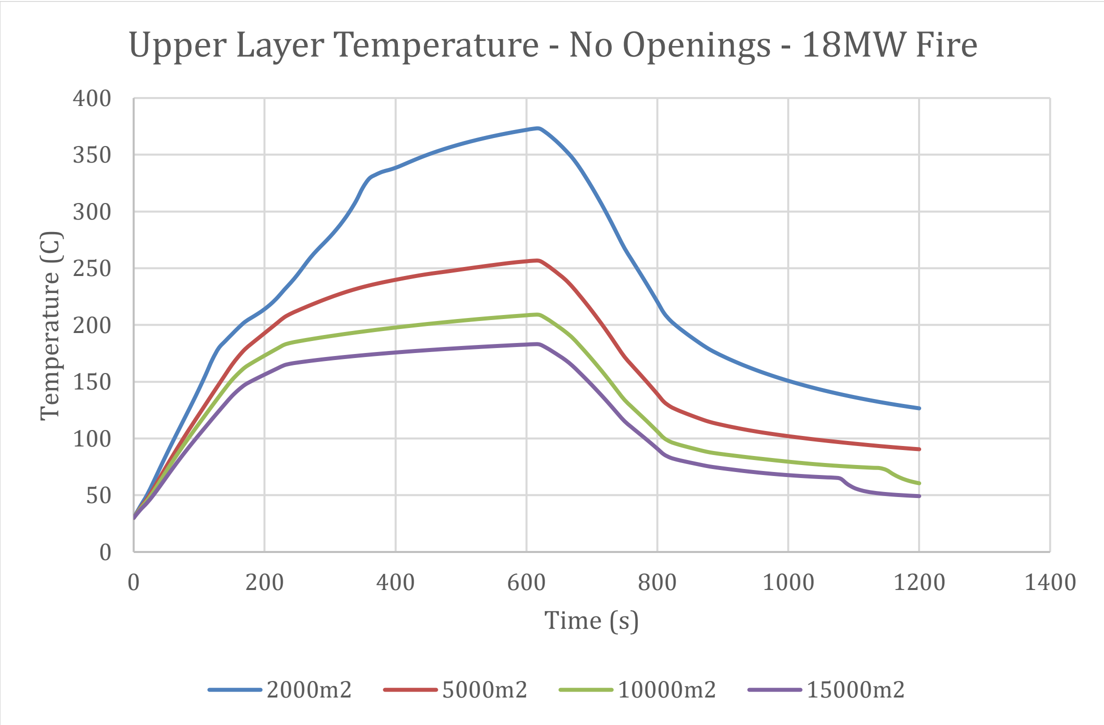


Height of Smoke Internally (12MW fire size)



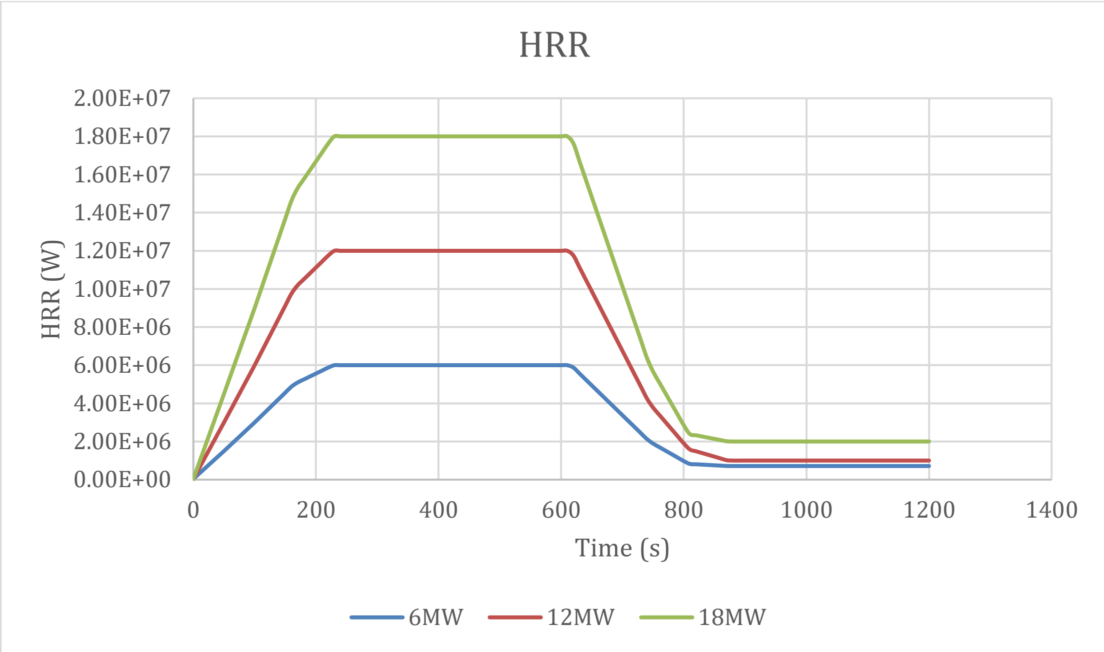
Temperature of Smoke in upper layer

Height of Smoke Internally (18MW fire size)



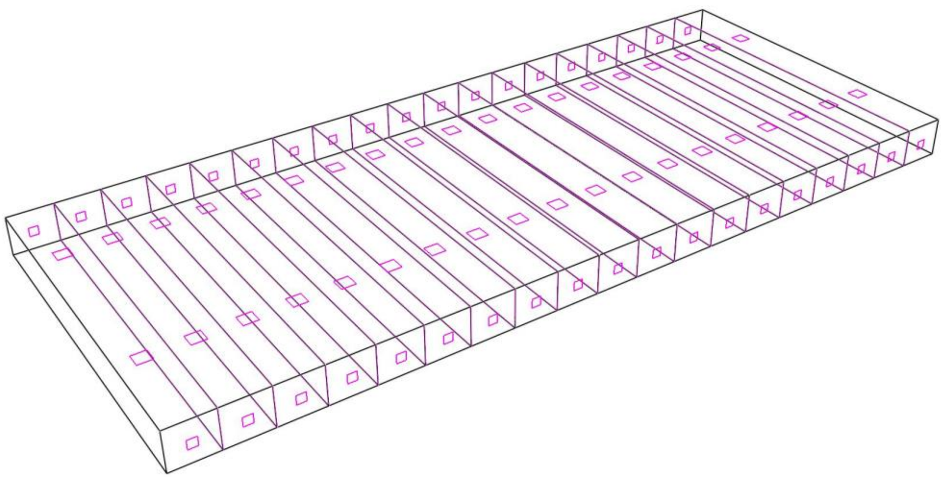
Temperature of Smoke in upper layer

These results shown indicate the simulation of a fire within a closed glass greenhouse structure of four sizes. There is no ventilation at all; meaning the fire essentially chokes itself out with the smoke layer it produces as the upper smoke starts to lose heat, which is at the 10 minute mark. Second round modelling assumes the high ventilation levels mentioned previously in the fire model outline.



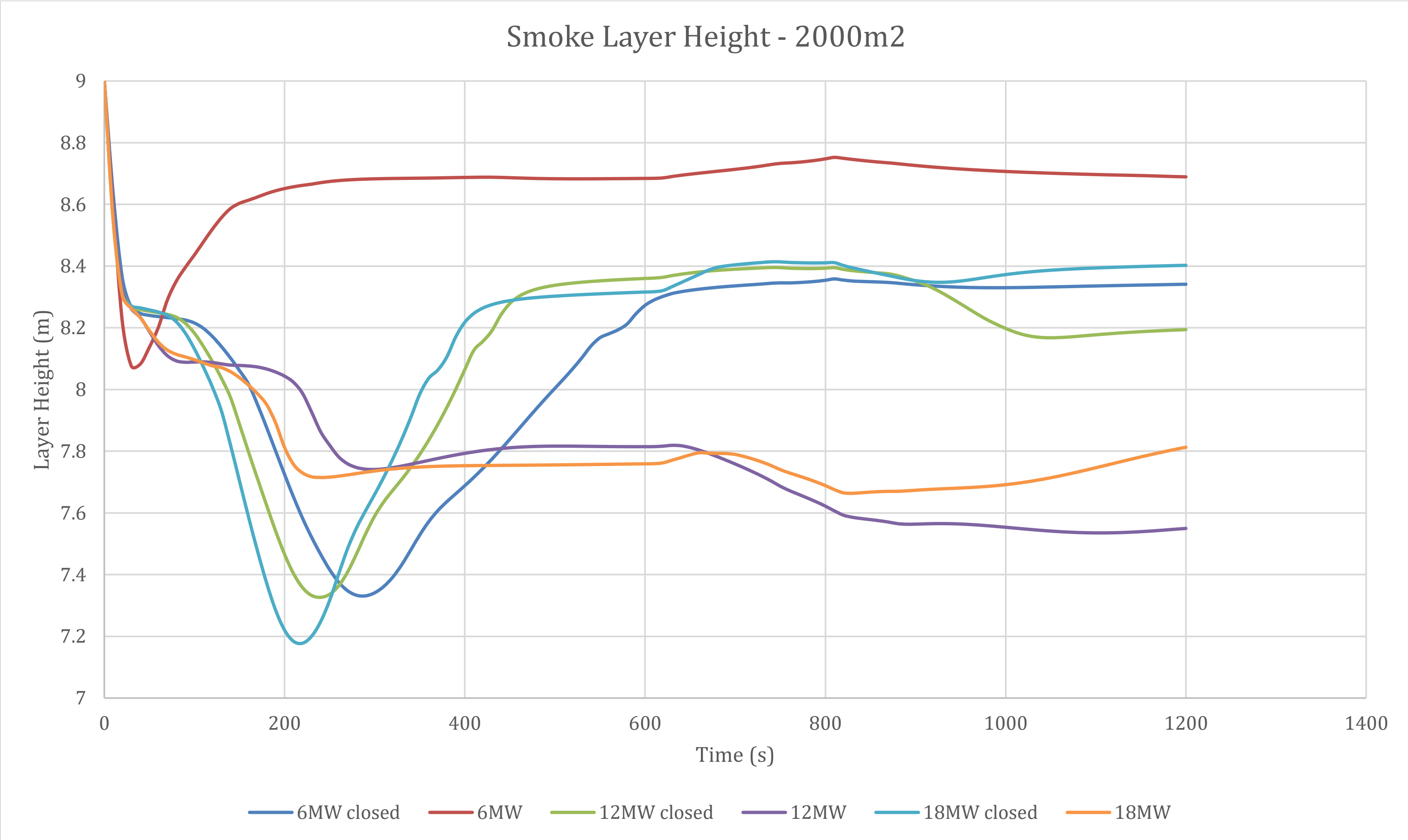
Fire Profiles Modelled

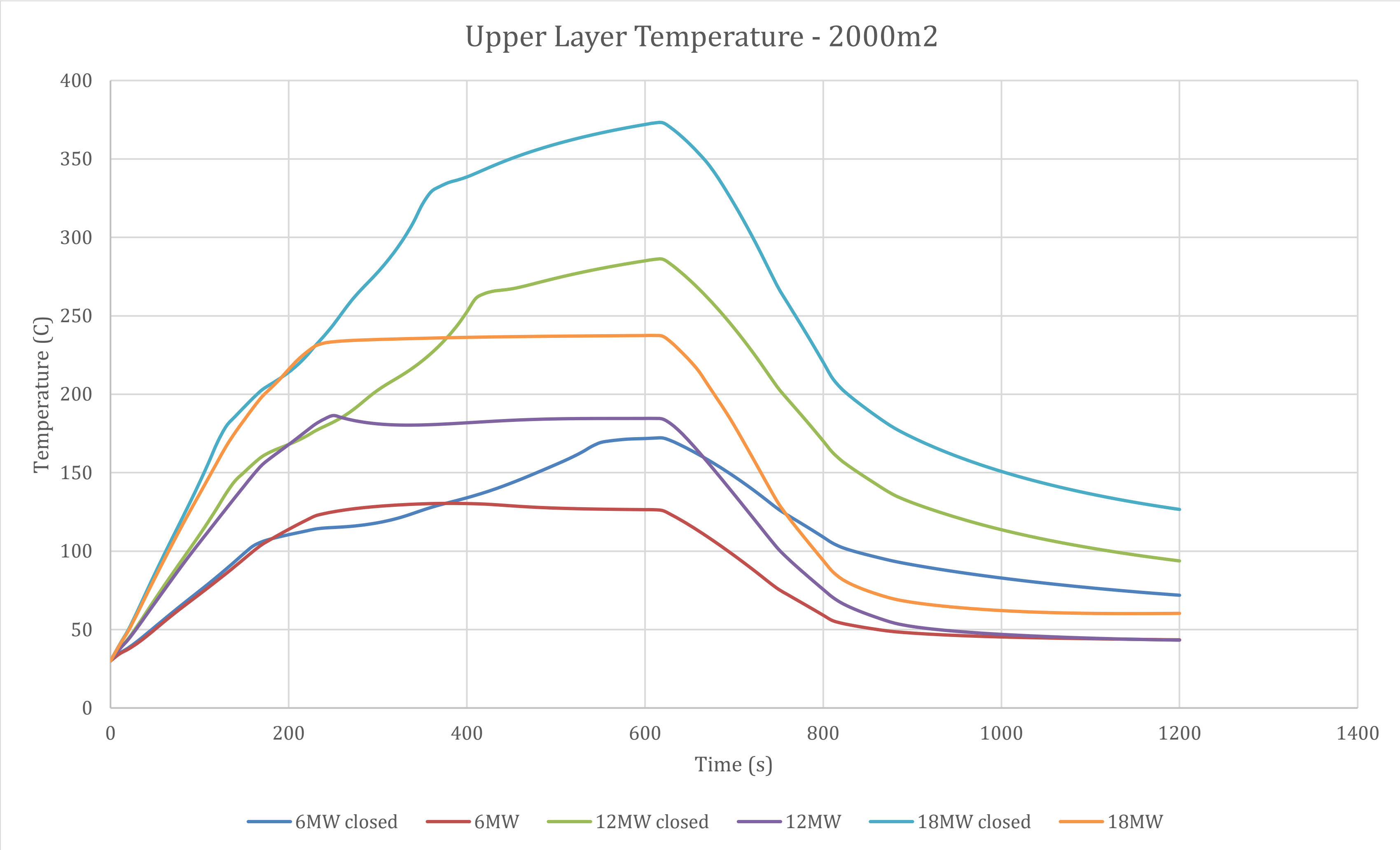
As discussed in the introduction, glass has a transition temperature range of approximately 500-550°C. No models reach this temperature.



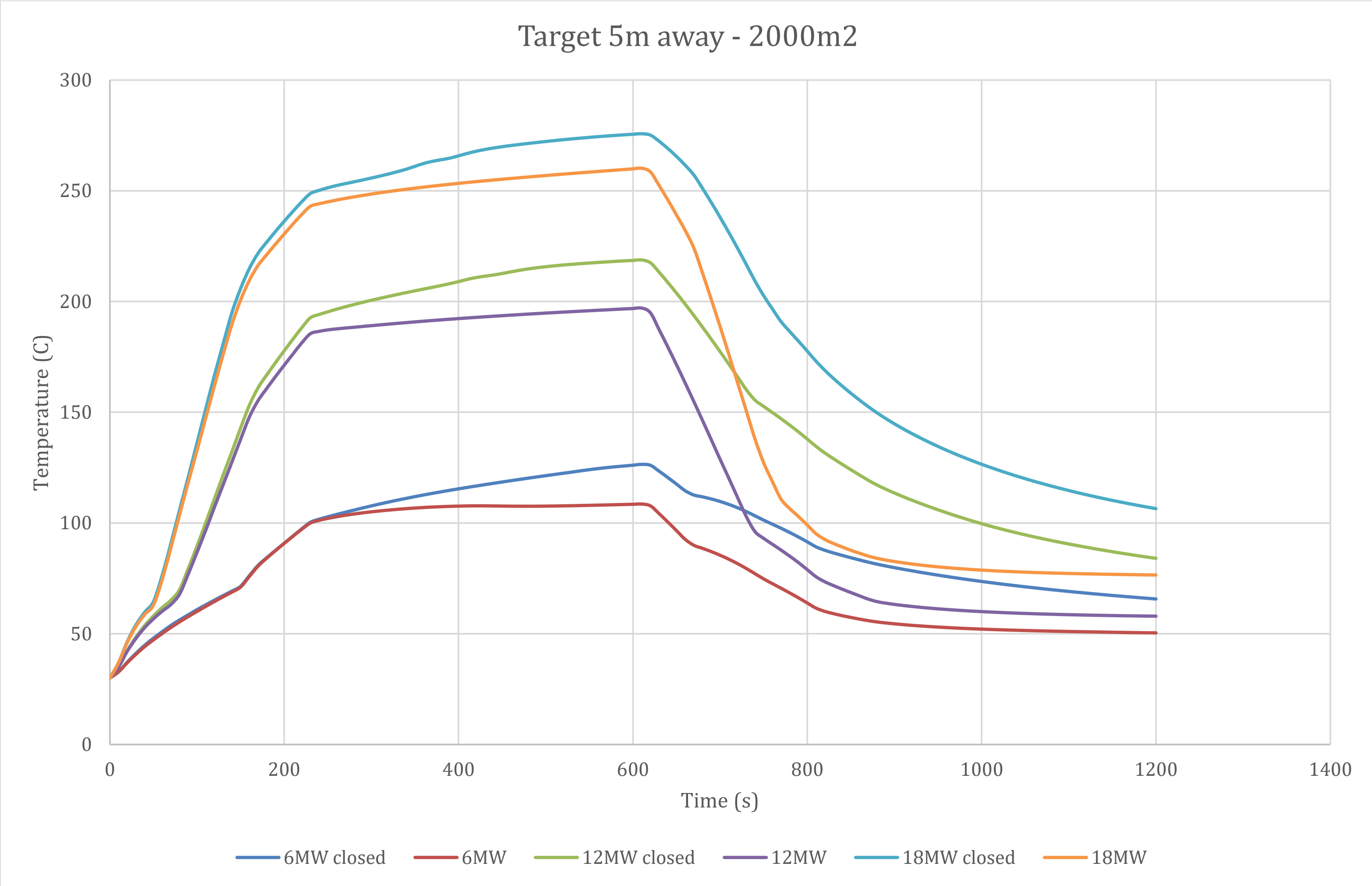
Group A Greenhouse Model with natural ventilation as shown in CFAST

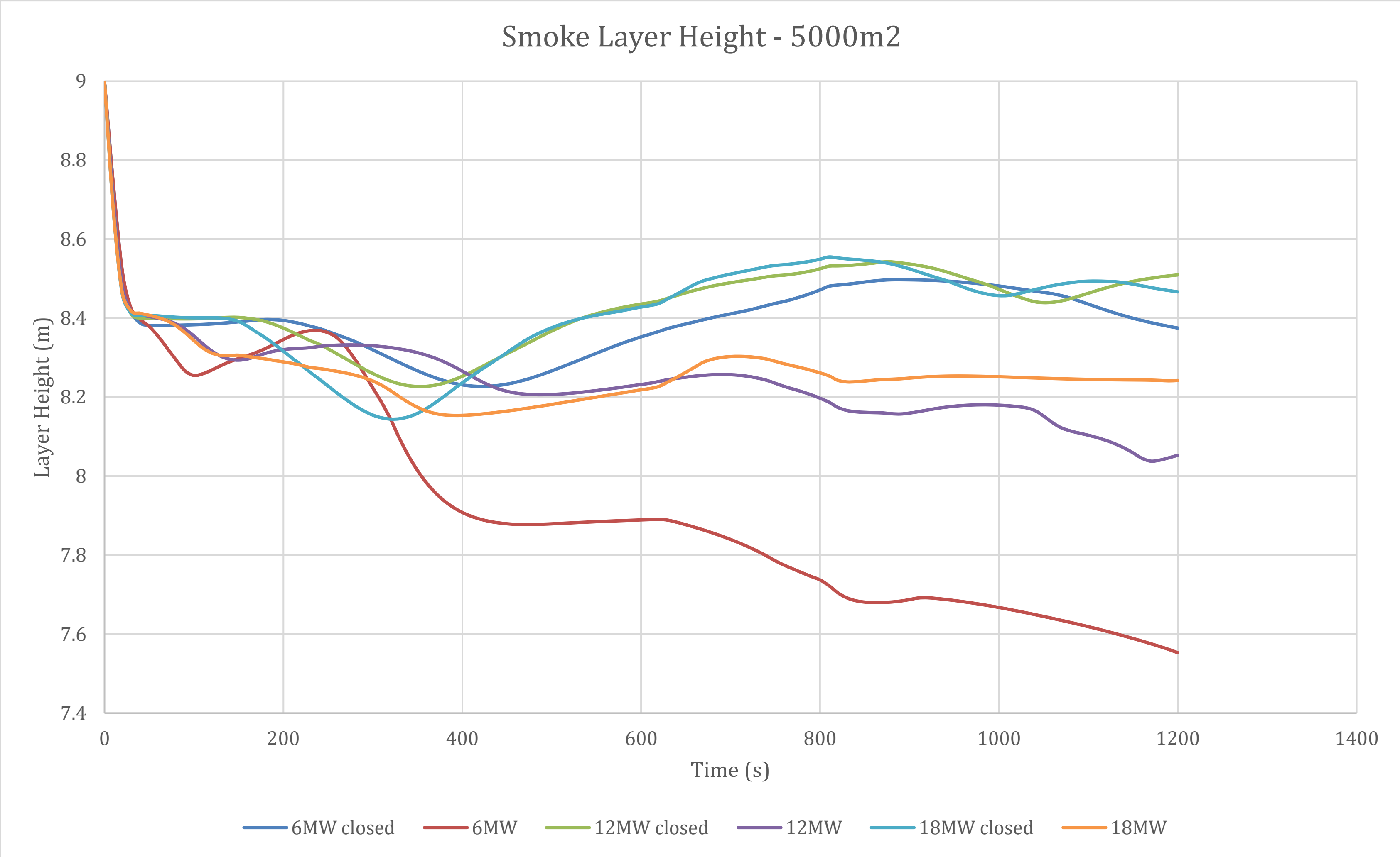
Figure 8 demonstrates the natural ventilation, shown in pink. Assumed were wall vents and ceiling vents that open on request and detection and are simplified due to the nature of the modelling program. Results are shown below.


Smoke Layer Height - 2000m2
9
8.8
8.6
8.4
8.2
8
7.8
7.6
7.4
7.2
7
Layer Height (m)
0
200
400
600
800
1000
1200
1400
Time (s)
6MW closed
6MW
12MW closed
12MW
18MW closed
18MW

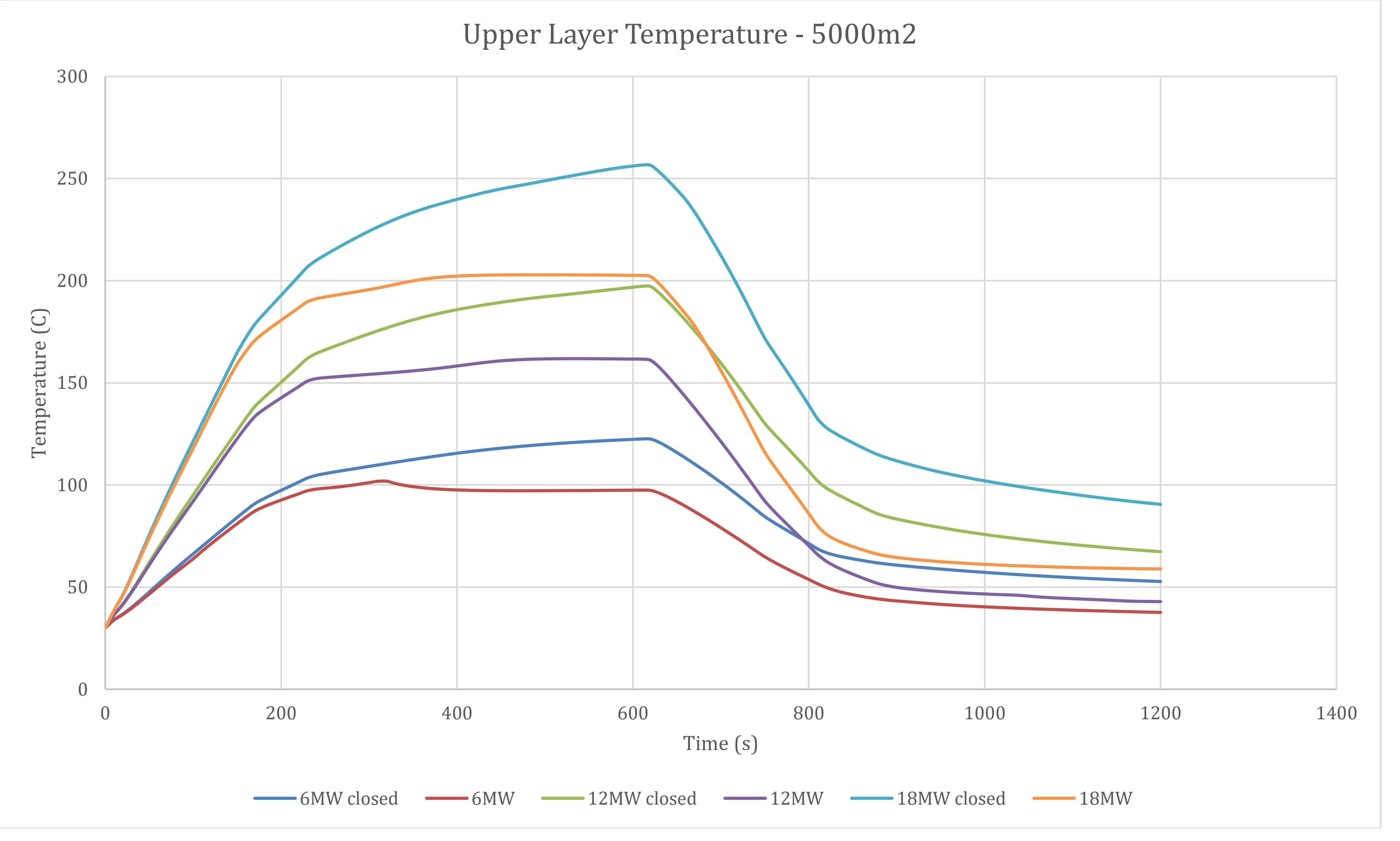


Temperature of Smoke in upper layer – 2000m²

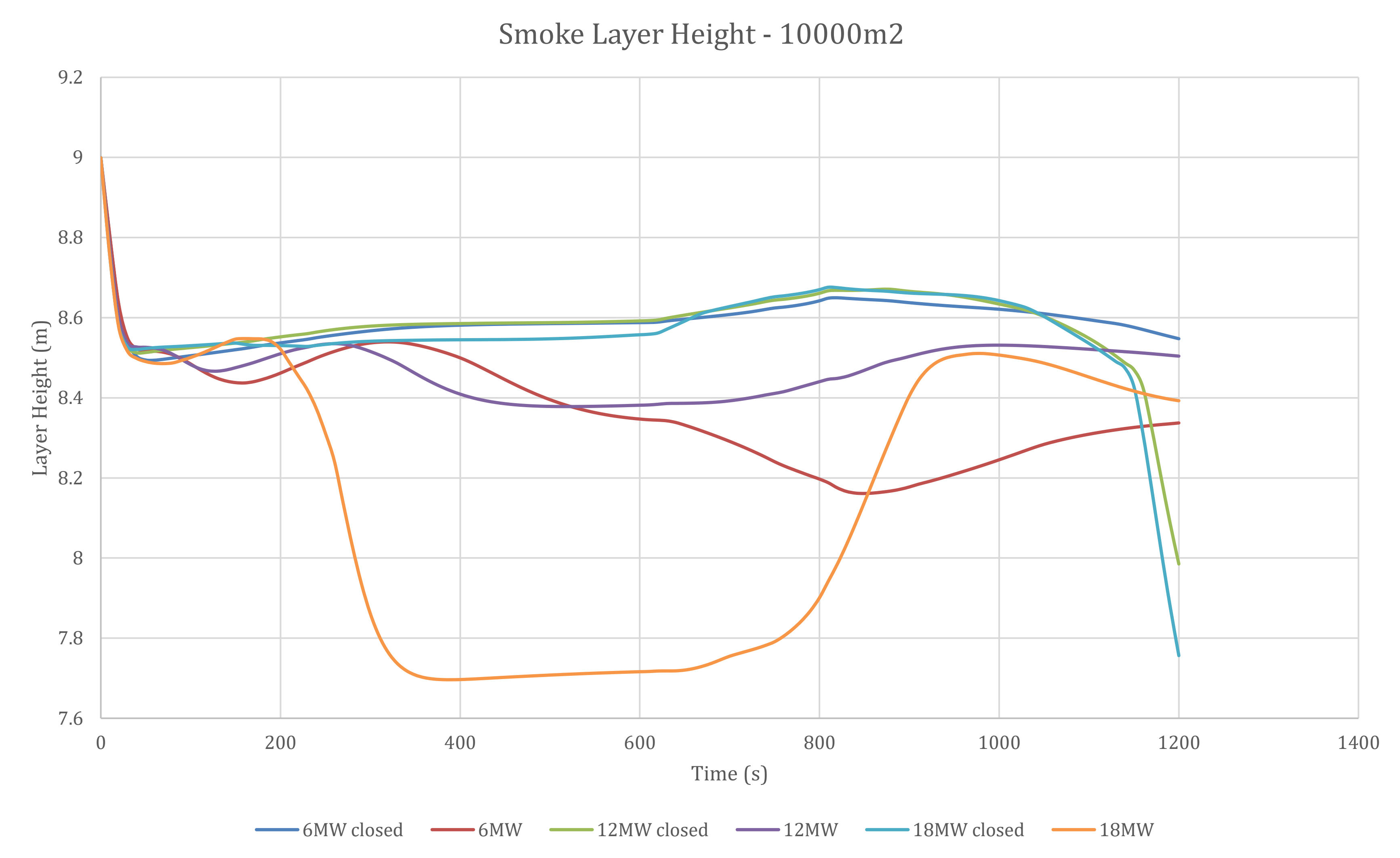

Target 5m away - 2000m2
Temperature (C)
300
250
200
150
100
50
0
0
200
400
600
800
1000
1200
1400
Time (s)
6MW closed
6MW
12MW closed
12MW
18MW closed
18MW

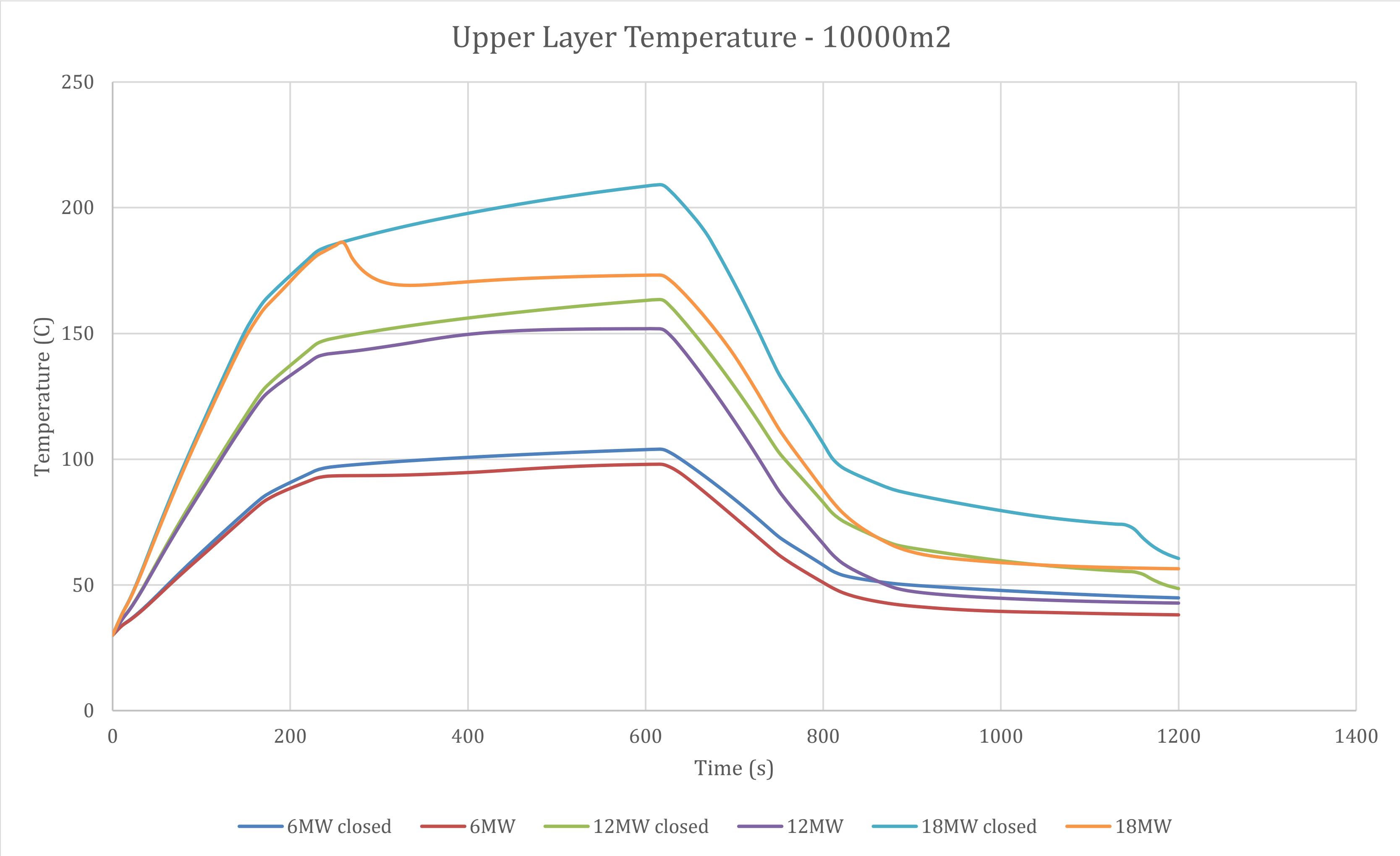


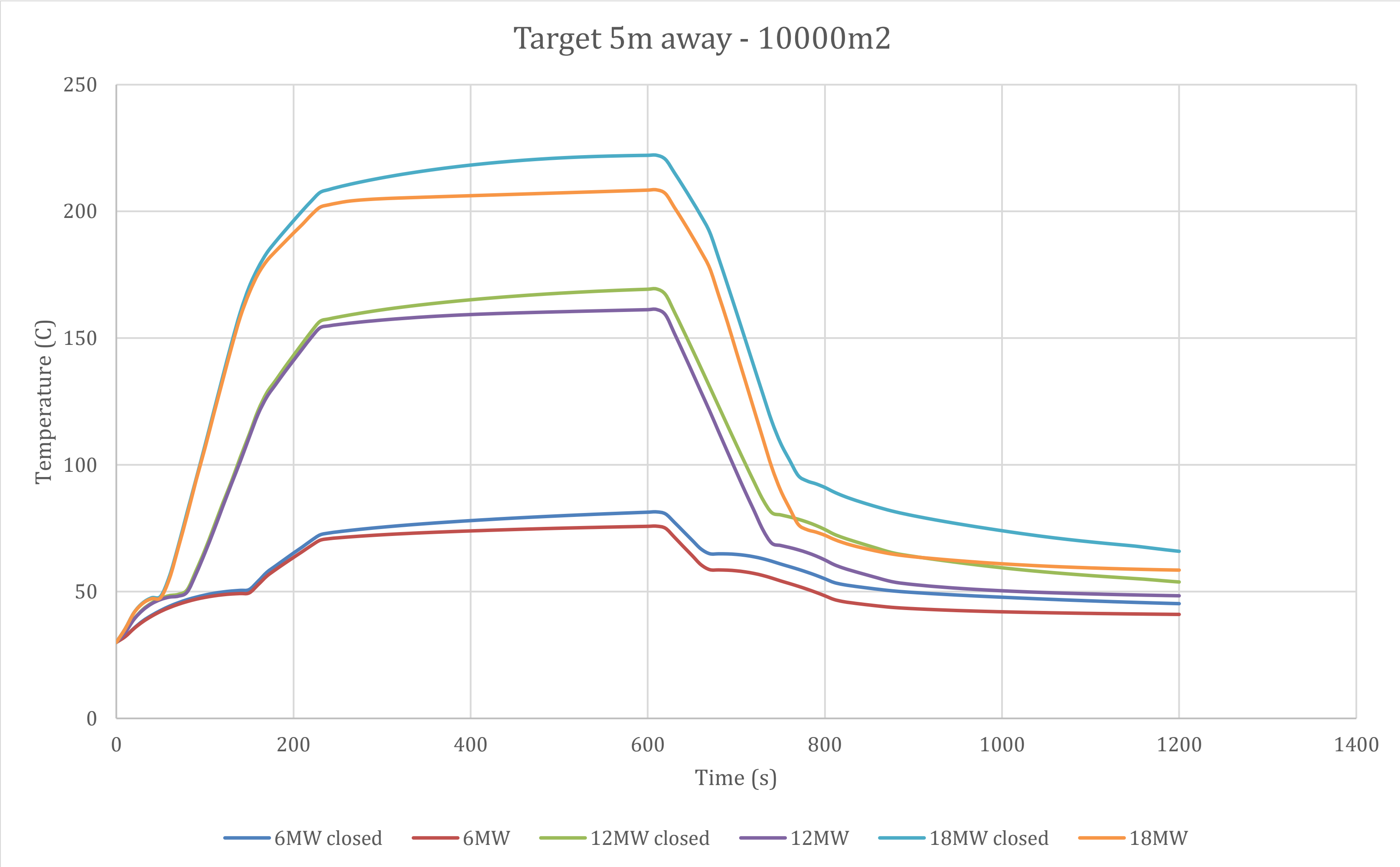
Temperature of Smoke in upper layer

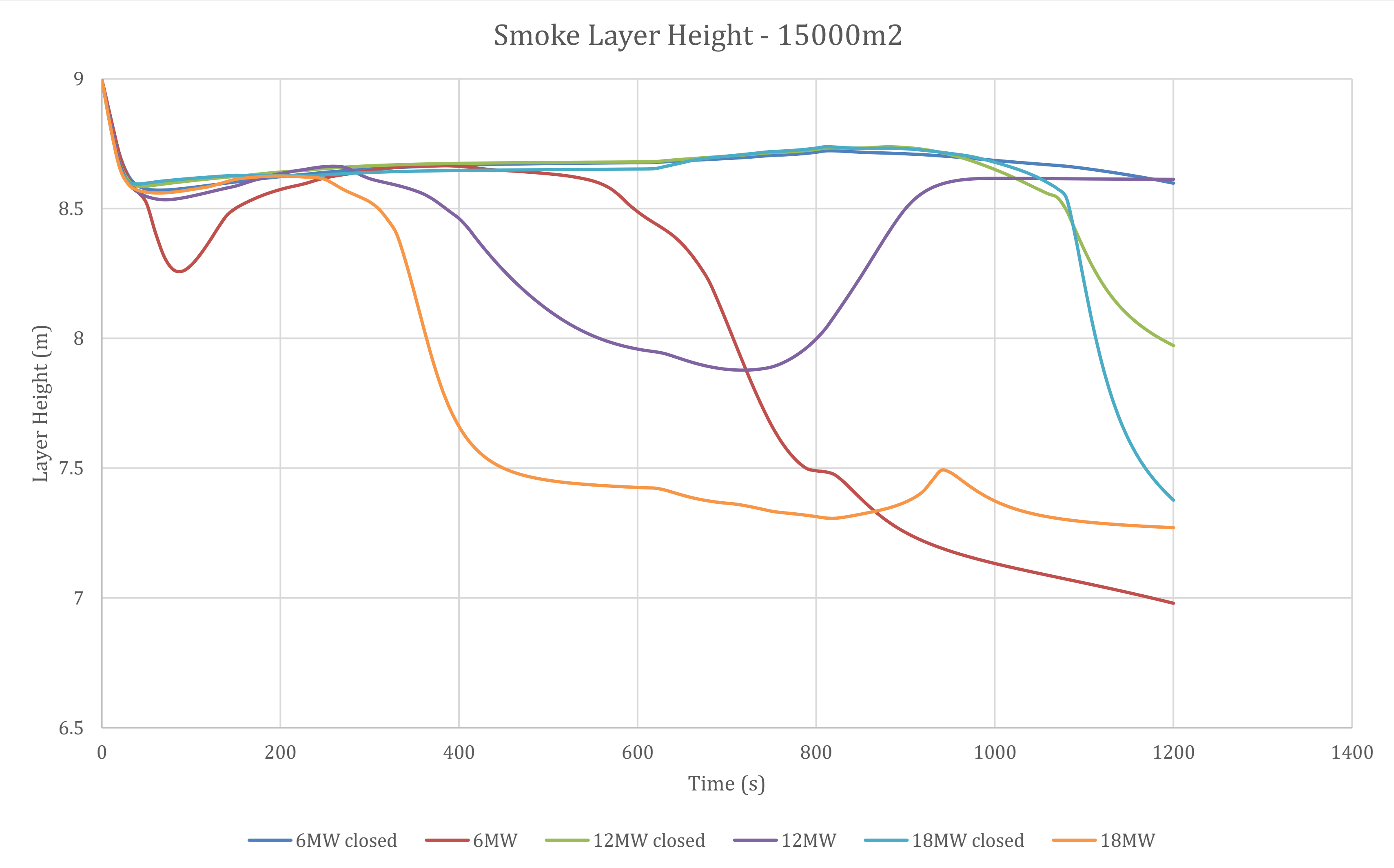

Upper Layer Temperature - 5000m2
Temperature (C)
300
250
200
150
100
50
0
0
200
400
600
800
1000
1200
1400
Time (s)
6MW closed
6MW
12MW closed
12MW
18MW closed
18MW


Target 5m away - 5000m2
250
200
150
100
50
0
Temperature (C)
0
200
400
600
800
1000
1200
1400
Time (s)
6MW closed
6MW
12MW closed
12MW
18MW closed
18MW


Smoke Layer Height - 10000m2
Layer Height (m)
9.2
9
8.8
8.6
8.4
8.2
8
7.8
7.6
0
200
400
600
800
1000
1200
1400
Time (s)
6MW closed
6MW
12MW closed
12MW
18MW closed
18MW


Upper Layer Temperature - 10000m2
Temperature (C)
250
200
150
100
50
0
0
200
400
600
800
1000
1200
1400
Time (s)
6MW closed
6MW
12MW closed
12MW
18MW closed
18MW


Target 5m away - 10000m2
250
200
150
100
50
0
Temperature (C)
0
200
400
600
800
1000
1200
1400
Time (s)
6MW closed
6MW
12MW closed
12MW
18MW closed
18MW


Smoke Layer Height - 15000m2
Layer Height (m)
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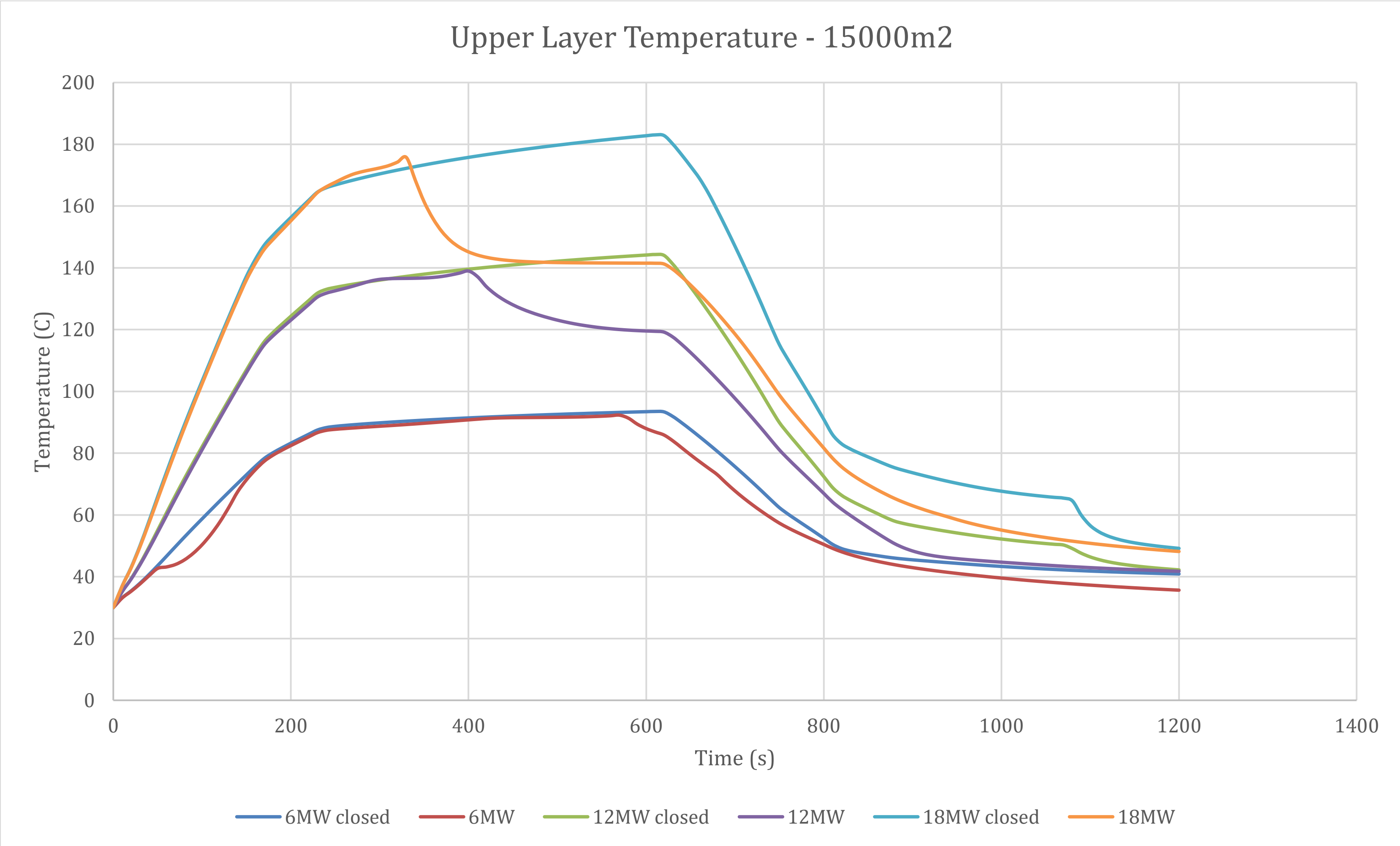
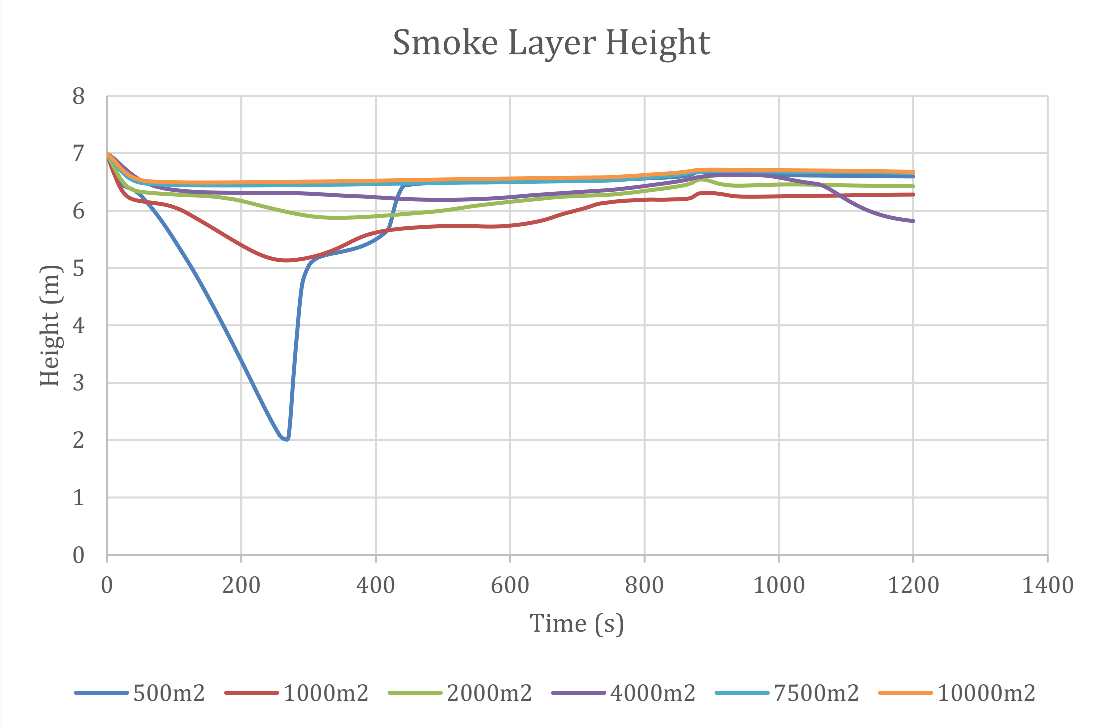
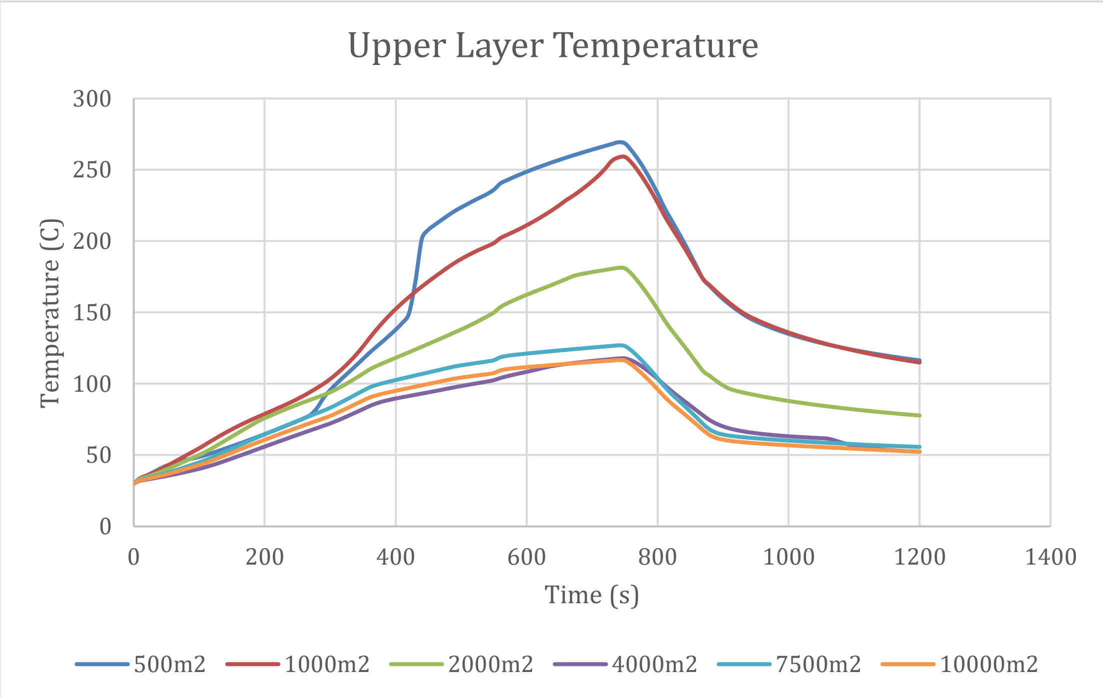
8.5
8
7.5
7
6.5
0
200
400
600
800
1000
1200
1400
Time (s)
6MW closed
6MW
12MW closed
12MW
18MW closed
18MW


Upper Layer Temperature - 15000m2
Temperature (C)
200
180
160
140
120
100
80
60
40
20
0
0
200
400
600
800
1000
1200
1400
Time (s)
6MW closed
6MW
12MW closed
12MW
18MW closed
18MW


Target 5m away - 15000m2
250
200
150
100
50
0
Temperature (C)
0
200
400
600
800
1000
1200
1400
Time (s)
6MW closed
6MW
12MW closed
12MW
18MW closed
18MW

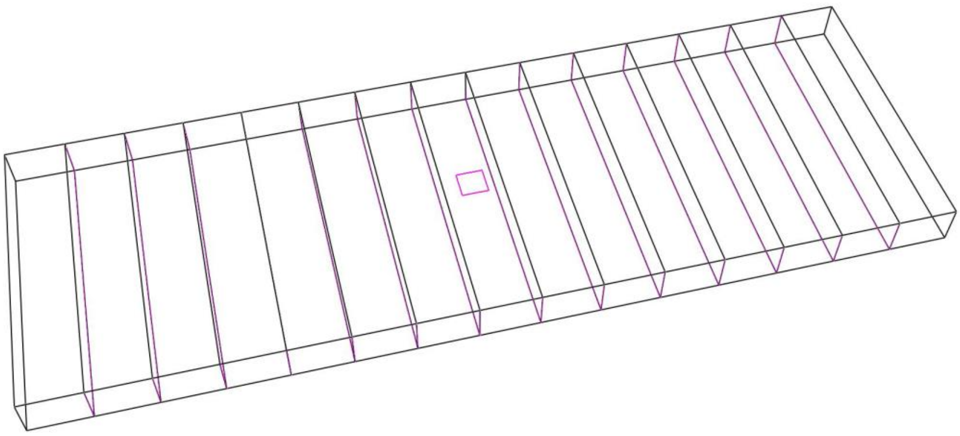
Group B





These results indicate the simulation of a fire within a closed PMMA greenhouse structure. There is no ventilation at all; meaning the fire essentially chokes itself with the smoke layer it produces and the upper smoke starts to lose heat, which is at the 12.5 minute mark. These graphs are used in the second round modeling, which assumes the PMMA covering fails at the melting temperature.

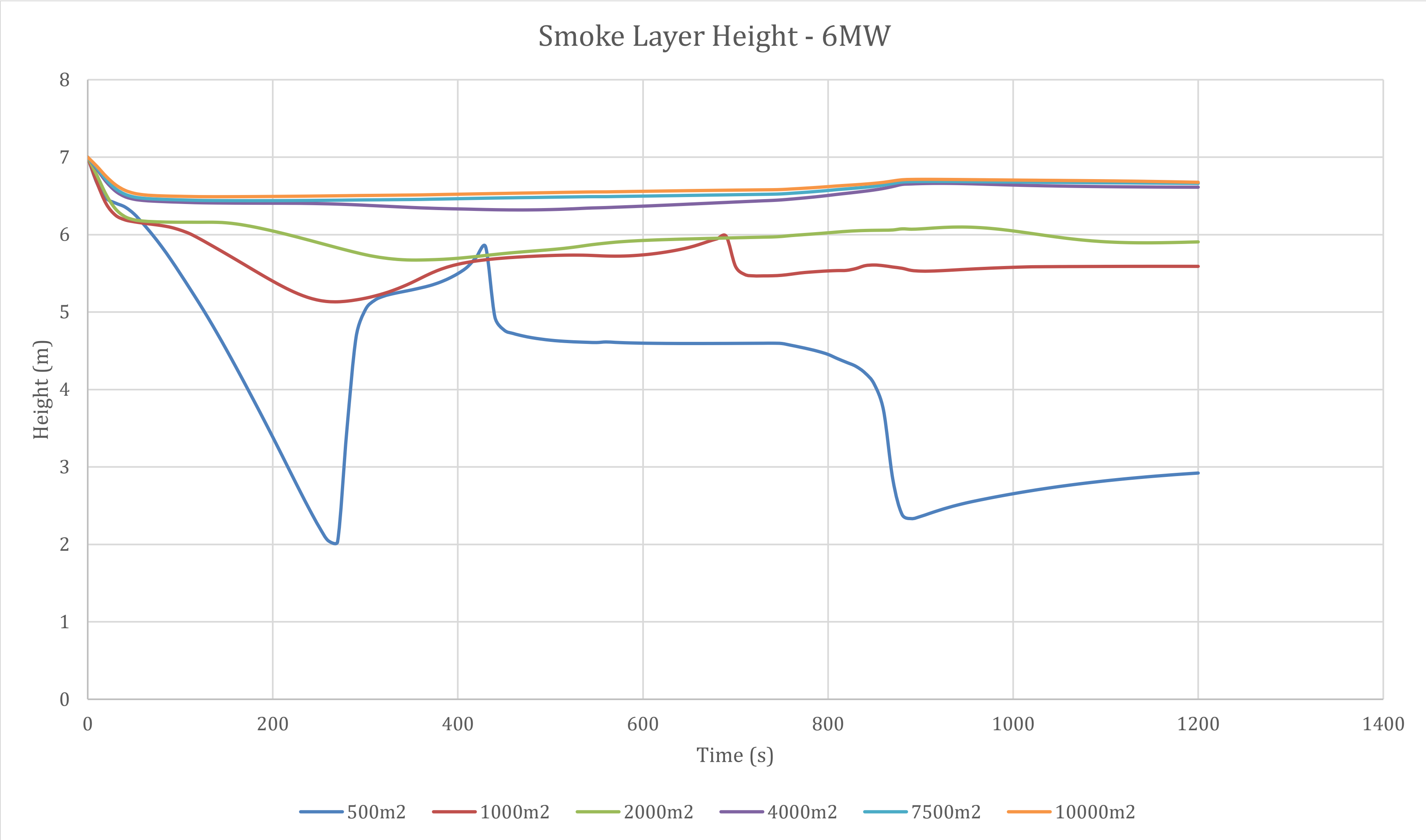
As discussed in the introduction, PMMA has a melting temperature in the range of 180-300°C. It can be seen from the upper smoke layer temperature above that 3 of the 6 revisions reach this temperature at different times. The graph above shows the fire timeline.

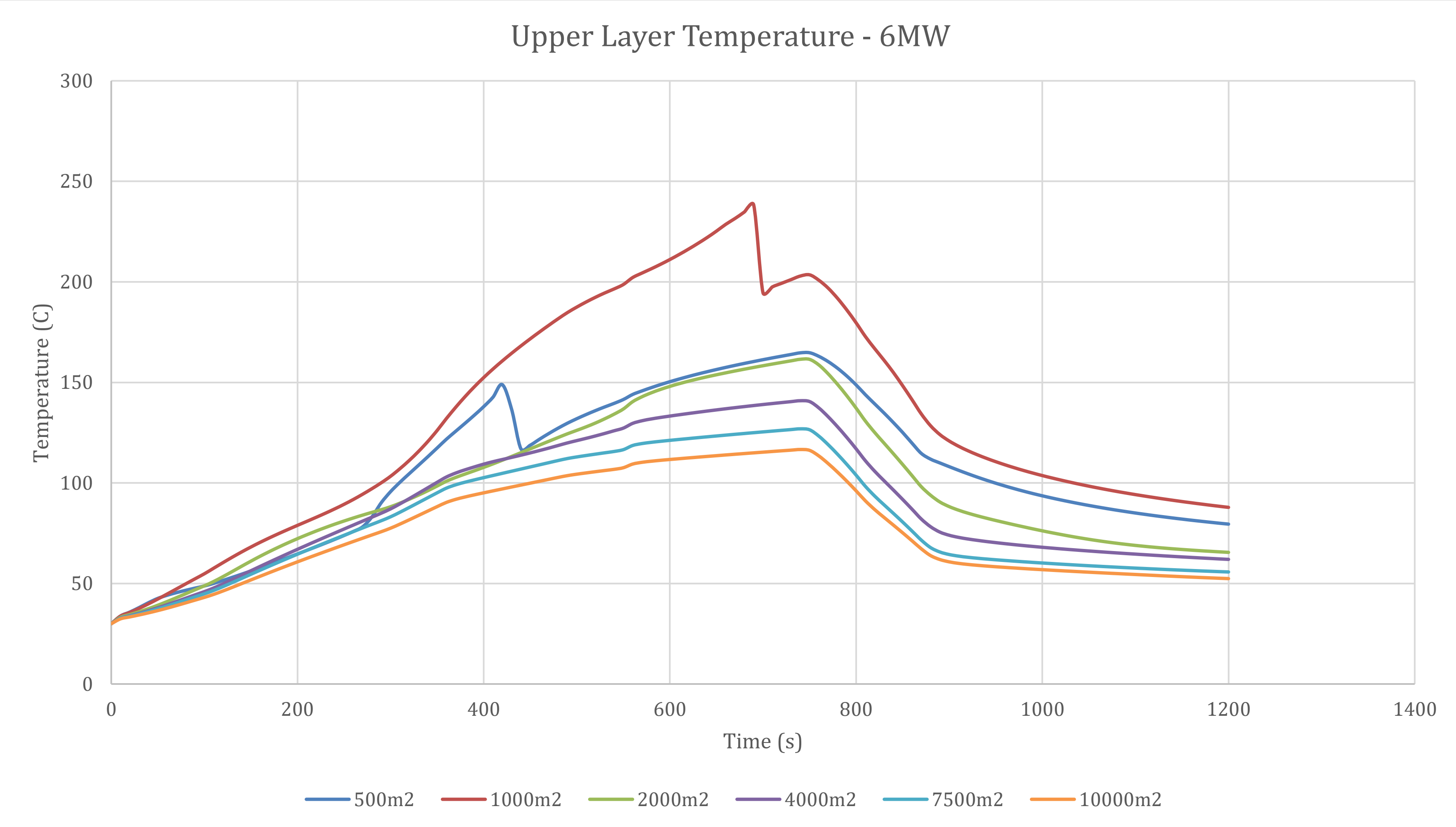


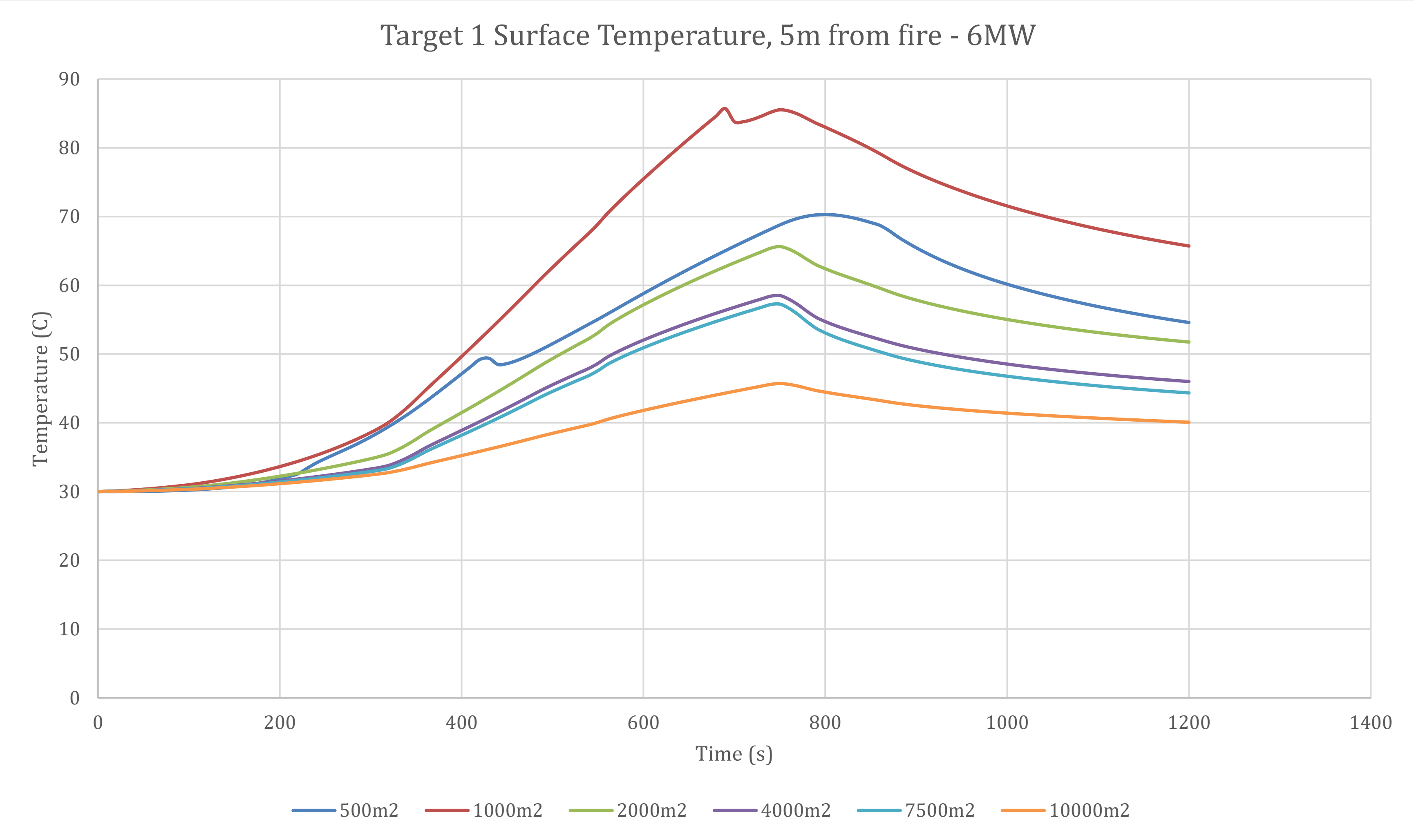
Group B Greenhouse with a void to simulate the 'bursting' of PMMA

Consequently, the second round of modeling was to create a ceiling vent to simulate the PMMA melting away and creating an open vent for smoke to escape.

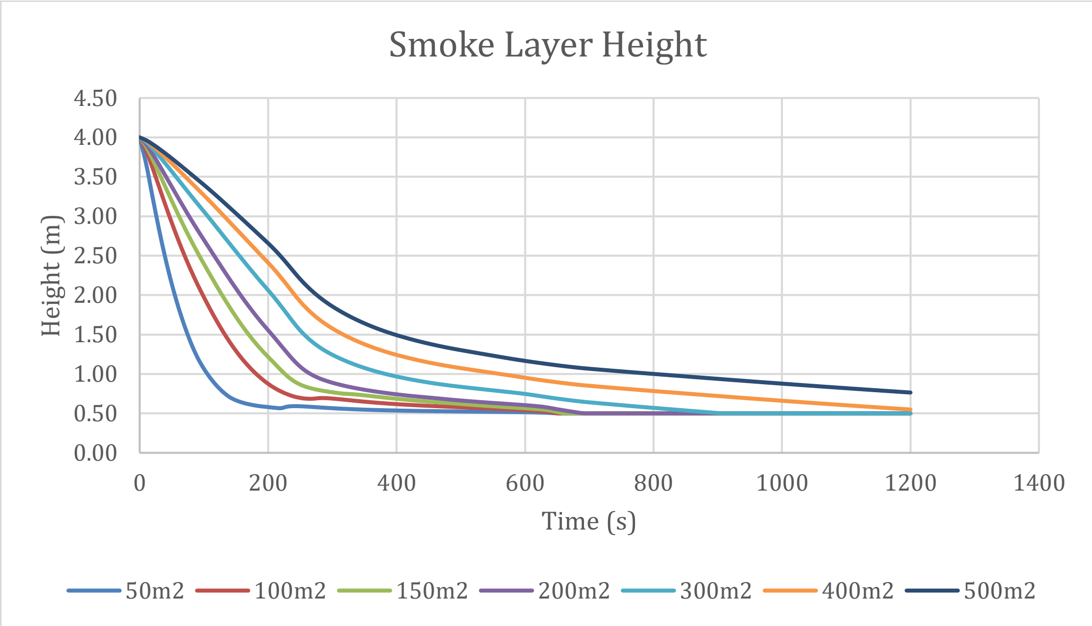
This can be seen in Figure 11, results are shown further into this report.

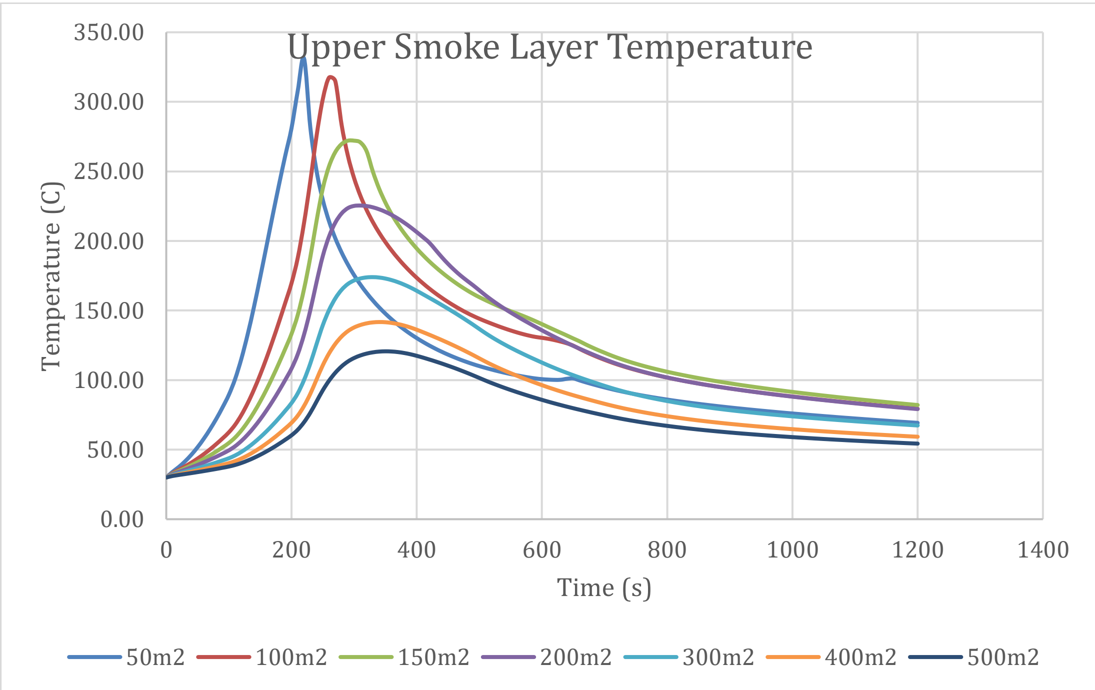

Smoke Layer Height - 6MW
Height (m)
Time (s)
0
1
2
3
4
5
6
7
8
0
200
400
600
800
1000
1200
1400
500m2
1000m2
2000m2
4000m2
7500m2
10000m2


Upper Layer Temperature - 6MW
Temperature (C)
Time (s)
300
250
200
150
100
50
0
0
200
400
600
800
1000
1200
1400
500m2
1000m2
2000m2
4000m2
7500m2
10000m2

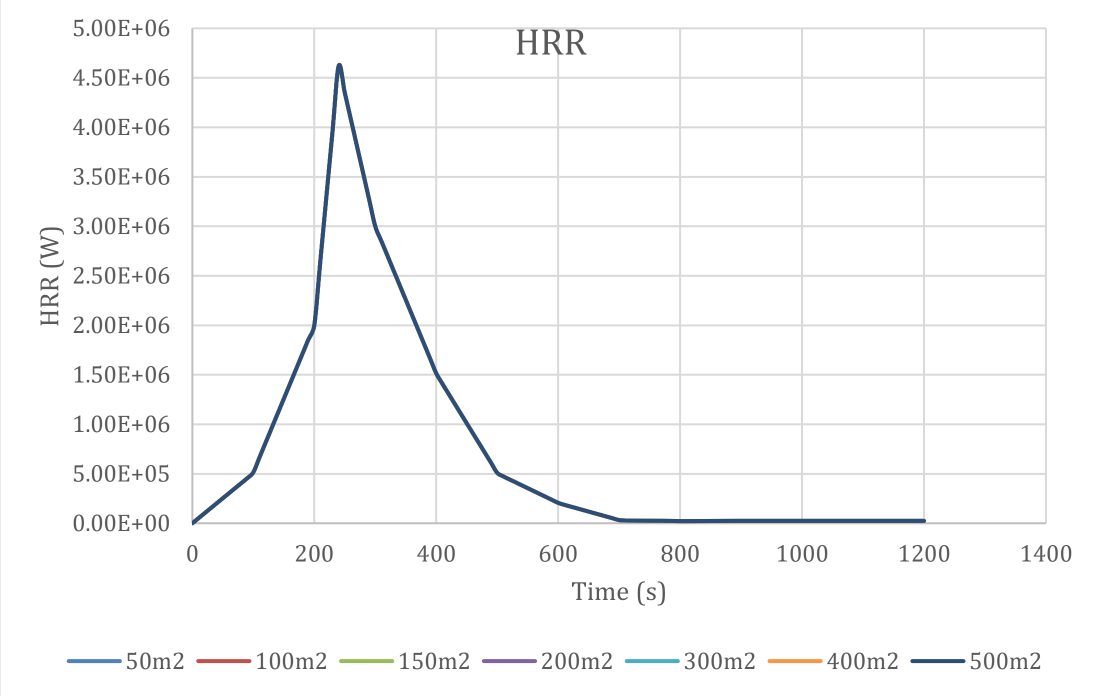

Target 1 Surface Temperature, 5m from fire - 6MW
Temperature (C)
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
Time (s)
500m2
1000m2
2000m2
4000m2
7500m2
10000m2

Group C

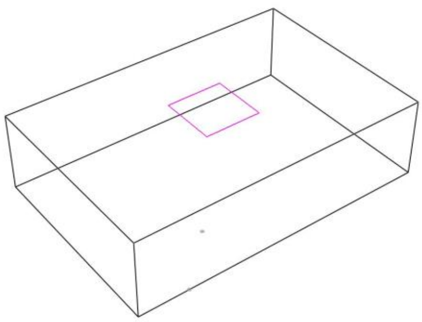




These results shown indicate the simulation of a fire within a closed polycarbonate building. There is no ventilation at all; meaning the fire essentially chokes itself out with the smoke layer it produces and the upper smoke starts to lose heat, which is at the 3.5-5 minute mark. These graphs are used in the second round modeling, which assumes the polycarbonate sheeting fails at the melting temperature.

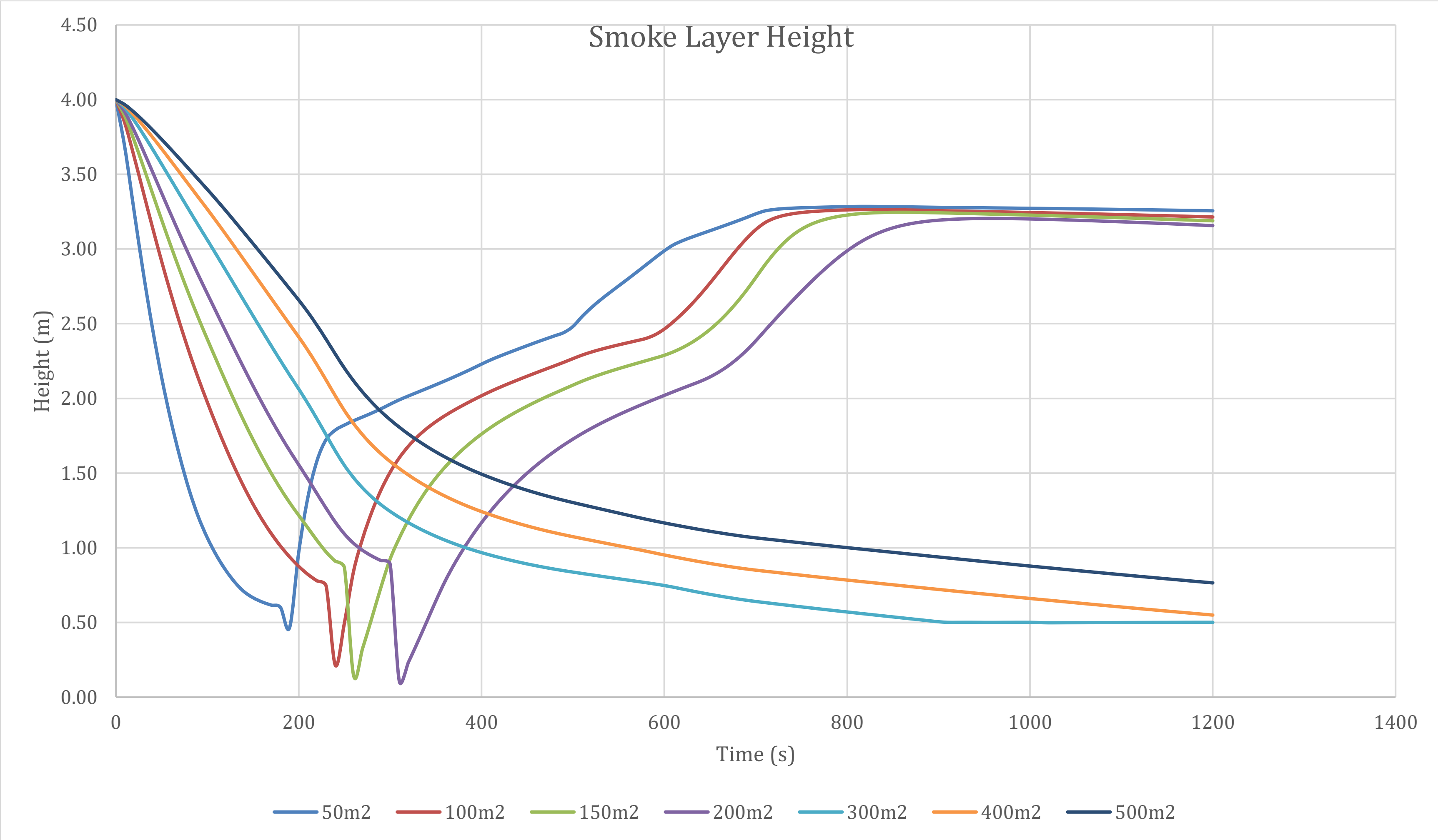


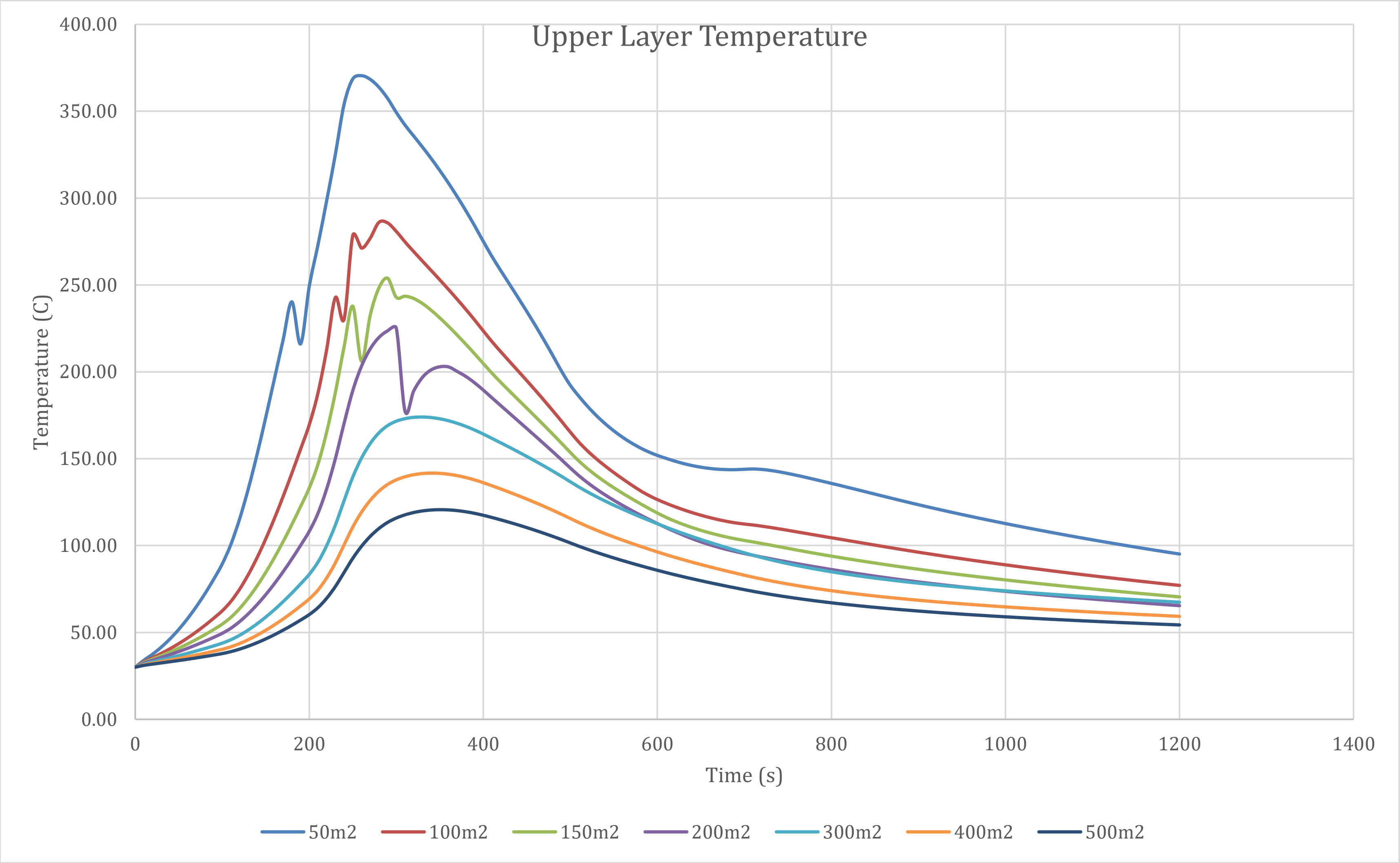
As discussed in the introduction, polycarbonate has a melting temperature in the range of 215-230˚C. It can be seen from the upper smoke layer temperature above that 4 of the 7 revisions comfortably reach this temperature at different times. Consequently, the second round of modeling was to create a ceiling vent to simulate the "bursting" of polycarbonate directly above the fire for these 4 revisions.



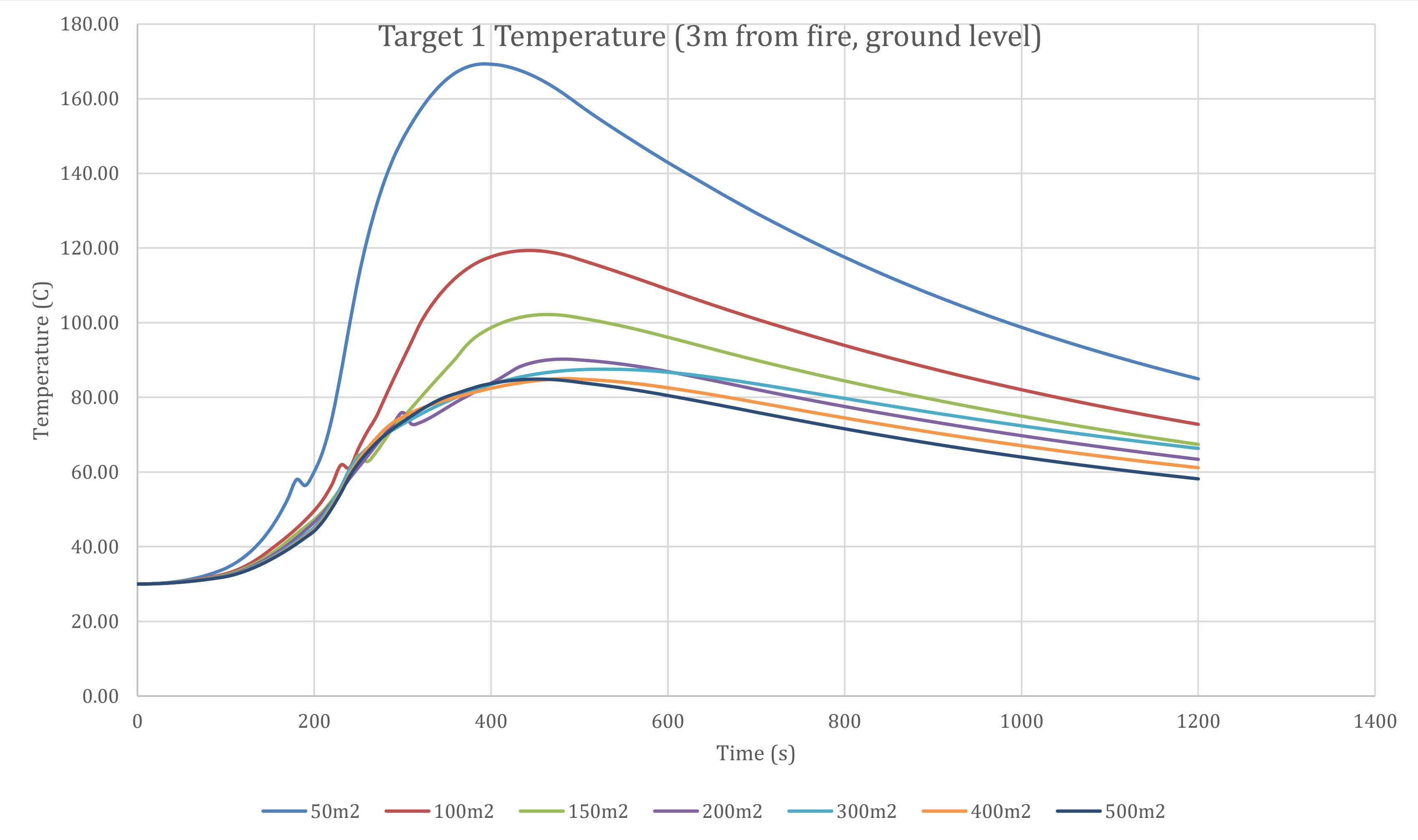
Group C with 'burst' polycarbonate sheeting

The same approach from Group B was applied here. A ceiling vent was calculated based off flame heights and plume calculations. The larger radius of the truncated cone was found to be approximately 7-8 square meters, which was the input area for the "burst" ceiling vent. Although the ceiling vent was a constant area, each revision had a specific timing that the polycarbonate would burst. The results are shown below for second round modelling.


Smoke Layer Height
Height (m)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
200
400
600
800
1000
1200
1400
Time (s)
50m2
100m2
150m2
200m2
300m2
400m2
500m2



Upper Layer Temperature
Temperature (C)
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
0
200
400
600
800
1000
1200
1400
Time (s)
50m2
100m2
150m2
200m2
300m2
400m2
500m2


Target 1 Temperature (3m from fire, ground level)
Temperature (C)
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0
200
400
600
800
1000
1200
1400
Time (s)
50m2
100m2
150m2
200m2
300m2
400m2
500m2

7. RESULTS DISCUSSION

The results shown identify a number of critical points arguing that these greenhouses are inherently safe for use. These are:

- Evacuation
- Room temperature
- Smoke inhalation

There is a smoke phenomenon called ceiling jet flow. In the event of a fire, hot plume gases rise to the ceiling. These hot gases fill empty space in a small layer underneath the ceiling. In a small compartment, this only exists briefly at the start before the compartment fills with smoke and this layer thickens to the floor. This can explain the smoke layer height figure shown above. The smaller structures are more irregular due to a smaller area for the ceiling jets to reach.

Similarities can be seen between the group B greenhouses and the group A greenhouses. Fire heat and buoyancy pressure in the fire compartment causes smoke to jet outwards resulting in extending very hot thin smoke layer radiating from the fire. Roof shape dictates how far this goes.

Separation distance

From the models, if these buildings are on fire then the impact of heat radiation on the adjoining area is shown to be low, radiant heat less than other forms of Type C construction, with the low fire loads. The separation distances studied were 3m, 6m, 10m and 18m. Justification for the selection of the distances is as follows:-

1. Separation distance of 3m is selected because the BCA already specifies a minimum distance of 3m from a fire source feature, so the impact of a minimum 3m setback from a boundary is acceptable.

2. Separation distance of 6m is selected since it's the BCA clause C3.2 specified distance between buildings on the same allotment to minimise the risk of fire spread for access by fire vehicles.

These will be recommended in the H3 revision.

Group A

The introduction of natural ventilation in Group A drastically decreases the effects of the fire in the greenhouse. This can be seen throughout the graphs as the closed situation is significantly hotter than its counterpart natural ventilation scenario. It should be noted that the smoke layer exhibits strange characteristics, which is due to the ratio of opening area to surface area of the greenhouse. The openings cause a pressure drop, allowing smoke to escape after the initial stages. This causes the apparent drop and flat profile shown. Each revision demonstrates that in no case does the smoke layer reach below the 7m mark. This provides adequate time and space for evacuation before structural failure.

Appendix A shows the remaining graphs and visual output from the CFAST simulation.

Group B

The smoke layer height and upper layer temperature graphs show the effect of the melting of PMMA in the smallest three structures. For the smallest structure (500m^2), as the fire grows, the smoke layer begins to thicken simply because the whole room is beginning to heat up. This can be seen from the similarities between upper and lower layer temperatures. However, once the fire peaks, ceiling jets begin to appear and push smoke to the edges (outer compartments not shown in graphs) and pressurize the center compartment where the fire is located. This cause the smoke layer of the center compartment to drastically reduce and become very hot very rapidly.

Once the opening is introduced for the PMMA melting, smoke is released. Temperature and pressure decreases causing ceiling jets to disappear and a thickened uniform hot upper layer across all compartments to replace the dangerous hot smoke layer. These effects can be seen in all revisions, however, the added area for each structure results in a less pronounced effect of this phenomenon.

The introduction of the PMMA melting allows the fire to explode due to a breath of fresh oxygen. This vent however, provides constant relief to the rest of the structure by decreasing the layer of hot smoke and localizes damage to directly above the fire.

Each revision has an increasingly longer evacuation distance and at some point will need 2 fire exits. The large areas modeled are very safe as the smoke layer is only dangerous for the 500m2 revision. Worst case scenario is that an evacuee will have to travel 30m in 200 seconds, or travel at 0.15m/s. Since the smoke layer does not reach below 2m, this travel can be easily attained in a fire situation.

Appendix B shows remaining graphs and Group B sensitivity analysis which includes 4m tall structures and double the fire load to 12MW. The 12MW increases the temperature of the smoke layer from 240°C to approximately 300°C, a relatively small change for the change in fire load. The same can be seen from a 4m structure, a smoke layer of 250°C is recorded, however, this increases to 350°C with a 12MW fire.

Group C

The impact of the polycarbonate bursting is very evident in this figure and almost becomes a precautionary measure. Once a ceiling vent is introduced, smoke starts to billow out of it, reducing the hot smoke layer and allowing a safe environment for someone to crawl. The polycarbonate bursting turns out to have a pronounced effect on smoke inhalation and temperatures at crawling levels. The introduction of the polycarbonate bursting allows the fire to explode due to a breath of fresh oxygen.

This vent however, provides constant relief to the rest of the structure by decreasing the layer of hot smoke and localizes damage to directly above the fire.

Each revision has an increasingly longer evacuation distance and at some point will need 2 fire exits. All figures show that at worst case, a person will have to travel approximately 15m in 210 seconds from when the fire starts to spread. This model assumes the worst case and the fire starts burning at time zero, it excludes any detection and suppression.

Appendix C shows Group C sensitivity analysis which includes 3m and 5m tall structures. An increase in height shows little changes to the temperature of the structure, but a decrease in the height results in a 50°C increase of internal temperatures.

Travel Distance Safety Review

All the travel distance ASET time analyses for the different structures revealed how much time is actually available in these structures. The way the fail with roof venting by the materials and volumes of released smoke, means the smoke spread is low. Areas are **not** filled with smoke rapidly.

It is taken as 60m as per concession in QDC Part 3.7. On this basis, a safety factor applied to the travel time is (T3+SF2), which is 120 seconds (i.e.60sec + 60sec) respectively. In comparison to this, safety factors are not applied in standard Deemed to satisfy design.

ASET Determination

Based on the IFEG, tenability for occupant life safety is assessed on the following conditions not endangering human life:

- Temperature
- Level of visibility For the purpose of this project, the limits of acceptability will be as follows:

- Occupant Tenability Criteria 1 - Smoke Layer ≥ 2.0m

- Hot Layer exposure less than 80-100C
- Fire Engineering Design Guide [i] suggests that the acceptance radiant heat from the upper smoke layer at the head height (2.1m above the floor level) should not exceed 2.5kW/m^2 which corresponds to the average upper smoke temperature of 200 □C).

Therefore, the adopted acceptance criteria are:

- When smoke layer height drops to ≥ 2.0m, radiant heat at head height (2.1m AFFL) shall be ≤ 2.5kW/m^2 (or ≤ 200 □C)

In all the cases listed above, these conditions prevailed to safely accommodation evacuation distances well above the 40m in the DtS and up 80m is of no additional risk to occupants.

8. FIRE BRIGADE INTERVENTION

The location of a farm buildings is recognized as remote, isolated and rural.

This has a major impact on the issues of fire intervention. Any local rural fire crew able to undertake the travel distances involved limit firefighting measures by the type of vehicles used and the equipment on board. In many rural fire jurisdictions, training is limited to grass and bush fire, and not structural fire fighting in buildings. The growers survey found very few fires in these structures. They present low risks of fire spread, not recognized in the NCC current classification and fire services requirements.

It is therefore considered reasonable to state that any fire crew upon arrival would face a fire well with local intervention by the farmer and staff, or fully developed or in decay stage, assuming fire development is sustained. Fires tend to be restricted to small areas where roofing and wall materials can be burnt away and fall in. Fire is then well vented.

Only external firefighting measures are considered to extinguish, like the machinery fire or any grass fire movements beyond the structure or to protect any structures in the vicinity of the building on fire. Consultation with the rural fire brigades and AFAC is part of the proposal with ABCB.

In addition, tanks storage, spray irrigation and other building elements in IHB's are available to be integrated for use in a method for fire protection in our opinion. These have been developed into the H3 proposal. For this reason fire brigade search and rescue inside a fully involved building is not considered, however Fire Hydrants and Water Supply is considered as reflected in this report for the larger Group A style structures.

Fig 10. Typical Fire In a Greenhouse

9. CONCLUSION

It is concluded that these greenhouses have level of inherent fire safety for egress and exposure as demonstrated by the modeling on CFAST.

The addition of natural ventilation creates a safer environment for evacuees at walking and in the smallest enclosures, at a crawling level, drastically reducing the hot smoke layer and reducing temperatures in the lower layer. It allows relief for the rest of the structure, localizing damage until the fire brigade arrives. The light weight fabrication is able to show thermal performance due to the sheer open sizes of these structures. Structurally weak roof or covering systems with polymer based products actually aids in the fire development, by burning away and allowing the heat top escape rapidly.

Glass roofed systems are Group A and will also fail at a point, but longer into the fire growth. Once the glazing fails or the support frames in Polymers or Aluminum, the heat is released. These allow very large sizes in our view with little to no evacuation risks.

In addition the products of combustion are few and far between inside and fire spread is very local.

Proposal for Change Element – H3

H3.1 Application of Part

(a) The Deemed-to-Satisfy Provisions of this Part apply to *farm buildings*, and *farm sheds* and *intensive horticultural buildings*.
(b) The Deemed-to-Satisfy Provisions of this Park take precedence where there is a difference to the Deemed-to-Satisfy Provisions of Sections C, D, E and F.
(c) H3.1 to H3.5, H3.8 and H3.11 to H3.18 apply to *farm sheds*.
(d) H3.1, H3.3, H3.5 to H3.7, H3.9 to H3.12, H3.14, H3.15 and H3.18 apply to a *farm building* but excludes *intensive horticultural buildings*.
(e) H3.1, H3.3 to H3.12, H3.14 to H3.19 apply to a Group A *intensive horticultural building*.
(f) H3.1, H3.3 to H3.19 apply to a Group B *intensive horticultural building*.

H3.2 Fire resistance and separation

A farm shed need not comply with the provision of Parts C1, C2, and C3, except for C1.11 if it is separated from any other building or allotment boundary by a distance of not less than 6 m.

H3.3 Provision for escape

(a) Except for D1.2, D1.4 to D1.6, D1.9, D1.10(a), D1.13(c), D1.14 and D1.15, the Deemed-to-Satisfy Provisions of D1 do not apply to a farm shed and intensive horticultural buildings. Where –
    a. Group A intensive horticultural building shall have no point on a floor more than 60 m from an exit, or a point from which travel in different directions to 2 exits is available, in which case the

maximum distance to one of those exits must not exceed 120 m. Exits that are required as alternative means of egress must be no greater than 140 m apart.

b. Group B intensive horticultural building shall have no point on a floor more than 40 m from an exit, or a point from which travel in different directions to 2 exits is available, in which case the maximum distance to one of those exits must not exceed 80 m. Exits that are required as alternative means of egress must be no greater than 100 m apart.

c. Farm shed buildings and Group C intensive horticultural buildings shall comply will H3.3 (a).

(b) An open space adjacent to a farm building, intensive horticultural building or a farm shed need not be directly connected with a public road.

H3.4 Construction of exits

Except for D2.13, D2.14, D2.16, D2.17 and D2.24, the Deemed-to-Satisfy Provisions of Part D2 do not apply to farm sheds.

Alternative exits for intensive horticultural buildings are -

(a) Single-use or sacrificial exits may be installed in intensive horticultural buildings if the building is deemed not *accessible*; these exits shall not exceed 1 to every 4 conventional exits.

Explanatory Note: A single-use or sacrificial exit is an exit which is used in an emergency. The means of alternative exit depend on construction materials used. For example, a non-rigid plastic film structure may allow for a cutting implement to be used to create a single-use exit; in which case a cutting implement shall be provided at every single-use exit location.

In a rigid structure 'kick-out' panels may be installed at each single-use exit location. These panels shall be constructed to allow a person to unlatch a holding device or kick out the panel with appropriate force (less than 110 N) in an emergency while ensuring structural stability during normal operations as per Part B. Egress kick-out panels and their supports require design from a suitably qualified and registered engineer.

H3.5 Fixed platforms, walkways, stairways and ladders

A fixed platform, stairway, ladder and any going and riser, landing, handrail or barrier may comply with AS 1657 in lieu of D2.13, D2.14, D2.16 and D2.17 where it serves a farm building, intensive horticultural building or a farm shed.

H3.6 Thresholds

The threshold of a doorway that services an area not required to be accessible by D3.1 in a farm building or intensive horticultural building need not comply with D2.15 where the door sill is not more than 700 mm above the finished surface of the ground, floor or the like, to which the doorway opens.

H3.7 Swing doors

A swing door in a required exit or forming part of a required exit need not swing in the direction of egress if it serves a farm building or intensive horticultural building.

H3.8 Fire fighting equipment
The Deemed-to-Satisfy Provisions of E1 do not apply to a farm shed. The Deemed-to-Satisfy Provisions of E1.5 and E1.8 do not apply to an intensive horticultural building.

Group A and Group B intensive horticultural buildings over 80m long or floor area more than 5000m^2 shall have an integrated fire fighting service and initiation devices within 6 m of hydrant points as defined in Part H3.9 and no less than 2 per building with additional devices as necessary for zone control of any water irrigation system.
Where –

(a) The fire fighting service and a fire initiation system shall include the integration of any water spray, mist and/or fogging irrigation system, if they are installed within the building and utilised as part of the normal intensive horticultural building construction.

In addition any other systems as listed below, as part of the fire fighting service shall be integrated to operate in a fire affected zone, with the fire initiating system.

These services include:
- Electrical Control System to operate the irrigation water pumps for the building
- Water irrigation zone controls and valves within the building
- Mechanically controlled vents, roof lights, louvers
- Retractable roof covers that can be opened in an activation zone

(b) One or more of the above services are available, then that service shall be made part of the fire fighting service for activation by occupants with a local fire initiation device, located within 6 m of hydrant points and signed and labelled accordingly. Zoning will be designed to match the normal irrigation or spray zones normally utilised by the owners for the building.
Fire hydrant operation will adopt those same zones. Zoning provisions include:

- Initiation devices shall be zoned to match those operational zones with no less than 1 device per zone. Devices include, break glass, Mushroom control buttons, Lever pull handle devices or suitable single action switch.
- Where an activation zone is the total floor area in which the integrated fire fighting service was activated, floor areas shall be distributed equally between the hydrant connection points not more than 60m apart

H3.9 Fire hydrants and water supply

(a) An intensive horticultural building–
   i. With a total floor area greater than 5000 m^2; and
   ii. Located where a rural fire brigade is available to attend a building fire, and

Must be –

iii. Provided with connection points no more than 90m apart

iv. Provided with local fire water storage tanks suitable for access within 18m of the building with '1 hour' reserve and suction points for local fire services vehicle; or

v. Provided with other water supply suitable for access near the building with drought based reserve and suction points for local fire services vehicle; and

vi. Located on the same allotment as an access point to water supply which –

A. Has a minimum total capacity of 72 000 litres; and

B. Is situated so as to enable emergency services vehicles access to within 4 m; and

C. Is located within 60 m of the building

D. Can be part of the irrigation network to the building

E. Have signage and valve locations clearly marked, visible from 100m away

F. Have a hydrant outlet connection from the irrigation system to cover the known worst hazard part within the building that may include the Main Power Supply, Generator unit, combustible or flammable goods storage bays, or the like, identified with the rural fire service locally as a fire hazard.

(b) A farm building –

i. With a total floor area greater than 500 m^2; and

ii. Located where a fire brigade is available to attend a building fire,

Must be –

iii. Provided with a fire hydrant system installed in accordance with AS 2419.1, except reference to '4 hours' water supply in clause 4.2 is replaced with '2 hours'; or

iv. Located on the same allotment as an access point to water supply which –

A. Has a minimum total capacity of 144 00 litres; and

B. Is situated so as to enable emergency services vehicles access to within 4 m ; and

C. Is located within 60 m of the building and not more than 90 m from any part of the building.

(c) For purposes of (a)(iv) or (b)(iv), water supply for a farm building or intensive horticultural building must consist of one or any number of the following

i. A water storage tank.

ii. A dam.

iii. A reservoir.

iv. A river.

v. A lake.

vi. A bore.

vii. A sea.

(d) If the whole or part of the water supply referred to in (a)(iv) or (b)(iv), is contained in a water storage tank, it must be –
   i. Located not less more than 10 60 m from the building; and
   ii. Fitted with at least one small bore suction connection and one large bore suction connection where –
      A. Each suction connection is located in a position so as to enable emergency service vehicles access to within 4 m; and
      B. The suction connections are located not less than 10 30 m from the building or the hazard part; and
      C. 'small bore suction connection' and 'large bore suction connection' have the meanings contained in AS 2419.1.

The Deemed-to-Satisfy Provisions of E1 do not apply to a farm shed. The Deemed-to-Satisfy Provisions of E1.5 and E1.8 do not apply to an intensive horticultural building.

H3.10 Fire hose reels

A fire hose reel system need not be provided to serve a farm building or intensive horticultural building where portable fire extinguishers are installed in accordance with H3.11.

H3.11 Portable fire extinguishers

(a) A farm building or intensive horticultural building not provided with a fire hose reel system in accordance with E1.4 must be provided with –
   i. One portable fire extinguisher rated at not less than 5ABE in each room or area containing a generator, flammable materials or electrical equipment with 240V or more containing flammable materials or electrical equipment; and
   ii. One portable fire extinguisher as per (b) rated at not less than 4A60BE adjacent to every required exit door; and
   iii. Location signs complying with clauses 3.3 to 3.9 of AS 2444 above each required portable fire extinguisher.

(b) A farm shed must be provided with not less than one portable fire extinguisher for every 500 m^2 of floor area or part thereof, distributed as evenly as practicable throughout the building.

(b) A portable fire extinguisher required by (b) must be –
   i. Of ABE or CO_2 type; and
   ii. Not less than 4.5 kg in size; and
   iii. Installed in accordance with Section 3 of AS 2444.

H3.12 Emergency lighting requirements

(a) An emergency lighting system need not be installed in a farm building or intensive horticultural buildings –
   a. With no artificial lighting as permitted by H3.18; or
   b. With artificial lighting where, if that lighting fails due to an emergency, automatic power supply to the building is provided by a fuel-driven generator.

(b) An emergency lighting system need not be installed in a farm shed.

H3.13 Exit signs

An exit serving a farm shed, Group B or C intensive horticultural building need not be provided with an exist sign where the exit is a permanent opening not less than 2 m wide.

H3.14 Direction signs

In a farm building, intensive horticultural building or a farm shed, if an exist is not readily apparent to persons occupying or visiting the building, exit signs complying with H3.15 must be installed in appropriate positions in corridors, hallways, lobbies, and the like, indicating the direction to a required exit.

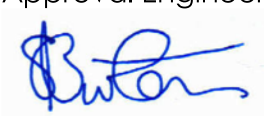
H3.15 Design and operation of exit signs

(a) In a farm building or intensive horticultural building, each required exit sign provided under E4.5 and H3.14 need not comply with E4.8 if –
   a. The use of illuminated exit signs may adversely impact the behaviour or welfare of animals being kept in the building; and
   b. Non-illuminated exit signs are installed in accordance with clauses 6.5, 6.6, 6.8 and 6.9 of AS 2293.1.

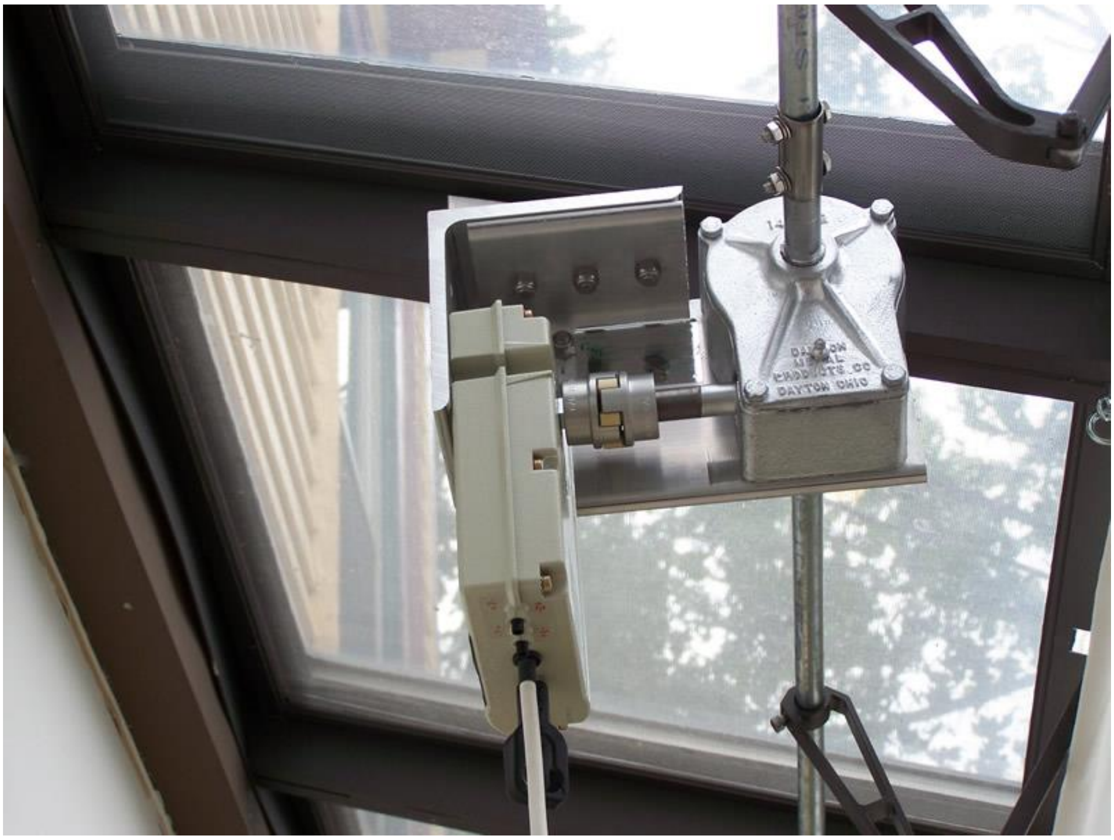
(b) In a farm shed or Group C intensive horticultural building, each required exit sign provided under E4.5 and H3.14 need not comply with E4.8 if exit signs complying with Section 6 and Appendix D of AS 2293.1 and provided except –
   a. The exit sign need not be illuminated; and
   b. The maximum viewing distance in clause 6.6 of AS 2293.1 must be not more than 24 m; and
   c. Clauses 6.3 and 6.7 of AS 2293.1 do not apply.

Please contact Mr Stephen Burton, on 07 3392 7722, should you have any questions regarding this assessment.

Fire Consultant
Approval Engineer



Stephen Burton
Fire Engineer
RPEQ 3633
(07) 3392 7722


DAYTON OHIO

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[5] Building Code of Australia; Australian Building Codes Board

[6] Horticultural applications of CO_2 enrichment; Plants in Action

[7] Worldwide status and history of CO_2 enrichment: Wittwer, S.H. 1986

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APPENDIX A CLASSIFICATION GUIDE OF BUILDINGS – ABCB

UNDERSTANDING THE NCC

ABCB

BUILDING CLASSIFICATIONS

The National Construction Code (NCC) sets out the minimum technical requirements for new buildings (and new building work in existing buildings) in Australia. In doing so, it groups buildings[1] by their function and use. These groups are assigned a classification which is then how buildings are referred to throughout the NCC. This information is crucial for all NCC users. The following is a general representation of the building classifications in the NCC. It is based on a national perspective and does not address any State or Territory variations[2].

BUILDING CLASSIFICATIONS

NCC Volume One (Part A3)
NCC Volume Two (Part 1.3)
NCC Volume Three (Part A4)

The building classifications are labelled "Class 1" through to "Class 10". Some classifications also have sub classifications, referred to by a letter after the number (e.g. Class 1a).

Class 2 to 9 buildings are mostly covered by Volume One of the NCC and Class 1 and 10 buildings are mostly covered by Volume Two of the NCC. Volume Three of the NCC, the Plumbing Code of Australia, refers to all building classifications.

A building may have parts that have different uses. In most cases, each of these parts must be classified separately.

A building (or part of a building) may also have more than one use and may be assigned more than one classification.

WHAT IS AN SOU?

A Sole Occupancy Unit (commonly known as an SOU) is defined in the NCC. It is a part of a building for occupation by an owner/s, lessee, or tenant, to the exclusion of any other owner/s, lessee, or tenant. So put simply, it is a space with an exclusive use in a building.

SOUs can be located in a number of different classifications. They include:

- A residential apartment or flat
- A self-contained unit
- A suite of rooms in a hotel or motel
- A shop in a shopping centre

CLASS 1 BUILDINGS

DID YOU KNOW?

Class 1 buildings cannot be located above or below any other dwelling (or any other class of building) other than a private garage.

Class 1 buildings are houses. Typically they are standalone single dwellings of a domestic or residential nature. They can also be horizontally attached to other Class 1 buildings such as terrace houses, row houses, or townhouses. In these situations they must be separated by a wall that has fire-resisting and sound insulation properties.

The Class 1 classification includes two sub classifications: Class 1a and Class 1b.

A **Class 1a** building is a single dwelling being a detached house; or one of a group of attached dwellings being a town house, row house or the like.

A **Class 1b** building is a boarding house, guest house or hostel that has a floor area less than 300 m^2, and ordinarily has less than 12 people living in it. It can also be four or more single dwellings located on one allotment which are used for short-term holiday accommodation.

1 In this document, a building may also refer to a structure such as a swimming pool.
2 State and Territory variations and additions to the NCC are located in the NCC. The NCC is available at the ABCB website.

The information in this document is intended to be used as guidance material only, and is in no way a substitute for the NCC and related State and Territory legislation. The information in this publication is provided on the basis that all persons accessing the information undertake responsibility for assessing the relevance and accuracy of the information to their particular circumstances.

The ABCB website is www.abcb.gov.au

CLASS 2 BUILDINGS

Class 2 buildings are apartment buildings. They are typically multi-unit residential buildings where people live above and below each other. The NCC describes the space which would be considered the apartment as a sole-occupancy unit (SOU).

Class 2 buildings may also be single storey attached dwellings where there is a common space below. For example, two dwellings above a common basement or carpark.

IS IT A CLASS 1B, 2 OR 3 RESIDENTIAL BUILDING?

Classification is a process for understanding risk in a building (or part of a building) according to its use.

Where it is unclear which classification should apply, the approval authority has the discretion to decide.

CLASS 3 BUILDINGS

Class 3 buildings are residential buildings other than a Class 1 or Class 2 building. They are a common place of long term or transient living for a number of unrelated people. Examples include a boarding house, guest house, hostel or backpackers (that are larger than the limits for a Class 1b building). Class 3 buildings could also include dormitory style accommodation, or workers' quarters for shearers or fruit pickers.

Class 3 buildings may also be "care-type" facilities such as accommodation buildings for children, the elderly, or people with a disability, and which are not considered to be Class 9 buildings.

DID YOU KNOW?

A Class 3 building includes the residential parts of hotels, motels, schools, hospitals, or jails.

CLASS 4 PART OF A BUILDING

A Class 4 part of a building is a dwelling or residence within a building of a non-residential nature. An example of a Class 4 part of a building would be a caretaker's residence in a storage facility. A Class 4 part can only be located in a Class 5 to 9 building.

IS IT THE ONLY RESIDENCE IN THE BUILDING?

If so, then it is likely to be a Class 4 part of a building. There can only be one Class 4 part in a building.

A Class 4 part cannot be located in a Class 1, 2 or 3 building.

CLASS 5 BUILDINGS

Class 5 buildings are office buildings that are used for professional or commercial purposes, excluding Class 6, 7, 8 or 9 buildings.

Examples of Class 5 buildings are offices for lawyers, accountants, general medical practitioners, government agencies and architects.

WHEN IS A GENERAL MEDICAL PRACTITIONER'S OFFICE NOT A CLASS 5 BUILDING?

Generally, a general medical practitioner's office will be a Class 5 building. However, if any medical treatment administered leaves patients unconscious or non-ambulatory, then the building would be considered a health-care building (as defined by the NCC) and be a Class 9a building, for example a hospital.

CLASS 6 BUILDINGS

Class 6 buildings are typically shops, restaurants and cafés. They are a place for the sale of retail goods or the supply of services direct to the public. Some examples are:

- A dining room, bar, shop or kiosk part of a hotel or motel
- A hairdresser or barber shop
- A public laundry
- A market or showroom
- A funeral parlour
- A shopping centre.

IS A SERVICE STATION A CLASS 6 BUILDING?

Yes, as they are intended for the servicing of cars and the sale of fuel or other goods.

However, the term "service station" does not cover buildings where panel beating, auto electrical, tyre replacement or the like are solely carried out. These would be Class 8 buildings.

CLASS 7 BUILDINGS

Class 7 buildings include two sub classifications: Class 7a and Class 7b.

Class 7a buildings are carparks.

Class 7b buildings are typically warehouses, storage buildings or buildings for the display of goods (or produce) that is for wholesale.

DID YOU KNOW?

Reference to wholesale means "sale to people in the trades or in the business of 'on-selling' goods and services to another party (including the public)".

CLASS 8 BUILDINGS

A factory is the most common way to describe a Class 8 building. It is a building in which a process (or handicraft) is carried out for trade, sale, or gain. The building can be used for production, assembling, altering, repairing, finishing, packing, or cleaning of goods or produce. It includes buildings such as a mechanic's workshop. It may also be a building for food manufacture, such as an abattoir. A laboratory is also a Class 8 building, even though it may be small in size. This is due to their high potential for a fire hazard.

ARE FARM BUILDINGS CLASS 7, 8, OR 10a?

It depends on the occupancy, use and size. Buildings used for farming-type purposes are often very diverse in nature. For example a shed for parking a single tractor may be a Class 10a, however if multiple tractors and other farm machinery is parked, the building may be a Class 7a (or even a Class 8 if mechanics were employed to work on the machinery).

The NCC defines a difference between a farm shed and a farm building. It also contains specific Deemed-to-Satisfy Provisions for these buildings under part H3 of Volume One.

CLASS 9 BUILDINGS

DID YOU KNOW?

Laboratories which are part of health-care buildings are classified as Class 9a buildings despite the general classification of laboratories being Class 8.

Class 9 buildings are buildings of a public nature. Class 9 buildings include three sub classifications: Class 9a, Class 9b and Class 9c.

Class 9a buildings are generally hospitals which are referred to in the NCC as health-care buildings. They are buildings in which occupants or patients are undergoing medical treatment and may need physical assistance to evacuate in the case of an emergency. This includes a clinic (or day surgery) where the effects of the treatment administered would involve patients becoming unconscious or unable to move. This in turn requires supervised medical care (on the premises) for some time after treatment has been administered.

Class 9b buildings are assembly buildings in which people may gather for social, theatrical, political, religious or civil purposes. They include schools, universities, childcare centres, pre-schools, sporting facilities, night clubs, or public transport buildings.

Class 9c buildings are aged care buildings. Aged care buildings are defined as residential accommodation for elderly people who, due to varying degrees of incapacity associated with the ageing process, are provided with personal care services and 24 hour staff assistance to evacuate the building in an emergency.

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CLASS 10 BUILDINGS OR STRUCTURES

Class 10 buildings are non-habitable buildings or structures. Class 10 includes three sub classifications: Class 10a, Class 10b and Class 10c.

Class 10a buildings are non-habitable buildings including sheds, carports, and private garages.

Class 10b is a structure being a fence, mast, antenna, retaining wall, swimming pool, or the like.

A **Class 10c** building is a private bushfire shelter. A private bushfire shelter is a structure associated with, but not attached to, a Class 1a building.

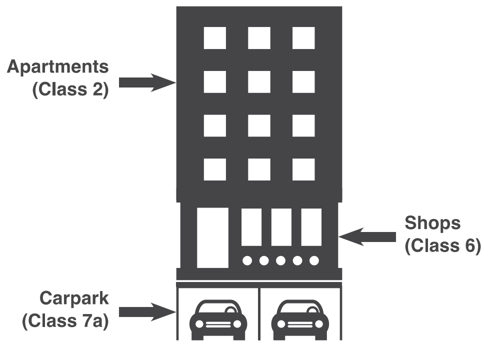
WHAT IS A PRIVATE GARAGE?

- A garage associated with a Class 1 building; or
- A single storey of a building containing not more than 3 vehicle spaces (limited to only one storey within a building); or

Any separate single storey garage associated with another building that contains no more than 3 vehicles.

MIXED USE BUILDINGS

As buildings can have mixed uses they can also have mixed (or multiple) classifications. For example, a building may have a basement carpark (Class 7a) with ground floor retail space (Class 6) and residential apartments above (Class 2). See below.



HOW BIG MUST A PART OF A BUILDING BE TO HAVE ITS OWN CLASSIFICATION?

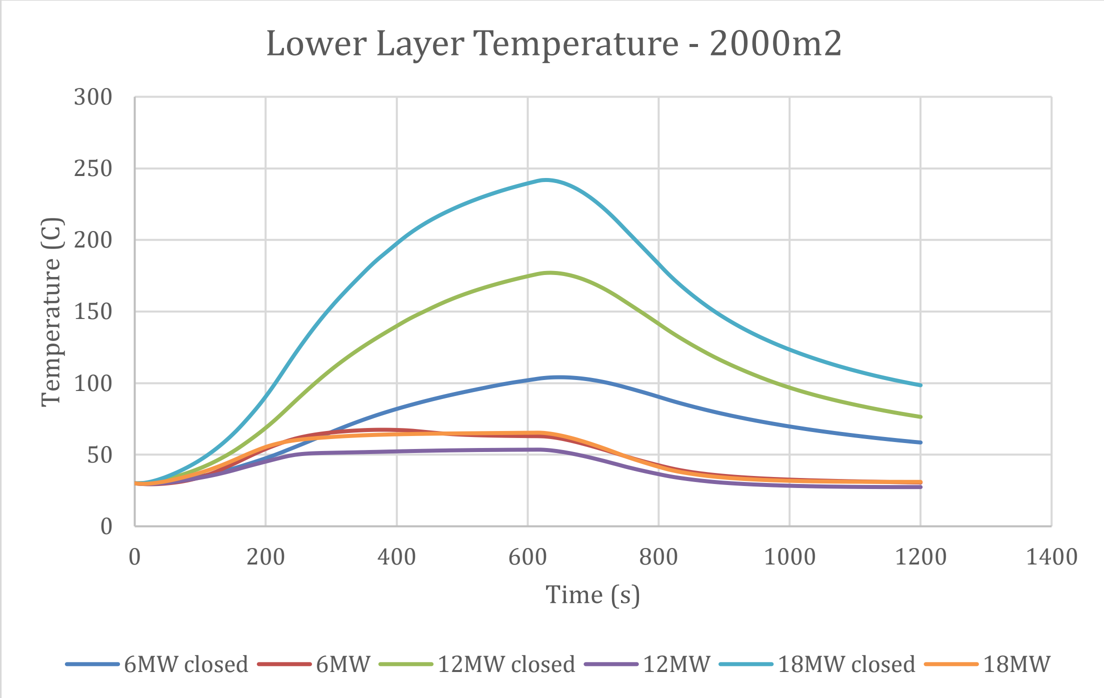
Every part of a building must be separately classified. However, where a part has a different purpose and is not more than 10% of the floor area of the storey it is on, then it may be considered to be ancillary to the major use.

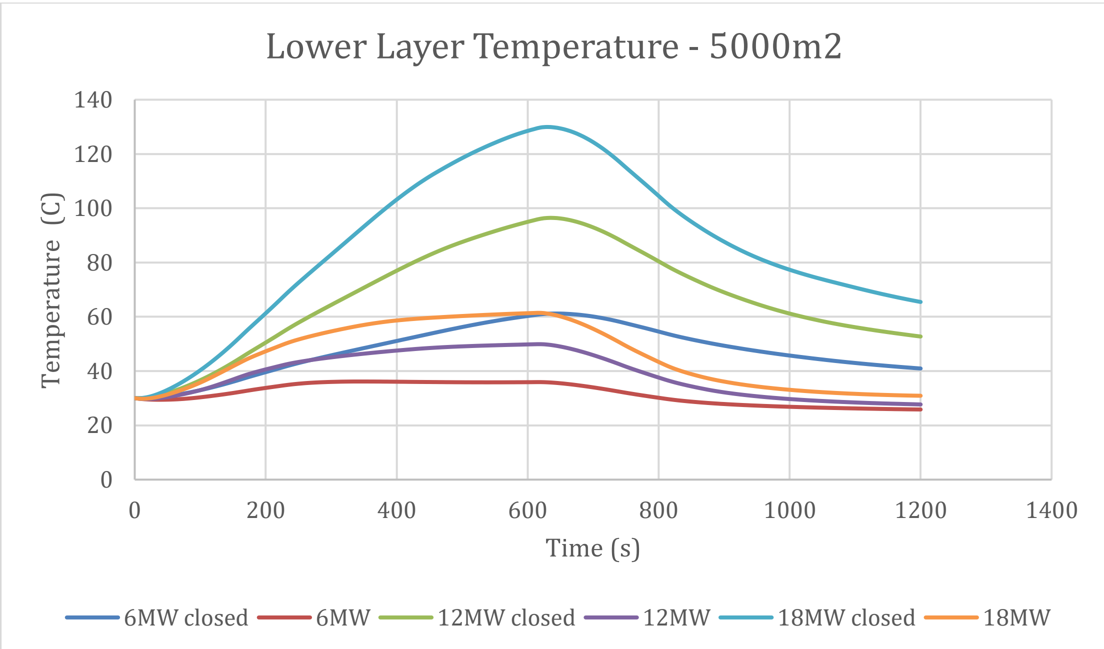
For instance, if a single storey warehouse (Class 8) has an office (Class 5) which takes up only 8% of the floor area, the whole building can be classified as a Class 8. However, if the office takes up 12% of the floor area then the building has mixed uses and the warehouse (Class 8) and office (Class 5) must be classified separately.

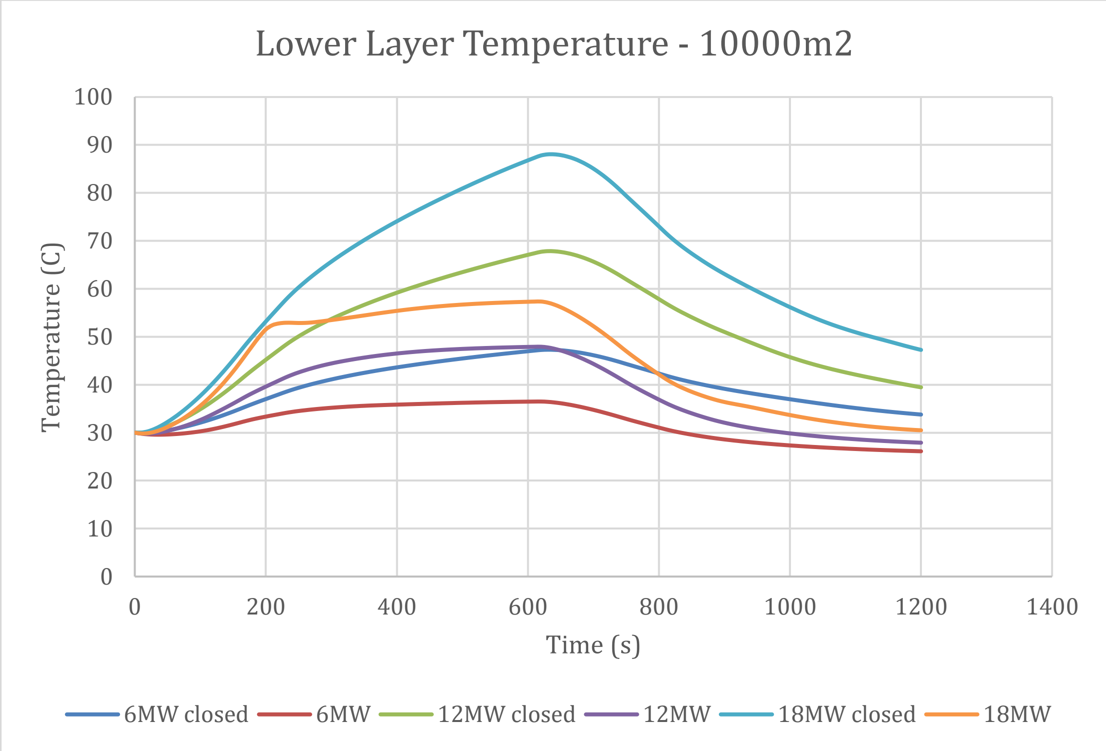
MULTIPLE BUILDING CLASSIFICATIONS

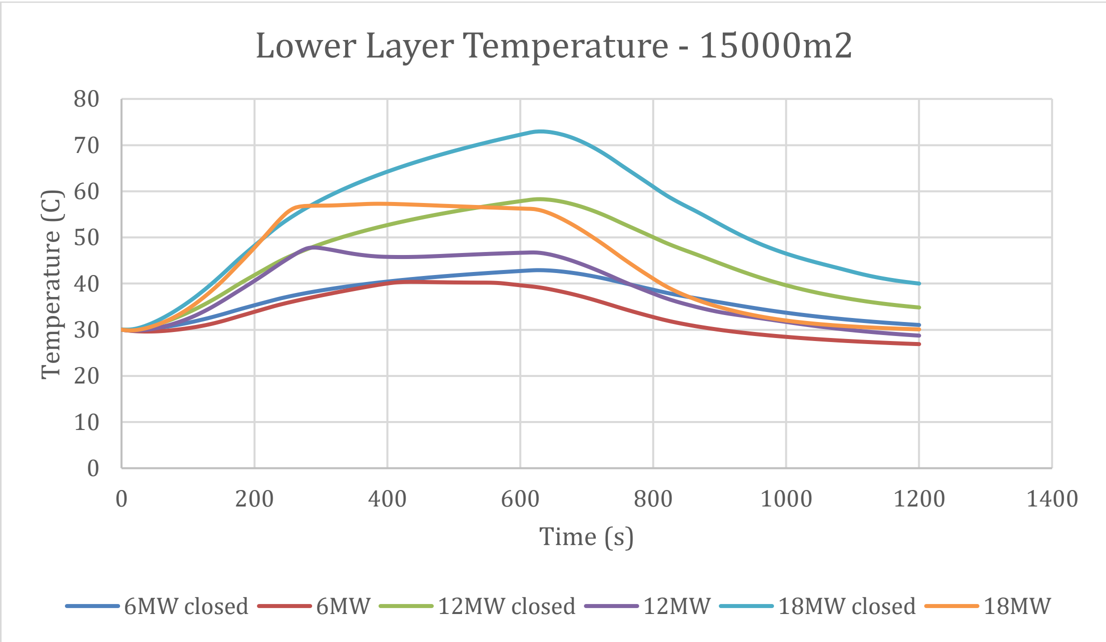
A building (or a part of a building) may be designed to serve multiple purposes and may have more than one classification. This means that it is permissible for a building to be a Class 6/7, or a Class 5/6, or whatever is appropriate. This allows flexibility in how the building might be used over time. For example, if a building is intended for retail shopping, storage or office space it may be designed as a Class 5/6/7. At the design stage, it may not be clear who the final tenant will be (or how they will be using their tenancy) so as long as the design meets the minimum requirements of all the classifications, it could be used for any of the purposes.

APPENDIX B GROUP A FURTHER GRAPHS AND GRAPHICS






Lower Layer Temperature - 10000m2
Temperature (C)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
Time (s)
6MW closed
6MW
12MW closed
12MW
18MW closed
18MW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70
60
50
40
30
20
10
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0
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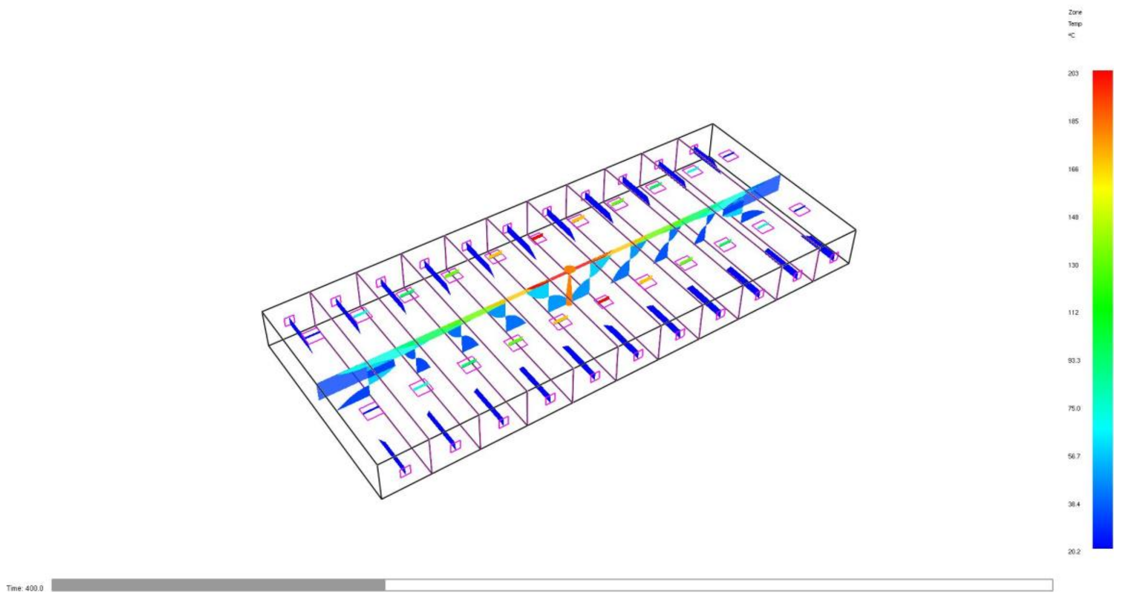
600
800
1000
1200
1400
Time (s)
6MW closed
6MW
12MW closed
12MW
18MW closed
18MW


Zone
Temp
°C
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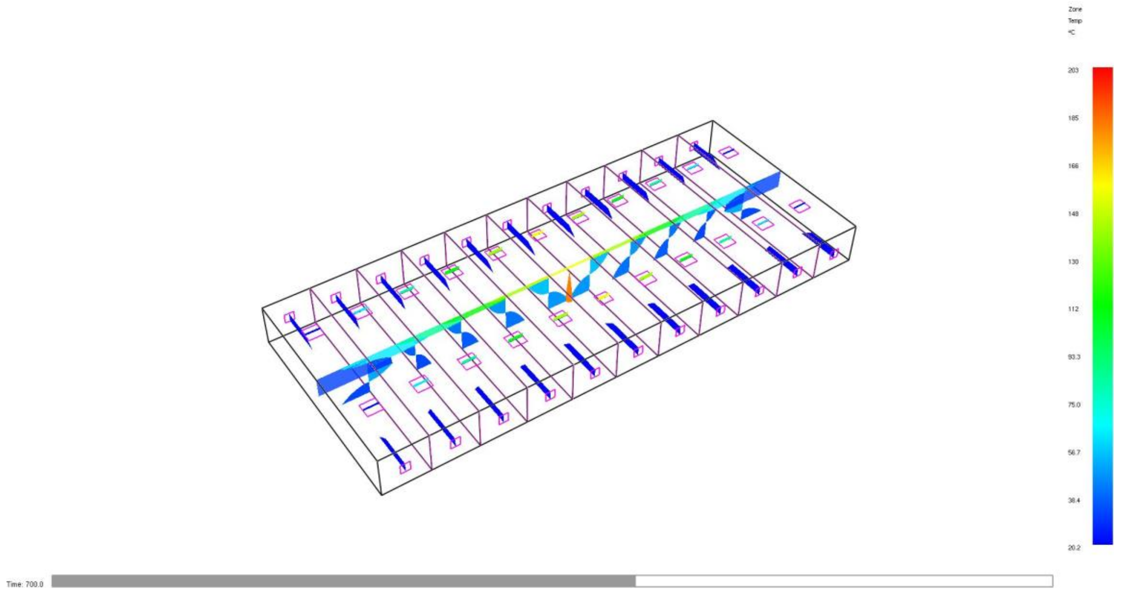
185
166
148
130
112
93.3
75.0
56.7
38.4
20.2
Time: 400.0


Zone
Temp
°C
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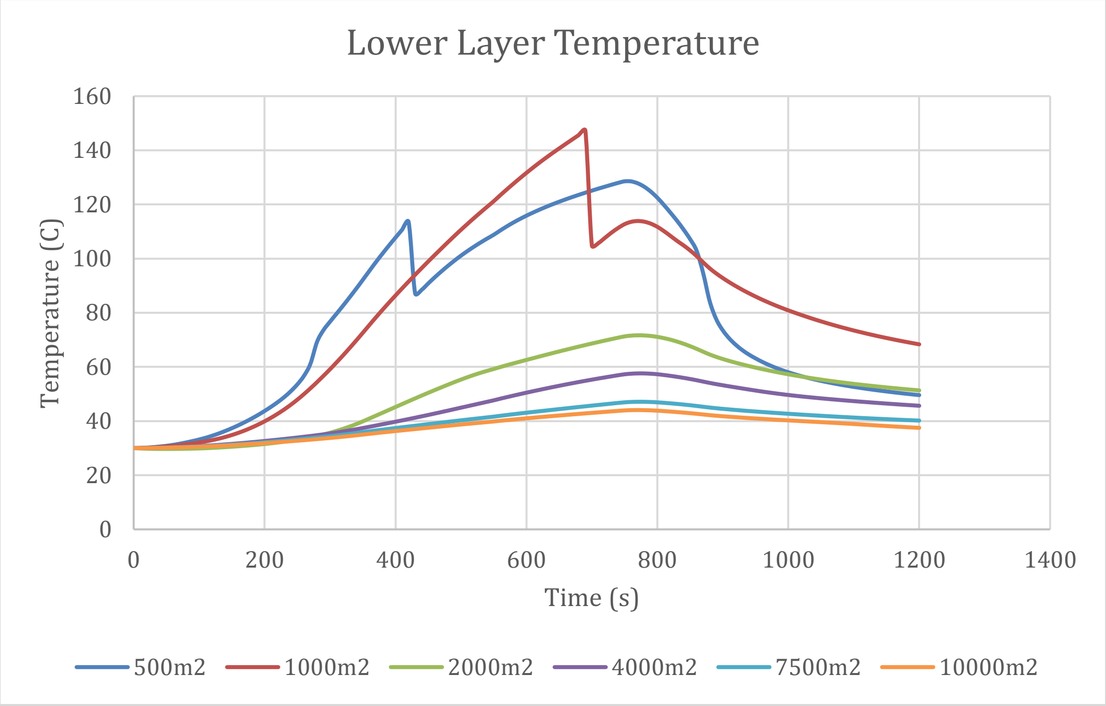
185
166
148
130
112
93.3
75.0
56.7
38.4
20.2
Time: 700.0

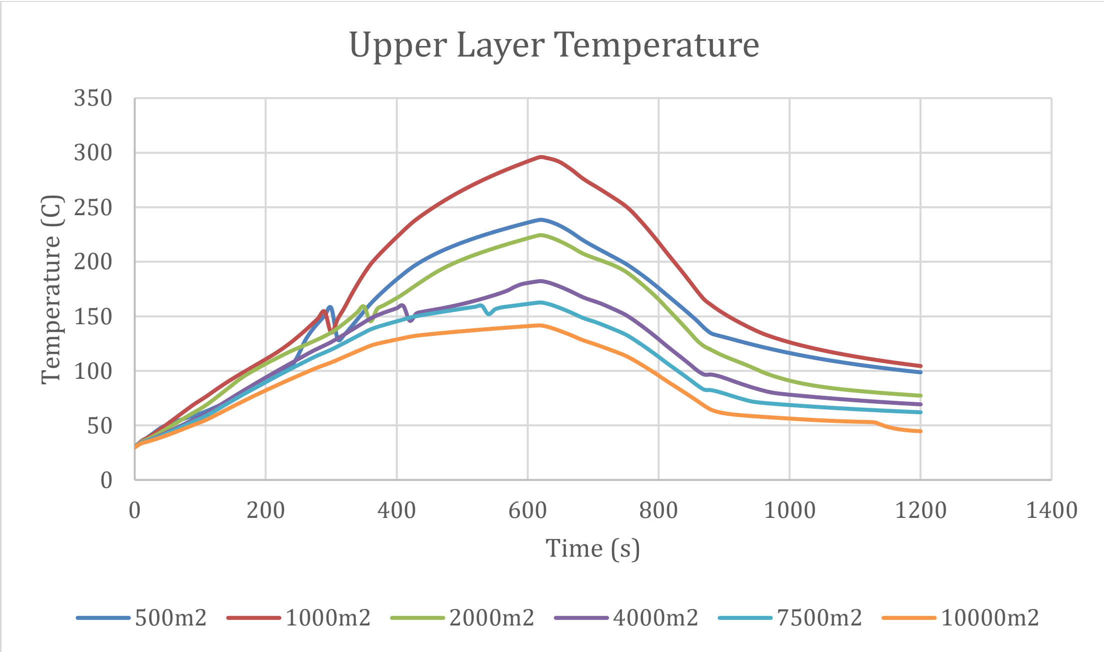
APPENDIX C GROUP B SENSITIVITY ANALYSIS

SECOND ROUND MODELING

6MW Fire, 7m Structure



12MW Fire, 7m Structure


Upper Layer Temperature
350
300
250
200
150
100
50
0
Temperature (C)
0
200
400
600
800
1000
1200
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Time (s)
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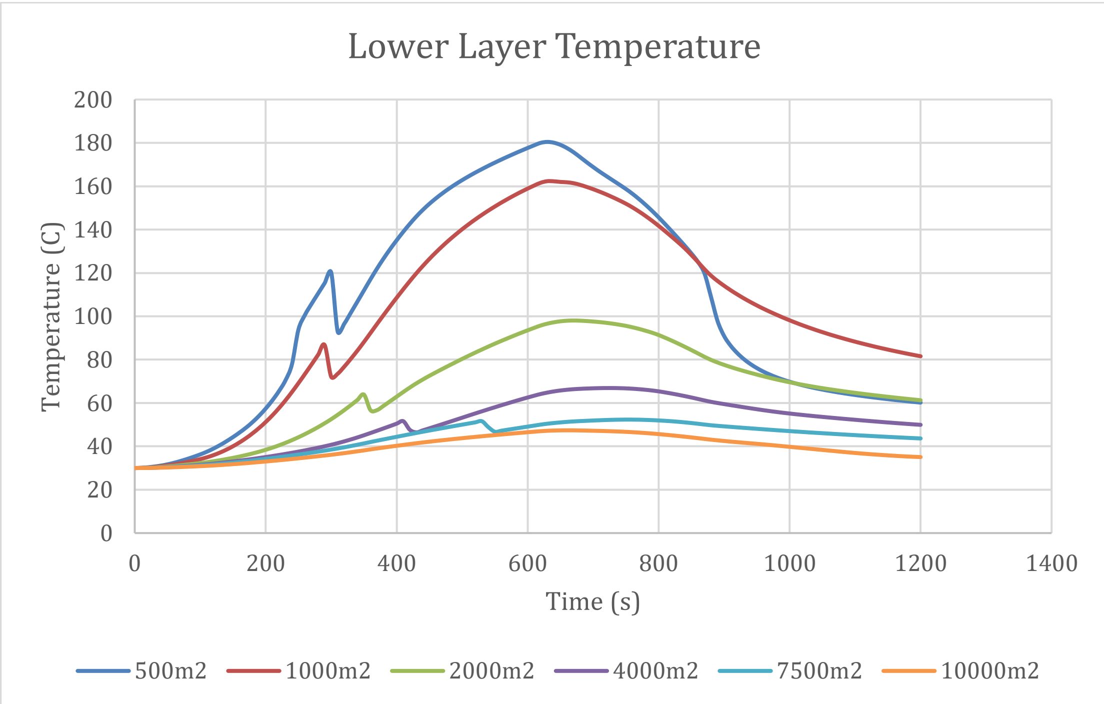
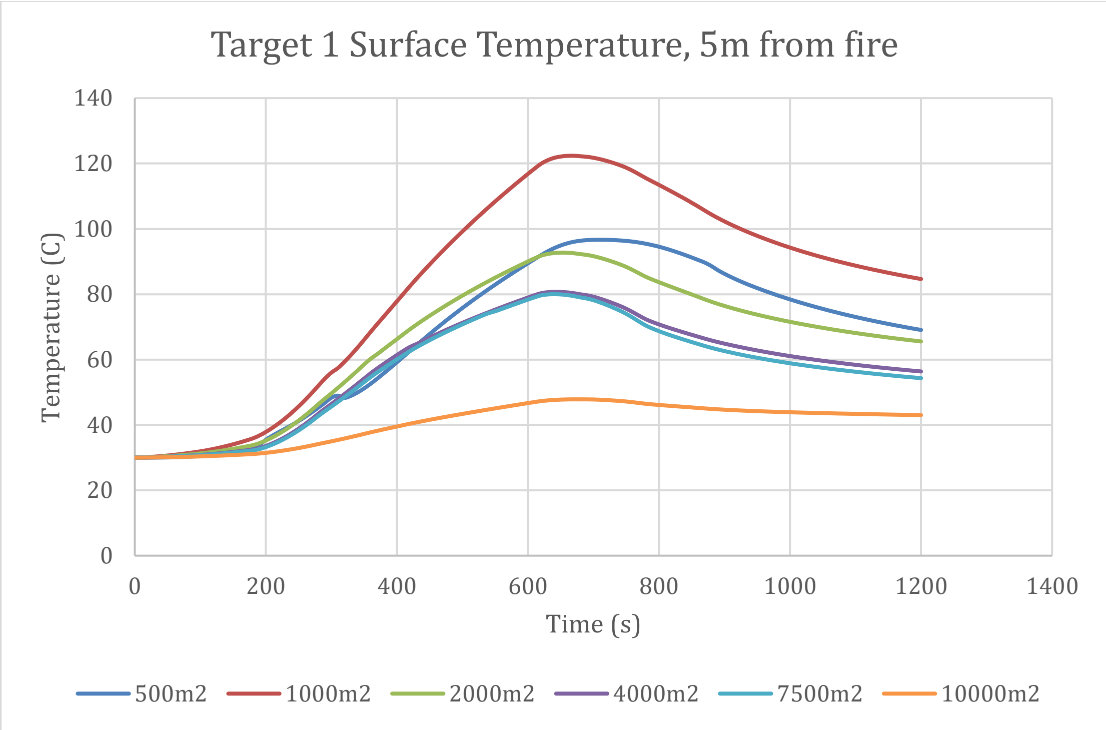
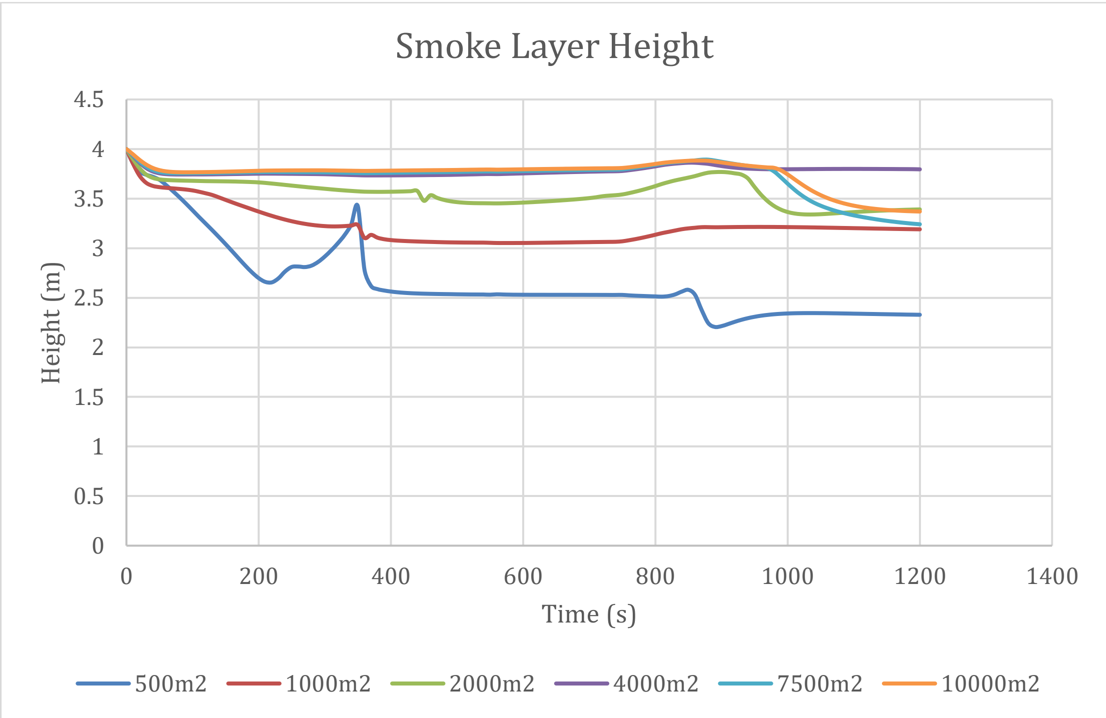
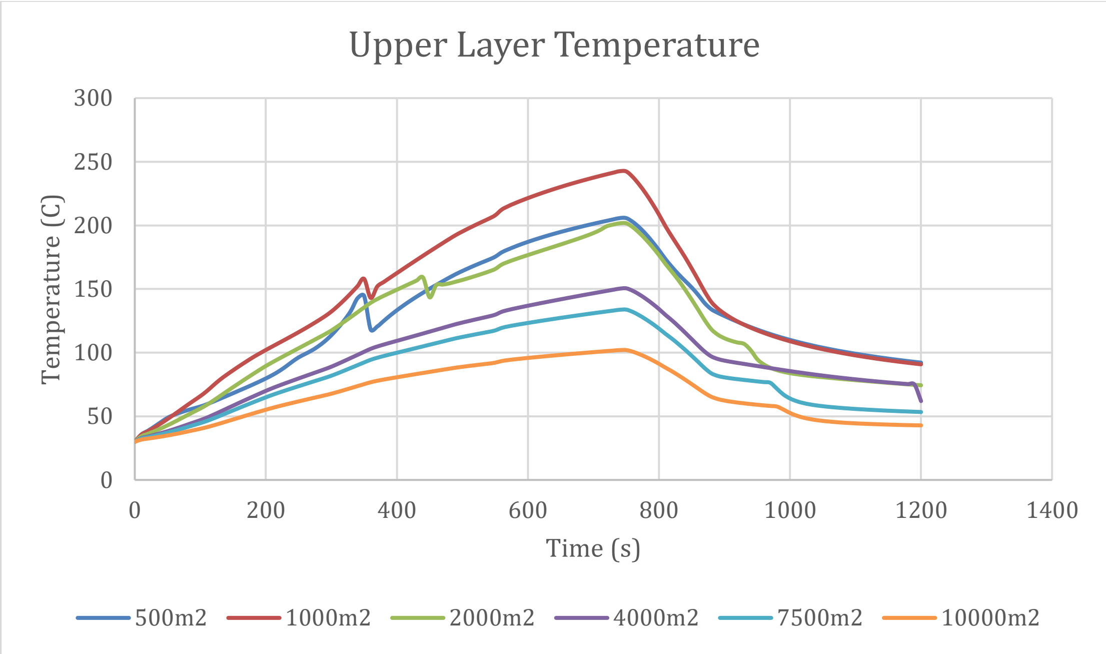
1000m2
2000m2
4000m2
7500m2
10000m2


Lower Layer Temperature
200
180
160
140
120
100
80
60
40
20
0
Temperature (C)
0
200
400
600
800
1000
1200
1400
Time (s)
500m2
1000m2
2000m2
4000m2
7500m2
10000m2



6MW, 4m Structure




Upper Layer Temperature
Temperature (C)
300
250
200
150
100
50
0
0
200
400
600
800
1000
1200
1400
Time (s)
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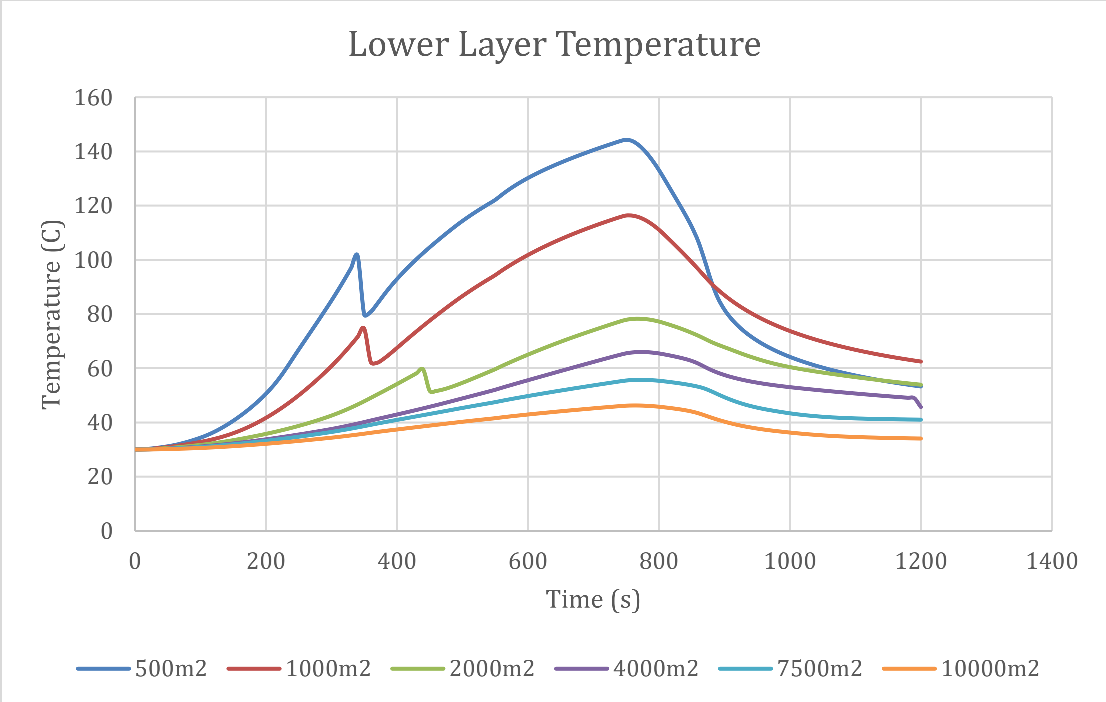
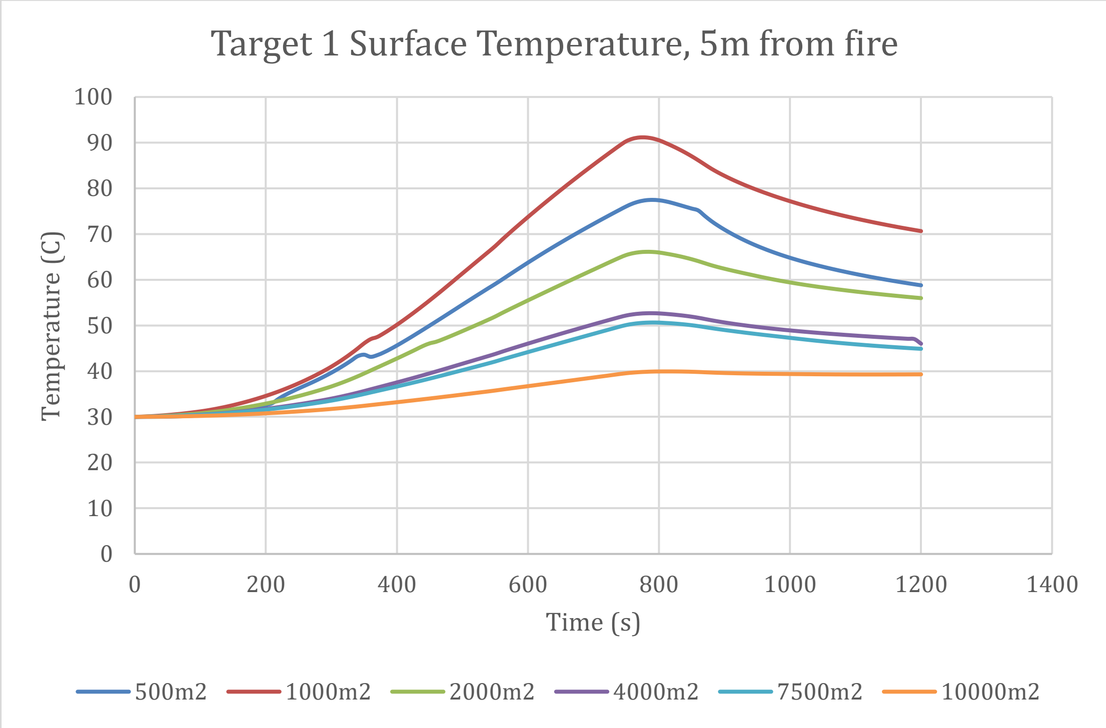
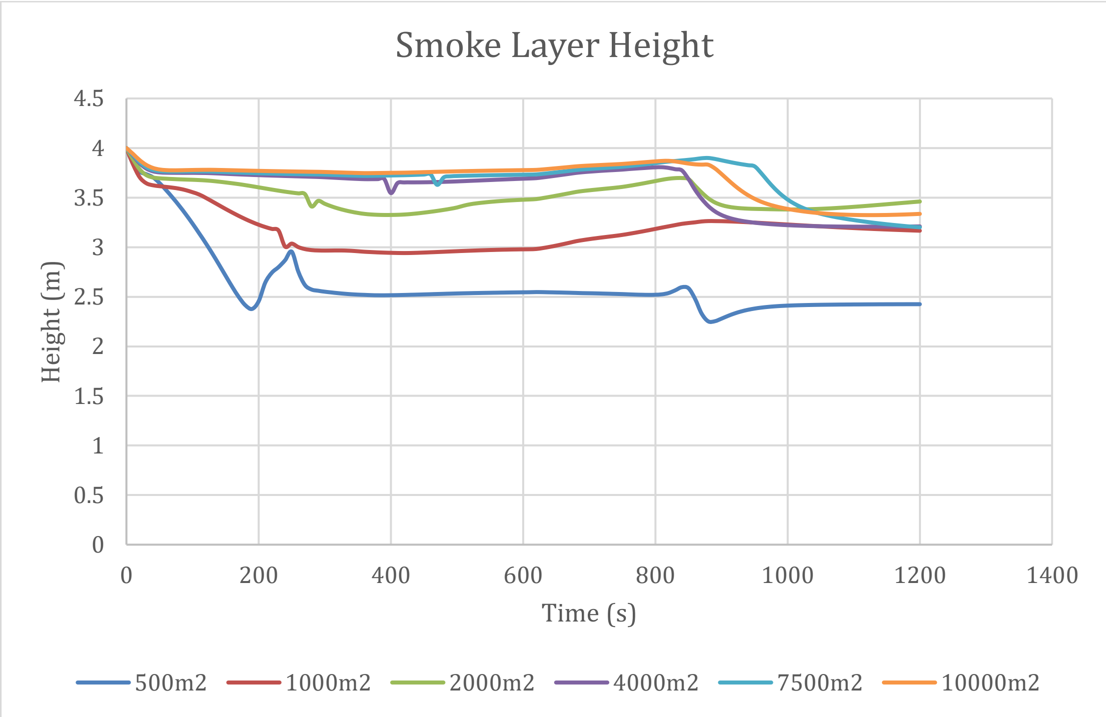
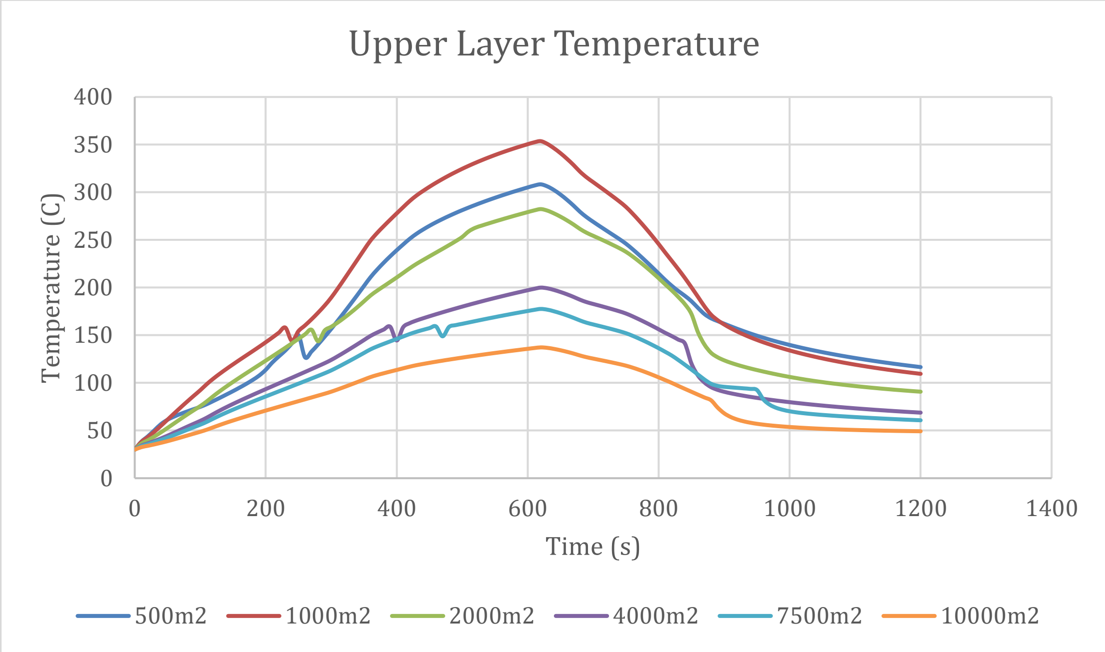
2000m2
4000m2
7500m2
10000m2

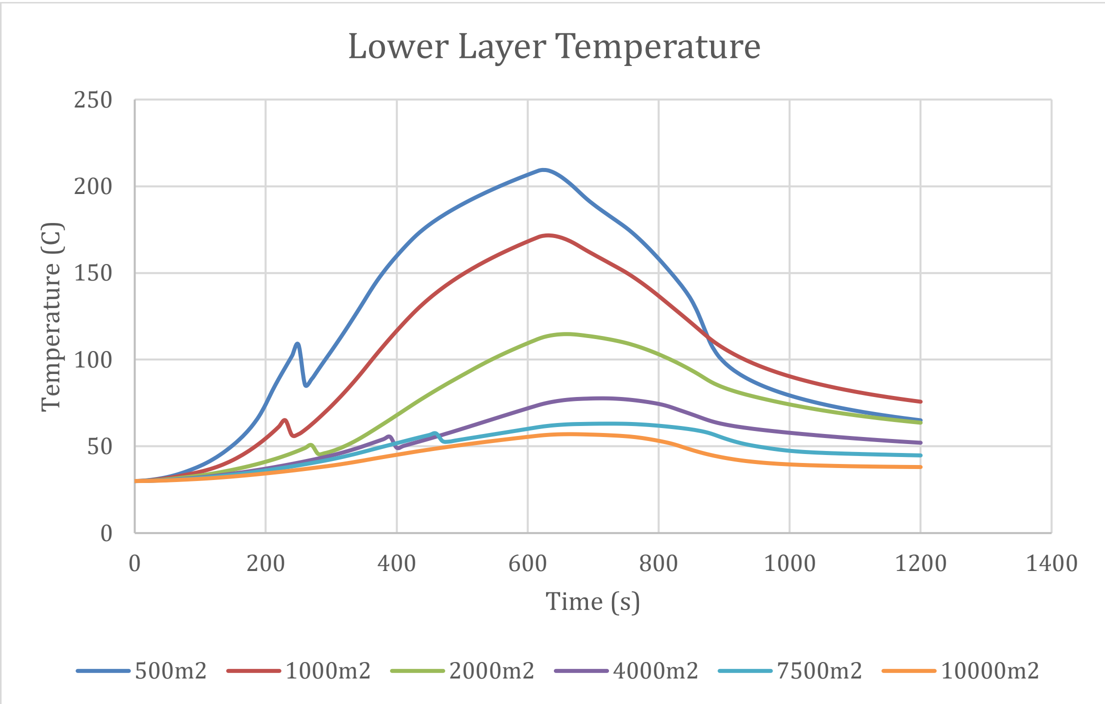

Lower Layer Temperature
Temperature (C)
160
140
120
100
80
60
40
20
0
0
200
400
600
800
1000
1200
1400
Time (s)
500m2
1000m2
2000m2
4000m2
7500m2
10000m2



12MW Fire, 4m Structure




Upper Layer Temperature
Temperature (C)
400
350
300
250
200
150
100
50
0
0
200
400
600
800
1000
1200
1400
Time (s)
500m2
1000m2
2000m2
4000m2
7500m2
10000m2


Lower Layer Temperature
Temperature (C)
250
200
150
100
50
0
0
200
400
600
800
1000
1200
1400
Time (s)
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1000m2
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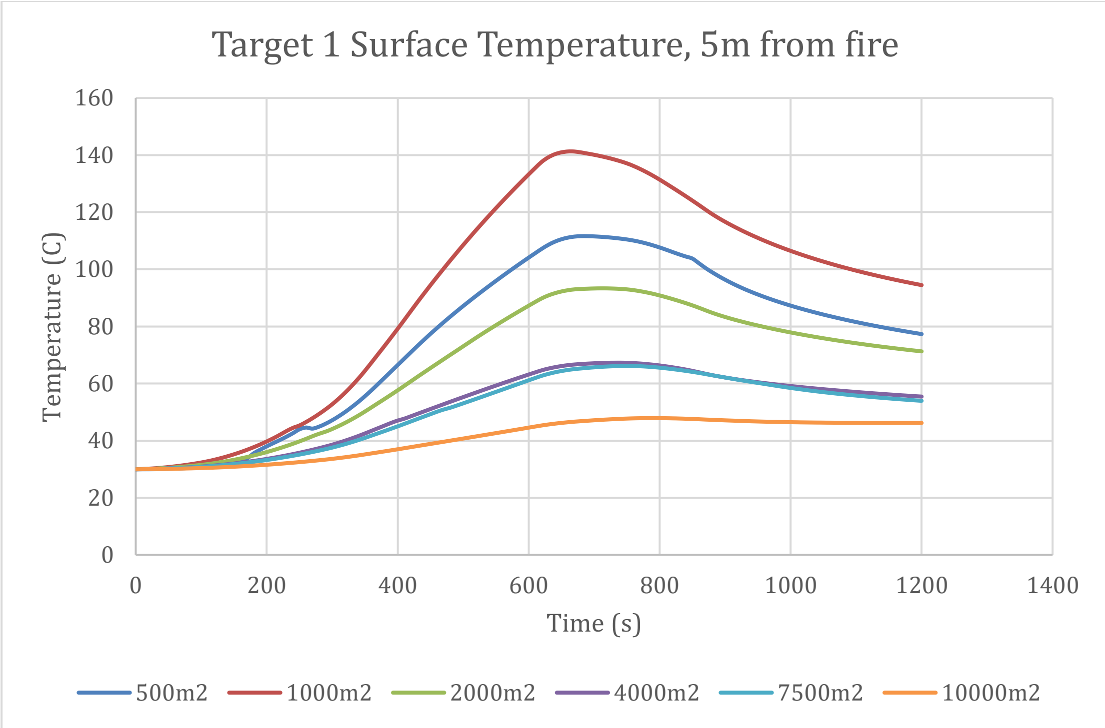
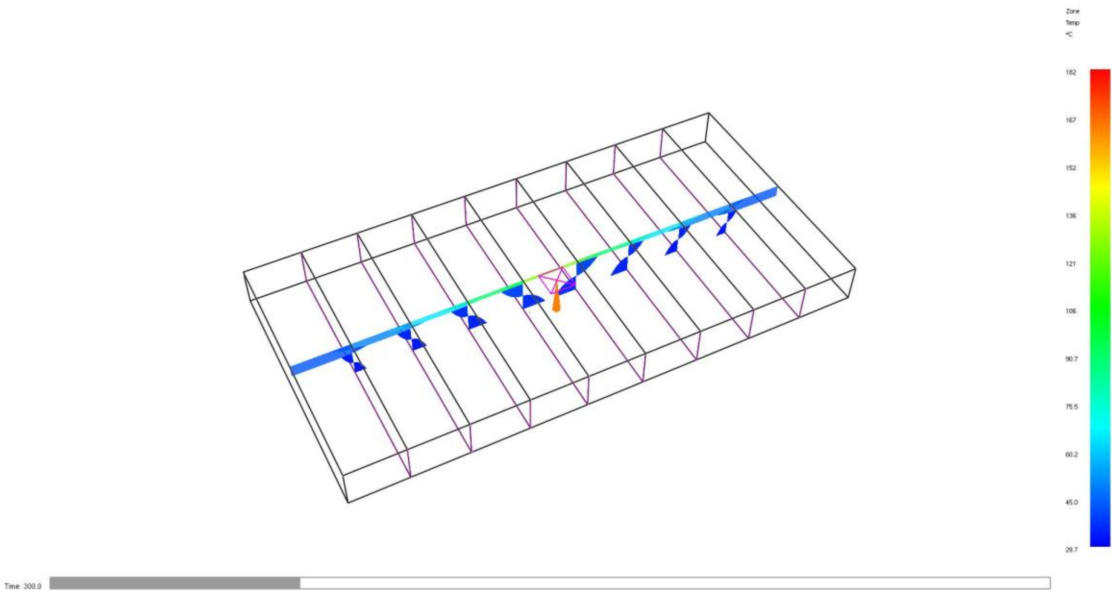
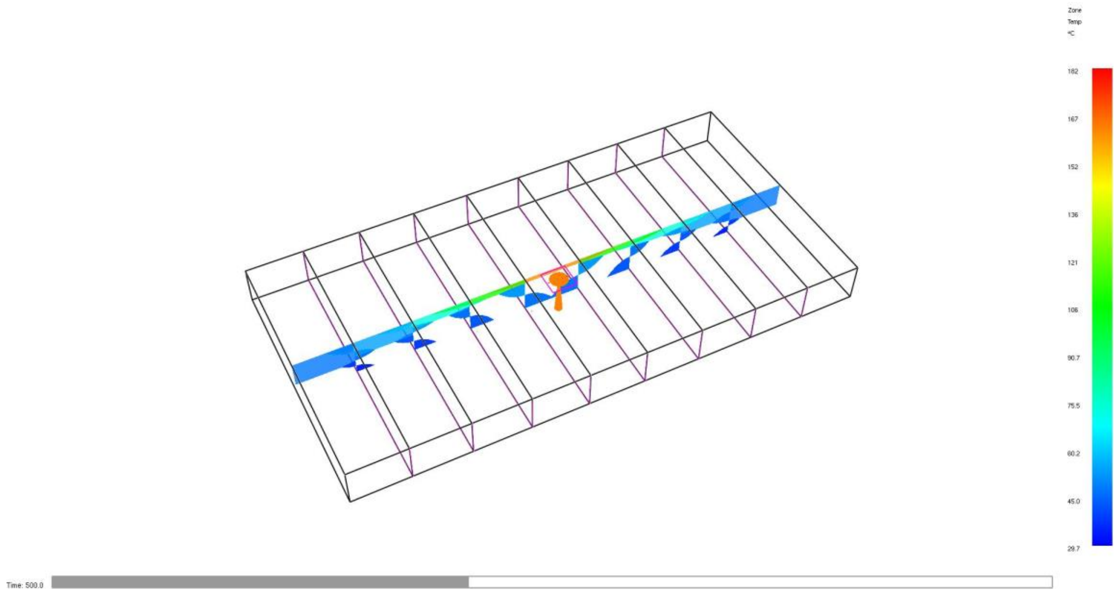
4000m2
7500m2
10000m2

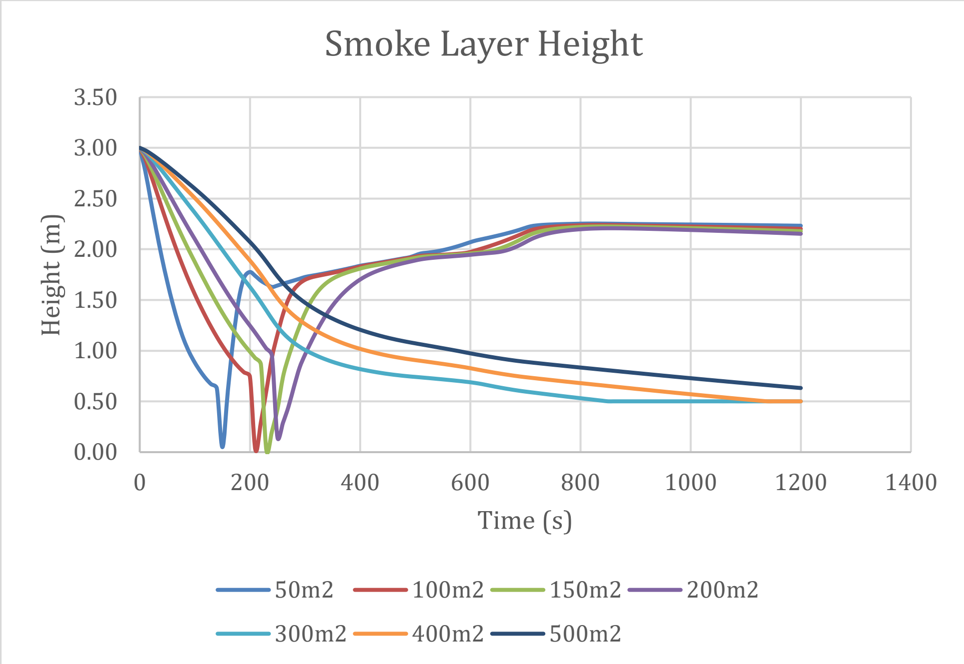

Target 1 Surface Temperature, 5m from fire
Temperature (C)
160
140
120
100
80
60
40
20
0
0
200
400
600
800
1000
1200
1400
Time (s)
500m2
1000m2
2000m2
4000m2
7500m2
10000m2

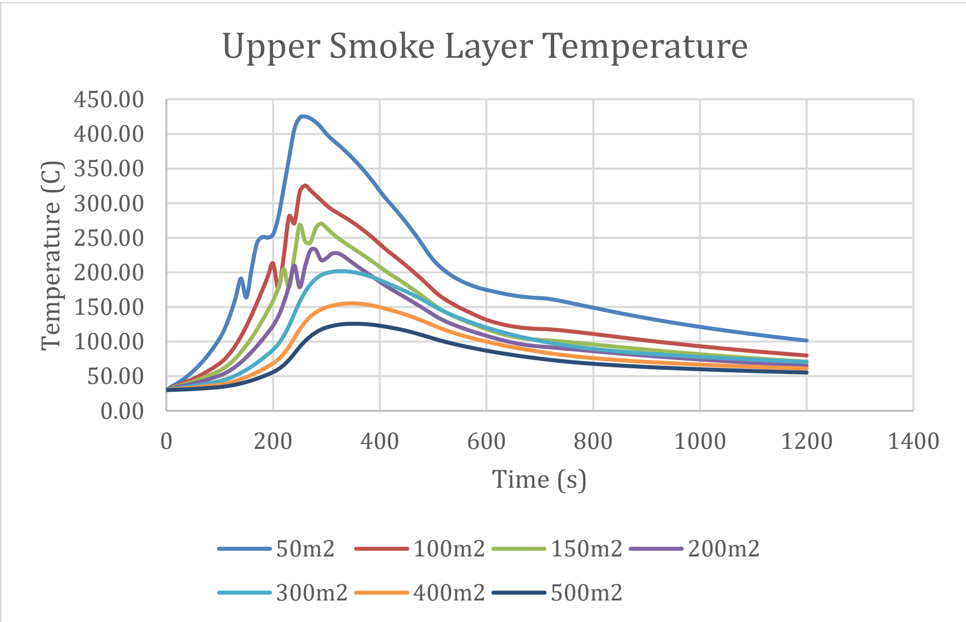

Zone
Temp
°C
182
167
152
136
121
106
90.7
75.5
60.2
45.0
29.7
Time: 300.0

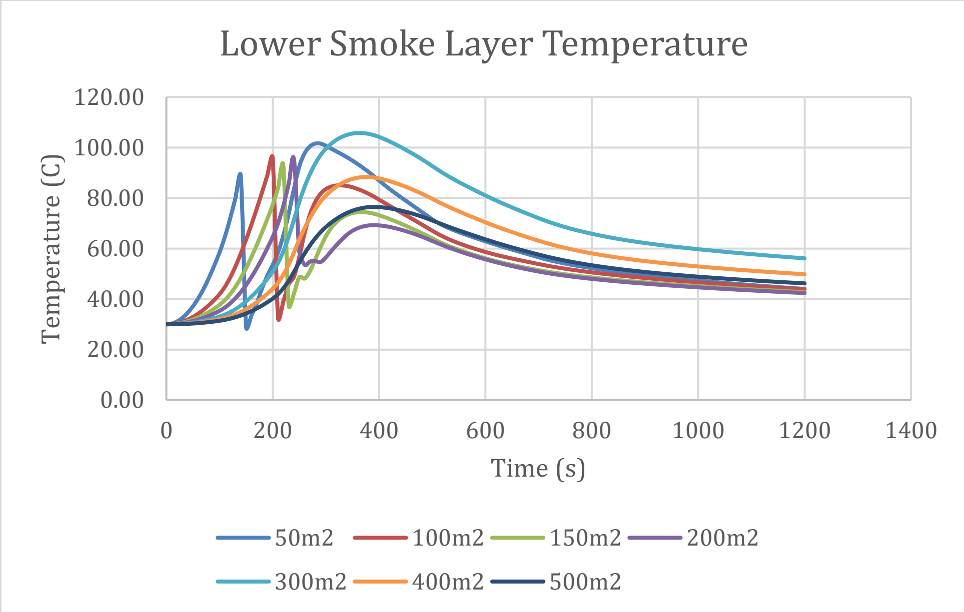

Zone
Temp
°C
182
167
152
136
121
106
90.7
75.5
60.2
45.0
29.7
Time: 500.0

APPENDIX C GROUP C SENSITIVITY ANALYSIS

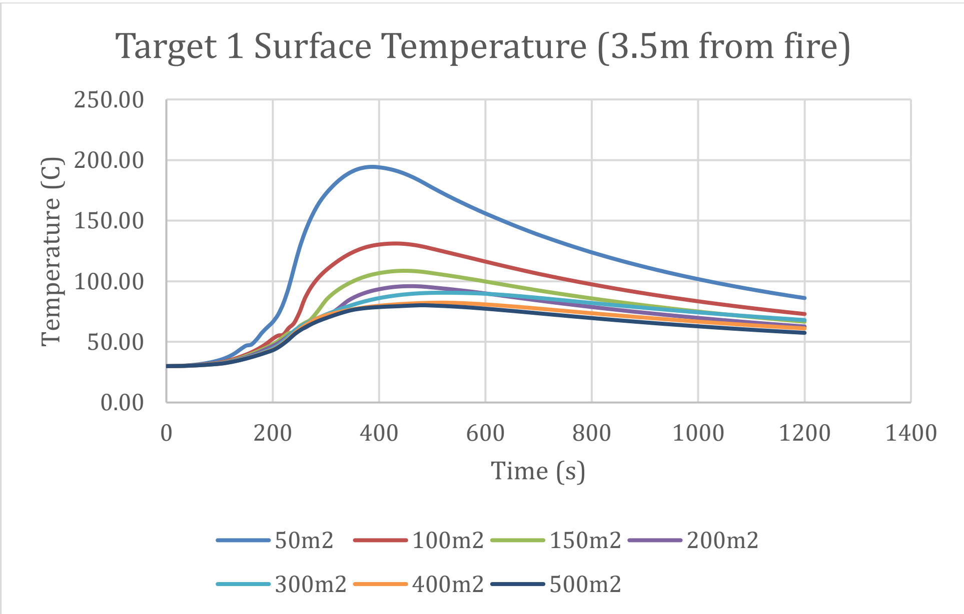
Second Round Modelling
3m Structure





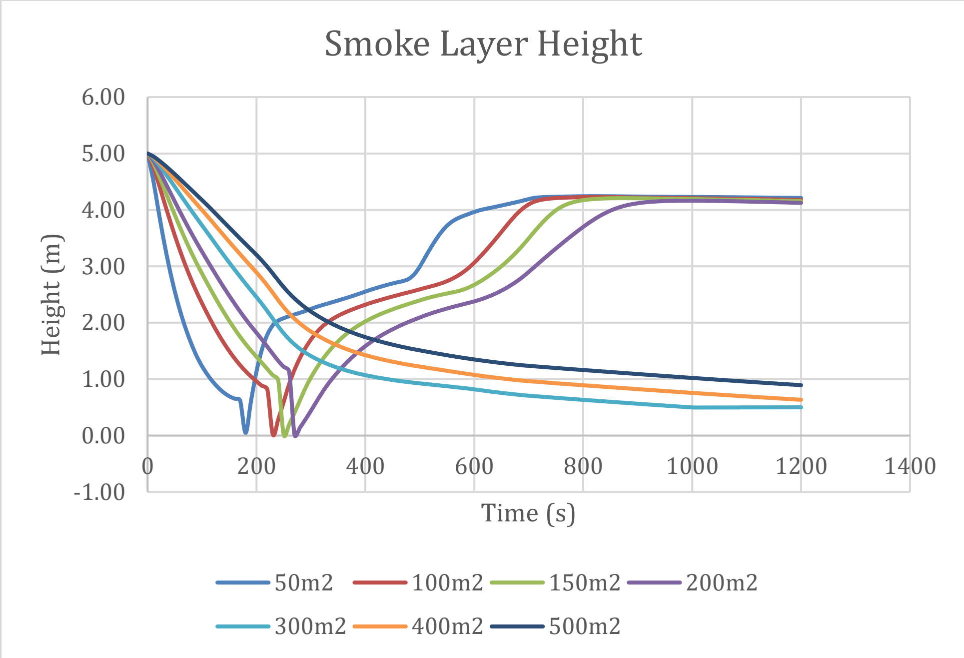


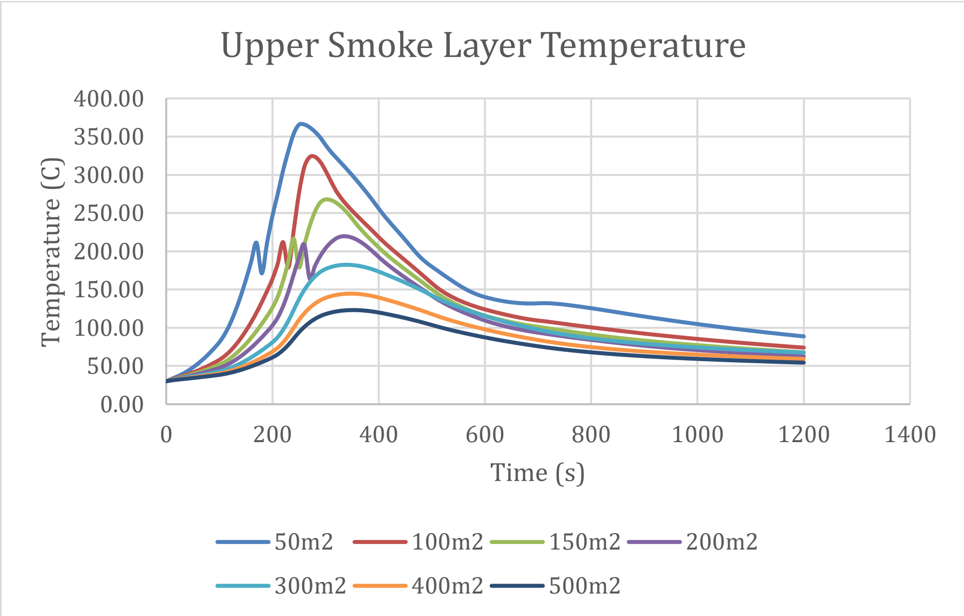
Lower Smoke Layer Temperature
Temperature (C)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0
200
400
600
800
1000
1200
1400
Time (s)
50m2
100m2
150m2
200m2
300m2
400m2
500m2

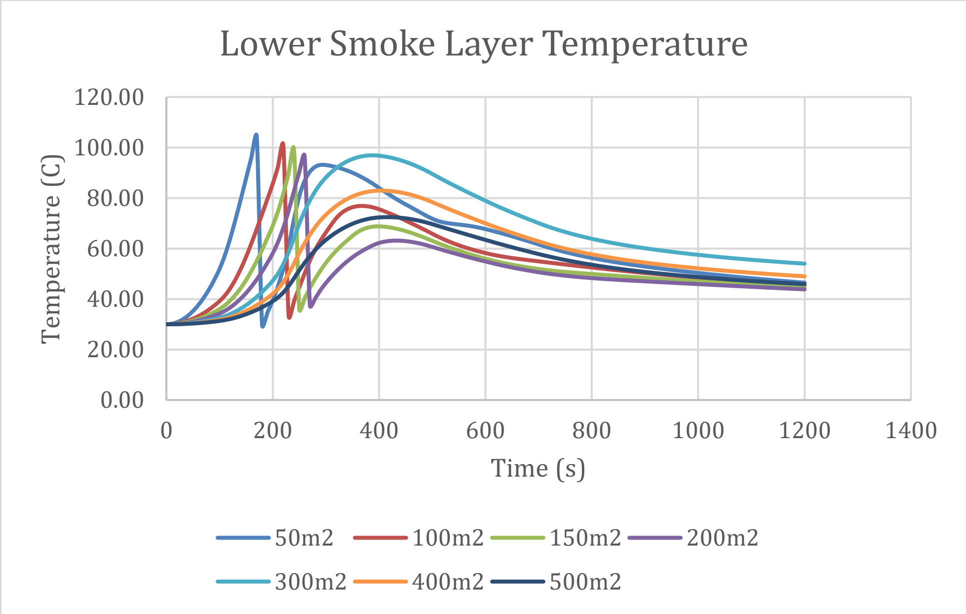


Target 1 Surface Temperature (3.5m from fire)
Temperature (C)
250.00
200.00
150.00
100.00
50.00
0.00
0
200
400
600
800
1000
1200
1400
Time (s)
50m2
100m2
150m2
200m2
300m2
400m2
500m2

5m Structure



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100.00
80.00
60.00
40.00
20.00
0.00
0
200
400
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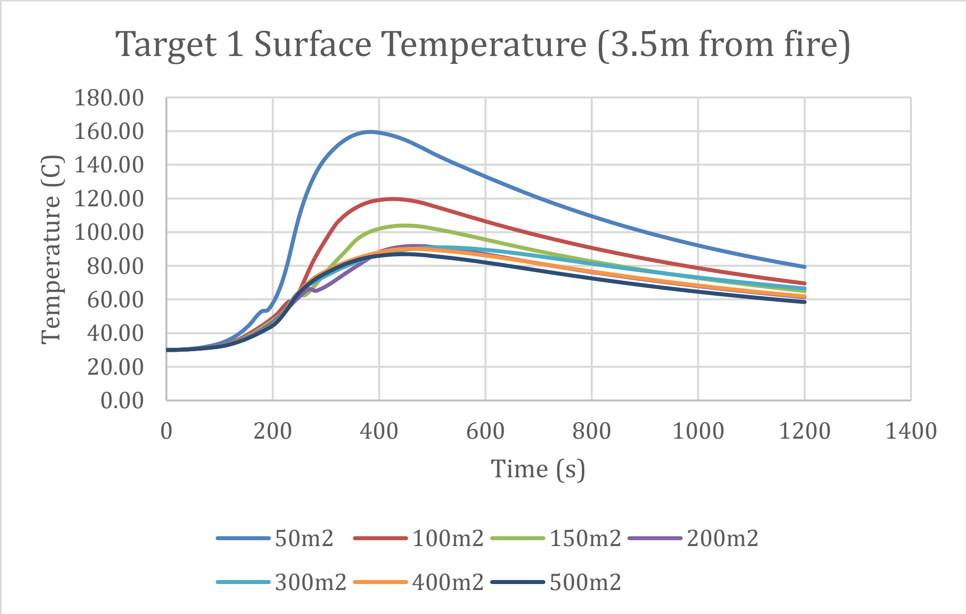
300m2
400m2
500m2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Temperature (C)
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160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0
200
400
600
800
1000
1200
1400
Time (s)
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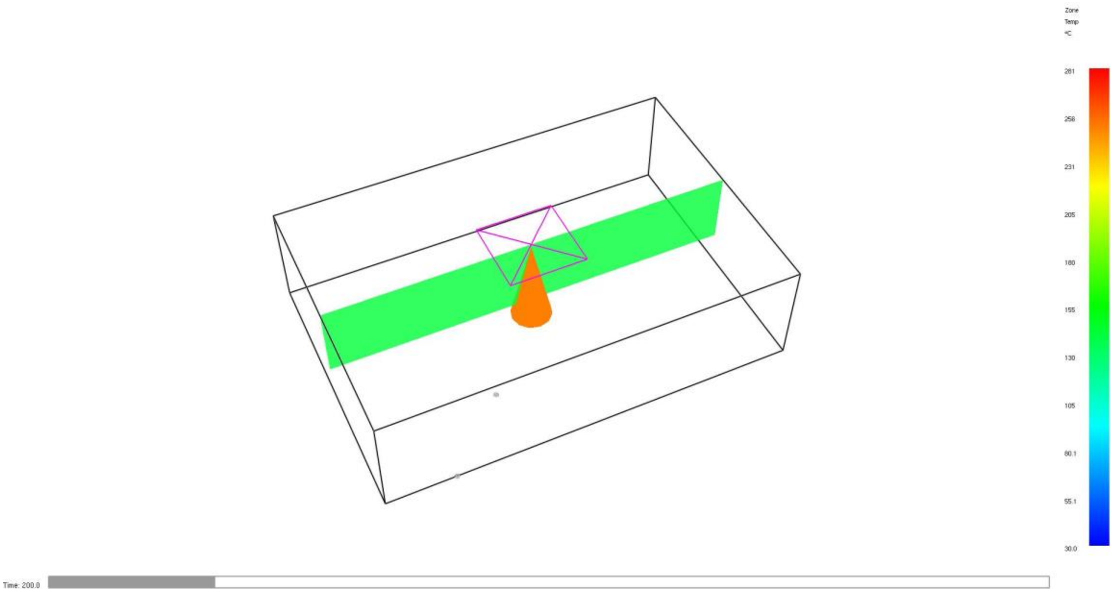
100m2
150m2
200m2
300m2
400m2
500m2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Temp
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231
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130
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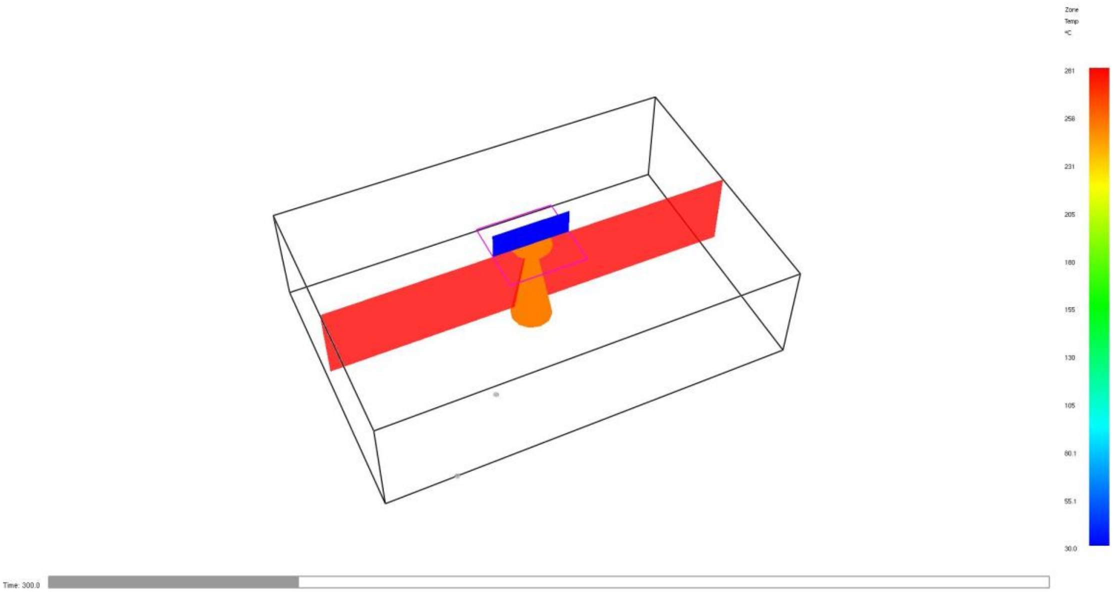
Time: 200.0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Appendix C: Best Practices Toolbox

Getting the basics right

General awareness and farm planning

TOOLBOX

GREENHOUSE CONSTRUCTION AND SAFE OPERATION

What is the Toolbox for Greenhouse Construction and Safe Operation?

The Toolbox for Greenhouse Construction and Safe Operation provides practical design, planning and prevention measures to implement during and after a development.

If you're planning to establish, expand or modify a greenhouse or grow structure there's several things you may wish to familiarise yourself with. Some of these are more complex than others, but there's a lot to consider. This includes the development application, fire prevention and emergency planning when working with greenhouse designers, builders, sub-contractors, insurers, local council and fire departments. It's also important that employees practice safe work habits day-to-day.

The toolbox provides a central information hub for growers. Growers can use this toolbox to find information based on a particular farm activity or issue including:

1. Getting the basics right (this fact sheet)
2. Overview of proposed changes to the 2019 National Construction Code
3. Local government approval processes
4. Fire prevention and safety
5. Working at heights and risk management
6. General design considerations
7. Wind loads
8. Resistance of materials
9. Access and egress
10. Construction of exits
11. Fire (access and egress)
12. Cladding and membrane light diffusion
13. General disaster control.

Some of the most important initial considerations in establishing, expanding or modifying a greenhouse or grow structure development are covered below. This includes site selection, as well as siting and design techniques.

KEY MESSAGES

- The Toolbox for Greenhouse Construction and Safe Operation provides practical planning and prevention measures if you're wanting to establish, expand or modify a greenhouse or grow structure
- Appropriate site selection can be considered the most cost-effective way of maximising environmental performance and reducing amenity issues such as odour, dust, noise, stormwater management, visual prominence and the protection of surface water and ground water
- Good siting and design may improve design outcomes and reduce the potential impact of large structures

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Defining your greenhouse

Greenhouses or grow structures are intensive horticultural structures for growing or propagation of plants, flowers and vegetables and excludes retail and wholesale nurseries and conservatories.

There are three broad categories of greenhouses and grow structures referred to throughout this series of toolbox fact sheets. This helps to define the types and structures, and therefore the most likely common problems and solutions for each. The definitions are outlined below.

Low technology: These greenhouses are less than 3 metres in total height. Tunnel houses, or “igloos”, are the most common type. They do not have vertical walls. They have poor ventilation. This type of structure is relatively inexpensive and easy to erect. Little or no automation is used.

Medium technology: Medium level greenhouses are typically characterised by vertical walls more than 2 metres but less than 4 metres tall and a total height usually less than 5.5 metres. They may have roof or side wall ventilation or both. Medium level greenhouses are usually clad with either single or double skin plastic film or glass and use varying degrees of automation.

High technology: High level greenhouses have a wall height of at least 4 metres, with the roof peak being up to 8 metres above ground level. These structures offer superior crop and environmental performance. High technology structures will have roof ventilation and may also have side wall vents. Cladding may be plastic film (single or double), polycarbonate sheeting or glass. Environmental controls are almost always automated.

Site selection

Protected cropping enterprises must comply with a range of regulations that are designed to protect the environment, including the local amenity as well as the health and welfare of human occupants.

Appropriate siting can be considered the most cost-effective way of maximising environmental performance and reducing amenity issues such as odour, dust, noise, stormwater management, visual prominence and the protection of surface water and ground water.

The following checklist identifies some of the factors you may wish to consider in selecting the right site.

Farm location

Amenity and environmental protection:

- Avoid locations that are in close proximity of towns, rural residential estates and hobby farms to reduce the likelihood of off-site impacts, objections to the application and having more conditions placed on the planning permit
- Ask Council where future residential development is proposed to avoid encroachment issues in the longer term
- Avoid locations within Declared Water Supply Catchments or land subject to flooding
- Avoid locations with extremely reactive soils. Extremely reactive soils may result in deep, highly reinforced concrete foundations and slabs (where applicable).

Planning policy:

- The land should be zoned either Farming or Rural Activity Zone
- Avoid land that has been identified for future residential development or development of earth resources.

Surrounding land use:

- Consider surrounding land uses and whether there is potential for cumulative impacts such as odour, dust, visual amenity, water quality, due to proximity to similar protected cropping enterprise farms

- Areas worthy of consideration would generally have large scale farms, few rural houses and be surrounded by vegetation.

Site layout and size

Amenity and environmental protection:

- Consider the location, topography, size and shape of the site relative to neighbours taking into consideration prevailing weather conditions, particularly wind direction and potential risk of conflict with neighbours due to odour and noise issues
- Sites for buildings and infrastructure should avoid rare or threatened species or ecological communities, areas of cultural heritage significance, drainage to waterways and wetlands
- It is beneficial to purchase enough land to accommodate separation distances or buffers from sensitive uses within the property boundaries
- The site for greenhouses and ancillary infrastructure should be relatively flat, cleared of native vegetation, setback from drainage lines and waterways and positioned in the landscape so that the topography provides natural screening or a vegetation screen is provided around exposed sites
- Buildings and works are designed and constructed to minimise their visual impact
- Close proximity to power and water connections will reduce infrastructure augmentation costs.

Infrastructure

Site access:

- Road and bridge infrastructure that provides access to the farm should support B-double transport
- Direct connection to major transport routes
- Routes that avoid urban and residential areas
- Design of access may be regulated by Council or Roads Authority

- Appropriate drainage and outside flooding zones or overlays.

Vehicle access points:

- Should provide for safe, all-weather entry and exit for the number and types of vehicles with consideration for local road and traffic conditions
- Located to minimise noise and light impacts on neighbours
- Location of access points may be stipulated by Council or Roads Authority.

Internal roads and parking:

- Designed and sited to minimise noise and light impacts on neighbours
- Designed and constructed to shed water to appropriate drainage. If relevant, Council may stipulate design requirements in Development Approval (DA).

Power:

- Three phase power is generally required for medium to high technology greenhouses
- Natural gas is essential for medium to high technology greenhouses.

Water:

- Reliable supply of suitable quality water
- Appropriate areas for storage of water for general use and/or firefighting
- Avoid locations that are near town storm water systems.

Siting and design techniques

The next important step is to think about where the structure(s) will be located on the site and what it will be built from after selecting an appropriate site. The aim should be to improve design outcomes and reduce the potential impact of large structures.

TOOLBOX
GREENHOUSE CONSTRUCTION AND SAFE OPERATION

IMPORTANT QUESTIONS TO ASK

- What relevant Toolbox fact sheets should I read before proceeding with a development?
- What do I need to consider when choosing the farm location, site layout and size?
- What are the infrastructure requirements for the type of structure I want to develop?
- Where should I locate the structures on my site?
- How should my proposed structure be designed and built?
- Who should I contact to discuss the siting and design requirements? (e.g. local Council, roads, environment protection, natural resource management, water and/or fire referral authorities)

Siting of structures

To achieve this, it's preferable the structure is located on land that fits with the surrounding gradient (topography) and considers other features such as vegetation characteristics, erosion prone areas, bushfire hazard areas, key views and local amenity

On flat land it's important to:

- Locate structures with sufficient setback from roadsides and adjoining property boundaries
- Utilise existing vegetation on the site to provide natural screening
- Avoid siting structures directly in the view line of adjacent roads and dwellings.

If the structure has to be on hilly land then you may need to:

- Restrict development in areas that are visually prominent or highly exposed
- Maintain existing ridgeline planting and site structures
- Avoid siting structures on very steep slopes (greater than 1 in 5)
- Locate structures to follow the contours of the land.

These siting guidelines assist in ensuring minimal earthworks and drainage design and construction is required, as earthworks can be a costly element of any construction project.

Design and materials

It's essential to maintain a high standard of amenity and presentation with all protected cropping structures. This can be achieved for:

- Low and medium technology greenhouses or grow structures: through regular maintenance and replacement of the plastic and frames
- High technology greenhouses or grow structures: by reducing building bulk, using non-reflective materials that blend with the dominant colours and textures of the surrounding environment.

Another key aspect is to mass, or group, structures together to limit the scattering of structures across the site. This can be assisted by:

- Avoiding structures adjacent to roadsides and dwellings on adjoining land
- Keeping the footprint of the structures below 60% of the total site area
- Providing enough adjoining open areas to allow structures to be extended if required
- Ensuring sufficient distances between buildings to reduce risk of fire spreading
- Maintaining vehicle access points and doorways to easily service the structure.

REFERENCES AND FURTHER READING

Olivotto, M. (2014) Building codes and greenhouse construction, Osborn Lane Consulting Engineers, Warwick, chapter 5

Department of Environment, Land, Water and Planning (2017) Planning considerations for horticultural structures; Planning Practice Note 18, Victorian Government, Melbourne, https://www.planning.vic.gov.au/__data/assets/pdf_file/0020/12746/PPN18-Planning-considerations-for-horticultural-structures_April-2017.pdf

Australian Building Codes Board (2017) Understanding the NCC; Building Classifications, Commonwealth of Australia and States and Territories of Australia

Queensland Government (2015) Queensland Development Code; Part 3.7 - Farm buildings, Queensland Government, Brisbane, http://hpw.qld.gov.au/SiteCollectionDocuments/QDCMP3.7FarmBuildings.pdf

Case study

The importance of site selection in south-east Melbourne, Victoria

A major greenhouse development underway in south-east Melbourne, Victoria, is working towards the entire relocation of the business from a nearby site, with the establishment of over 3 hectares under glasshouses.

During the approval process and construction phase there have been some significant time and cost blow-outs due to unforeseen circumstances with the site. What could have been done to minimize these unforeseen impacts when the site was being considered for purchase?

A minor waterway runs through the site, which meant that environment protection and off-site drainage impacts became a concern for the local Council and waterway management agency. The earthworks to allow a retention basin and appropriate drainage were larger than originally expected, increasing more than 10 fold. There were also additional revegetation works required along the existing part of the waterway.

"We're dealing with a few issues relating to the selection of the site. One of the major ones has been drainage, and the long timeframes and continued to-and-fro to get things right" the manager said.

Roads and the movement of vehicles in and out of the property without impacting on the busy arterial roads adjacent to residential developments was also problematic. Access roads in and around the site have been required to be built to a higher standard, and the public road widened to allow for a turning lane. This was a considerable additional amount that was not budgeted for.

The operation also relies heavily on a large and secure supply of natural gas. Unfortunately, the site did not have access to natural gas before the development started. What was meant to be a $100,000 task to connect the property ended up costing approximately three times this amount.

All of these modifications and additional works and measures have resulted in the project costing more than double the original budget.

"We never thought it could cost us this much. It's really put us back in terms of bringing production online and the continual changes have been a real challenge" stated the manager.

This highlights the importance of site selection that will suit the purpose and function of your greenhouse operation. Doing some homework before you decide to purchase and develop new land could save lots of time and money down the track. This could include, for example, the availability of essential services like three-phase power, gas and water, or broader site access. Meeting with these organisations and involving other experts early may help you understand if the site will meet your needs. This is also important for testing some of your assumptions involved in the development.

Overview of proposed changes to the 2019 National Construction Code

What it means for growers

TOOLBOX
GREENHOUSE CONSTRUCTION AND SAFE OPERATION

Overview

The National Construction Code (NCC) is a uniform set of technical provisions for the design and construction of buildings and other structures throughout Australia. Each building type is arranged into 'classifications' and the NCC allows for variations in what to build based on size, height, climate and geological or geographic conditions. The NCC has three volumes with the main differences being:

- **Volume 1 contains the requirements for Class 2 to 9 (multi-residential, commercial, industrial and public) buildings and structures**
- **Volume 2 contains the requirements for Class 1 (residential) and Class 10 (non-habitable) buildings and structures**
- **Volume 3 is the National Plumbing Code.**

Driver for change

Australia does not have a unified building classification of horticultural buildings within the NCC. This means that greenhouses or grow structures can be classified under the sometimes onerous and inappropriate classification of Class 7 or Class 8 within the NCC.

In order to better meet growers' needs and to ensure the protected cropping industry can continue to develop sustainably, Horticulture Innovation Australia has commissioned a project to propose changes to the NCC in 2019.

A nationwide survey of greenhouse growers was undertaken by the project team that determined, among other findings, that 65% of the respondents consider 'understanding the preparation, lodgement, assessment and approval process with local government' as the most pressing issue.

Changes to the current NCC would assist in creating certainty in the assessment and approval processes while also encouraging further development of the protected cropping industry.

Summary of changes

The proposed changes to the NCC in 2019 and the implications for growers and service providers is outlined on the next page.

KEY MESSAGES

- The National Construction Code (NCC) is a uniform set of technical provisions for the design and construction of buildings in Australia
- To better meet industry and growers' needs there are proposed changes to the NCC in 2019
- Changes are being proposed to address priority industry issues identified during recent national consultation
- The proposed changes relate to definitions and verification methods for intensive horticultural buildings
- The changes cover both Volume 1 and Volume 2 of the NCC

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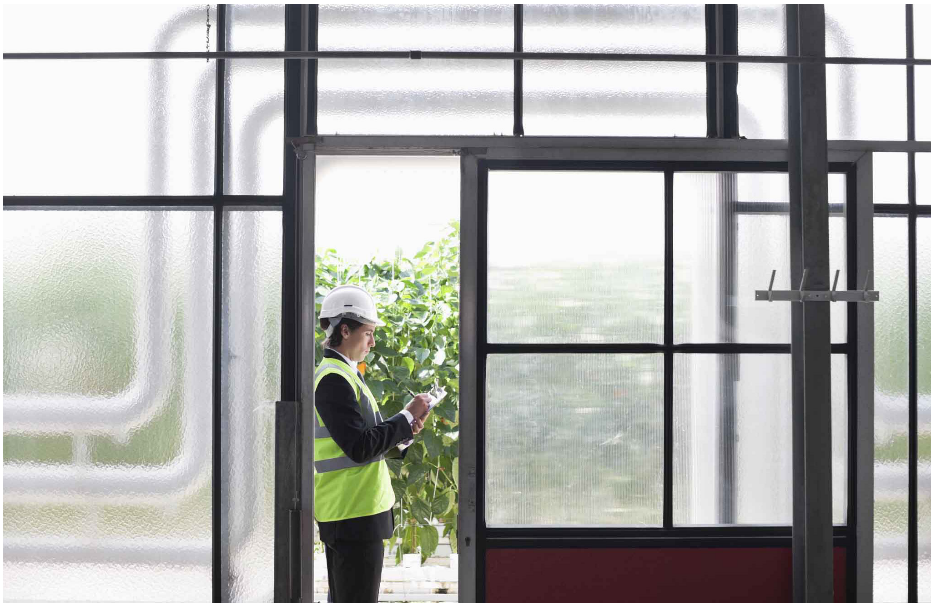
Overview of proposed changes to the 2019 National Construction Code

#	AREA	PROPOSED CHANGE
VOLUME 1		
1	Redefine Farm Building	It is proposed that farm building definitions shall be revised to include Intensive Horticultural Buildings (IHB) as is provided within the Classification Definitions category on pages 4-6 of this document. This option retains the farm building definitions and incorporates the IHB definitions. An IHB shall be classified as either a Group A, B or C structure. *NCC Change Location: NCC Vol 1 2016 > A1 Interpretation > Part A1.1 Definition > Farm building (REVISED)*
2	Provide Definition for Intensive Horticulture Building	This proposed change adds a definition into the NCC Volumes One and Two for intensive horticulture buildings which specifies the building's primary usage for horticultural means. An IHB is a greenhouse, grow structure, canopy or the like belonging to one or a combination of the aforementioned in NCC Volume One, Part A1.1, Farm Buildings. *NCC Change Location: NCC Vol 1 2016 > A1 Interpretation > Part A1.1 Definition > Intensive horticulture building (NEW)*
3	Alteration to Part H3 Farm Buildings and Farm Sheds	To be added to NCC Vol 1 Part H3. This allows for inclusion of the Intensive Horticultural Building into Part H3 of the NCC – here specific deemed-to-satisfy provisions for each identified classification of Intensive Horticultural Building will be documented. *NCC Change Location: NCC Vol 1 2016 > Part H3 Farm Buildings and Farm Sheds > Part H3.1 Application of parts (REVISED)*
VOLUME 2		
4	Part 1.1 Interpretation	An addition shall be made to Part 1.1.7 Language of Volume Two to include the classification Class 10d. *NCC Change Location: NCC Vol 2 2016 > Part 1.1 Interpretation > Part 1.1.7 Language (REVISED)*
5	Part 1.1 Interpretation	This proposed change adds a definition into the NCC for intensive horticulture buildings which specifies the building's primary usage for horticultural means. *NCC Change Location: NCC Vol 2 2016 > Part 1.1 Interpretation > Part 1.1.1 Definitions > Intensive horticulture building (NEW)*
6	Part 1.3 Classification	An addition shall be made to Class 10 at Part 1.3 Section 1.3.2 Classification whereby a subclass 10d shall be added. This allows for inclusion of the Group C Intensive Horticultural Building into Volume Two of the NCC. An explanatory information note has also been included in this part. *NCC Change Location: NCC Vol 2 2016 > Part 1.3 Classification > Part 1.3.2 Classification > Class 10 (REVISED/ ADDITION)*
7	Part 1.3 Classification	An addition shall be made to Class 10 at Part 1.3 Section 1.3.3 Multiple classifications whereby a subclass 10d shall be added. This allows for inclusion of the Group C Intensive Horticultural Building into Volume Two of the NCC for multiple classification applications. *NCC Change Location: NCC Vol 2 2016 > Part 1.3 Classification > Part 1.3.3 Multiple Classifications (REVISED)*
8	Part 2.3 Fire Safety	An alteration shall be made to Part 2.3 Fire Safety to ensure a Class 10d building does not significantly increase the risk of fire spread between Class 2 to 9 buildings. *NCC Change Location: NCC Vol 2 2016 > Part 2.3 Fire Safety > Part 2.3.1 Protection from the spread of fire (REVISED)*
9	Part 2.3 Fire Safety	An explanatory information note has been included in Part 2.3 Fire Safety which outlines specification for Class 10d structures. *NCC Change Location: NCC Vol 2 2016 > Part 2.3 Fire Safety > Explanatory information (REVISED/ADDITION)*



IMPORTANT QUESTIONS TO ASK

- How do the proposed changes to the NCC relate to my current greenhouse or proposed new development?
- Is my local government planner aware of the proposed changes to cover intensive horticulture buildings?
- Have I sought guidance from my local government and a professional engineer as to how these changes may affect my greenhouse development?
- Do I need to change anything in relation to my current greenhouse?

REFERENCES AND FURTHER READING

Australian Building Codes Board (2016) National Construction Code 2016; Volume 1; Building Code of Australia; Class 2 to Class 9 Buildings, Commonwealth of Australia and States and Territories of Australia

Australian Building Codes Board (2016) National Construction Code 2016; Volume 2; Building Code of Australia, Commonwealth of Australia and States and Territories of Australia

Local government approval processes

Preparing a development application and tips for success

TOOLBOX

GREENHOUSE CONSTRUCTION AND SAFE OPERATION

Development application process

If you're planning to establish, expand or modify a greenhouse or grow structure a development application may be required. It's important to determine what type of development you are undertaking and seek advice from your local government authority to confirm if an application is required.

Development applications are required in most instances for intensive horticultural buildings so a process of preparation, lodgement and assessment will be undertaken. This is to make sure the potential impacts on the site and neighbouring properties are managed, as well as reduce the potential for land use conflict. Always check with local Council if a development application, planning permit or building works approval is required.

Assessment of applications for development consent is a statutory process usually administered by either local government or a private certifier, depending on the state or territory legislation. The terminology varies between states due to the difference in planning and building Acts but the overall process is similar (Figure 1). If a development application is required, this is the general process followed:

1. The development application provides information to the assessment manager, usually a local government planning officer or certifier, about the proposed development to enable the assessment manager to properly assess the application against the planning scheme, building code and other legislation in your area.
2. Depending on the type of development proposed, the application may require information about the development. This may include, for example, necessary application forms, buildings plans detailing the building dimensions and appearance, structural plans, location of building on the property, the materials to be used, and any impacts the proposed development may have on the surrounding environment and how these may be mitigated e.g. landscaping and screening to reduce visual impacts, road treatments to provide safe access and egress, areas subject to bushfires or flooding, exit locations, and fire safety systems.
3. After an application is lodged with the assessment manager, it may be necessary to refer the application to any other parties which also have an interest in the proposed development. This may include state agencies

KEY MESSAGES

- Development applications are required in most instances for intensive horticultural buildings with a process of preparation, lodgement and assessment being undertaken
- Generally local government is required to assess and make decisions on applications within specified timeframes. There are also fees associated with lodgement of a development application
- In addition to complying with planning policy, building codes and relevant regulations, there are a number of steps you can take to improve likelihood of success in identifying a suitable site and after purchasing the land
- Gaining approval or broad social acceptance, i.e. a social licence to operate, occurs outside the formal permitting or regulatory processes
- Prior to occupation and use of the building final certification is also required to be obtained from the certifier upon completion of construction

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responsible for roads, environment protection, natural resource management, water and/or fire. These are called ‘referral authorities’ who provide advice and input to the approval process.

4. Public notification is generally required for certain development applications to ensure that the public is aware of the development and they have the opportunity to make submissions about it. Public notification may involve publication in a newspaper, a notice placed on the subject land and/or a notice given to the owners of all land adjoining the subject land.
5. Assessment of the development application is made against the matters specified in the relevant state legislation and local government requirements, and will take into consideration feedback from referral authorities and submissions received during public notification.
6. Once the assessment manager has assessed the application, they must decide on the application by either approving the application or refusing the application. If the application is approved, the assessment manager may impose conditions on the approval.
7. An applicant or submitter may appeal the decision at the relevant planning tribunal or court.

Generally local government is required to assess and decide on applications within specified timeframes. There are also fees associated with lodgement of

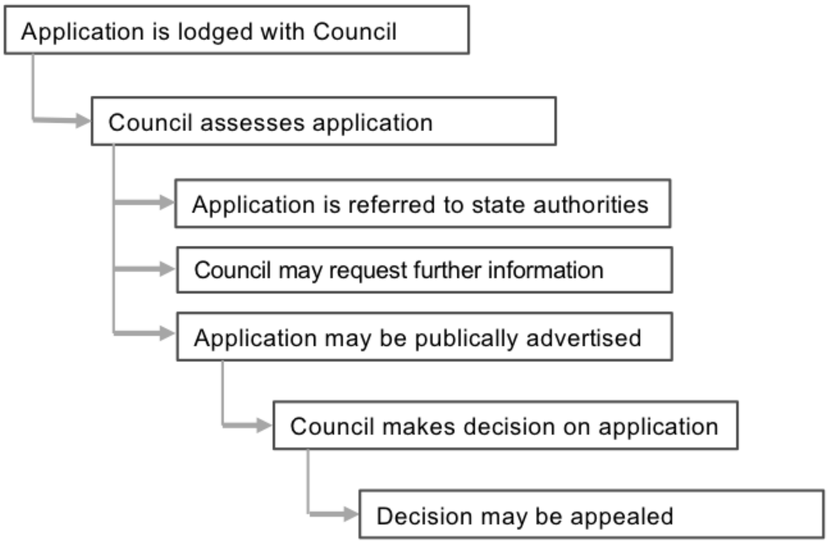


Figure 1: Development application process

a development application for planning permits and building works. Note that additional fees may be required by referral agencies for their assessment.

You should check with your local Council planning department, their website or your certifier to confirm the information and forms that will be required to support the development application. Information that will generally be required to support and development or planning permit application includes:

- Site layout plans (drawn to scale) showing:
  – Location and uses of existing buildings
  – Existing vegetation and waterways
  – Location and uses of buildings on adjoining land
- Site development plans (drawn to scale) showing:
  – Location of proposed buildings and works
  – Floor plans and elevations of proposed buildings
  – Levels of the land in relation to existing and proposed buildings and roads
  – Building materials and finishes
  – Proposed landscaping and impact of bushfire hazards in some states.

The local Council contacts the referral authorities on your behalf as part of the development application process. This includes providing and collecting relevant information and informing any applicable conditions that may be placed on the permit.

In relation to greenhouse modification, the previous planning submission may have already catered for this situation. This means a more simplified notification and design process may follow, which highlights the importance of planning ahead.

Prior to occupation and use of the building final certification is also required to be obtained from the certifier upon completion of construction. This specifically relates to development applications for building works approval.

Site selection

In addition to complying with planning policy and relevant codes and regulations, there are a number of steps you can take to improve likelihood of success. This list has been compiled in consultation with local government, referral authorities, industry and producers.

Identifying a suitable site

1. Meeting with Council

Before purchasing land or committing to developing a particular site, a meeting with Council may be crucial. Council officers including economic development and planning officers can:

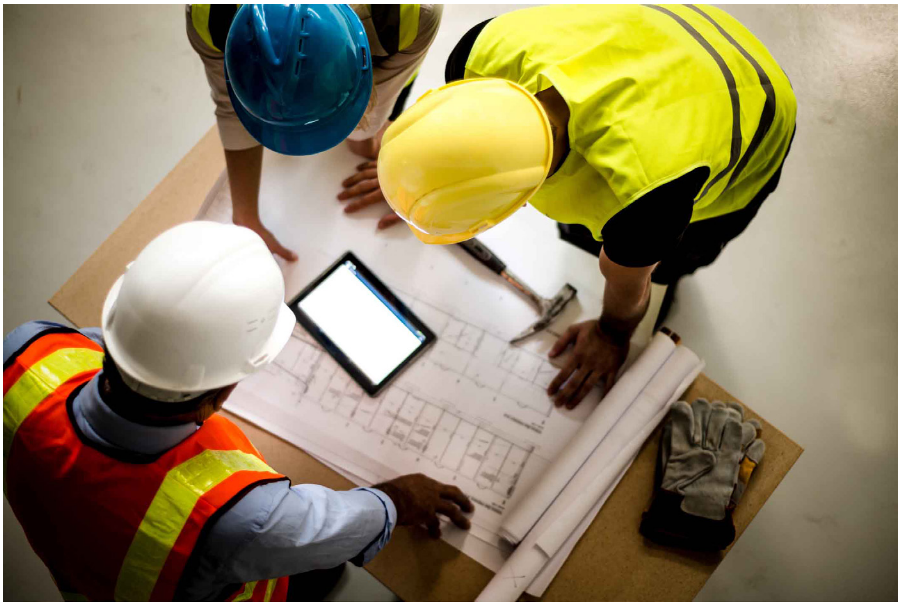
- Provide advice on Council's position with regard to protected cropping and whether they are seeking to promote the industry within the municipality
- Determine whether the proposed agricultural activity is permitted, permitted with a planning permit or prohibited
- Explain the planning permit process, what information will be required, the application steps, the role of referral authorities and who they are, and public advertising requirements
- Identify areas where protected cropping is more likely to be supported as well as areas to avoid
- Provide useful contacts including referral authorities and other agencies.

Once a number of candidate sites have been identified, you are encouraged to meet with Council planning staff again to review the merits of each site, ensure that the proposed use is consistent with the planning policy and discuss potential issues.

2. Meet with industry and value chain representatives

Industry representatives can:

- Advise on technical experts to assist in the preparation of the planning permit application
- Provide useful contacts, such as experienced growers and producers.



3. Meet with referral authorities and utilities

Before committing to a particular site, a meeting with the relevant referral authorities may determine what approvals will be required and whether it is possible to meet these requirements. Early meetings with authorities may identify and find solutions to potential 'showstoppers'.

Utility and infrastructure service providers may be able to confirm whether services can be extended and/or upgraded, approximate costs and identify opportunities to leverage from system or infrastructure upgrades and augmentation. Utility providers, such as electricity and gas, are not referral authorities.

4. Engage technical expertise

You are strongly encouraged to engage planning and industry specialists to assist with identifying a suitable site, preparing documentation to support the planning permit application and, if required, they may provide expert witness at tribunals or land court. Well-informed, reputable, experienced, locally respected professionals with ability to communicate effectively may also assist in building credibility with community and stakeholders.

After purchasing the land

5. Pre-application meeting with Council and referral authorities

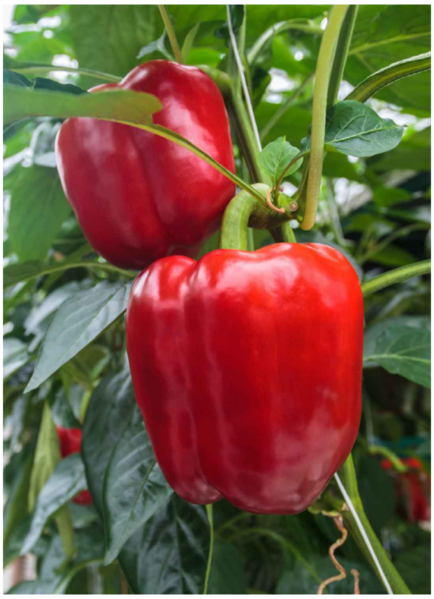
Having selected and purchased a site, another meeting should be held with Council officers and referral authorities to confirm the information to be submitted with the planning permit or application relevant to the specific site.

Your local Council can provide guidance on who the appropriate referral authorities are and how to best contact them. Referral authorities will usually include roads, environment protection, natural resource management water and/or fire. For larger developments, particularly high technology greenhouses, it's best to meet with all referral authorities at once to better understand their information requirements and how to proactively address any potential concerns. This may also limit potential contradictory needs from separate referral authorities.

6. Joint Council and referral authority meeting

Having prepared the supporting information for the planning permit application, a joint meeting of referral authorities and Council is strongly encouraged. Local government and state government agencies are increasingly working together to support new developments. Permit conditions can add substantially to the time and cost of a development.

As each referral authority generally recommends conditions in isolation of each other and Council, it is not uncommon for duplication or even conflicting conditions to be placed on a planning permit. For example, it may be worthwhile having a joint meeting between the Environmental Protection Authority (EPA) and rural fire brigade. A joint meeting provides an opportunity for Council and referral authorities to review the plans, discuss concerns and identify alterations to the proposal that could reduce the need for some conditions and agree to an achievable and reasonable set of permit conditions.



While not always possible, there is some merit in putting a number of options for consideration by neighbours and Council. It is a useful approach to demonstrate flexibility and a willingness to work with stakeholders to achieve an agreed outcome.

Building work cannot commence until the building approval is in place, even if a planning permit has already been approved. It is important to consult with the building design team in the initial design stage, which may include designers, engineers and certifiers. This will make sure any potential design issues are addressed before the building work commences.

7. Meet with neighbours

Local government and referral authorities make their decision according to the law and planning policy. The level of support, or alternatively the opposition, from the local community and neighbours may additionally have an effect upon the outcome of a development application. If there is strong community opposition to a protected cropping development, the permit may not be approved. Community opposition will usually lead to the imposition of additional conditions on a planning permit.

It is important to inform potential neighbours before committing to a proposal. Taking time to explain the proposal and listening to what your neighbours have to say may save time if changes can be made to the plans to address their concerns.

Providing neighbours with wide-ranging information regarding your application may provide positive reinforcement with regard to your flexibility and willingness to cooperate. It may further serve to assist your application and may help to reduce some possible opposition. For instance, minor changes in siting and design of the development may prevent future problems and delays. Organising a visit to a nearby similar enterprise that demonstrates high standards or taking people on a tour of your existing farm may reduce the concerns of neighbours or communities who are unfamiliar with how the proposed development would operate.

Social licence

There has been a continuous trend towards more intensive horticulture production systems to take advantage of cost efficiencies and new technology. Protected cropping systems enable producers to closely monitor and manage all aspects of the production process to achieve a high degree of quality control with efficient unit production costs. These production systems also have wider benefits: providing on farm employment and increased demand for local services and suppliers.

However, protected cropping systems have the potential to adversely impact the environment and neighbours. The regulatory framework aims to ensure that the risk of adverse impacts is minimised while providing the producer with confidence to develop and operate the enterprise.

Adverse impacts of protected cropping include:

- **Noise**: can be generated by building cooling and heating systems and heavy vehicle movements. Nearby residents can be more sensitive to noise during the evening and night where there is greater potential to interrupt sleep
- **Traffic**: in addition to dust and noise, increased traffic movement, particularly large trucks, may increase the risk of accidents and damage to local rural roads
- **Visual amenity**: horticultural buildings are an acceptable part of the rural landscape. Construction of large sheds and glasshouses may significantly alter the visual amenity of a rural landscape
- **Light reflection or spill**: sunlight reflections off roofing, or lights from roads, parking areas and structures can impact nearby residences.

The regulatory framework seeks to minimise adverse impacts on neighbours and the environment. Often though, simply complying with regulation is not enough. However, new protected cropping development applications may be contested due to fears that adverse impacts will cause the surrounding amenity to decline. For example, this may include noise from machinery, increased traffic volume, and visual impacts of concern to the community. There is generally a management action to address each of these issues by talking with your neighbours and local Council early and often.

Gaining approval or broad social acceptance, i.e. a **social licence** to operate, occurs outside the formal permitting or regulatory processes. It requires investment by you to build and maintain trust-based relationships founded on timely and effective communication, meaningful dialogue, and ethical and responsible behaviour. In return for this investment you may:

- Gain credibility and legitimacy for its presence and activities
- Build a reputation for acting responsibly and genuinely striving for good performance
- Reduce the risk of costly delays in regulatory approvals due to opposition (refer to the site selection section of this fact sheet for guidance)
- Protect the business reputation in the event of an unforeseen event.

Actions that may help build social licence include:

- Effectively communicating the proposed enterprise and activities, including providing timely and complete information
- Undertaking community engagement in a respectful manner
- Listening to what a local community is saying, addressing concerns and issues, and using community input to improve a development proposal
- Undertaking developments in an environmentally, fiscally, and socially responsible manner, including but not necessarily limited to regulatory compliance
- Seeking ways for local communities to benefit from the development.

REFERENCES AND FURTHER READING

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Department of Environment, Land, Water and Planning (2017) Planning considerations for horticultural structures; Planning Practice Note 18, Victorian Government, Melbourne, https://www.planning.vic.gov.au/__data/assets/pdf_file/0020/12746/PPN18-Planning-considerations-for-horticultural-structures_April-2017.pdf

Olivotto, M. (2014) Building codes and greenhouse construction, Osborn Lane Consulting Engineers, Warwick, chapter 5, pp. 38

IMPORTANT QUESTIONS TO ASK

- What are the industry guidelines?
- Who is my local Council contact?
- Who are my relevant referral authorities covering roads, environment protection, natural resource management, water and/or fire?
- What areas are suitable for a protected cropping development and is a development application required?
- What provisions of the Local Environment Plans and State Environmental Planning Policies apply?
- What is involved in making an application?
- How long will it take to obtain approval?
- How will my proposed development affect the environment and neighbours?
- What other legislation affects my proposed development?
- What experience does Council have in protected cropping development?
- What examples of industry best practice are available?

STATE/TERRITORY	DEPARTMENT OF PLANNING (OR EQUIVALENT)	DEPARTMENT OF PRIMARY INDUSTRIES (OR EQUIVALENT)
New South Wales	23-33 Bridge Street, Sydney NSW 2000 GPO Box 39, Sydney NSW 2001 Tel: 02 9228 6111, Fax: 02 9228 6455 Email: information@planning.nsw.gov.au	161 Kite Street, Orange NSW 2800 Locked Bag 21, Orange NSW 2800 Tel: 02 6391 3100 (International +61 2 6391 3100) Fax: 02 6391 3336 (International +61 2 6391 3336)
Victoria	Tel: 1300 366 356 Email: planning.info@delwp.vic.gov.au	Tel: 136 186 Online enquires
Queensland	PO Box 15009, City East, QLD 4002 Tel: 13 74 68, Fax: +61 7 3224 4683 Email: info@dsdip.qld.gov.au	Tel: 13 25 23, Fax: +61 7 3404 6900 Email: callweb@daff.qld.gov.au
Western Australia	140 William Street, Perth WA 6000 Lock Bag 2506, Perth WA 6001 Tel: 08 6551 9000, Fax: 08 6551 9001	3 Baron-Hay Court, South Perth WA 6151 Locked Bag 4, Bentley Delivery Centre WA 6983 Tel: 08 9368 3333, Fax: 08 9474 2405 Email: enquiries@agric.wa.gov.au
South Australia	GPO Box 1533, Adelaide SA 5001 Email: DPTI.enquiriesadministrator@sa.gov.au	Level 14, 25 Grenfell Street, Adelaide GPO Box 1671, Adelaide SA 5001 Tel: 08 8226 0900, Fax: 08 8226 0476
Tasmania	Level 4, 144 Macquarie Street, Hobart TAS 7001 GPO Box 1691, Hobart TAS 7001 Tel: 03 6165 6828, Fax: 03 6233 5400 Email: enquiry@planning.tas.gov.au	GPO Box 44, Hobart TAS 7001 Tel: 1300 368 550 Online enquires
Northern Territory	Tel: 08 8999 8985 Email: bas.lpe@nt.gov.au	Tel: 08 8999 5511, Fax: 08 8999 2010 Email: info.dpif@nt.gov.au
Australian Capital Territory	Dame Pattie Menzies House, 16 Challis Street, Dickson ACT 2602, GPO Box 158 Canberra ACT 2601 Tel: 02 6207 1923 Online Enquiry	Refer to New South Wales contact

TOOLBOX
GREENHOUSE CONSTRUCTION AND SAFE OPERATION

Case study

High technology greenhouse development in Carisbrook, Victoria

An up-and-coming greenhouse business near Maryborough in western Victoria was looking to modernise and expand their operation. The location was ideal, as it was 10km from the edge of town, with access to natural gas right to the property. However, the process involved in progressing the development came with its challenges.

The business started under small plastic houses in 1999 and covered approximately 1,500m2, following the transition out of sheep grazing on the family farm. They now grow tomatoes and baby cucumbers entirely under glass as a result of two 1.5 hectare developments, with plans for an on-site packing shed in the pipeline.

“We weren’t aware of the situation we were jumping into. We just wanted to start growing, and the Country Fire Authority were telling us we had all these other issues to take care of. It was pretty difficult to understand”, stated the grower.

The grower, along with their father and brother, embarked on the development application process with the local Council. This hit a few hurdles early, especially when it came to objections from the neighbours relating to sunlight reflection and noise. They then met with the neighbours to talk through their plans with the planners and came up with some agreed solutions. But it didn’t stop there.

“We had some inexperienced local builders, they hadn’t done this type of thing before. But it seems that everything’s done slightly differently everywhere.”

There were also issues with the CO_2 enrichment in the greenhouses and fire loading from the Country Fire Authority’s perspective, as one of the main referral agencies. However, because there is no Australian Standard the American Standard was used instead.

The main impacts to the grower from the uncertainty during the development application process were:

- Time delays, with lots of back-and-forth with fire engineers, building surveyors and Country Fire Authority with reporting, approval and recommendations
- Increased cost, both in employing additional expertise and paying for reports and infrastructure, but also lost production.

These challenges were addressed by:

- Installing reasonable treatments in the boiler rooms that were low pressure (1 bar), but had a very low risk profile
- Appointing a certified engineer to introduce sensible treatments and avoid costly ones, like ring mains
- Strategically locating static water sources around the property in above ground tanks with firefighting fittings, which has been a good compromise compared to network fire hydrants
- Replacing fire exit doors with push-out doors, which has also satisfied the local Council and Country Fire Authority, in combination with compliant stairs
- Minimising waste streams to reduce truck traffic to and from the property. The grower now uses coia that can be composted and sold locally. There is also a closed loop water and nutrient system, and the small amount of wastewater is used to irrigate the lawn around the greenhouses.

So what were some of the lessons? “Second time around we got a building surveyor and fire engineer from Melbourne. Getting the right people in early is critical. We did spend a bit more, but we saved so much more at the back end of the project with time and infrastructure”, said the grower.

Fire prevention and safety

Safe operations management practices

TOOLBOX

GREENHOUSE CONSTRUCTION AND SAFE OPERATION

KEY MESSAGES

- Greenhouse fires are a significant threat and prevention is preferred to remedy
- Fire is dependent on the presence of heat, oxygen and fuel that govern how easily a fire ignites, spreads and its duration
- Fires can be prevented through good farm management practices relating to: technical standards, building materials, compartmentalisation, power delivery, lights, maintenance of equipment, and fire and smoke early warning detection
- Develop an Emergency Response Plan to ensure all staff know what to do in the event of a fire or other emergency to protect human safety and reduce loss and damages

Common causes of fire

Understanding the nature of fire is crucial to applying appropriate farm and risk management techniques to protect your greenhouse or grow structure. Each growing activity should be considered in these structures.

Fire is dependent on the presence of three elements; heat, oxygen and fuel. The quantity and availability of each element directly determine how easily a fire ignites, spreads and its duration. Removing one of the elements ensures the fire cannot start or survive.

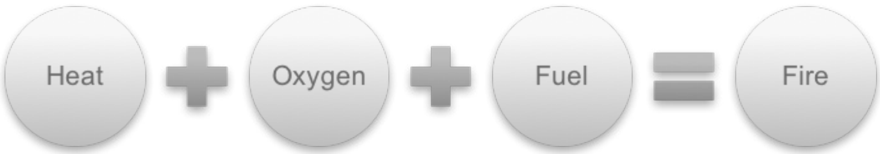

Figure 1: Elements of a fire

Heat and ignition

Influence on fire: heat causes ignition of a fire load and can be produced by several forms of energy that are commonly found in a greenhouse or farm building.

Sources include, but are not limited to:

- **Hot work**: sparks and molten metal can easily ignite combustible materials such as plastic membranes from welding or soldering, as well as combustible engine (tractor) exhaust
- **Heating**: natural gas or oil heaters, CO2 generators and any other combustion burning equipment within a greenhouse can create a fire without appropriate clearance to combustible material
- **Electrical**: faulty installation, physical wear and deterioration, and overloading electrical equipment can cause sparks and heat to ignite a fire. Even professionally installed electrical work can become faulty due to overloading or physical damage
- **Smoking**: discarded cigarette butts usually cause a fire risk when policy and designated smoking areas are not provided by the employer
- **Spontaneous combustion**: occurs by self-heating followed by a thermal runaway and finally ignition. For example, the storage of oily rags absorbing oxygen from the air and generating enough heat to combust
- **Accidental**: natural occurrences such as lightning strikes, bushfires and associated ember attack, or power surges to equipment, as well as criminal acts like arson.

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Oxygen

Influence on fire: oxygen has a large influence in the speed of spread of fire and the severity of the fire damage

Sources include, but are not limited to:

- **Incorrect installation of mechanical ventilation systems**: tend to exacerbate a fire. The installation of automatic ventilation systems that do not have fire failsafe systems should be an area of consultation with a professional fire engineer and/or fire department official
- **Combustible linings**: in the walls and roof may fail if exposed to heat and allow the fire access to more oxygen, as opposed to solid roofing and walls that may restrict air flow.

Fuel

Influence on fire: fuel influences the duration of a fire, with combustible components and materials stored within the greenhouse acting as fuel, as well as the greenhouse itself

Sources include, but are not limited to:

- Non-permeable membrane: all polymer coverings are combustible, some coatings on glass panes are also combustible
- Permeable membrane, sequential curtain and ground covers
- Timber or plastic benches, work tables and storage racks
- Plastic or polystyrene grow containers
- Fertilisers, typically nitrogen based
- Dried vegetation, plants, grasses and leaf matter
- Oils, petroleum, diesel, propane/natural gas stored inside or around the structure perimeter
- Vehicles and machinery
- Electrical systems, cabling and lighting.

Fire prevention through good farm management

Technical standards

A well-designed greenhouse or grow structure can be the most effective way to reduce the risk of a fire. This will depend on the type of structure, size, location and compliance to relevant regulation. Make sure you use qualified licensed professionals for all design, equipment installation and repairs.

It's important to identify what will be required of you during the preliminary stages of development. Many local councils are not experienced in development applications relating to greenhouses or certification of greenhouses. Documents to be brought to the attention of the certifier include the Internal Building Code administered by the International Code Council.

Once occupied, good housekeeping standards and enforcing these standards are the best way to prevent fires from ignition or accidently starting. Most local fire brigades are able to provide information and advice to support you.

Read the toolbox fact sheet *Local government approval processes* in this series for further information.

Building materials

Greenhouse and grow structure materials vary considerably, and all have a different impact on fire risk. The most common Australian building materials are glass, film plastic membrane, sheet plastic membrane and metal framing as outlined in Table 1 below.

Table 1: Material fire loading and desription

MATERIAL TYPE	DESCRIPTION	FIRE LOADING
Glass	Tempered or non-tempered glass (soda-lime glass), melting point of approximately 1,400°C in accordance with AS 1288 Glass in Buildings and AS 2047 Windows in Buildings	Not combustible and does not spread flame, unless they have been laminated with a film that may be combustible
Film plastic membrane (FPM)	Single layer plastic film is commonly polyethylene, EVA or PVC between 150 to 200 microns thick. Includes impermeable membrane, permeable woven netting or shade cloth, and shade or energy curtains	Combustible and need to be protected from high heat sources and open flames, particularly the edges which are more susceptible than the flat surface. Can spread fire quickly due to melting and dripping onto other combustible material below (e.g. polystyrene boxes)
Sheet plastic membrane (SPM)	Commonly polycarbonate, acrylic and fibreglass that come in corrugated sheets or twin-wall panels	Flame-retardant and considered to be non-flammable (most commonly), which should be confirmed with the manufacturer
Metal framing	Commonly steel, aluminium or composite of the two metals	Although flame is unable to spread over metal they are not 'fireproof'. Unprotected metal framed buildings can fail more rapidly than a wooden structure due to rising temperature and structural failure

Separation and compartmentalisation

It's important to separate a greenhouse or farm building to limit your risk of loss. The National Construction Code (NCC) has limitations on how much fire load in a given area can be created. So separation of building, fire breaks, and compartments should be considered. In Group A type buildings, one method is to form two or more sections of your greenhouse with a fire-resistant boundary in accordance with the current, relevant NCC and Australian Standards (accessible online).

To do this:

- Place buildings at three or six metre separations to accommodate both buildings and a fire break to reduce fire spread externally
- Maintain an appropriate distance to vegetation that will reduce the risk of spreading bushfires
- Separate the greenhouse into fire zones based on risk using non-combustible materials as partitions (e.g. fire wall, concrete tilt panels, fire-rated cladding)
- Isolate generators, heaters and boilers from the greenhouse with non-combustible partitions
- Isolate ignition sources such as heating pipes, CO2 generators and other electrical switches from combustible materials.

The greenhouse manufacturer in conjunction with a professional fire engineer (if required) will determine a separation and compartmentalisation strategy best suited to the development based on the information you supply on layout of growing area and plant areas.

Power delivery

Electrical faults and/or misuse of the electricity supply result in many fires. Tips for ensuring safe installation and operation of electrical equipment include:

- Ensure electrical work is undertaken by a professional electrician and compliant with relevant Australian Standards
- Ensure each circuit is protected by a fuse or breaker that will blow if safe capacity is exceeded to reduce the risk of fire from overloading
- Install electrical panels and boxes in the driest and most accessible location within the greenhouse to avoid areas of excessive, prolonged moisture
- Install corrosion resistant and weatherproof electrical panels and boxes
- Consider a secondary power supply panel and disconnect switch outside the structure
- Ensure the installation is verified by a qualified electrical contractor who uses thermal imaging of systems.

Further detail and design guidance can be obtained from a registered professional fire engineer or electrical engineer, and is highly recommended.

Lights

Lights should be protected with a non-combustible conduit (i.e. metal) wherever possible, however lights are not common in Australian greenhouses. They should also be maintained regularly to remove dust and debris and check electrical wiring. When installing lights be sure to:

- Maintain an appropriate distance between lights and combustible materials
- Use a licenced electrician and ensure approved fittings are used

- Replace old or faulty parts with original manufacture approved components.

Maintenance of equipment

General:

- Ensure a maintenance protocol is in place to check mechanical and electrical equipment
- Replace or repair damaged or faulty equipment immediately, or where not possible remove from operation.

Fans and motors:

- Keep the area around fans and motors clear of combustible materials
- Provide appropriate ventilation and maintain regularly to remove dust and debris build up
- Ensure they are installed by a licenced professional and voltage and amperage corresponds to the motor nameplate.

Appliances and tools:

- Service and clean vehicles, including fork-lifts and tractors, to ensure dust and oil does not build up around the engine block and electrical connections
- Service and maintain tools as per manufacturer's recommendations, particularly those that are powered by an internal combustion engine
- Store tools and vehicles that may be hot from operation away from combustible material with adequate ventilation.

Fire and smoke early warning detection

General upkeep:

- Test fire and smoke alarms at regular intervals, the codes in Australia indicate the periods of inspection and testing (AS1851)
- Flush private fire hydrants at least once a year or as instructed by the manufacturer (if installed)
- Check fire doors are performing adequately, are unobstructed and in good condition
- Check all water control valves and air and water pressures of automatic sprinkler and misting systems
- Ensure a licenced electrician checks all wiring, power boards and electrical equipment for faults or deterioration on regular intervals
- Check and maintain all boilers and heating systems to ensure they are in good operating condition.

Fire extinguishers and fire house reels:

- Install fire extinguishers and hose reels in locations instructed by the relevant Australian Standards or professional fire engineer
- Install fire extinguishers near potential hazards (e.g. gas storage tanks, boilers and CO_2 generators), aisles and near exterior doorways
- Use the correct fire extinguisher for the type of fire as per Table 2
- Only use fire hose reels when fighting an ordinary combustible fire (wood, paper, plastic and fabric)
- Educate staff on the identification of types of fires, use of equipment, and when to combat fire or evacuate.

Table 2: Fire extinguisher classes

CLASS	TYPE OF FIRE	APPROPRIATE EXTINGUISHERS
A	Ordinary combustibles (i.e. wood, paper, fabric, plastic)	Water, foam, dry chemical, vaporising liquid, wet chemical
B	Flammable liquids	Foam, dry chemical, carbon dioxide, vaporising liquid, as well as sand cover and fire blankets
C	Flammable gas	Dry chemical, vaporising liquid
E	Electrical	Dry chemical, carbon dioxide, vaporising liquid

Storage of combustibles:

- Locate in a ventilated open outdoor area that is well separated from buildings, streets and property boundaries
- Ensure storage room is labelled and secure
- Document the locations of combustible storage areas in the farm's Fire Prevention and Emergency Response Plan
- Keep an inventory of the type, quantity, date of purchase and location of the chemicals and combustibles
- Ensure electrical services near flammable goods are properly designed and maintained
- Keep the inventory safe and available for inspection by emergency personnel
- Store flammable liquids only in approved containers
- Ensure chemical storage rooms have appropriate ventilation and spill contaminate design in accordance with Australian Standards (where applicable)
- Storage should be in accordance with the National Code of Practice for the Storage and Handling of Workplace Dangerous Goods (see AS1940).

Emergency Response Plans:

- Prepare an Emergency Response Plan to ensure all staff know what to do in the event of a fire or other emergency to protect human safety and reduce loss and damages
- Ensure operation of common alert systems, including:
  – PA systems, sirens or bells clearly audible anywhere on the farm
  – Exit routes from buildings clearly identified on emergency exit plans
  – Exit signs to mark exits (illuminated signs are not required in typical greenhouses)
- Install and appropriately label 'knockout panels' in greenhouse sidewalls and gable ends if required by fire authority
- Undertake one onsite fire and evacuation drill per year in accordance with Australian Standard 3745:2010
- Train staff in how to implement and follow the response plan, including practice of kicking through a knockout panel.

For assistance in developing an Emergency Response Plan you should refer to your state Workplace Health and Safety Commission, complete the checklist developed by Safe Work Australia, or engage a professional fire engineer for a fee.

REFERENCES AND FURTHER READING

Olivotto, M. (2014) Building codes and greenhouse construction, Osborn Lane Consulting Engineers, Warwick

National Greenhouse Manufacturers Association (2010) Fire Safety, Pennsylvania, https://www.ngma.com/standardpdf/FireSafety2010.pdf

Safe Work Australia (2012) Emergency Plans Fact Sheet, Canberra, http://www.safeworkaustralia.gov.au/sites/swa/about/publications/Documents/657/Emergency_plans_fact_sheet.pdf

IMPORTANT QUESTIONS TO ASK

- What are the main risks that could cause a fire in my greenhouse or grow structure?
- Do I need to enlist the services of a professional fire engineer to properly manage fire risk on my farm?
- What measures do I have in place to prevent a fire from occurring?
- Where is the closest fire department located and when did they last tour the site?
- Do I have an Emergency Management Plan in place and when was it last updated?
- Do staff need training for dealing with different fire types?
- What training could I provide employees to maintain a low risk of accidental fires and safe egress?

Working at heights and managing the risk of falls

Safe operations management practices

TOOLBOX

GREENHOUSE CONSTRUCTION AND SAFE OPERATION

Working at heights

Falls are a major cause of death and serious injury in Australian workplaces. Fall hazards are found in protected cropping environments by working on roofs, operating machinery for maintenance, and loading and unloading trucks.

Everyone has a responsibility for health and safety relating to falls. This includes, but is not necessarily limited to:

- Business owners who have the primary duty under the Work Health and Safety Act (WHS Act)
- Designers, manufacturers, suppliers, importers and installers of plant or structures
- Officers, such as company directors
- Workers who have a duty to take reasonable care for their own health and safety.

Identifying fall hazards

Look for potentail hot spots

It's important to identify all locations and tasks that could cause injury due to a fall. Tasks that are particularly high risk in greenhouses or grow structures are those undertaken on:

- Structures or plant being constructed or installed, demolished or dismantled, inspected, tested, repaired or cleaned
- Fragile surfaces such as plastic membrane, sheet or glass
- Equipment to work at the elevated level such as elevating work platforms or portable ladders
- Sloping or slippery surface where it is difficult for people to maintain their balance, for example glazed roofs.

Inspect the workplace

Walk around the workplace and have a discussion with your workers to find out where work is carried out that could result in falls. Key things to look for include:

- Surfaces: how stable and/or slippery is the surface
- Levels: where levels change and workers may be exposed to a fall from one level to another
- Structures: the stability of temporary or permanent structures
- Ground: the evenness and stability of the ground for safe support of scaffolding or a work platform
- Working area: whether it is crowded or cluttered
- Entry and exit from the working area

KEY MESSAGES

- Falls are a major cause of death and serious injury in Australian workplaces
- Everyone has a responsibility for health and safety relating to falls
- Taking a risk-based approach is the most effective way to eliminate or reduce falls. This includes identifying fall hazards, assessing risk, controlling risk and reviewing control measures
- Removing the need to work at height is the most effective way of protecting workers from the risk of falls

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- Edges: protection for open edges of floors, working platforms, walkways, walls or roofs
- Hand grip: places where hand grip may be lost.

Advice may be needed from technical specialists, such as structural engineers, to check the stability of structures or load bearing capacity. Refer to the toolbox fact sheet General design considerations in this series for further information.

Review available information, including incident records

It's recommended to check your records of previous injuries and 'near miss' incidents related to falls.

Information and advice about fall hazards and risks relevant to the protected cropping industry and work activities is also available from regulators, industry associations (Protected Cropping Australia and AUSVEG), technical specialists and safety consultants.

Assessing risk

A risk assessment can assist to determine:

- What could happen if a fall did occur and how likely it is to happen
- How severe a risk is
- Whether any existing control measures are effective
- What action you should take to control the risk
- How urgently the action needs to be taken.

This should consider the design and layout of the elevated work area, number and movement of people, as well as the suitability of plant and equipment, lighting, weather conditions, personal protective equipment, staff knowledge and emergency procedures.

However, you may have already undertaken a risk assessment as part of your greenhouse WHS procedures and know the risk and how to control it.

Controlling risk

The risk of falls can be controlled in a number of different ways. A hierarchy of control will help you rank the effectiveness of each of these controls from highest to lowest.

The Workplace Health and Safety (WHS) regulations require the following specific control measures to be implemented to manage the risk of falls, where reasonably practicable:

1. Can the need to work at height be avoided to eliminate the risk of a fall? (e.g. on the ground)
2. Can the fall be prevented by working on solid construction? (e.g. properly constructed stairs with fixed handrails)
3. Can the risk of a fall be minimised by providing and maintaining a safe system of work? (e.g. installing guard rails and fall-arrest systems).

Control measures are needed where there is a risk of injury irrespective of fall height. It's also important that these control measures don't create new hazards.

You must ensure that the control measures you implement remain effective. This includes checking that the control measures are fit for purpose; suitable for the nature and duration of the work; are installed and used correctly:

- Develop work procedures on how to correctly install, use and maintain the control measure
- The manufacturer and/or supplier of the equipment should be consulted for any product specific requirements
- Provide information, training and instruction to workers, including procedures for emergency and rescue
- Provide supervision by ensuring that workers exposed to a risk of a fall are adequately supervised by a competent person.

This is covered by Regulation 37 under the WHS Act accessible online.

Reviewing control measures

The control measures that are put in place to prevent falls must be reviewed, and if necessary revised, to make sure they're effective. This should be done in accordance with Regulation 38 under the WHS Act:

- When the control measure does not control the risk so far as is reasonably practicable
- Before a change at the workplace that is likely to give rise to a new or different health and safety risk that the control measure may not effectively control

Working at heights and managing the risk of falls

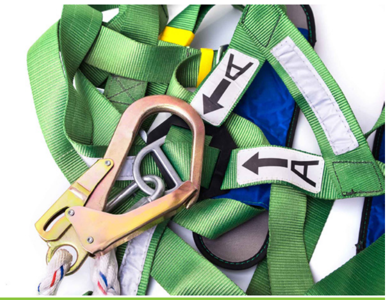
TOOLBOX
GREENHOUSE CONSTRUCTION AND SAFE OPERATION

- If a new hazard or risk is identified
- If the results of consultation indicate that a review is necessary
- If a health and safety representative requests a review.

Control measures can be reviewed using the same methods as the initial hazard identification step.

Tips for good farm management

The below table provides guidance on good farm management practices that can eliminate or significantly reduce the risk of falls in greenhouses and grow structures.



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Department of Justice and Attorney-General (2011) Managing the risk of falls at workplaces, Queensland Government, Brisbane, https://www.worksafe.qld.gov.au/__data/assets/pdf_file/0004/58171/managing-risk-falls-workplaces-cop-2011.pdf

IMPORTANT QUESTIONS TO ASK

- What are the main locations and tasks that could cause injury due to a fall on my farm?
- Have I undertaken a risk assessment to determine the likelihood and consequence of these events?
- Do the measures and practices comply with WHS requirements?
- What is the hierarchy of control for measures to address my main risks?
- When was the last time I reviewed and revised my control measures?
- Are there areas where I could remove the need to work at height on my farm?

Table 1: Tips to manage the risk of falls in greenhouses

AREA	EXPLANATION	EXAMPLE
Work on the ground or on a solid construction	Removing the need to work at height is the most effective way of protecting workers from the risk of falls	Using tools with extendable handles
Fall prevention devices	A fall prevention device is any equipment that is designed to prevent a fall for temporary work at heights	Perimeter guard rails
Work positioning systems	A work positioning system involves the use of equipment that enables a person to work supported in a harness in tension in such a way that a fall is prevented	Industrial rope access systems
Fall-arrest systems	A fall-arrest system is intended to safely stop a worker falling an uncontrolled distance and reduce the impact of the fall	Catch platforms
Ladders	Ladders are primarily a means of access and egress. Many falls take place when people are working from ladders	Placing ladders at a slope of 4:1
Administrative controls	Administrative controls may be used to support other control measures	'No go' areas, permit systems, sequencing of work
Emergency procedures for falls	Whenever there are risks from working at height, appropriate emergency procedures and facilities must be established and provided	First aid
Design of plant and structures	Consideration of the potential risk of falls early when designing plant or structures can result in the elimination of such risks	Specifying the strength of roof membranes

General design considerations

Structural provisions and loading

TOOLBOX

GREENHOUSE CONSTRUCTION AND SAFE OPERATION

KEY MESSAGES

- There are many greenhouse design considerations undertaken by engineers, which are important in understanding how to better plan, develop and operate your greenhouse
- The administrative issues to consider include design requirements, required information on plans, additions and alterations, and load testing. These will inform the design methodology
- There are many types of loads on greenhouse structures. These include dead, live, collateral, plant, wind, flood and hydrostatic
- Engage a professional structural engineer with experience in the design and construction of greenhouse and grow structures, that has appropriate qualifications to practice in your state or territory

Basic requirements

There are many greenhouse design considerations undertaken by engineers. It's important to have an understanding of these considerations to better plan, develop and operate your greenhouse so that it can safely support the specified loads.

High and medium technology greenhouses are usually designed by an experienced protected cropping engineering firm. However, low technology structures are often designed and certified by engineering service providers located closest to the farm and may not have adequate experience in designing greenhouses. For further information on the technology levels please refer to the Getting the basics right toolbox fact sheet in this series.

The table below outlines the types of considerations and relevant standards that engineers use when designing a greenhouse in Australia.

Table 1: Types and design consideration and relevant loading standards

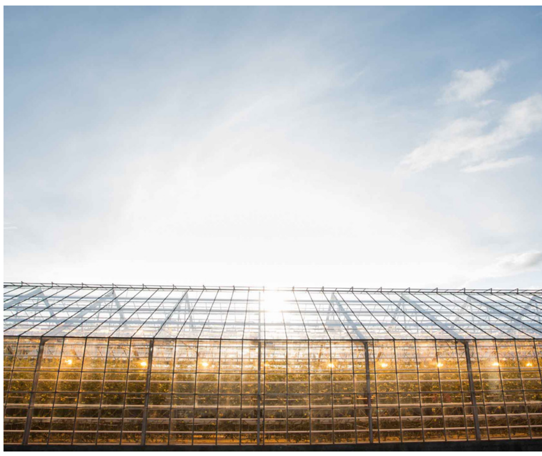
CONSIDERATION	RELEVANT STANDARD
General	AS/NZS 1170.0:2002 Structural Design Actions – General Principles
General	AS/NZS 1170.1:2002 Structural Design Actions – Permanent, Imposed and Other Actions
General	AS/NZS 1170.2:2011 Structural Design Actions – Wind Actions
General	AS/NZS 1170.4:2007 Structural Design Actions – Earthquake Actions in Australia
General	Steel, aluminium, timber, concrete and glazing standards: - AS 4100 and AS 4600 Steel Structures - AS 1664 Aluminium Structures - AS 3600 Concrete Structures
Special	EN 13031-1 Greenhouses – Design and Consideration (European Standard used If wind loadings on structures cannot be appropriately estimated through the use of AS/NZS 1170.2 due to geometries not covered in the standard)
Special	Further research, which may include wind-tunnel testing to improve AS/NZS 1170.2 to include actions upon all relevant structures to Australia and its industries and to cover GRP support systems and international based design codes if applicable

Administrative issues

Design requirements

The manufacturer of the greenhouse or structure needs to know the following local information:

- Relevant local government area
- Determination of loads (e.g. roof live load, wind speed)
- Soil type and allowable pressure.



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Required information on plans

There is certain information that should be shown on construction drawings and plans. This includes, but is not necessarily limited to:

- Dead loads
- Roof live loads
- Collateral loads, which covers irrigation equipment, including water
- Plant loads
- Wind load, which includes basic wind speed 3-second gust, wind importance factor Iw and building category, wind exposure category, applicable internal pressure coefficient and prevailing wind direction, and design wind pressure on components and cladding
- Earthquake load, which includes seismic use group, spectral response coefficients (SDS and SD1), site class, basic seismic-force resisting system, design base shear, and analysis procedure
- Flood load if a structure is in a flood zone or overlay as indicated by the relevant local government.

Additions and alterations

Additions to existing greenhouses can be made provided the new structure does not make the existing structure unsafe. This relates to the percent of overstress in structure members, as well as the ability of the structure to withstand any loads superimposed by the greenhouse, including lateral loads due to attachment.

Alterations can be made to any greenhouse provided the new work complies with the current National Construction Code (NCC) and any loads imposed on the existing structure do not make it unsafe. It should be noted that such alterations may potentially require a further development application. Read the toolbox fact sheet Local government approval processes in this series for further information on additions and/or alterations.

Load testing

Load testing is usually not required unless specialty products such as cladding components have been used in construction. Any load testing must be undertaken by an independent approved testing agency.

Design methodology

The engineer needs to consider the following steps in designing the greenhouse:

- Allowable stress design versus strength design requirements
- Safety factors for greenhouse components
- Greenhouse classification
- Deflection and drift
- Reactions of the structure in fire (NCC Part CP1).

Types of loads

The different types of loads engineers need to consider and an explanation of each are outlined in the table to the left.

Table 2: Types of loads

LOAD	EXPLANATION
Dead (permanent)	Includes structure weight and cladding weight.
Live (imposed)	Includes imposed loads applied to the structure through general use, maintenance loading and temporary concentrated loads. Typically prescribed in a uniformly distributed load (kPa) or concentrated load (kN).
Collateral	Weight of support equipment used for the operation or maintenance of plant material, including: - Mechanical equipment such as irrigation, transfer systems, including water - Permanently mounted service equipment (heaters, fans, water lines)
Plant	Weight of supported or suspended plant material: - Hanging plants, 0.1 kPa minimum, applied as a concentrated load at the truss panel points.
Wind	The calculation of wind loading on the main windforce-resisting system and the components and cladding (including glazing) of the structure. Read the toolbox fact sheet Wind loads in this series for further information.
Earthquake	Uses maps, soil type and occupancy to determine the seismic design.
Flood and hydrostatic	Soil and hydrostatic pressure and flood loads (local government regulations will identify flood design zones).
Other	- Thermal expansion and the need for joints - Rainwater - Fire

Professional structural engineers

It is recommended that you engage a professional structural engineer with experience in the design and construction of greenhouses and grow structures. The structural engineer should also have the appropriate qualifications and certification to practice in your location, as these vary by state or territory as outlined in the table below.

Queensland and Victoria are the only Australian states to have legislation requiring registration to perform professional engineering services.

Table 3: Certification required for professional structural engineers by state and territory

STATE/TERRITORY	QUALIFICATIONS	REGISTERING BODY	TYPE
New South Wales	National Professional Engineering Registration (NPER)	National Engineering Registration Board (NERB)	Voluntary
	Professional Engineer – Chartered Professional Engineer (CPEng)	Engineers Australia	Voluntary
Victoria	Registered Professional Engineer (RPEng) Structural Victoria	Professionals Australia	Mandatory
	NPER	NERB	Voluntary
	CPEng	Engineers Australia	Voluntary
Queensland	RPEng Structural Queensland	Board of Professional Engineers Queensland (BPEQ)	Mandatory
	NPER	NERB	Voluntary
	CPEng	Engineers Australia	Voluntary
Western Australia	NPER	NERB	Voluntary
	CPEng	Engineers Australia	Voluntary
South Australia	NPER	NERB	Voluntary
	CPEng	Engineers Australia	Voluntary
Tasmania	NPER	NERB	Voluntary
	CPEng	Engineers Australia	Voluntary
Northern Territory	Certifying Engineer (Structural, Mechanical, Hydraulic)	Building Practitioners Board NT	Mandatory
	NPER	NERB	Voluntary
	CPEng	Engineers Australia	Voluntary
Australian Capital Territory	NPER	NERB	Voluntary
	CPEng	Engineers Australia	Voluntary

IMPORTANT QUESTIONS TO ASK

- What experience does my engineer or designer have with protected cropping structures? Do they have the appropriate qualifications to practice in my state or territory?
- What design considerations and relevant standards do I need to consider in planning, developing or operating my greenhouse?
- Is the designer of my greenhouse aware of the necessary administrative requirements, such as local government regulations?
- Has the engineer adequately considered all the necessary loads in my greenhouse structure?

REFERENCES AND FURTHER READING

National Greenhouse Manufacturers Association (2010) Chapter 2 – Design Considerations, Pennsylvania, https://www.ngma.com/standardpdf/Chap22010.pdf

Engineers Australia (2017) National Engineering Register, https://www.engineersaustralia.org.au/national-engineering-register

Wind loads

Structural provisions and loading

TOOLBOX

GREENHOUSE CONSTRUCTION AND SAFE OPERATION

Overview

Wind loads can prove particularly challenging for greenhouses in Australian conditions. It's important to note what the following terms mean:

- **Windward is toward the wind; toward the surface or point from which the wind blows**
- **Leeward is the side, surface or point to which the wind blows.**

Wind loads are covered by the AS/NZS 1170.2:2011 Structural Design Actions – Wind Actions. The objective of this Standard is to provide wind actions for use in the design of structures subject to wind action.

This fact sheet provides an overview of the best practice considerations, as well as an overview of the AS/NZS 1170.2:2011, before outlining specialist wind loading of porous canopy structures.

Best practice considerations

These best practice considerations mainly relate to low and medium technology greenhouses and grow structures rather than high technology. For further information on the technology levels please refer to the *Getting the basics right* toolbox fact sheet in this series.

Durability

Important considerations include, but are not limited to:

- All components of the structure should be chosen by taking into account the design working life of the structure and the environment where they will be in service. Ease and costs related to access to the components, should they need to be replaced, also needs to be considered
- Galvanized steel structures are quite durable, however other steel components, such as square hollow section (SHS) columns, should be provided with an appropriate paint system, for example specified with a 'Duragal' finish or alternatively galvanized.

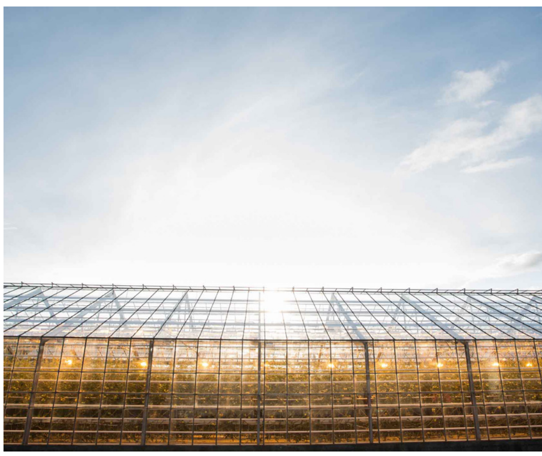
Foundations

Some points to consider include, but are not limited to:

- Each type of footing for a particular structure should be purpose designed (do not copy footing sizes from other areas where factors such as the design loads and soil type are likely to be different)
- Generally, footings in sand will usually be wider than those in clay due to the reduced bearing capacity
- Generally, footings in highly or extremely reactive soil will have additional depth and steel reinforcement to control soil heave movements
- The sides of footings should be close to vertical, wherever feasible

KEY MESSAGES

- Wind loads are covered by the AS/NZS 1170.2:2011 Structural Design Actions – Wind Actions, which outlines the design procedure, calculation of wind loads, regional wind speeds, and site exposure multipliers
- It's important to consider wind loads on durability, foundations, cable-guyed structures, cantilever post structures, hoop structures and igloo structures
- Recent research has provided significant breakthroughs in the effectiveness and design security of porous canopy structures



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- Extend the tops of footings at least 75 mm above finished ground level and provide a slope to the top surface.

Cable-guyed structures

Always check:

- Connections between cables: horizontal steel cables should be connected to each other to improve the overall stiffness of the cable grid system
- Connections to top of exterior columns: the tensile force in the inclined cable (assuming it is sloped at 45°) will typically be about 1.4 times larger than in the horizontal cable and so good practice is to ensure that the inclined cable is also at least 1.4 times stronger
- Connections to top of interior columns: horizontal cables are best run continuously from one exterior column to the other exterior column at the other end of the complete cable length. However, these cables need to be restrained to the tops of the interior columns
- Exterior footings for inclined cables: should be designed to resist the combined effects of the horizontal and uplift loads that will be applied by the inclined cable. In order to prevent:
  – Water pooling on the footer, the top of the footing should also be finished with a slight bevel/slope
  – Corrosion of the perimeter cable, the footing should be extended high enough off the ground so it's raised.

Cantilever post structures

It's important that:

- Horizontal top rails are a sufficient diameter so they will not buckle if subjected to compression loads. As a guide, ensure the ratio of the top rail length (i.e. distance between their supporting posts) to their diameter is not more than 100 and the pipe wall thickness is not less than 3 mm
- Galvanized bolts are considered in the top rails to prevent them becoming loose or applying tension elsewhere in the structure.

Hoop structures

It is recommended that pipe clamp joints use an extra 10 mm bolt installed through the clamp and the end wall mullion. This will add a higher degree of structural strength to wind loads.

Igloo structures

It is recommended that three sets of crossed tension roof bracing and three ties between the end and first internal frames should be used at both ends. This ensures the top of the end wall mullions are supported by struts/ties to transfer the wind loads from the end walls via the roof bracing to the wall bracing member.

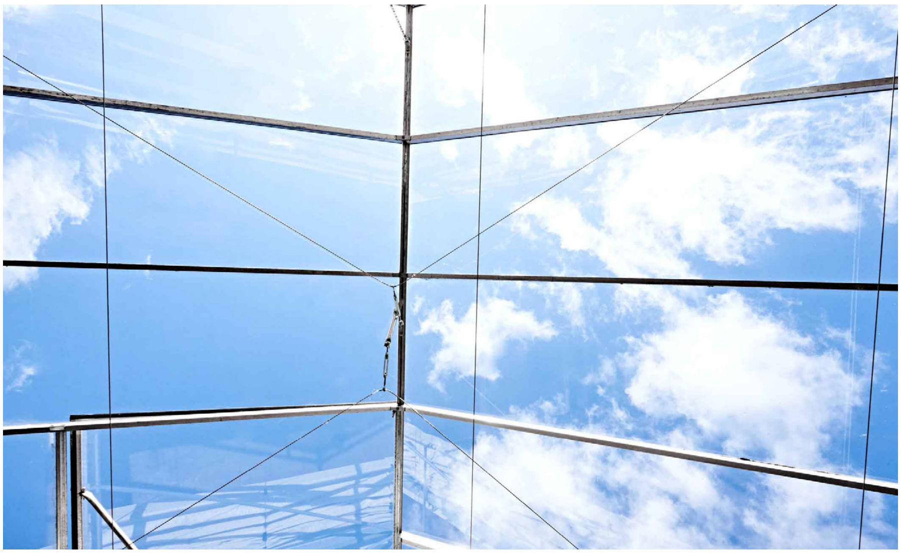
Design procedure

Design wind loads for greenhouses need to consider the:

- Basic wind speed (**V**)
- Velocity pressure ($\mathbf{q}_z$) where z is the height, which is calculated taking into consideration the exposure category, the surrounding terrain, the wind direction, and the occupancy of the structure
- Design wind pressure (**p**) which is calculated taking into consideration the direction of the wind, the exposure category, the height of the building or element, and the porousness and openness of the structure.

Calculation of wind loads

In order to determine the wind action (**W**) on greenhouse structures engineers need to:



- Determine site wind speeds ($V_{sit,\beta}$): defined for the 8 cardinal directions (β) at the reference height (**z**) above ground
- Determine design wind speed from the site wind speeds ($V_{des,\theta}$): which is taken as the maximum cardinal direction site wind speed ($V_{sit,\beta}$) linearly interpolated between cardinal points within a sector ±45 degrees to the orthogonal (right angle) direction being considered
- Determine design wind pressures (Pa in Pascals) and distributed forces (drag force per unit area f in pascals)
- Calculate wind actions based on:
  – Directions to be considered
  – Forces on surfaces or structural elements (e.g. wind pressure, frictional drag, force coefficients)
  – Forces and moments on complete structures
  – Performance of fatigue-sensitive elements
  – Serviceability of wind-sensitive structures.

The structure types and associated importance levels are outlined in Table 1 below.

Table 1: Classification of greenhouses for importance levels as per AS/NZS 1170.0:2002

CONSEQUENCES OF FAILURE	DESCRIPTION	IMPORTANCE LEVEL	COMMENT
Low	Low consequence for loss of human life, or small or moderate economic, social or environmental consequences	1	Minor structures (failure not likely to endanger human life)
Ordinary	Medium consequence for loss of human life, or considerable economic, social or environmental consequences	2	Normal structures and structures not falling into other levels
High	High consequence for loss of human life, or very great economic, social or environmental consequences	3	Major structures (affecting crowds)
		4	Post-disaster structures (post disaster functions or dangerous activities)
Exceptional	Circumstances where reliability must be set on a case by case basis	5	Exceptional structures

Regional wind speeds

Regional wind speeds (**V**$_R$) for all directions based on three second gust wind data are outlined in the table and figure below.

Table 2: Regional wind speeds[1]

REGIONAL WIND SPEED (M/S)	REGION				
	NON-CYCLONIC			CYCLONIC	
	A (1 to 7) Southern and inland Australia	W	B Inland northern Australian coast	C Northern Australian coastline	D West coast north of Perth
V_5	32	39	28	F_C 33	F_D 35
V_{10}	34	41	33	F_C 39	F_D 43
V_{20}	37	43	38	F_C 45	F_D 51
V_{25}	37	43	39	F_C 47	F_D 53
V_{50}	39	45	44	F_C 52	F_D 60
V_{100}	41	47	48	F_C 56	F_D 66
V_{200}	43	49	52	F_C 61	F_D 72
V_{500}	45	51	57	F_C 66	F_D 80
V_{1000}	46	53	60	F_C 70	F_D 85
V_{2000}	48	54	63	F_C 73	F_D 90
V_R	$67 – 41R^{-0.1}$	$104 – 70R^{-0.045}$	$106 – 92R^{-0.1}$	F_C x $(122 – 1\text{-}4R^{-0.1})$	F_D x $(156 – 142R^{-0.1})$

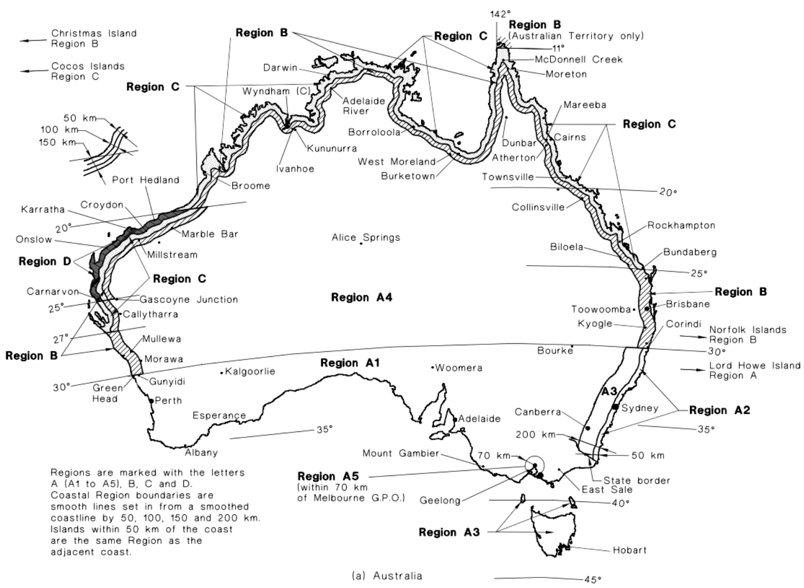


Figure 1: Wind regions in Australia in accordance with AS/NZS 1170.2:2011

Regional wind speeds also need to consider the:

- Wind direction multiplier (**M**$_d$)
- Wind speed factors in cyclonic zones (regions C and D), which are:
  – For ultimate limit states wind speeds, **F**$_D$ = 1.1.
  – For ultimate limit states wind speeds, **F**$_C$ = 1.05.
  – For serviceability limit states wind speeds, FC and **F**$_D$ = 1.0.

[1] Where R (average recurrence interval) is the inverse of the annual probability of exceedance of the wind speed (i.e., P for ultimate or serviceability limit states).

TOOLBOX
GREENHOUSE CONSTRUCTION AND SAFE OPERATION

Site exposure multipliers

Engineers may also need to calculate the exposure multipliers relating to site conditions related to:

- Terrain/height ($M_{z,cat}$) over which the approach wind flows towards a structure, which includes:
  – Category 1: exposed open terrain with few or no obstructions
  – Category 2: water surfaces, open terrain with scattered obstructions (1.5-10m high)
  – Category 3: terrain with a number of closely spaced small obstructions (3-5m high)
  – Category 4: terrain with a number of closely spaced large obstructions (10-30m high)
- Shielding (M_s) is 1.0 where the average upwind ground gradient is greater than 0.2 or where the effects of shielding are not applicable for a particular wind direction or are ignored
- Topography (M_t).

The design must take account of known future changes to terrain roughness when assessing terrain category as well as protected cropping structures providing shielding.

Specialist wind loading of porous canopy structures

Porous canopies are those structures covered by woven net and the resilient, lightweight, tensile systems provide great structural efficiency. However, they are not appropriately covered by the standard AS/NZS 1170.2:2011 Structural Design Actions – Wind Actions. Recent research has provided significant breakthroughs in the effectiveness and design security of these structures.

The key findings of the recent research undertaken by Osborn (2016) are:

- Reduction in the magnitude of the wind action on the roof from increasing the porosity of the canopy compared to a non-porous canopy
- Redistribution of wind action on the walls from increasing the porosity due to the flow of wind in and out of the canopy interior, rather than a reduction
- Less separation or disturbance of the wind at the wall to roof intersection than would occur on a non-porous structure.

This has provided a strong basis for the structural design of large flat roofed porous canopies for normal wind actions in Australia, which will assist engineers to design safer protected cropping structures.

IMPORTANT QUESTIONS TO ASK

- What is the basic wind speed in my region?
- Does the designer have experience with assessment of wind loads under the local conditions?
- Has the designer or manufacturer of my new greenhouse considered AS/NZS 1170.2:2011 Structural Design Actions – Wind Actions?
- Is the new structure certified to AS/NZS 1170.2:2011 standards?
- What are the main areas of my structure that are subject to wind loads? Are durability, foundations, cable-guyed structures, cantilever post structures, hoop structures and igloo structures all relevant?

REFERENCES AND FURTHER READING

Standards Australia (2011) Australian/New Zealand Standard Structural design actions Part 2: Wind actions, SAI Global Limited, Sydney

Leitch, C. & Holborn, S. (2012) Improving the Performance of Crop Protection Enclosures to Resist Wind Loads, Cyclone Testing Station in conjunction with DAFFQ, Queensland, https://www.jcu.edu.au/__data/assets/pdf_file/0007/322000/Technical-Report-TS846-Improving-the-Performance-of-Crop-Protection-Enclosures-to-Resist-Wind-Loads.pdf

Nursery and Garden Institute Queensland (2012) Recommended Good Practice, summary of Improving the Performance of Crop Protection Enclosures to Resist Wind Loads, Cyclone Testing Station in conjunction with DAFFQ, Queensland

Osborn E.P. (2016) Characteristic wind actions on large flat roofed porous canopies, James Cook University, Townsville, http://researchonline.jcu.edu.au/44649/1/44649-osborn-2016-thesis.pdf

Resistance of materials

Structural provisions and loading

TOOLBOX
GREENHOUSE CONSTRUCTION AND SAFE OPERATION

Structural reliability is an overall concept covering structural actions, response and resistance, workmanship and quality control, all of which are dependent on each other.

The National Construction Code (NCC) outlines a number of important considerations for the resistance of materials used in the construction of greenhouses and grow structures in Australia. These are outlined below.

Structural resistance of materials

The structural resistance of materials and forms of construction must be determined using five percentile characteristic material properties. This includes:

1. Known construction activities
2. Type of material
3. Characteristics of the site
4. Degree of accuracy inherent in the methods used to assess the structural behaviour
5. Action effects arising from the differential settlement of foundations, and from restrained dimensional changes due to temperature, moisture, shrinkage, creep and similar effects (BP1.2).

Glazing impact resistance

Glass or glazing that are at risk of being subjected to human impact must have glazing that resists a reasonably foreseeable human impact without breaking (BP1.3).

Structural reliability

Overview

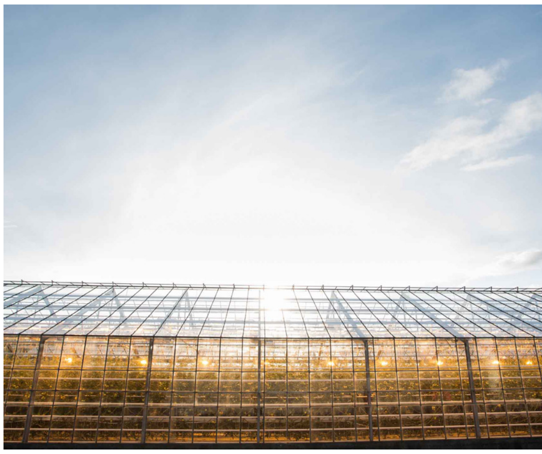
Structural reliability can be quantified by failure probability (**pF**) or reliability index (β), which are connected by the relation $\beta = - \Phi\text{-}1(pF)$.

Reliability indices

Target reliability indices, or 'safety factors', are set for structural components and connections in the NCC. These indices are found in current design practice for steel, concrete and timber. Reliability indices are quantified using verification methods, specifically BV1 and V2.1.1. Verification methods may be used to demonstrate compliance with Performance Requirements BP1.1 and BP1.2 in the NCC.

KEY MESSAGES

- It is important to understand the structural resistance of materials that you use
- Engage a suitably qualified structural engineer to provide advice and input to the structural reliability of your greenhouse in accordance with national standards
- It's important to consider structural resistance of materials and glazing impact resistance covered under BP1.2 and BP1.3 of the National Construction Code



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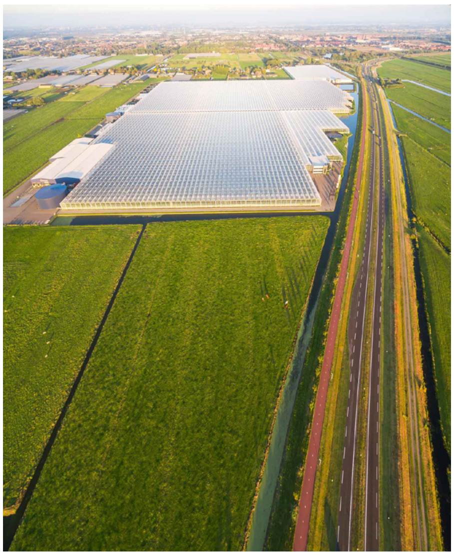
Primary and secondary structural components

Structural components and connections can be classified as primary or secondary. Put simply, primary components or connections are responsible for structural integrity and their failure could result in a collapse of the protected cropping structure, whereas secondary components are not. Primary components and connections must meet unadjusted reliability indices, whereas these can be reduced for secondary components and connections when it does not affect the building, structure or other property.

Probabilistic models

The reliability index takes actions and resistances, and represents these as random variables in probabilistic models.

The peaks in the curve models represents the most frequent value, and the distance between the action and resistance curves is the performance of the component under question, shown in Figure 1. These are in accordance with AS/NZS 1170 and follow a lognormal distribution.



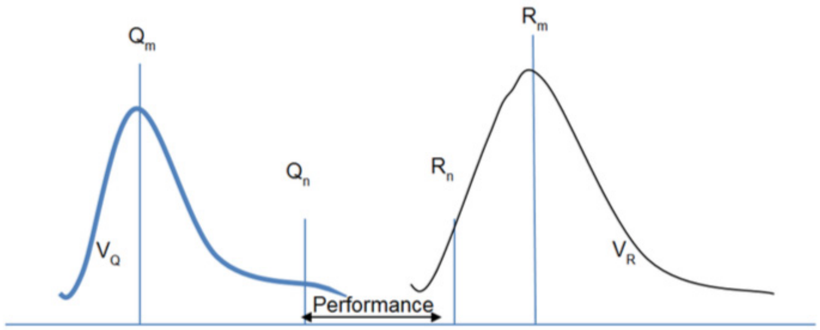


Figure 1: Action (left) and resistance (right) models

IMPORTANT QUESTIONS TO ASK

- Do I understand the structural resistance of different materials?
- Who is my local qualified structural engineer? What is their experience with protected cropping structures?
- What materials will I need to develop my new or modify my existing greenhouse?
- Has my engineer adequately considered the reliability indices of the primary structural components and connections in the greenhouse?

REFERENCES AND FURTHER READING

Australian Building Codes Board (2016) National Construction Code 2016; Volume 1; Building Code of Australia; Class 2 to Class 9 Buildings, Commonwealth of Australia and States and Territories of Australia – Part B1 Structural Provisions, BP1.2 and 1.3, pp. 71

Australian Building Codes Board (2015) Structural Reliability Handbook, Section 3: Structural Reliability pp. 7, https://www.abcb.gov.au/-/media/Files/.../Handbook-Structural-Reliability-2015.pdf

Access and egress

Compliance with the National Construction Code

TOOLBOX

GREENHOUSE CONSTRUCTION AND SAFE OPERATION

Australia currently does not have a unified building classification of horticultural buildings within the National Construction Code (NCC). This means that greenhouses or grow structures can be classified as Class 7 or Class 8 within the NCC which can be onerous and inappropriate.

Access and egress requirements should be completed in accordance with the NCC. Access must be provided to enable people to approach the greenhouse from the road boundary, car park, any accessible building, and other spaces or amenities, as well as identify accessways at appropriate locations that are easy to find.

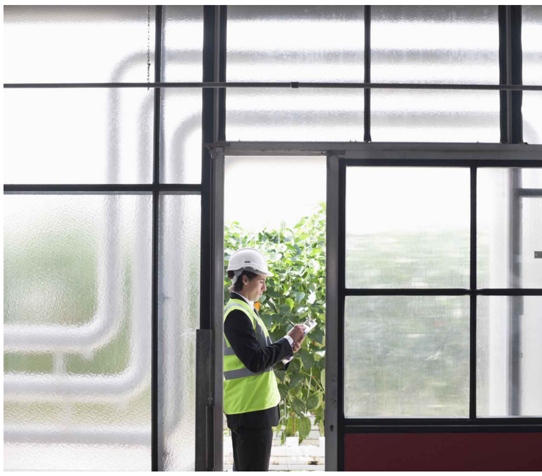
Under the current NCC Part H3, the Deemed-to-Satisfy Provisions of Section D1 do not apply to a farm shed, except for D1.2, D1.4 to D1.6, D1.9, D1.10(a), D1.13(c), D1.14 and D1.15. This is further explained for greenhouses in the table below.

Table 1: Deemed-to-Satisfy Provisions for access and egress

NCC SECTION	AREA	DEEMED-TO-SATISFY PROVISIONS FOR GREENHOUSES
D1.2	Number of exits required	Every building must have at least one exit from each storey. Access to exits – without passing through another sole-occupancy unit every occupant of a storey or part of a storey must have access to an exit.
D1.4	Exit travel distances	No point on a floor must be more than 20 m from an exit, or a point from which travel in different directions to 2 exits is available, in which case the maximum distance to one of those exits must not exceed 40 m.
D1.5	Distance between alternative exits	Exits that are required as alternative means of egress must be: - Distributed as uniformly as practicable - Not less than 9 m apart - Not more than 60 m apart - Located so that alternative paths of travel do not converge such that they become less than 6 m apart.
D1.6	Dimensions of exits and paths of travel to exits	In a required exit or path of travel to an exit the unobstructed: - Height throughout must be not less than 2 m - Width of each exit or path of travel to an exit, except for doorways, must be not less than 1m.

KEY MESSAGES

- Greenhouses or grow structures can be classified under the sometimes onerous and inappropriate classification of Class 7 or Class 8 within the National Construction Code (NCC)
- It's important to understand the access and egress requirements of your greenhouse under the NCC
- There are several Deemed-to-Satisfy Provisions for greenhouses under the NCC that you need to be aware of, which cover exits, ramps, occupancy, and measurement of distances



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TOOLBOX
GREENHOUSE CONSTRUCTION AND SAFE OPERATION

Table 1 continued

NCC SECTION	AREA	DEEMED-TO-SATISFY PROVISIONS FOR GREENHOUSES
D1.9	Travel by non-fire-isolated stairways or ramps	A non-fire-isolated stairway or ramp serving as an exit must provide a continuous means of travel to the level at which egress to a road or open space is provided. The distance from any point on a floor to a point of egress to a road or open space by way of a required non-fire-isolated stairway or ramp must not exceed 80 m. A required non-fire-isolated stairway or ramp must discharge at a point not more than: - 20 m from a doorway providing egress to a road or open space - 40 m from one of 2 such doorways or passageways.
D1.10(a)	Discharge from exits	An exit must not be blocked at the point of discharge and where necessary, suitable barriers must be provided to prevent vehicles from blocking the exit, or access to it.
D1.13(c)	Number of persons accommodated	The number of persons accommodated in a greenhouse must be determined considering the layout of the floor area by any suitable means of assessing its capacity.
D1.14	Measurement of distances	The nearest part of an exit means in the case of a: - Non-fire-isolated stairway, the nearest part of the nearest riser - Non-fire-isolated ramp, the nearest part of the junction of the floor of the ramp and the floor of the storey - Doorway opening to a road or open space, the nearest part of the doorway - Horizontal exit, the nearest part of the doorway.
D1.15	Method of measurement	The following rules apply: - Only the shortest distance is taken along a corridor, hallway, external balcony or other path of travel that curves or changes direction - The distance between exits is measured in a straight line between the nearest parts of those exits (subject to above) - If more than one internal path of travel connects required exits, the measurement is along the path of travel through the point at which travel in different directions to those exits is available - If a wall that does not bound a greenhouse or hallway causes a change of direction in proceeding to a required exit, the distance is measured along the path of travel past that wall - In the case of a non-fire-isolated stairway or ramp, the distance is measured along a line connecting the nosings of the treads, or along the slope of the ramp, together with the distance connecting those lines across any intermediate landings.

Read the toolbox fact sheets *Construction of exits* and *Fire* in this series for further information on access and egress requirements.

IMPORTANT QUESTIONS TO ASK

- Have I considered and appropriately addressed the Deemed-to-Satisfy Provisions that cover exits, ramps, occupancy, and measurement of distances under the NCC?
- Who is my local accredited building certifier and/or professional fire engineer with experience in the protected cropping industry?

REFERENCES AND FURTHER READING

Australian Building Codes Board (2016) National Construction Code 2016; Volume 1; Building Code of Australia; Class 2 to Class 9 Buildings, Commonwealth of Australia and States and Territories of Australia:

Part H3 Farm Building and Farm Sheds, pp. 377-380

Section D, Section D1.2, D1.4 to D1.6, D1.9, D1.10(a), D1.13(c), D1.14 and D1.15 Access and Egress, pp. 155-218

Construction of exits

Access and egress

TOOLBOX

GREENHOUSE CONSTRUCTION AND SAFE OPERATION

Construction of exits should be completed in accordance with the National Construction Code (NCC). To ensure people can move safely to and within a greenhouse it must have walking surfaces with safe gradients, doors installed that avoid risk of occupants being blocked or trapped, as well as any stairways and ramps allowing safe passage.

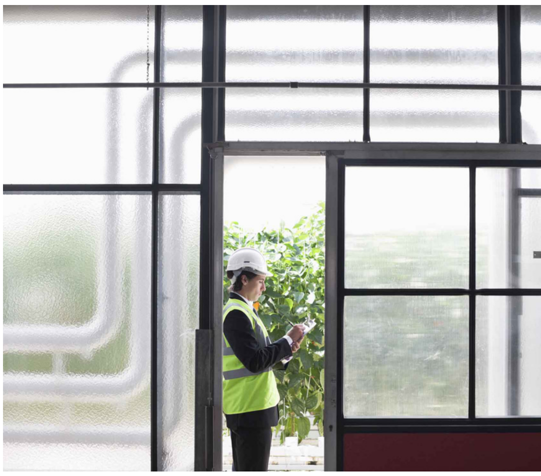
Under the current NCC Part H3, the Deemed-to-Satisfy Provisions of Part D2 do not apply to a farm shed, except for D2.13, D2.14, D2.16, D2.17 and D2.24. This is further explained in the table below.

KEY MESSAGES

- Greenhouses or grow structures can be classified under the sometimes onerous and inappropriate classification of Class 7 or Class 8 within the National Construction Code (NCC)
- It's important to understand the construction of exit requirements of your greenhouse under the NCC
- There are several Deemed-to-Satisfy Provisions for greenhouses under the NCC that you need to be aware of, which cover stairs, platform handrails, landings and swing doors

Table 1: Deemed-to-Satisfy Provisions for construction of exits

NCC SECTION	AREA	DEEMED-TO-SATISFY PROVISIONS FOR GREENHOUSES
D2.13	Goings and risers	A stairway must have: - Not more than 18 and not less than 2 risers in each flight - Going (G), riser (R) and quantity (2R + G) in accordance with NCC - Constant goings and risers throughout each flight - Risers which do not have any openings that would allow a 125 mm sphere to pass through between the treads - Treads which have a surface with a slip-resistance classification, or a nosing strip with a slip-resistance classification not less than specified in the NCC In the case of a non-required stairway the: - Stairway must have not more than 3 winders in lieu of a quarter landing, and not more than 6 winders in lieu of a half landing - Going of all straight treads must be constant throughout the same flight - Going of all winders in lieu of a quarter or half landing may vary from the going of the straight treads within the same flight.
D2.14	Landings	In a stairway: - Landings having a maximum gradient of 1:50 may be used in any building to limit the number of risers in each flight and each landing must: - Be not less than 750 mm long - Have a surface with a slip-resistance classification compliant with the NCC - Have a strip at the edge of the landing with a slip-resistance classification not less than that listed in the NCC.



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TOOLBOX
GREENHOUSE CONSTRUCTION AND SAFE OPERATION

Table 1 continued

NCC SECTION	AREA	DEEMED-TO-SATISFY PROVISIONS FOR GREENHOUSES
D2.16	Barriers to prevent falls	- A continuous barrier must be provided along the side of any of the following if the trafficable surface is 1 m or more above the surface beneath: - Roof - Stairway or ramp - Floor, corridor or hallway - Any delineated path of access to a building - The above requirements do not apply to: - Loading dock - Fixed platforms, walkways, stairways and ladders - Retaining wall - A required barrier must be constructed in accordance with the NCC (considering barrier heights, openings and climbability), which includes those constructed of wire (horizontal, non-continuous vertical and continuous vertical systems).
D2.17	Handrails	Handrails must be: - Located along at least one side of the ramp or flight - Located along each side if the total width of the stairway or ramp is 2 m or more - Fixed at a height of not less than 865 mm measured above the nosings of stair treads and the floor surface - Continuous between stair flight landings - In a required exit serving an area required to be accessible.
D2.24	Protection of openable windows	A barrier: - With a height not less than 865 mm above the floor is required to an openable window - Must not permit a 300mm sphere to pass through it in fire-isolated stairways, fire-isolated ramps and other areas used primarily for emergency purposes, excluding external stairways and external ramps.
H3.7	Swinging doors	A swinging door in a required exit or forming part of a required exit need not swing in the direction of egress if it serves a greenhouse.

An innovative approach to constructions of exits in low technology membrane structures is to hang an appropriate cutting implement at designated locations. This tool can be used to cut through the plastic membrane and create an exit for escape in emergency situations. For further information on the technology levels please refer to the *Getting the basics right* toolbox fact sheet in this series.

Read the toolbox fact sheets *Access and egress* and *Fire* in this series for further information on access and egress requirements.

IMPORTANT QUESTIONS TO ASK

- Have I considered and appropriately addressed the Deemed-to-Satisfy Provisions that cover stairs, platform handrails, landings and swing doors under the NCC?
- Who is my local accredited building certifier and/or professional fire engineer with experience in the protected cropping industry?

REFERENCES AND FURTHER READING

Australian Building Codes Board (2016) National Construction Code 2016; Volume 1; Building Code of Australia; Class 2 to Class 9 Buildings, Commonwealth of Australia and States and Territories of Australia:

Part H3 Farm Building and Farm Sheds, pp. 377-380

Section D, Section D2.13, D2.14, D2.16, D2.17 and D2.24 Access and Egress, pp. 155-218

Fire

Access and egress

TOOLBOX

GREENHOUSE CONSTRUCTION AND SAFE OPERATION

Many greenhouses are relatively isolated from the nearest fire station and may lack adequate water supply to fight structural fires. As protected cropping structures become larger and evolve from low technology greenhouses to medium or high technology greenhouses the risk of faults in equipment and wiring and human error may also increase. Plant containers, packaging, glazing and shade cloth are readily-available combustible fuels found throughout a typical greenhouse. As a result of these compounding risk factors, fires can spread rapidly throughout the facility, causing severe economic losses, negative environmental impact and loss of human life.

Under the occupational health and safety (OH&S) and new work health and safety (WHS) legislation an employer is obliged to provide, among others:

- Safe premises
- Safe machinery and materials
- Safe systems of work
- Information, instructions, training and supervision
- A suitable working environment and facilities.

The above safety obligations must also be considered by greenhouse designers/manufacturers, consultants and certifying bodies (local government or private certifiers) during the design and approval process.

For more extensive information please refer directly to the relevant sections of your state Acts that are accessible online.

Fire hazards for access and egress should be considered in accordance with the National Construction Code (NCC). Under the current NCC Part H3, the following Deemed-to-Satisfy Provisions of Part apply.

Table 1: Deemed-to-Satisfy Provisions for fire

NCC SECTION	AREA	DEEMED-TO-SATISFY PROVISIONS FOR GREENHOUSES
H3.9	Fire hydrants and water supply	- A greenhouse with a total floor area greater than 500 m2 and located where a fire brigade is available to attend a building fire must be: - Provided with a fire hydrant system installed in accordance with AS 2419.1 - Located on the same allotment as an access point to a water supply - Water supply for a greenhouse must consist of one or any number of a water storage tank, dam, reservoir, river, lake, bore or a sea - If any part of the water supply is contained in a water storage tank it must be: - Located not less then 10 m from the building - Fitted with at least one small bore suction connection and one large bore suction connection.

KEY MESSAGES

- Greenhouses or grow structures can be classified under the sometimes onerous and inappropriate classification of Class 7 or Class 8 within the National Construction Code (NCC)
- It's important to understand the fire access and egress requirements of your greenhouse under the NCC
- There are several Deemed-to-Satisfy Provisions for greenhouses under the NCC that you need to be aware of, which cover fire hydrants and water supply, fire hose reels, and portable fire extinguishers

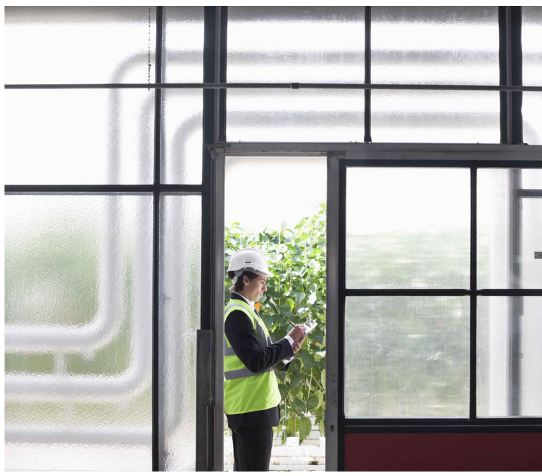

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Table 1 continued

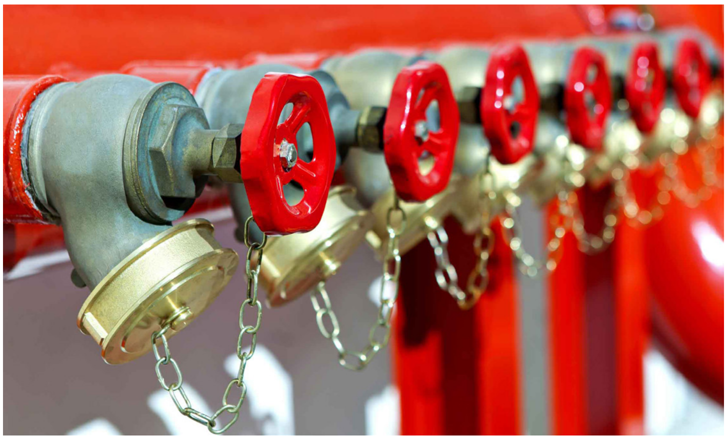
NCC SECTION	AREEA	DEEMED-TO-SATISFY PROVISIONS FOR GREENHOUSES
H3.10	Fire hose reels	A fire hose reel system need not be provided to serve a farm building where portable fire extinguishers are installed in accordance with the below provisions.
H3.11	Portable fire extinguishers	- A greenhouse not provided with a fire hose reel system in accordance with the NCC must be provided with: - one portable fire extinguisher rated at not less than 5ABE in each room containing flammable materials or electrical equipment - one portable fire extinguisher rated at not less than 4A60BE adjacent to every required exit door - location signs complying with clauses 3.3 to 3.9 of AS 2444 above each required portable fire extinguisher - A farm shed must be provided with not less than one portable fire extinguisher for every 500 m2 of floor area - A portable fire extinguisher must be: - Of ABE type - Not less than 4.5 kg in size - Installed in accordance with Section 3 of AS 2444.

Managing fire risk and associated consequences appropriately is becoming increasingly important to the financial viability of the greenhouse and grow structure industry in Australia. There are three major risk management tools that are commonly considered. These are:

- Risk control
- Risk sharing
- Risk communication.

Fire risk control may consist of risk assessment procedures, fire prevention, fire contingency plans and employee training. Insurance is considered a risk-sharing tool. Risk communication is usually between an employer and employees and is covered by a separate toolbox fact sheet Fire prevention and safety in this series.

Read the toolbox fact sheets Access and egress and Construction of exits in this series for further information.



IMPORTANT QUESTIONS TO ASK

- Do I understand my WHS obligations?
- Have I considered and appropriately addressed the Deemed-to-Satisfy Provisions that cover fire hydrants and water supply, fire hose reels and portable fire extinguishers under the NCC?
- Who is my local accredited building certifier and/or professional fire engineer with experience in the protected cropping industry?

REFERENCES AND FURTHER READING

Olivotto, M. (2014) Building codes and greenhouse construction, Osborn Lane Consulting Engineers, Warwick

Australian Building Codes Board (2016) National Construction Code 2016; Volume 1; Building Code of Australia; Class 2 to Class 9 Buildings, Commonwealth of Australia and States and Territories of Australia:

Part H3 Farm Building and Farm Sheds Section3.9, pp. 378

Part H3 Farm Building and Farm Sheds Section3.10, 3.11, pp. 379

Case study

Compliance with fire access and egress requirements in the Sydney Basin, NSW

A couple of growers in a cluster of medium technology and older polyhouse designed greenhouses decided to expand their area of production. This was so they could better supply the Sydney markets, which are just down the road. Unbeknown to them some of the conditions placed on the planning permit for fire compliance would prevent them achieving their business vision.

The group of growers had discussed the expansion opportunity for a while, but eventually decided to put their plans into action. They first met with the local Council, and the economic development officers were enthusiastic about the positive impact on the local economy.

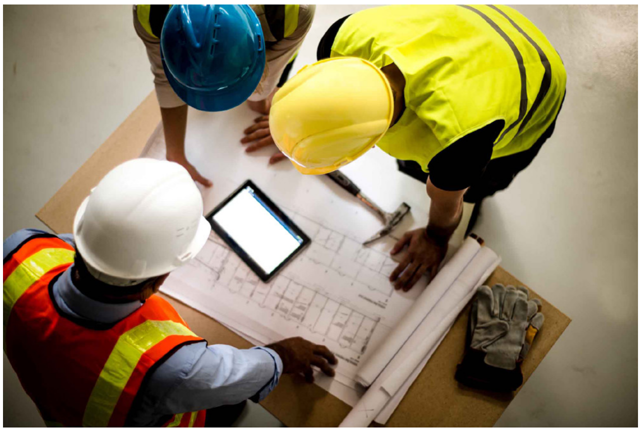
After their development application was submitted, there were a number of changes requested by the local Council planning department and Fire Authority. Firstly, this included a height restriction below 3.5 metres because of the close proximity to a residential area. But the growers claimed they needed the additional height and ventilation to create a stable and homogenous climate for plant growth.

“Creating the right environment for plant growth is what it’s all about, that’s our business. We need to do this using the best technology available, not the old stuff we already had” said one of the growers.

Secondly, there were numerous fire safety matters to address. This mainly related to fire pumps and hydrants, however the existing greenhouses didn’t have these installed to the density the new development required. With the assistance of a fire engineer, the growers outlined the planned irrigation system and fire loading of the new structures. The Fire Authority still had concerns with the risk profile due to the existing structures on the farms. The planning officer at the local Council hadn’t seen a development like this before, so was unsure how to weigh-up the different information.

“We just kept meeting these road blocks. The compliance delays were really difficult to deal with” mentioned another grower.

Understanding who the local Council planning contact and main referral authorities are in your area is an integral first step. Often the Fire Authority, in this case metropolitan, will want to understand the site layout, existing structures and risk profile to better inform their requirements for the new development. Making sure you access the right experts is also important.



Cladding and membrane light diffusion

Other issues and common grower concerns

TOOLBOX

GREENHOUSE CONSTRUCTION AND SAFE OPERATION

What is diffuse light

Growers can control the greenhouse climate including light levels, temperature and humidity. These variables can impact plant quality, yield and the efficiency of heating and cooling systems. Diffuse light through cladding and membranes plays an important role in increased and uniform productivity.

Light from the sun is composed of a diffuse and direct component. Diffuse light is light scattered by particles, which can be found in clouds or in whitewash, various types of glazing or shades. Diffuse light comes from all directions so shadows are only cast directly underneath objects, while direct light will cause high contrast between dark shadows and brightly illuminated surfaces.

What are the benefits

Most plants can benefit from diffuse light as they use it more efficiently. This is because diffuse light:

- Stimulates greater photosynthesis due to less shading by upper leaves and greater penetration into the canopy
- Promotes better growth due to more even distribution of light horizontally, with less hot and shady areas.

Research has shown that the benefits of diffuse light to the grower can include:

- Improved crop yield
- Higher leaf count
- Lower crop temperature
- Shorter crop time
- Improved quality
- Increased uniformity of plants and fruiting bodies.

These results have been demonstrated in commercial fruit and vegetable crops with a high plant canopy, as well as ornamentals with a small plant canopy. The benefits are greater during the summer.

For example, research in The Netherlands conducted by Hemming et al. (2007) found that cucumber yield and number increased by 4.3% and 7.8% respectively with a diffuse light cover compared to a clear cover protected environment. This was despite the fact that the diffuse cover reduced the total light transmission by 4%.

These benefits have the potential to be much larger in sunnier climates like Australia, compared to cloudier locations like The Netherlands. This is because it's important that the crop still receives the same amount of light, just scattered, rather than reducing absolute light transmission.

KEY MESSAGES

- Diffuse light is light scattered by particles, which can be found in clouds or in whitewash
- Most plants can benefit from diffuse light as they use it more efficiently
- The benefits of diffuse light can include improved crop yield and quality, as well as shorter crop time
- Diffuse light can be provided by installing cladding and membranes in your greenhouse

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TOOLBOX
GREENHOUSE CONSTRUCTION AND SAFE OPERATION

How to implement diffuse light on-farm

Diffuse light can be provided by installing cladding and membranes in your greenhouse. These can include curtains, glazing, whitewash, screens and more recently Svensson's white strips. Cladding and membranes can convert direct sunlight into diffuse light without decreasing light transmission to the crop.

However, there are some important considerations when introducing diffuse light. These include, but are not limited to:

- Fixed or semi-permanent cladding or membrane will generally be cheaper, easier to install and operate, but risk losing light transmission, therefore crop growth, when conditions are too dark. For semi-permanent covers like whitewash there is also a significant amount of uncertainty about when is the best time to apply during the season (e.g. spring)
- Moveable cladding or membrane are usually more expensive, more complex to install and operate, but have the benefit of customising the amount of diffuse and direct light in response to the conditions. This means you can maximise crop growth year-round.

The general 'rule of thumb' is only apply diffuse light to the crop when needed. This will usually be during the warmer months when direct light could slow growth or damage the crop.

Directions for further research

While the concept of diffuse light is well understood, there are still many areas for further research to better understand it's impact on commercial crop growth in a protected cropping environment. This includes:

- Effect of diffuse light on crops during different seasons
- Methods for measuring leaf photosynthesis
- Orientation and spacing of crop rows to maximise light reflection
- Crop architecture and the influence on light distribution and absorption
- Correlation between pre-harvest growth conditions and fruit and vegetable quality.

IMPORTANT QUESTIONS TO ASK

- What are the best diffuse light options for my greenhouse? For example, fixed or moveable solutions.
- What have I learnt from implementing diffuse light in the past, or from other growers?
- How do diffuse lighting structures interact with my energy saving measures for heating and cooling?

REFERENCES AND FURTHER READING

Parbst K. (2013) Diffuse Lighting Offers Multiple Benefits, Greenhouse Growers, http://www.greenhousegrower.com/technology/equipment/diffuse-lighting-offers-multiple-benefits/

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Cockshull K. E., Graves C. J., Cave R. J. (1991) The influence of shading on yield of glasshouse tomatoes, Journal of Horticultural Science Vol 67, Iss 1

Li, T. & Yang, Q. (2015) Advantages of diffuse light for horticultural production and perspectives for further research, Frontiers in Plant Science, Vol. 6, Art. 704, http://journal.frontiersin.org/article/10.3389/fpls.2015.00704/full

General disaster control

Other issues and common grower concerns

TOOLBOX

GREENHOUSE CONSTRUCTION AND SAFE OPERATION

Extreme weather events and disasters can strike greenhouse growers unexpectedly, often with serious and costly consequences. However, there are several things you can do to reduce, mitigate and control these consequences.

The main potential disasters facing greenhouse growers in Australia include catastrophic fire, high winds, storms and hail. The most effective way to manage risk relating to these potential disasters is the emergency management spectrum, which includes prevent, prepare, respond and recover (PPRR).

There are a range of management actions that may help to reduce risk and lessen the impact of fire, wind, storms and hail on your greenhouse operation. The below table is a practical guide using the emergency management spectrum to assist your decision-making.

Table 1: Emergency management spectrum for greenhouse fire, wind and storms

LEVEL	FIRE	WIND, STORMS AND HAIL
Prevent Aim: reduce risk occurring	- Ensure greenhouse is constructed to National Construction Code (NCC) standards - Ensure wiring is compliant with electrical standards - Install sprinklers, fire hydrants and hoses as per regulation - Build a separate ventilated area, preferably outside of your facility, to store flammable liquids - Use non-combustible building materials for walkways and other appropriate areas - Place heating systems, electrical equipment, and other combustion-type equipment a safe distance away from flammable materials, such as covers, shade cloths and chemicals - Reduce high temperatures from poor electrical wiring, overloaded circuits, soldering or welding work, heating systems - Reduce the amount of oxygen in your greenhouse, for example turning off fans	- Research the typical wind patterns on your property - Ensure greenhouse is constructed to NCC standards - Ensure you've considered withdrawal resistance, building orientation, and exposure to prevailing wind directions and weather patterns - Use windbreaks to reduce the wind speed or deflect wind over the greenhouse - If you have a metal chimney, stove pipe, or any exterior ventilation susceptible to high winds, secure them in an appropriate manner

KEY MESSAGES

- Extreme weather events and disasters can strike greenhouse growers unexpectedly
- There are a range of management actions to reduce risk and lessen the impact of fire, wind and storms on your greenhouse operation
- Developing and enacting an emergency management and response plan is critical

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Table 1 continued

LEVEL	FIRE	WIND, STORMS AND HAIL
Prepare Aim: prevent impact of risk once arisen	- Develop an emergency management plan - Ensure you have the appropriate level of insurance cover - Regularly inspect and control fire hazards	- Develop an emergency management plan - Ensure you have the appropriate level of insurance cover - Close all the openings, including vents, louvers, and the doors before a high wind event or storm. Whatever outside force is applied to the high tunnel is potentially doubled when allowed inside the structure - For air-inflated greenhouses, increase the pressure on the inside to reduce rippling effect of the poly in a high wind or storm event. Double down and make sure any slits or openings are taped with film repair tape - Minimise the number of people in and around greenhouses during high winds and storm events
Respond Aim: control risk once eventuated	- Enact your emergency response plan (e.g. how and when to use a fire extinguisher, emergency contact numbers to call, and where to exit the facility) - Ensure employees are aware of what to do if a fire breaks out to minimise spread and reduce significant damage	- Enact your emergency response plan (e.g. high wind lock-down procedures, emergency contact numbers to call)
Recover Aim: return to normal production as soon as possible	- Make sure it's safe for your employees to return to work on those areas of the farm unaffected by the fire, their safety is your priority - Contact your insurance agency immediately to expedite the necessary claims and inspections	- Make sure it's safe for your employees to return to work on those areas of the farm unaffected by wind damage or the storm event - Contact your insurance agency immediately to expedite the necessary claims and inspections - Invest in a wind speed measuring station and locate it near the greenhouse structures. This will assist in justifying wind speeds and may speed-up potential insurance claims
Other relevant toolbox fact sheets in this series	- Fire prevention and safety - Fire (access and egress)	- Wind loads

IMPORTANT QUESTIONS TO ASK

- Have I developed an emergency management and response plan?
- Are my employees trained to implement the emergency management and response plan as part of their induction?
- When was the last time my emergency management and response plan was updated? Is it still relevant to my business?

REFERENCES AND FURTHER READING

Sparks B. (2016) Protect Your Greenhouse from The Worst Disasters, Greenhouse Growers, http://www.greenhousegrower.com/technology/protect-your-greenhouse-from-the-worst-disasters/

Appendix D: Hort Innovations VG13055 Report (Previous Project)

Building codes and greenhouse construction

Marcel Olivotto
Osborn Lane Consulting Engineers

Project Number: VG13055

VG13055

This report is published by Horticulture Australia Ltd to pass on information concerning horticultural research and development undertaken for the vegetables industry.

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Code of Practice

Building Codes and Greenhouse Construction

VG13055 (August 2014)

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Eric Peter Osborn (Project Administrator)

Research Provider: **Osborn Lane Consulting Engineers**

Funding Provider: **Horticulture Australia Limited**

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HAL Project Number: VG13055

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- Consultation by Milton Stennet from Acacia Building Approvals – Building Certifier;
- Growers that allowed staff to complete a site investigation of their farm; and,
- Grower that completed and returned HAL Project Questionnaire.

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Media Summary:

Building Codes and Greenhouse Construction is a project that has been funded by Horticulture Australia Limited and the Australian Government in response to cost of local council compliance concerns raised by growers. This Code of Practice document provides the protected cropping industry in Australia with guidelines to reduce the cost of compliance for greenhouse or grow structure by providing local council with guidelines that encourage a consistent building approval approach across Australia.

The Code of Practice is separated into four (4) sections; these sections cover the four major areas where cost of compliance can be better controlled to achieve a smoother, more cost effective, development/building approval for growers. Sections are:

- Classification of Greenhouse/Grow Structures (G/GS)
    - Current National Construction Code (NCC) building classifications of G/GS;
    - Uniform classification through the International Building Code (IBC); and
    - Egress, height and area requirements specific for G/GS.
- Fire and Egress Directives
    - Determining fire and egress hazards within a G/GS;
    - Quantify risks through the use of a Risk-Point Matrix; and
    - Determining fire and egress consequences for the aforementioned risk.
- Structural Adequacy
    - Identifying alternative design resources to effectively design G/GS buildings.
- Farm Management
    - Documents practical farm management recommendations and procedure that decrease the risk and associated consequence of a fire within and around a G/GS structure;

It is recommended that future R&D work includes expert and industry review which will lead to recommendations to be included in the National Construction Code.

Technical Summary:

Building Codes and Greenhouse Construction provides solutions for several identified issues under the premise of ‘reducing cost of compliance’. This document provides research and recommendations for both growers and certifiers to effectively and efficiently reduce cost of compliance on greenhouse and grow structures. The nature of each issue is as follows:

Classification of Greenhouse/Grow Structures: Australia does not have a unified building classification of agricultural buildings (greenhouses/grow structures) within the National Construction Code (NCC). G/GS can be classified under the sometimes onerous and inappropriate classification of Class 7 or Class 8 within the NCC. These classifications impose requirements not suitable for the occupancy and use type of the G/GS building. This project included exhaustive literary reviews of national and international standards to determine how best to unify the classification of G/GS in Australia.

It was determined that the most practical way of defining and unifying the classification of G/GS buildings was to utilise an international standard that already documents requirements specific for G/GS. The International Building Code identifies G/GS within a Group U classification and provides tailored requirements for agricultural buildings, such as G/GS. Consultation with certifiers and fire engineers determined that the utilisation of the IBC was currently the most ideal classification process for Australia.

Fire and Egress: Identification and quantification of fire risk and its associated fire consequence is an important tool for both growers and certifiers. The use of a risk-point matrix assessment (see Section 3.3) outlines risk levels for each typical aspect of a G/GS design. Consultation with a Professional Fire Engineer underpinned steps and risk-point weighting within the assessment. Once a grower or certifier completes the risk-point matrix it is appropriate to associate the quantified risk with a fire consequence level of low, medium or high. Tailored recommendations have been given for each fire consequence level.

Structural Adequacy: Many G/GS do not have geometries or porosities that are documented within AS/NZS 1170.2 Wind Loading. As such, it is common for an inexperienced engineer/designer to drastically over-design or under-design a G/GS. This Code of Practice has identified international resources, such as EN 13031-1 Greenhouses – Design and Construction that provide designers with a greater design wind loading resource.

Farm Management: Farm management documented in this Code of Practice provides growers with a resource that documents preventative management processes to efficiently reduce the risk of a fire and to minimise the associated consequences. These processes have been obtained through literary review and consultation with growers, certifiers and fire engineers.

Consultation with growers, building certifiers, greenhouse manufacturers and fire engineers underpin recommendations made within this Code of Practice. Research and information to support the Code of Practice is also provided as a Support Document. This Support Document outlines research completed, expert consultation, field investigations and grower questionnaire responses.

It is recommended that future R&D work includes expert and industry review which will lead to recommendations to be included in the National Construction Code.

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Glossary of Abbreviations

AS	**Australian Standards**
ASTM	**American Society of Testing and Materials**
BA	**Building Approval**
BCA	**Building Code of Australia**
CPM	**Compartmentalised Plastic Membrane**
DA	**Development Application**
FPM	**Film Plastic Membrane**
FRP	**Fibre Reinforced Plastic**
G/GS	**Greenhouse and Grow Structures**
HAL	**Horticulture Australia Limited**
IBC	**International Building Code**
ICC	**International Code Council**
NCC	**National Construction Code**
OLCE	**Osborn Lane Consulting Engineers**
PM	**Plastic Membrane**
SPM	**Sheet Plastic Membrane**

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1.0 Introduction

1.1 Scope and Application

The objective of this document is to reduce the cost of compliance for construction of Greenhouse and Grow Structures (G/GS) and provide guidelines for a consistent building approval approach across Australia. Completing investigations within the following areas determine where cost reduction measures can be implemented to economically assist the protective cropping industry and provide a defined approval process:

- Literary review of national and international codes;
- Investigation into fire and egress regulations and their application to G/GS;
- The potential to include classification of G/GS within the National Construction Code (NCC); and
- Possible uses of innovative construction materials and methods.

Reference should be made to the accompanying 'Guidelines and Supporting Documentation' document while completing an assessment on new G/GS developments. This document provides supporting evidence based on recommendations and literary reviews of relevant international documents; the document also provides case studies of growers' concerns regarding issues with G/GS development.

Cost of compliance reduction measures included in this Code of Practice provide both certifiers and growers with information and procedures regarding the classification of G/GS buildings that do not rely solely on the NCC for building classification. Risk assessment matrices, also provided in this document, identify fire and egress risk associated with each G/GS development and outlines possible action upon the determined risk to reduce the consequence of a fire.

This document also provides growers with useful farm management protocol that reduces the risk of fire and the subsequent spreading and severity of the fire.

This document is not exhaustive and does not provide special considerations for every greenhouse or grow structure combination. Each greenhouse and grow structure's design and operation is unique and therefore requires an individualised approach to development approvals.

Important Note: Consultation with a Professional Fire Engineer should be undertaken if and when questions or issues arise that are not covered within this document, the National Construction Code, Australian Standards or, where appropriately used, the International Building Code.

1.2 General Background

A protective cropping structure is a structural building usually constructed from timber or steel with glass or plastic used as a covering material; coverings can be permeable or impermeable. They are used mainly for horticultural applications to control specific environmental conditions to facilitate high quality, high quantity production of a defined fruit, vegetable or flower.

Identification of a greenhouse is generally according to its basic profile shape; most commonly these profiles are flat, arch, raised dome, sawtooth, gable, skillion and tunnel. Being a technology-based investment, the higher the level of technology used, the greater the potential for achieving tighter and more accurate controlled growing conditions. Technology levels in G/GS can be categorised as ‘Low’, ‘Medium’ and ‘High’.

Low technology G/GS – these structures are very common in Australia. The greenhouses are usually less than 3 metres in height and have a tunnel or ‘igloo’ profile shape. The structures are popular because they are relatively inexpensive and easy to erect. Large span, cable-supported net structures covering large areas usually up to 6.0 m high also can be included in this category.

Medium technology G/GS – characterised by vertical walls (between 2 and 4 metres) and commonly have roof or side ventilation, or both. Medium technology greenhouses are seen as a compromise between the low and high technology or cost relative to increased environmental control (compared to low technology greenhouses).

High technology G/GS – achieve the highest level of environmental control and automation to offer potential for a higher quality and quantity of produce. These structures are usually constructed with walls at least 4 metres high with the roof peak being up to 8 metres.

In Australia, protected cropping structures such as G/GS do not currently have an individual construction code and therefore relies on general design and construction practices specified in the Australian Standards (AS) and the National Construction Code (NCC). A key concern for the protected cropping sector is that the current building codes applied to greenhouse construction are not relevant to today’s operations; this project was originally put forward as a suggestion by a levy- paying grower due to this fact.

As mentioned previously G/GS do not have their own code or exemptions; they are usually (at the discretion of a private certifier or local council) required to conform to a code that applies to commercial/storage structures. Achieving compliance for the G/GS buildings can become a large economic burden when adhering to, for example, current NCC Class 8 egress and fire regulatory requirements.

1.3 Document Utilisation

This Code of Practice document sets out practical guidelines for the design, approval and management of G/GS buildings. The Code of Practice presents design data, approval guidelines, and building management information that are a useful resource for both certifiers and growers. The document is divided into four (4) parts:

- Classification of Greenhouse/Grow Structures;
- Fire and Egress Directives;
- Structural Adequacy; and
- Farm Management and General Practices.

The information and procedures provided within this document are based on literary review of national and international codes and guidelines, along with consultation with fire engineers, building certifiers and interested manufacturers and growers. These recommendations will help obtain the maximum project economic success while providing suitable guidelines for a safe working environment.

The Code of Practice consists of four (4) technical sections, these sections can be read separately or in the order shown in the below figure (see Figure 1). The document has been developed to be utilized by both certifiers and growers, it is therefore expected that certifiers and growers will find particular value in specific sections of the Code of Practice. A brief description of each section has been provided below.

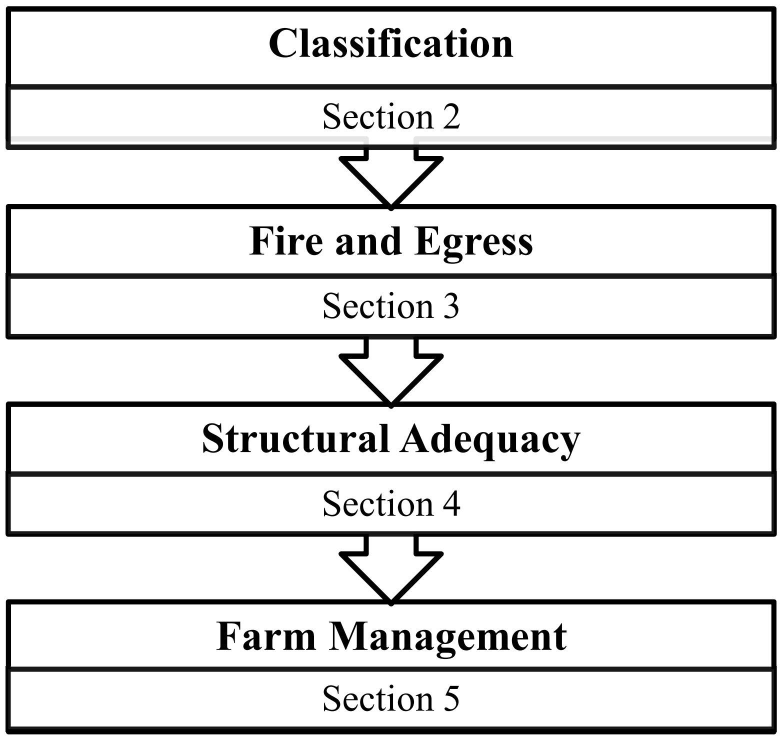


Figure 1 Document Structure

Classification – Section 2

Section 2 'Certification of Greenhouse/Grow Structures' provides guidance when determining classification of G/GS and provides alternative international resources to the National Construction Code (NCC) if the G/GS classification is found not to be covered by the NCC.

Fire and Egress – Section 3

Section 3 'Fire and Egress Directives' provides guidance in minimising fire risk and controlling associated fire consequences. A fire and egress risk-point matrix assessment tool has also been provided in this section to determine risk and then documents general measures that control/minimise the consequences.

Structural Adequacy – Section 4

Section 4 'Structural Adequacy' provides guidance if a structure is not covered by the AS/NZS 1170 Design Loading Actions set and also offers recommendations to resolve common issues such as structural geometries not supported within AS/NZS 1170.2 Wind Actions.

Farm Management – Section 5

Section 5 'Farm Management and General Practices' provide guidance for a grower to passively reduce the risk and consequences of a fire by investing in good farm practices.

General document utilisation notes:

1. *This Code of Practice document should be utilized and referenced by certifiers during the initial stages of development and throughout the approval stages of a proposed G/GS development. The document provides a detailed procedure for the determination of G/GS building classifications and fire risk management procedure.*
2. *This Code of Practice document should be read in conjunction with VG13055: Building Codes and Greenhouse Construction – Supporting Documentation.*
3. *The provisions documented in the following technical sections are consistent with good practices, but they are not mandatory requirements, now or in the future. This Code of Practice is not a building code; a certifier must still refer to relevant National/International Codes and Standards, and local or state authorities for regulations governing structural adequacy, human health, or fire safety.*
4. *It is important that both the certifier and grower keep an open dialogue during the application process, discussing potential issues and resolutions.*

1.4 Terms and Definitions

For the purposes of this Code of Practice, the following terms and definitions apply.

Area:
<any part of a roof> area normal to the slope.

Area:
<storey of a building> total area bounded by the inner finished surfaces of the enclosed wall or, on any side where there is no enclosing wall, by the outermost edge of the floor on that side.

Boundary:
border between land under the same occupation as the building and land under a different occupation.

Certifier:
Private and Local Government certifiers, building surveyors, development application staff, town planners and building assessors shall henceforth be referred to as certifier/s.

Compartment wall:
wall constructed between compartments to achieve a stated period of fire resistance and which is imperforate, except for openings fitted with self-closing doors or shutters having the same period of fire resistance as the wall.

Element of structure:
any loadbearing element of a structure.

Fire hazard:
physical situation with a potential for harm to persons, or damage to property, or both, from the effects of fire.

Fire risk:
probability that a damaging fire will occur as a result of the existence of a fire hazard.

Fire consequence:
the effect, result, or outcome of a fire. Consequence relates to damage to or loss of life and/ or property.

Greenhouse:
Greenhouses or grow structures refers to intensive horticultural structures growing vegetables and excludes nurseries, conservatories and flower production.

Grower:
Growers, G/GS owners, G/GS developers and farm operators shall henceforth be referred to as grower/s.

Height:
<of a building, for the purposes of fire considerations> vertical height from ground level to half the height of the roof in a pitched roof building, or to the top of the roof or parapet (whichever is the higher) in a flat roof building.

Protected area:
part of the external wall constructed to achieve the required period of fire resistance.

2.0 Classification of Greenhouse/Grow Structures

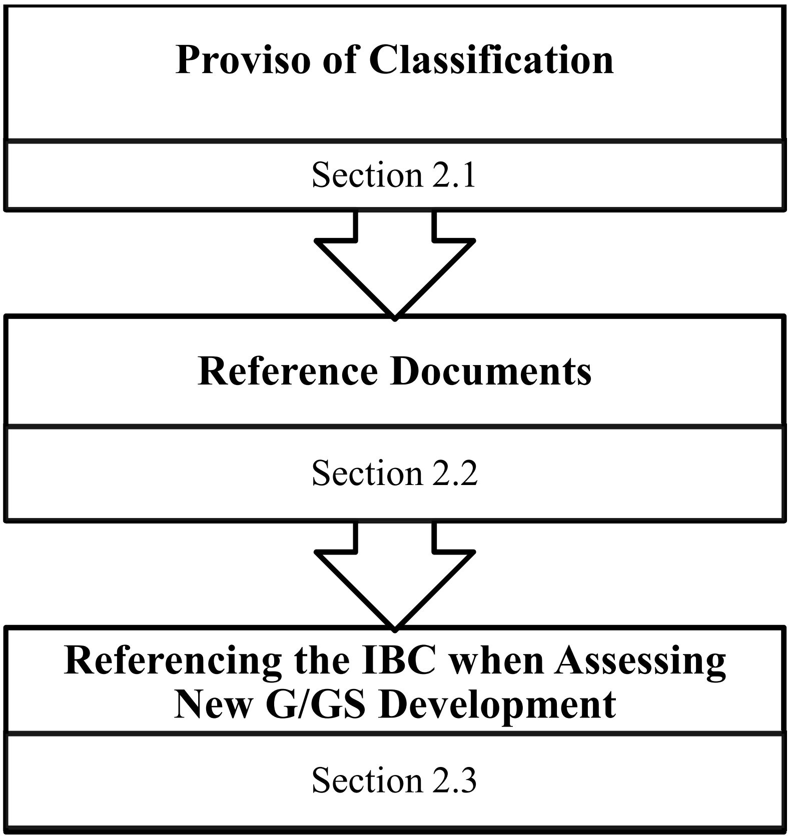


Figure 2 Section 2 Structure

Proviso of Classification – Section 2.1

Section 2.1 'Proviso of Classification' documents statements that must be compliant in order to utilise the recommendations specified within the section.

Reference Documents – Section 2.2

Section 2.2 'Reference Documents' provides a list of national and international documents that have been utilised during the documentation of the recommendations outlined in this section.

Referencing the IBC when Assessing New G/GS Development – Section 2.3

Section 2.3 'Referencing the IBC when Assessing New G/GS Development' outlines alternative provisions in the event that the NCC does not provide relevant requirements and specifications for proposed G/GS' being assessed for a building approval.

2.1 Proviso of Classification

This section of the Code of Practice applies to Greenhouses and Grow Structures that are commonly classified as Class 7, 8 or 10 in accordance with Part A3 of the National Construction Code Volume One, subject to the below:

1. Subject to paragraph 3, a structure which is used as a greenhouse, grow structure or crop protection structure.
2. A building used, subject to paragraph 3, for agriculture provided in each case that –
    a. No part of the building is used as a dwelling.
    b. No point of the building is less than two times its height from any point of a building that contains sleeping accommodations.
    c. No more than 30 occupants.
    d. No part of the G/GS has more than one storey.
3. The descriptions of a building in paragraphs 1 and 2 do not include a G/GS or building used for agriculture if the principal purpose of which they are used is retailing, packing or exhibiting of produce.
4. In paragraph 2, "agriculture" includes horticulture, fruit growing, growing of vegetables and seedlings through hydroponic or traditional means.

If the above paragraphs are compliant with the proposed G/GS development, it is this Code of Practice's recommendation that the International Building Code be partially adopted to determine building or performance requirements placed upon this development. The reason for this recommended adoption is the lack of information provided within the Australian NCC regarding G/GS and specific requirements for agricultural type buildings.

2.2 Reference Documents

National Construction Code of Australia (NCC, BCA), Volume One & Volume Two

International Building Code (IBC), International Code Council INC.
(See Section 2.3.1.2 for more information on the IBC and ICC)

International Fire Code (IFC), International Code Council INC.

AS 2444	Portable fire extinguishers and fire blankets – Selection and location
AS 1288	Glass in Buildings
AS 2047	Windows in Buildings
AS/NZS 1170	Structural Design Actions
AS 4100	Steel Structures
AS 1720	Timber Structures
AS 3600	Concrete Structures
AS 1664	Aluminium Structures
EN 13031-1	Greenhouses –Design and Construction
BS 5502-23	Buildings and structures for agriculture – Part 23: Fire Precautions

National Code of Practice for the Storage and Handling of Workplace Dangerous Goods (NOHSC: 2017)
Relevant existing State and Local Government documentation

2.3 Referencing the IBC when Assessing New G/GS Development

2.3.1 Adoption of the IBC

Section 2.1 has provided the user with 4 paragraphs that must be found compliant before proceeding through Section 2.3. If any of the paragraphs were found to be non-compliant, it is this Code of Practice's recommendation that all classification remains with the NCC or consultation with a Professional Fire Engineer be sought.

Utilising alternative solutions, such as the IBC, is accepted by the NCC on the condition that the alternative solutions comply with the provisions documented within the NCC (see Section 2.3.1.1).

2.3.1.1 Provisions in the NCC to use Alternative Solutions

The NCC of Australia provides provisions for alternative solutions at the compliance level of a proposed buildings assessment. The NCC stipulates in A0.8 BCA Vol. 1 & 1.0.8 BCA Vol. 2 that –

- An Alternative Solution must be assessed according to one or more of the Assessment Methods (A0.9 BCA Vol. 1 & 1.0.9 BCA Vol. 2).
- An Alternative Solution will only comply with the NCC if the Assessment Methods used to determine compliance with the Performance Requirements have been satisfied.
- The Performance Requirements relevant to an Alternative Solution must be determined in accordance with (A0.10 BCA Vol. 1 & 1.0.10 BCA Vol. 2).

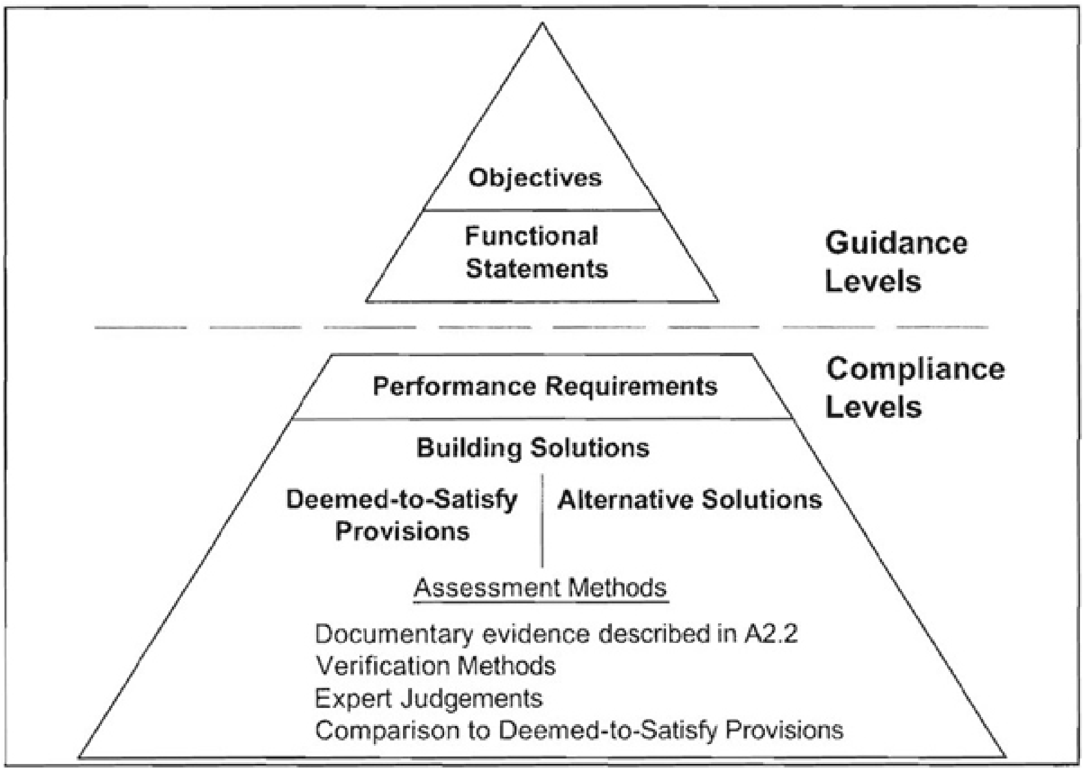


Figure 3 Vol. 1 BCA Structure (Source: NCC BCA Vol. 1)

Where Assessment Methods (A0.9 BCA Vol. 1 & 1.0.9 BCA Vol. 2) specifies the following –

The following Assessment Methods, or any combination of them, can be used to determine if a Building Solution complies with the Performance Requirements:

- Evidence to support that the use of a material, form of construction or design meets a Performance Requirement or Deem-to-Satisfy Provision as described in 1.2.2 (BCA Vol. 2) and A2.2 (BCA Vol. 1).
- Verification Methods such as –
    - The Verification Methods in the BCA; or
    - Such other Verification Methods as the appropriate authority accepts for determining compliance with the Performance Requirements.
- Comparison with Deemed-to-Satisfy Provisions.
- Expert Judgement.

Vol. 1 and Vol. 2 of the BCA documents Relevant Performance Requirements. The following method must be used to determine the Performance Requirement/s relevant to an Alternative Solution:

- Identify the relevant Deem-to-Satisfy Provision of each Section or Part that is to be subject of the Alternative Solution.
- Identify the Performance Requirements from the same Sections or Parts that are relevant to the identified Deemed-to-Satisfy Provisions.
- Identify Performance Requirements from other Sections and Parts that are relevant to any aspects of the Alternative Solution proposed or that are affected by the application of the Deemed-to-Satisfy Provisions, which are the subject of the Alternative Solution.

If the NCC and its associated BCA Volumes are found to be inadequate, costly or impractical to enforce when completing an assessment for a proposed G/GS development there are two alternatives. These are –

- Such other Verification Methods as the appropriate authority accepts for determining compliance with the Performance Requirements - Use of the International Building Code.
- Expert Judgement – Example: The engagement of a Professional Fire Engineer.

2.3.1.2 IBC Verification Method

The IBC is developed, written and published by the International Code Council (ICC). The ICC consists of professional individuals and bodies that are expert code and building officials, engineers, builders, designers, architects and firefighters.

Important Note: The IBC is revised or updated every three (3) years (2009, 2012, 2015…) to allow for new materials, technologies, products and correct technical information; it is the responsibility of the certifier to ensure the most recent version of the IBC is utilised while assessing a G/GS application.

The intent for this code is as per IBC Section 101.3, which states –

"The purpose of this code is to establish minimum requirements to safeguard the public safety, health and general welfare through affordability, structural strength, means of egress facilities, stability, sanitation, light and ventilation, energy conservation and safety to life and property from fire and other hazards attributed to the built environment and to provide safety to fire fighters and emergency responders during emergency operations."

The International Building Code (IBC) is available for adoption and use by jurisdictions internationally. Its use within a governmental jurisdiction is intended to be accomplished through adoption by reference in accordance with proceedings establishing the jurisdiction's laws.

2.3.2 Generalised Procedure for Classification under the IBC

The NCC, in its current state, does not provide adequate reference for agricultural buildings, specifically classification and determination of regulatory necessities for G/GS and other agricultural buildings. The IBC, however, provides a more relevant set of requirements for the construction of agricultural buildings. Rather than strictly following the specific 'Class' building provision, each building type is reflective of their specific usage and limited occupant load. The provisions of the Appendix C of the IBC allow reasonable heights, areas and egress requirements that are proportionate to the risk associated with agricultural buildings.

The below procedure for classification of G/GS under the IBC provides generalised instruction on the combined use of the NCC and IBC to achieve appropriate protection of life and economic viability for new G/GS developments.

Step	Clause	Procedure
1	2.3.2.1	Determine if reference to the IBC required and or recommended (see Table 2.1 and Table 2.2)
2	2.3.2.2	Determine Building Class/Group of the G/GS
3	2.3.2.3	Determine Type of Construction (see Table 2.3)
4	2.3.2.4	Confirm appropriateness of IBC use
5	2.3.2.5	What to reference in the IBC (see Table 2.5)
6	2.3.2.6	Use of the NCC and Australian Standards

2.3.2.1 STEP 1 - Is Reference to the IBC Required/Recommended?

While processing a new G/GS development a certifier should ask him/herself a series of questions which will assist in determining if reference to the IBC would benefit the assessment process and final development result for the grower. Examples of these questions are given below in Table 2.1.

Table 2.1
Self-Assessable Questions

Can the G/GS be unequivocally categorised within a NCC Classification (as per Part A3 of the NCC)? *Paying close attention to the interpretation of Class 8, refer to Note 1 below for further guidance.*	**YES / NO**
Does the NCC provide adequate information on reasonable egress requirements? *(Note 2 for definition of "reasonable").*	**YES / NO**
Does the NCC provide adequate information on reasonable fire prevention measures? *(Note 2 for definition of "reasonable").*	**YES / NO**
Does the NCC provide adequate information on reasonable building separation distances for new G/GS buildings? Does the NCC differentiate between the distance to a residential building and other agricultural buildings, for example?	**YES / NO**
Generally, does the NCC provide reasonable building regulation for the assessable G/GS?	**YES / NO**

Notes:

1. *Under current Part A3 of the NCC, a Class 8 building is one that is utilised as a laboratory, or a building in which a handicraft or process for the production, assembling, altering, repairing, finishing, or cleaning of goods or produce is carried on for trade, sale or gain. If a G/GS is not also utilised as a vegetable packing and or cleaning area the certifier should strongly consider not classifying the G/GS as a Class 8 building.*
2. *Define: Reasonable. In the case of 'reasonable', mentioned in Table 2.1, the definition is a common sense approach to the G/GS; are the imposed requirements unnecessary/impractical for the specific type of building? An example: illuminated exit signs are required to be installed in a glass-constructed greenhouse that is occupied only through daylight hours.*

It is the certifier's prerogative and responsibility to determine which of the below options (see Table 2.2) best serve the assessment of a new G/GS, and in turn serve the safety of occupants and economic viability of the grower.

If **'Yes'** was identified in all of the questions outlined in Table 2.1, it is this Code of Practice's recommendation that Option 1 (see Table 2.2) be considered.

If **'No'** was identified in any of the questions outlined in Table 2.1, it is this Code of Practice's recommendation that Option 2 (see Table 2.2) be considered.

Table 2.2
Reference to Resources

Option 1 *(Table 2.1 All 'Yes')*	Sole use of the NCC and Australian Standards when assessing a new G/GS development against regulatory requirements. Assessment should be completed in a typical manner, using the NCC and relevant Australian Standards – Termination of 2.3.2 here.
Option 2 *(Table 2.1 'Yes' & 'No')*	Combined use of the NCC, Australian Standards and the IBC when assessing a new G/GS development against regulatory requirements. Continue 2.3.2 procedure (see 2.3.2.2 STEP 2).

2.3.2.2 STEP 2 - Determine Building Class/Group of the G/GS

2.3.2.1 STEP 1 has found that it is pertinent to use the IBC when assessing a new G/GS development. It is now important to determine the building use and occupancy classification as per IBC Chapter 3. Buildings and structures, or part thereof, shall be classified with respect to occupancy in one or more of the groups listed below.

- **Group A – Assembly Buildings**
  - Civic, social or religious functions, recreation, food or drink consumption or awaiting transportation.
- **Group B – Business**
  - Offices, professional services-type transactions, including storage of records and accounts.
- **Group E – Education**
  - Occupied by six or more persons at anyone time for educational purposes through the 12th grade. Religious educational rooms and religious auditoriums.
- **Group F – Factory and Industrial**

    - Assembling, disassembling, fabricating, finishing, manufacturing, packaging, repairing or procession operations.
- **Group H – High Hazards**
    - Manufacturing, processing, generation or storage of materials that constitute a physical or health hazard in quantities in excess of those allowed in control areas.
- **Group I – Institutional**
    - Buildings where people are cared for or live in a supervised environment.
- **Group M – Mercantile**
    - Building for the display or sale of merchandise and involves stocks of goods, wares or merchandise incidental to such purposes.
- **Group R – Residential**
    - Use of a building for sleeping purposes when not classified as another group.
- **Group S – Storage**
    - A building, or part thereof, for storage that is not classified as hazardous.
- **Group U – Utility**
    - Agricultural buildings, barns, **greenhouses**, livestock shelters, sheds and stables.

Refer to Chapter 3 of the IBC for detailed occupancy and utilization for each group.

Group U (Utility and Miscellaneous) buildings and structures of an accessory character and miscellaneous structures not classified in any specific occupancy shall be constructed, equipped and maintained to conform to requirements of this code commensurate with the fire and live hazard incidental to their occupancy.

2.3.2.3 STEP 3 – Determine Type of Construction

The provisions in Chapter 6 of the IBC shall control the classification of buildings as to the type of construction. Buildings and structures erected or to be erected shall be classified in one of the five construction types defined in Section 602.2 through 602.5 of the IBC or shown below. Type of construction is directly associated with the fire-resistance rating of each structural element, wall or partition.

While determining the type of construction, it is important to bear in mind that a structure is only as fire-resistant and/ or strong as its weakest or most susceptible element; it is therefore important to select the appropriate type of construction upon the most susceptible element within the structure.

There are five (5) types of construction classifications defined in Chapter 6 of the IBC, which are –

Table 2.3
Type of Construction as per the IBC

Type	Description
Type I & II	Building elements are non-combustible materials
Type III	Exterior walls are of non-combustible materials and the interior building elements are of any material permitted by the code.
Type IV	Heavy Timber – Exterior walls are of non-combustible materials and the interior building elements are of solid or laminated wood without concealed spaces.
Type V	Frame Construction: Structural elements, exterior and interior walls are of any materials permitted by the code.

Each type of construction is then classified further into A and B construction types.

- **A is protected**, meaning that all structural members of a building or structure have an additional fire-rated coating or cover by means of fire protective board, spray-on or other approved method. The additional fire-rated coating or cover extends the fire resistance of the structural member by at least 1 hour. See Table 601 in the IBC for fire-resistance rating requirements for building elements.
- **B is unprotected**, meaning that all structural members of a building or structure have no additional fire resistant properties other than their natural ability, characteristics and fire rating.

Once a Type of Construction has been stipulated for the structure it is appropriate to proceed to 2.3.2.4 STEP 4.

EXAMPLE: CLASSIFICATIONS

The following Type of Construction classifications are typical for the below common G/GS structure types (see Table 2.4). These classification examples should only be used as a guide; an accurate classification must be provided for each individual proposed G/GS development. Reference must be made to Chapter 6 of the IBC to determine appropriate classifications.

Table 2.4
Example Type of Constructions

Type	*Type of Construction*
Impermeable Plastic Membrane with Steel Support Framework (elements not protected)	*Type V B*
Permeable Plastic Membrane with Steel Support Framework (elements not protected)	*Type V B*
Fire Resistant Plastic Membrane with Steel Support Framework (elements not protected)	*Type III B*
Glass Greenhouse with Steel Support Framework (elements not protected)	*Type III B*

2.3.2.4 STEP 4 – Confirm appropriateness of IBC use

STEP 1, STEP 2 and STEP 3 have identified that the G/GS development can be partially assessed under the current IBC (see 2.3.2.1); a Building Class/Group has been selected (see 2.3.2.2) as has a Type of Construction (see 2.3.2.3), confirmation that it is appropriate to partially reference the IBC can be completed by checking compliancy of the following statements. These are –

1. The G/GS is compliant with the conditions in Part 2.1 paragraph 1 through to 4.
2. The building shall be used exclusively as a G/GS building and shall not be designed, equipped or intended for processing, cleaning or packing of produce.
3. The structure is detached, single storey building with a maximum height specified in Table C102.1 of the IBC (refer to Section 1.4 for definition of height).
4. The structure shall maintain a fire separation distance of 3000 mm measured from the building face to all of the following:
    a. The closest interior lot line,
    b. To the centreline of a street, alley or public way,
    c. To an imaginary line between two buildings on the property.
5. The means of egress for a G/GS building shall comply with the applicable provisions of Chapter 10 of the IBC, based on an occupant loading factor of 1 person per 30 m^2 of the gross floor area. Both statements below must be adhered:

  a. The maximum travel distance from any point in the building to an approved exit shall not exceed 91,440 mm.
  b. One exit is required for each 1390 m^2 of area or a fraction thereof.
6. The floor area of a G/GS building shall not be limited (see Table C102.1 IBC) if the building is surrounded and adjoined by public ways or open space no less than 18,288 mm in width. If public ways or open spaces are not provided and the G/GS exceeds 500 m^2, assessment via the IBC is not appropriate and must revert to the NCC and relevant Australian Standards or consultation with a Professional Fire Engineer.

Proceed to 2.3.2.5 STEP 5 if paragraphs 1 to 6 are conforming. If one (1) or more paragraphs are nonconforming it is not appropriate to utilise the IBC as a partial alternative to determining regulation; reference should only be made to the NCC and relevant Australian Standards or consultation with a Professional Fire Engineer.

2.3.2.5 STEP 5 – What to reference in the IBC

STEP 5 identifies the importance to recognize which elements within the IBC should be referenced and which should revert back to the NCC and relevant Australian Standards. The below table outlines the IBC clauses that can be referenced when completing assessments upon a proposed G/GS development (see Table 2.5). It is not appropriate to adopt, adapt or utilise the IBC for every assessable building element. All elements of a development assessment process which are not documented in the below table shall be referenced through the NCC and relevant Australian Standards.

Table 2.5
Elements of Reference within the IBC

Clause	Description
Chapter 3	**Chapter 3 - Use and Occupancy Classification**
312	Utility and Miscellaneous Group U
Appendix C	**Group U – Agricultural Buildings**
	Provisions and exceptions for the Group U subgroup, Agricultural Buildings (barns, G/GS, sheds etc.)
Chapter 10	**Means of Egress**
1001	Administration
1002	Definitions
1003	General Means of Egress
1004	Occupant Loading (Agricultural Building = 1 person per 30 m^2)
1005	Egress Width
1007	Accessible Means of Egress
1013	Guards
1014	Exit Access
1015	Exit and Exit Access Doorways
1016	Exit Access Travel Distance
1017	Aisles
1020	Exits
1021	Number of Exits and Continuity
1026	Exterior Exit Ramps and Stairways
1027	Exit Discharge
1028	Assembly
	Exceptions for agricultural buildings provided in Appendix C

Important Note: Consultation with Professional Fire Engineers in Australia has determined that an approved exit must be installed at 60 metre maximum intervals along each wall. This may contradict the specifications documented in the IBC; as such the lesser egress requirements should be implemented. Alternatively the services of a Professional Fire Engineer can be obtained to determine egress requirements for the assessable G/GS.

2.3.2.6 STEP 6 – Use of the NCC and Australian Standards

As mentioned in STEP 5, any and all assessable elements not specifically identified in Table 2.5 are to be assessed through the current NCC and relevant Australian Standards. For example, the NCC and Australian Standards must be used to assess the following elements:

- Fire extinguisher quantities, types and placement;
- Fire hose reel necessity, type and placement;
- Building access;
- Carparking and passenger loading facilities;
- Exit facilities (i.e. doors and openings);
- Locations and types of public safety signs (i.e. Exit and 'No Smoking' signs);
- Structural materials, membrane and glass; and
- Ventilation requirements.

3.0 Fire and Egress Directives

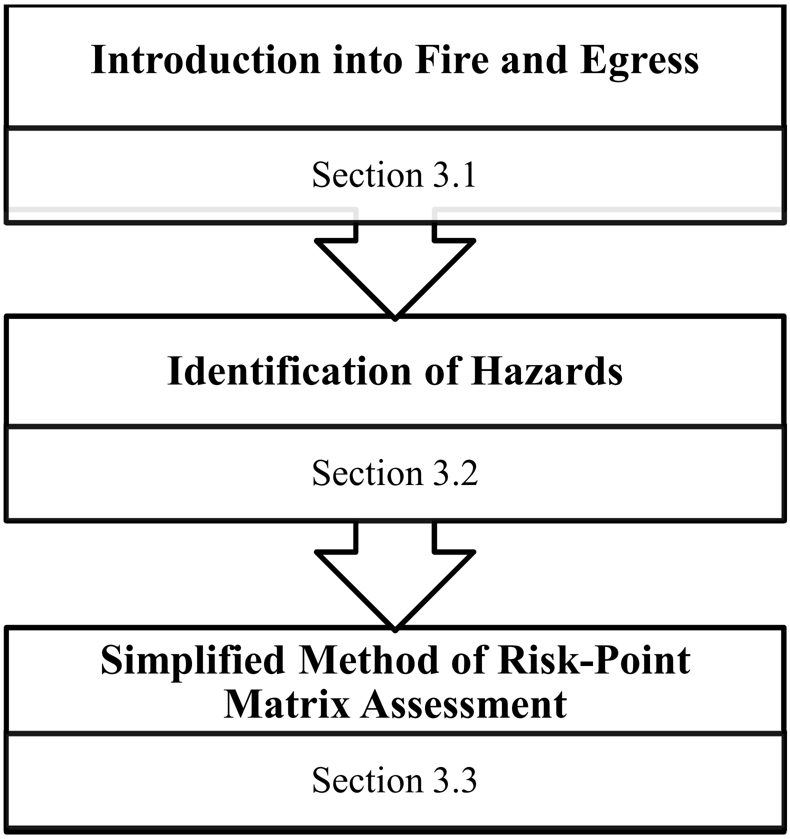


Figure 4 Section 3 Structure

Introduction into Fire and Egress – Section 3.1

Section 3.1 ‘Introduction into Fire and Egress’ provides both certifiers and growers with a general background to fire and egress and ensures only relevant requirements are imposed.

Identification of Hazards – Section 3.2

Section 3.2 ‘Identification of Hazards’ outlines several of the most common fire risks within a G/GS.

Simplified Method of Risk-Point Matrix Assessment – Section 3.3

Section 3.3 ‘Simplified Method of Risk-Point Matrix Assessment’ provides users with a detailed step-by-step process for completing the provided Risk-Point Assessment on fire risk. Completing the matrix determines risk of fire. Recommendations have also been included to control and minimise fire consequences.

3.1 Introduction into Fire and Egress

Many greenhouses/grow structures are relatively isolated from the nearest fire station and may lack adequate water supply to fight G/GS fires. As G/GS buildings become larger and evolve from low technology greenhouses to medium or high technology greenhouses the risk of faults in equipment and wiring and human error also increases. Plant containers, packaging, glazing and shade cloth are readily-available combustible fuels found throughout a typical G/GS. As a result of these compounding risk factors, fires can spread rapidly throughout the facility, causing severe economic losses, negative environmental impact and most notably, loss of human life.

Under the occupational health and safety (OH&S) and new work health and safety (WHS) legislation an employer is obliged to provide the following:

- Safe premises,
- Safe machinery and materials,
- Safe systems of work,
- Information, instructions, training and supervision,
- A suitable working environment and facilities.

The above safety obligations must also be considered by G/GS designers/manufacturers, consultants and certifying bodies, be they local government or private certifiers, during the design and approval process. It is especially important for the certifier to ask the following theoretical questions while assessing an application for a new G/GS development:

> ***"Do I have appropriate knowledge and experience to stipulate fire and egress requirements upon this development and affirm that they are both pertinent for safety and economically viable to the grower?"***
>
> ***"Am I aware of the inherent fire and egress risks associated with this specific G/GS design?"***

Answering either of the above questions as 'No,' identifies that further investigation, consultation and research is required before fire and egress regulation is imposed on any new G/GS development. It is the responsibility of the certifier or building surveyor to impose regulation stipulated within the NCC and Australian Standards upon a proposed development, this may include the application of alternative solutions. If a Standards publication does not aptly provide fire and egress requirements for a specific building, particularly a G/GS, it is important to determine risk associated with the specific synergetic relationship between the building and fire. If a certifier is unable to determine these risks unequivocally, it is important to make reference to this document and if still unclear to request a Fire Engineer be consulted as part of the development process.

Due to the fact that the duty to take reasonable care is implied in the provision of employment, the fundamental obligation owed by the employers towards employees is to ensure their safety. It is the duty of an employer to take 'reasonable care' to avoid foreseeable risk or injury. As such, growers should take an active role in the design and management of their G/GS buildings to ensure employees receive reasonable care in relation to fire, egress and other OH&S elements.

3.2 Identification of Hazards

3.2.1 Hazards in a G/GS Environment

Growing vegetables under a G/GS is an extension and the next evolutionary stage of field farming, which is often located in areas void of a prompt fire fighting response. It is common knowledge that the longer a fire is left unattended, the more difficult it is to contain. Fires commonly start at a discreet point within a building and can quickly spread through combustible materials. Due to farm expansion and development, it is common for G/GS facilities to be open and inter-connected. Although there have been relatively few documented serious greenhouse fires, each occurrence has taken place where there was high potential fire risk. This high fire risk leads to a high fire consequence, consequences including loss of life and serious property damage. The various high risks that may be present are the increased size of the installation due to add-on growth, high value of the protected crop, the use of highly combustible modern plastics and the use of automation including production, lighting and environmental controls.

Materials used within a G/GS are usually chosen for their useful structural properties and features. It is, however, common for these materials to have unwanted or unexpected risks especially in the area of fire and egress.

Though able to transmit light, plastic glazing materials are not as energy efficient as other building materials that can be insulated. Modern plastic glazing and woven fabrics have been engineered to transmit light, resist wind, hail and chemical attack while at the same time improving energy efficiency. Electronic automation of a typical G/GS is also increasing, computer controlled open vents, lamps and fans are all environment control systems commonly installed in an Australian Greenhouse. These advancements assist in increased crop yield, stability and quality. It is, therefore, reasonable to assume that modern plastics and automation offer appropriate compromise between efficiency and risk.

An increase of electronic automation in a G/GS encourages an addition risk of fire, being electrical components. A faulty electronic component can short circuit and emit sparks. Sparks can ignite combustible materials, such as plastic membrane. Growers, certifiers and designers recognise these undesirable risks, however accept the compromise because the value of these properties exceeds the alternative of designing and certifying a G/GS that is truly fireproof and useless for growing plants. It is, therefore, important to determine the appropriate balance between risk management and benefits.

In addition to the structural aspects and contents of a greenhouse, its environment is unique to all other buildings. A typical greenhouse environment includes high levels of temperature, moisture, and sometimes UV light to achieve the highest yield and crop quality. Chemicals used on plants within a G/GS can aggressively attack structural elements and membrane. All equipment, especially mechanical and electrical, is subject to wear and degradation.

Fires in a G/GS have been observed to move quickly throughout the facility. Growers have witnessed fires in plastic membrane structures, particularly woven netting, rapidly engulf an entire G/GS building. Crops, property and structures are often severely damaged if a fire occurs. Fires also interrupt the business that supports and impacts the lives of many including owners, employees and customers for weeks, months and sometimes years.

Fortunately, steps can be taken in farm planning and management that assist in minimising fire risks, and provide procedures that result in a cleaner, safer and more efficient G/GS operation. Many correlations exist between good fire risk management and good G/GS farm operation management. It is not reasonable to assume the risk of a G/GS fire will reach zero; however, risk and associated consequences can be managed to levels that will minimise threats to human life and loss of property.

3.2.2 G/GS Fire Risk Assessment

Managing fire risk and associated consequences appropriately is becoming increasingly important to the financial viability of the greenhouse and grow-structure industry in Australia. There are three major risk management tools that are commonly considered. These are:

- Risk control;
- Risk sharing; and
- Risk communication.

Risk control consists of risk assessment procedure, fire prevention, fire contingency plans and employee training. Insurance is considered a risk-sharing tool. Risk communication is usually between an employer and employees and is documented in Section 5 Farm Management and General Principals.

Fire risks in G/GS can be evaluated on a cumulative risk point matrix. The below risk assessment matrix (Section 3.3) should be utilized by certifiers when determining risk and associated fire prevention measures. The more ‘risk-points’ that are accumulated during the assessment, the more attention should be paid to control such fire risks. If high risk-points are found, certain components, materials and or procedures may need to be implemented to reduce the fire consequence.

3.3 Simplified Method of Risk-Point Matrix Assessment

For the simplified procedure, the following steps (elements) should be used to determine the Risk-Point Assessment for all assessable G/GS. Once each step has been determined, reference should be made to 3.3.11 Table 3.6, providing quantification of risk.

An example Risk-Point Matrix Assessment has been completed and documented in Appendix A of the VG13055 Supporting Document.

Step	Clause	Procedure
1	3.3.1	Determine the size of the new G/GS (see Table 3.1).
2	3.3.2	Determine flammability for typical glazing and framing materials.
3	3.3.3	Determine egress for typical glazing materials.
4	3.3.4	Determine glazing types and associated risk for smoke capture.
5	3.3.5	Determine fire risk associated with assimilation lighting.
6	3.3.6	Determine value of the G/GS and predicted crop value per year (see Table 3.2).
7	3.3.7	Determine the presence of other flammable/combustible materials.
8	3.3.8	Determine environmental control used for the G/GS (see Table 3.3).
9	3.3.9	Determine local council zoning area for the G/GS.
10	3.3.10	Determine distances between G/GS and other buildings (see Table 3.4 and Table 3.5).
11	3.3.11	Risk-Point Assessment Matrix (see Table 3.6).
12	3.3.12	Determine Risk-Point Result (see Table 3.7).

This Risk-Point Assessment is based upon the following three common glazing and covering types. These are: glass, film plastic membrane and sheet plastic membrane. Materials not documented specifically are not covered within the assessment. Consultation should be made with a Professional Fire Engineer to determine where specific glazing types fall within the zero (0) to (5) Matrix risk level (see Section 3.3.11), five (5) being the highest risk and one (1) being the least, where zero (0) is negligible risk.

Glass

Tempered or non-tempered glass, aka soda-lime glass, which commonly contains silicon dioxide, sodium oxide from sodium carbonate and lime is a non-flammable amorphous solid and has an approximate melting point of 1400 ^{0}C. Glass should be in accordance with AS 1288 Glass in Buildings and AS 2047 Windows in Buildings.

Plastic Membrane (PM)

The category of plastic membranes consists of dozens of commonly used G/GS membrane materials. It is therefore appropriate to categorise G/GS plastics as typically organic polymers of high molecular mass, usually synthetic and most commonly derived from petrochemicals. Plastic membrane cladding is typically sheet, film or permeable woven netting.

Film Plastic Membrane (FPM)
Single layer plastic film is commonly polyethylene, EVA (ethyl vinyl acetate) and PVC (poly vinyl chloride). Thickness of the film commonly varies between 150 to 200 microns in thickness and is marketed and sold on a roll. It should be noted that most chemicals will adversely affect the lifespan of polyethylene films. Plastic woven netting is considered a category of FPM. Film plastic membrane can be impermeable or permeable.

Sheet Plastic Membrane (SPM)
Plastic sheeting is commonly polycarbonate, acrylic (polymethyl methacrylate) and fibreglass. There are many forms of SPM on the market; corrugated sheets or twin-wall panels are frequently used in Australia.

These materials are commonly flame retardant and considered to be non-flammable; this should be confirmed with the SPM manufacturer.

Figure 5 A typical roll of FPM (left)

Figure 6 A typical twin-wall SPM (right)

Metal Framing – This Risk-Point Matrix Assessment element for flammability only accepts steel, aluminium or a composite of the two metals for evaluation; if an alternative framing material is provided (i.e. polyethylene PE circular hollow section members) it is important to consult with a professional fire engineer.

It is common for an unprotected metal framed building to fail much sooner than its hardwood timber counterpart in the event of a fire. Strength of steel decreases rapidly when a structural element becomes hot; this can result in a complete structural collapse long before actual flames spread through the building.

Consultation with fire engineers has determined that a solid hardwood timber column/post will typically remain structurally sound for a longer period of time in the event of a fire than its steel counterpart, therefore it would be conservative to use the risk points allocated to steel framing for solid timber framing.

3.3.1 STEP 1 - Determine G/GS Size

The appropriate area band should be selected in accordance with Table 3.1. The area of the G/GS should be taken as the footprint, in hectares, of the new development. The building footprint is any area covered by permeable or impermeable wall and /or roof cladding. Make note of the associated Band.

Important Note: If a new G/GS development is attached, or has covered access/walkway, to an existing G/GS, the total combined area of the new and existing G/GS must be considered as the total G/GS area.

Table 3.1
G/GS Area (ha)

	Band 1	Band 2	Band 3
Area (ha)	< 1 ha *(Less than 1 ha)*	1 ha to 3 ha	> 3 ha *(Greater than 3 ha)*

NOTE:

1 m^2 = 0.0001 hectares.

3.3.2 STEP 2 – Glazing/Covering Type: (Flammability)

All common G/GS materials and framing respond uniquely in the event of a fire. It is therefore important to identify which of the following three (3) typical materials should be used. See Section 3.3 for common material descriptions. Flammability is both how easily something will burn/ignite and the degree of difficulty required to cause combustion of a substance. It is again important to note what glazing type is applicable for assessment in STEP 11.

Important Note: For glazing and framing not mentioned below it is important to seek the services of a professional fire engineer.

Glazing types for G/GS flammability are provided below:

- **Glass** – Glass is considered to be non-flammable and will not support combustion.
  Glass manufactures should specify any coatings applied to the glass that may be flammable. If flammable coatings are present on the glass, it is important to utilise the Risk-Point Result for CPM instead of Glass. Glass enclosures will withstand considerable heat. The expected glass breakage temperature is approximately 400 to 450°C.

- **PM (Plastic Membrane)** – Most PM materials are coated with a fire retardant material as part of the manufacturing process. Plastic films are more likely to burn when flame is applied to the edge of a sheet rather than the flat surface of the sheet. All plastics will burn once a fire has started. However the low melting point of Plastic Membrane materials will allow smoke and heat to dissipate rapidly.

- **CPM (Compartmentalised Plastic Membrane)** – Compartmentalised plastic membrane structures have been designed to actively suppress a spreading fire by creating separation between flammable plastic membranes. Separation can come in many different forms and should be confirmed with a fire engineer; however a common means of separation for a plastic film membrane G/GS would be installing fire-resistant plastic bands, creating a separation. Compartmentalisation design should always be completed by a registered, professional fire engineer.
  More information on compartmentalisation and band separation can be found in Section 5.

3.3.3 STEP 3 - Glazing Type: (Egress)

Glazing types have a considerable influence over the means and ease of egress during a fire event. It is again important for the certifier to determine which glazing type is proposed for the new development and how the glazing type will affect egress during a fire event.

Important Note: The Simplified Method of Risk-Point Matrix Assessment assumes all escape paths and egress are to relevant Australian and International Standards (see Section 2). Also, for glazing and framing not mentioned below, it is important to seek the services of a Professional Fire Engineer.

The following three (3) materials exhibit different characteristics when exposed to a fire event:

- **FPM (Film Plastic Membrane)** – Single layer plastic film membrane on the walls/sides of a G/GS is relatively easy to penetrate in comparison to SPM and Glass. FPM's that are tested to ASTM standards can be considered to reduce risk factors associated with fire; these standards are ASTM D-1929, ASTM D-2843, and ASTM D-635 also UL-94.

- **SPM (Sheet Plastic Membrane) & Glass** –Both SPM and Glass walls/sides are rigid and commonly difficult to escape at locations other than the defined exit points. If determined necessary, it is possible to provide breakout panels in SPM materials which will allow emergency egress in the event of a fire; similarly for glass.

And,

- **No sides** – A G/GS without membrane on the walls/sides does not restrict escape; therefore egress issues with wall/side are negligible (0) within the Risk-Point Assessment.

3.3.4 STEP 4 - Glazing Type: (Smoke)

Build-up of smoke within a G/GS is a crucial concern during a fire event. In the event of a fire it is vital for occupants to escape before smoke inhalation occurs. Glazing options have been given below:

- **FPM (Film Plastic Membrane)** – Single layer FPM does not have the structural integrity to capture large quantities of heat and smoke before it fails/melts. However, a slow build-up fire can produce a substantial amount of smoke which can compromise the walls and ceiling. Permeable woven nets will allow smoke to escape.

- **SPM (Sheet Plastic Membrane) & Glass** – SPM and Glass can capture heat and smoke under the G/GS for a prolonged period. Though venting systems may be installed it is not possible to reduce Risk-Point results without a guarantee/certification from the G/GS manufacturer or Professional Fire Engineer in relation to appropriate roof ventilation.

And,

- **No sides** – If there are no sides/walls on a G/GS there is still a risk, though reduced, of smoke build-up under the G/GS.

3.3.5 STEP 5 - Lighting

Lighting makes reference to assimilation lighting and does not apply to general illumination. Assimilation lighting, also known as grow lamps or supplementary lighting, has an increased risk of being the origin of a fire, as such a high Risk-Point Assessment has been given.

> **Important Note:** Refer to Section 4.3.2.6 for lighting specification on fixture, insulation and maintenance.

3.3.6 STEP 6 - Value of Crop & G/GS

Determining the predicted value of the crop per year and value of the G/GS is an important element of the Risk-Point Assessment. Growers should be consulted to correctly determine value of both the crop and G/GS.

Table 3.2
Value of Crop & G/GS

	Low	Average	High
Predicted Value of Crop per Year	< $30,000 *(less than $30,000)*	$30,000 to $150,000	> $150,000 *(greater than $150,000)*
Value of G/GS	< $40,000 *(less than $40,000)*	$40,000 to $200,000	> $200,000 *(greater than $200,000)*

NOTES:

1.If value of crop and value of G/GS are not within the same 'value column' it is important to interpolate results within Table 3.6 Risk-Point Matrix.

3.3.7 STEP 7 - Other Flammable/Combustible Items

If any of the below listed items are located/installed within the new G/GS development, it can be assumed that 'Other Flammable Items' are present and a high Risk-Point result is given. The Risk-Point result is negligible if flammable items are not stored or used within the G/GS.

Several examples of flammable/combustible items include, but are not limited to:

- EPS foam growing containers;
- Timber and or cardboard growing containers;
- Sequential curtains;
- Combustible pallet or frames;
- Combustible flooring material (i.e. plastic or timber);
- Dry vegetation, including pruned suckers, leaves and mulch;
- Electrical lighting and other appliances; and
- Fuel powered heaters such as LPG.

3.3.8 STEP 8 - Environmental Control Systems

Which of the following environmental control systems are proposed to be implemented into the new G/GS:

Table 3.3
Environmental Control Systems

	Low Tech	Medium Tech	High Tech
Control	No mechanical or electrical environmental control.	Mechanical ventilation and fan motors for air movement.	Boilers, fan motors, mechanical vents, electronic environmental control systems, etc.

3.3.9 STEP 9 - Location of G/GS

In which local council zoning area is the G/GS located within:

- Rural, farming, industrial zones,
- Semi-rural, semi-residential zones,
- Low density residential zone

Important Note: The names of council zones may not exactly match what is above; however it is important to match the actual zone within the above three options. If zoning is not similar to that given above, additional consultation and consideration is required to determine a Risk-Point Assessment result.

3.3.10 STEP 10 - Distance from other buildings

Determining the distance between a proposed G/GS and existing combustible buildings is vital to impede fire spreading. The below distances shown in Table 3.4 are based on surrounding combustible buildings with a height no greater than 6 meters, for buildings with a height over 6 m reference should be made to Table 3.5. The below figures should be taken as minimum distances, it should be understood that the further away from other buildings a G/GS is the better.

Table 3.4
Distance from other buildings (surrounding buildings height < 6 m high)

	Distance 1	**Distance 2**	**Distance 3**
Distance (m)	> 15 m *(greater than 15 m)*	15 m to 5 m	< 5 m *(less than 5 m)*

NOTES:

1. Refer to Section 1.4 Terms and Definitions for 'Height'.

Table 3.5
Distance from other buildings (surrounding buildings height > 6 m high)

	Distance 1	**Distance 2**	**Distance 3**
Distance (m)	> 30 m *(greater than 30 m)*	30 m to 10 m	< 10 m *(less than 10 m)*

NOTES:

1. Refer to Section 1.4 Terms and Definitions for 'Height'.

3.3.11 STEP 11 - Risk-Point Matrix

The determination of Risk-Point Assessment Result for a site using 3.3 Simplified Method shall be determined in accordance with the following:

- Make note of the relevant findings in Sections 3.3.1 to 3.3.10 (Step 1 to Step 10) in relation to 3.3.11 Table 3.6.
- Using relevant tables and information, determine the Risk-Points for each of the elements outlined in Table 3.6.
- Tally, through addition, the Risk-Points for each element to give a Total Risk-Point for the STEP 1 through to STEP 10.
- Proceed to 3.3.12 STEP 12 – Risk-Point Results for appropriate certification measures (see Table 3.7).

NOTES:

1. Tally of individual Risk-Points to give the Total Risk-Point is completed as follows;
   Step 1 Risk-Point + STEP 2 Risk-Point + STEP 3 Risk-Point + … = Total Risk-Point
2. Where any of the input values contained in Table 3.6 are not appropriate for the site being assessed, the assessor should consult and gain guidance from a Profession Fire Engineer.
3. It must be kept in mind that the measures dealt within this Simplified Method of Risk Assessment cannot guarantee that a building and its inhabitants will survive and be uninjured by a fire event. This is due mainly to the unpredictable nature and belabour of fire and the difficulties associated with extreme weather conditions.

Table 3.6
Risk-Point Matrix Analysis

No.	Element	Risk-Points					
		0	1	2	3	4	5
1	G/GS Size	*	Band 1	*	Band 2	*	Band 3
2	Glazing Type: For Flammability	*	Glass	CPM	*	*	PM[1]
3	Glazing Type: For Egress	No Sides	*	*	*	FPM[2]	SPM & Glass
4	Glazing Type: For Smoke	*	No Sides	FPM	*	*	SPM & Glass
5	Lighting	No Assimilated Lighting	*	*	*	*	Assimilated Lighting
6	Value of Crop & G/GS	*	Low	*	Average	*	High
7	Other Flammable Items	None	*	*	*	*	Other items, such as EPS growing containers, sequential curtains
8	Environmental Control Systems	Low Tech	*	*	Medium Tech	*	High Tech
9	Location of G/GS	*	Rural / Farming / Industrial Zone	*	Semi-Rural / Residential Zone	*	Low Density Residential Zone
10	Distance from Other Buildings	*	Distance 1	*	Distance 2	*	Distance 3

Note:
1. Fire retardant and low combustion netting may have a reduced risk point of 3 for STEP 2 Flammability.
2. FPM's with low tensile strength that are easily penetrated for escape may have a reduced risk point of 2 for STEP 3 Egress.

3.3.12 STEP 12 - Risk-Point Assessment Results

This Section specifies general requirements for the certification of G/GS buildings for relevant fire risks and consequences associated with the specific building.

The Total Risk-Point, found within 3.3.11 (see STEP 11), and the corresponding Sections for the specific certification requirements are listed in Table 3.7.

Important Note: A risk assessment tool such as the one used below is only an indication of the character and magnitude of fire risks. The above point system is intended only as an aid in this process of risk assessment for commercial production G/GS.

Table 3.7
Risk-Point Results

	Lowest Risk (see 3.3.12.1)	Medium Risk (see 3.3.12.2)	Highest Risk (see 3.3.12.3)
Total Risk-Point	< 16 *(less than 16)*	16 to 38	> 38 *(greater than 38)*

3.3.12.1Lowest Risk

A G/GS that falls within the 'Lowest Risk' Risk-Point Result Bracket (see Table 3.7) has the lowest risk of a catastrophic fire event. This assessment is dependent on the following conditions:

- That good farm practices and management are implemented within the farm (see Section 5.0 Farm Management and General Practices);
- Relevant Codes are adhered to, especially in relation to egress (See Section 2.0);
- All electrical work has been installed in strict accordance with Local, State and Federal Standards by a qualified professional electrician; and
- All maintenance of electrical or other equipment is carried out under the manufacturer's recommendations.

Expectation of Fire Engineers Consultation: It is not expected that consultation with a Professional Fire Engineer would be required for a G/GS which has obtained a 'Lowest Risk' score. It is, however, at the certifier's discretion to request consultation if deemed a necessity. Discussion with the Grower is highly advised before fire engineer's consultation is commissioned. All plastic will burn; the use of shade cloth that is not fire retardant or has low combustion should be limited as the wave design of these materials allows rapid fire spread should one occur.

3.3.12.2Medium Risk

A G/GS that falls within the 'Medium Risk' Risk-Point Result Bracket (see Table 3.7) exhibits a medium risk of a catastrophic fire event. This assessment is dependent on the following conditions:

- That good farm practices and management are implemented within the farm (see Section 5.0 Farm Management and General Practices);
- Relevant Codes are adhered to, especially in relation to Egress (See Section 2.0);
- All electrical work has been installed in strict accordance with Local, State and Federal Standards by a qualified professional electrician;
- The Grower is aware of the heightened fire risk and has incorporated appropriate measures within the farm's Occupational Health and Safety Procedure; and

- Maintenance is carried out to the manufacturer's recommendations and all electrical equipment is tested and tagged 6 monthly.

Expectation of Fire Engineers Consultation: Though not recommended for all G/GS within the 'Medium Risk' bracket, it is at the discretion of the certifier to request the services of a Professional Fire Engineer. Growers should be made aware of this consultation and the associated fees. Common Professional Fire Engineer recommendations for a G/GS with Medium Risk are as follows:

- Emergency operation manual is produced and maintained to ensure all staff are aware of any risk and evacuation procedures that are to be followed in the event of an emergency.
- Emergency equipment such as extinguishers and hose reels are tested at intervals as required by AS 1851-2012.

3.3.12.3Highest Risk

A G/GS that falls within the 'Highest Risk' Risk-Point Result Bracket (see Table 3.7) exhibits the highest risk of a catastrophic fire event. This assessment is dependent on the following conditions:

- That good farm practices and management are implemented within the farm (see Section 5.0 Farm Management and General Practices);
- Relevant Codes are adhered to, especially in relation to Egress (See Section 2.0);
- All electrical work has been installed in strict accordance with Local, State and Federal Standards by a qualified professional electrician; and
- The Grower is aware of the heightened fire risk and has incorporated appropriate measures within the farm's Occupational Health and Safety Procedure.

Expectation of Fire Engineers Consultation: It is recommended that consultation with a Professional Fire Engineer is undertaken for a G/GS which has obtained a 'Highest Risk' score. Growers should be made aware of this consultation and associated consultation fees. Typical Professional Fire Engineer recommendations for a G/GS with the Highest Risk are as follows:

- Emergency operations manual is produced and maintained to ensure all staff are aware of any risks and evacuation procedures that are to be followed in the event of an emergency.
- Emergency equipment such as extinguishers and hose reels are tested at intervals as required by AS 1851-2012.
- High risk activities or equipment should be monitored automatically to provide early warning should a fire occur.
- Mechanical ventilation should be connected to automatic detection systems to allow for the dissipation of smoke and heat in a fire situation.
- Ensure combustible materials such as cardboard boxes or plastic trays are kept away from ignition sources and are disposed of and not allowed to accumulate.

4.0 Structural Adequacy

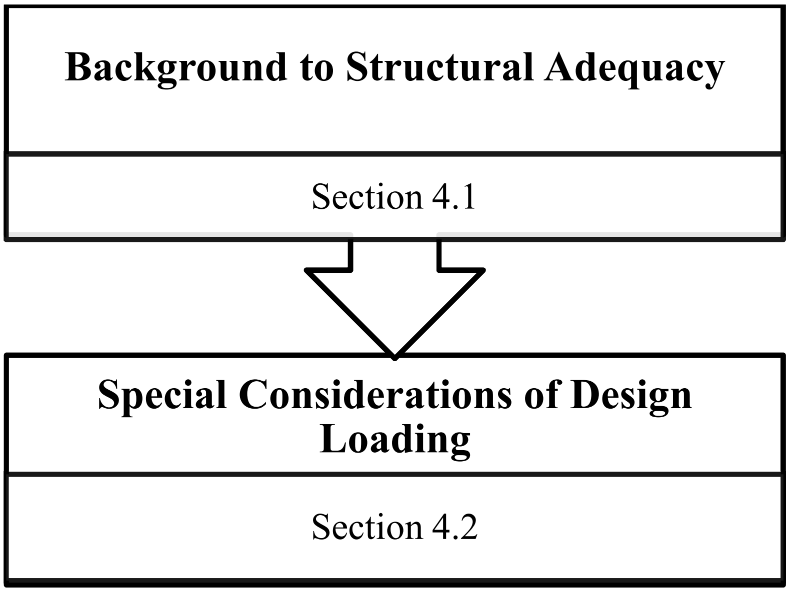


Figure 7 Section 4 Structure

Background to Structural Adequacy – Section 4.1

Section 4.1 'Background to Structural Adequacy' documents Australian Standards currently used by designers and engineers in Australia. This section also outlines limitations of the Standards and recommends special considerations where required.

Special Considerations of Design Loading – Section 4.2

Section 4.2 'Special Considerations of Design Loading' provides designers and engineers with design loading alternatives in the event that structural geometries and permeabilities are not covered in the Australian Standards, specifically AS/NZS 1170.2 Wind Actions.

4.1 Background to Structural Adequacy

High and medium-tech G/GS are usually designed by an experienced engineering firm that works closely with the protective cropping industry, whereas low-tech G/GS are often certified by the geographically closest engineering service that may not have ample experience in designing G/GS.

It is common practice for engineers to utilise the following Structural Design Actions Australian Standards while designing a G/GS located within Australia. These are -

- AS/NZS 1170.0:2002 Structural Design Actions – General Principles
- AS/NZS 1170.1:2002 Structural Design Actions – Permanent, Imposed and Other Actions
- AS/NZS 1170.2:2011 Structural Design Actions – Wind Actions

It is however important to note that the abovementioned Standards provide design loading actions and regulation upon structures that are most commonly designed in Australia/New Zealand; it is therefore common for a G/GS to require special consideration during the design process. Special consideration is provided in Section 4.2, below.

4.2 Special Consideration for Design Loading

Special consideration is required where Structural Design Actions specified in the AS/NZS 1170 set are not relevant to the structure being designed. This occurs most when designing a structure to comply with AS/NZS 1170.2 Structural Design Actions – Wind Actions. If wind loadings on structures cannot be appropriately estimated through the use of AS/NZS 1170.2 due to geometries not covered in the standard, it is appropriate to utilise the below options. These are –

- European Standards; and
- Further research, which may include wind-tunnel testing.

4.2.1 European Standards

Where appropriate, engineers have the option to utilise AS 1170.2 in conjunction with European Standard numbered EN 13031-1 Greenhouses – Design and Consideration.

EN 13031-1 provides an engineer with external pressure coefficients c_{pe} for common greenhouse structural geometries which are not documented within AS 1170.2.

4.2.2 Australian Research

Research is continually being completed to increase the inclusivity of AS/NZS 1170.2 to include actions upon all relevant structures to Australia and its industries. An example of current research is the work being completed at James Cook University to determine characteristic wind loads on large flat roofed porous canopies.

5.0 Farm Management and General Practices

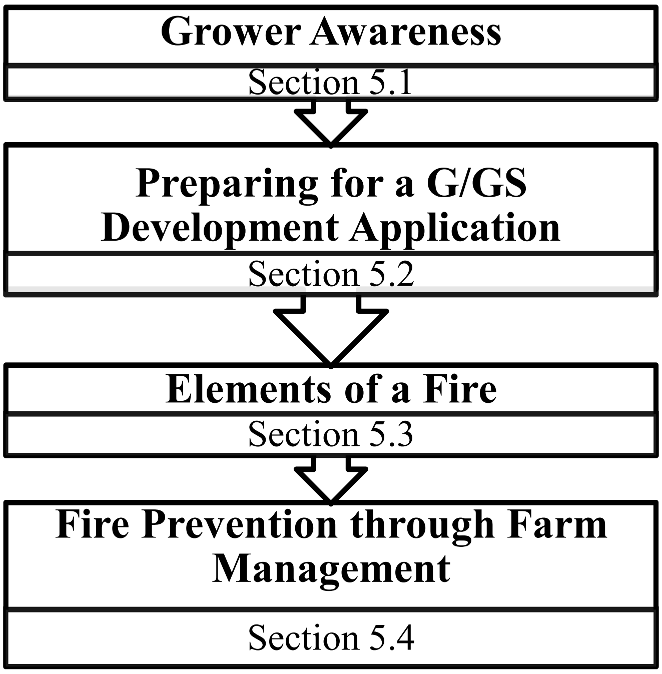


Figure 8 Section 5 Structure

Grower Awareness – Section 5.1

Section 5.1 'Grower Awareness' provides background as to why grower awareness is important, especially in relation to understanding the building approval process and common fire prevention procedures that can be implemented into a good farm management policy.

Preparing for a G/GS Development Application – Section 5.2

Section 5.2 'Preparing for a G/GS Development Application' gives growers a basic understanding of the typical process undertaken by local council/ private certifiers during a building application. It is important for a grower to engage with a certifier early in the application stage to determine specific G/GS approval processes.

Elements of a Fire – Section 5.3

Section 5.3 'Elements of a Fire' provide growers with information about the rudimentary chemical process of combustion. Knowing what three elements are required for a fire to survive is vital when developing good farm management protocol to minimise risk of fire within and around a G/GS.

Fire Prevention through Farm Management – Section 5.4

Section 5.4 'Fire Prevention through Farm Management' provides a grower with procedure/farm management procedure that reduces the risk of fire and the associated fire consequences.

5.1 Grower Awareness

The proposed outcome of Chapter 5.0 Farm Management and General Practices is to promote awareness and practical prevention measures for a Grower to implement during and after a G/GS Development. Reviewing these guidelines will assist in developing a good knowledge base of the issues of development application, fire prevention and emergency planning when working with greenhouse designers, builders, sub-contractors, insurers, local council and fire departments. The guidelines also encourage G/GS employees to practise safe work habits on a daily basis.

This Chapter is not comprehensive, and each G/GS may have special considerations that may not be addressed within these guidelines. Local government and other organisations such as State workplace health and safety bodies can provide a wealth of information on fire prevention, safe practices and emergency planning beyond the scope of this Chapter.

Important Note: All uses of the word 'you' in Section 4 of the Code of Practice refer to the grower, developer and/or owner of G/GS developments.

5.2 Preparing for a G/GS Development Application

Section 5.2 of the Code of Practice has been developed to assist growers in preparing and submitting a development application (DA) to local councils for its approval to establish, expand or modify a G/GS development within Australia. Refer to Section 1.4 of this code to establish meaning and definitions of intensive agricultural buildings. It is only appropriate to utilise the following sections when making an assessment upon intensive agricultural buildings. DAs are generally required for these structures so that potential impacts on the site and on adjoining land are managed and the potential for land use conflict diminished.

The following commissioning guidelines clearly show the path a grower typically needs to consider before a DA.

Before beginning to plan a G/GS Development:

- **Be aware of industry guidelines.**
- **Contact your local council to identify areas suitable for intensive agriculture developments and determine whether a DA is required. Several questions to ask Council are –**
  - **Ask if a DA is required for your G/GS.**
  - **Determine what provisions of the Local Environment Plans and State Environmental Planning Polices apply.**
  - **What is involved in making an application?**
  - **How long will it take to obtain approval?**
- **Consider how your development may affect the environment and neighbours. It is good practice to discuss your intentions with your immediate neighbours before submitting your DA to Council.**
- **Find out what other legislation affects your proposed development. What other permits or licences are required?**

(Source: Preparing a Development Application for Intensive Agriculture in NSW, NSW DIP 2006)

The crucial steps in a typical planning assessment are outlined in the following Figure 4 and discussed below. Every State and Local Government in Australia have documents for public viewing on how to effectively advance through the DA process. Growers are encouraged to find these specific documents and become familiar with specific and sometime unique local council steps.

STEP 1: Is a DA Required?

- Determine what type of development you are undertaking. Seek advice from your local government authority.

STEP 2: Preparation

- Determine the type of assessment required. Seek advice from your local government authority.

STEP 3: Lodgement

- Complete the appropriate application (seek advice from local government authority) and submit to your local government authority.

STEP 4: Assessment

- Local government authority will issue a Decision Notice.

Figure 9 DA Approval Steps for Local Government (Typical)

Throughout the process, the applicant may modify development applications. Depending on the nature of the change, some steps of the assessment process may need to be repeated, fees may apply. Timeframes, costs and processes for Development Approval and Building Approval vary between state and local government authorities.

The Departments of Planning and or Primary Industries in several States have documents directly related to the DA process of agricultural buildings. The “Preparing a Development Application For Intensive Agriculture in NSW” which is published and distributed by partnership between the NSW Department of Planning and NSW Department of Primary Industries can be downloaded from the Departments websites.

Contact information for each Australian State and Territory Department of Planning and Department of Primary Industries can be found in the table below (see Table 5.1).

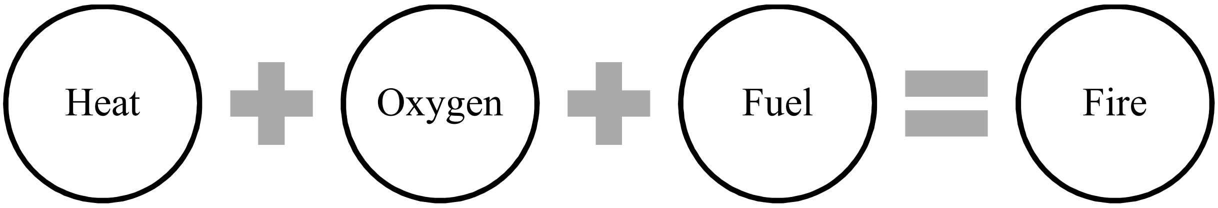
Table 5.1
State Government Contact Details

State/Territory	***Department of Planning (or Similar)***	***Department of Primary Industries (or Similar)***
New South Wales	*GENERAL* *23-33 Bridge Street, Sydney NSW 2000* *GPO Box 39, Sydney NSW 2001* *Tel: 02 9228 6111* *Fax: 02 9228 6455* *Email: information@planning.nsw.gov.au*	*HEAD OFFICE* *161 Kite Street, Orange NSW 2800* *Locked Bag 21, Orange NSW 2800* *Tel: 02 6391 3100* *(International +61 2 6391 3100)* *Fax: 02 6391 3336* *(International +61 2 6391 3336)*
Victoria	*GENERAL* *Tel: 1300 366 356* *Email: planning@diird.vic.gov.au*	*GENERAL* *Tel: 136 186* *Online Enquires*
Queensland	*GENERAL* *PO Box 15009, City East, QLD 4002* *Tel: 13 74 68* *Fax: +61 7 3224 4683* *Email: info@dsdip.qld.gov.au*	*GENERAL* *Tel: 13 25 23* *Fax: +61 7 3404 6900* *Email: callweb@daff.qld.gov.au*
Western Australia	*HEAD OFFICE* *140 William Street, Perth WA 6000* *Lock Bag 2506, Perth WA 6001* *Tel: 08 6551 9000* *Fax: 08 6551 9001*	*HEAD OFFICE* *3 Baron-Hay Court, South Perth WA 6151* *Locked Bag 4, Bentley Delivery Centre WA 6983* *Tel: 08 9368 3333* *Fax: 08 9474 2405* *Email: enquiries@agric.wa.gov.au*
South Australia	*GENERAL* *GPO Box 1533, Adelaide SA 5001* *Email: DPTI.enquiriesadministrator@sa.gov.au*	*HEAD OFFICE* *Level 14, 25 Grenfell Street, Adelaide* *GPO Box 1671, Adelaide SA 5001* *Tel: 08 8226 0900* *Fax: 08 8226 0476*
Tasmania	*GENERAL* *Level 4, 144 Macquarie Street, Hobart TAS 7001* *GPO Box 1691, Hobart TAS 7001* *Tel: 03 6165 6828* *Fax: 03 6233 5400* *Email: enquiry@planning.tas.gov.au*	*GENERAL* *GPO Box 44, Hobart TAS 7001* *Tel: 1300 368 550* *Online Enquiry*
Northern Territory	*DIRECTOR BUILDING CONTROL* *Tel: 08 8999 8985* *Email: bas.lpe@nt.gov.au*	*GENERAL* *Tel: 08 8999 5511* *Fax: 08 8999 2010* *Email: info.dpif@nt.gov.au*
Australian Capital Territory	*GENERAL* *Dame Pattie Menzies House, 16 Challis Street, Dickson ACT 2602* *GPO Box 158 Canberra ACT 2601* *Tel: 02 6207 1923* *Online Enquiry*	*REF: New South Wales Contact*

5.3 Elements of a Fire

5.3.1 Common Causes of G/GS Fires

Understanding the nature of fire is crucial to applying appropriate farm and risk management techniques and policies. Fire is dependent on the presence of three elements. These are heat, oxygen and fuel. The quantity and availability of each element directly depend on how easily a fire ignites, spreads and its duration. Removing one of the elements ensures the fire cannot survive.



To remove or mitigate the risk of G/GS fires it is first important to identify the heat, oxygen and fuel elements that are in the G/GS.

5.3.1.1 Heat

Heat can be produced by several forms of energy that are common in a greenhouse. The typical forms of energy are hot works, heating, electrical, smoking and spontaneous combustion.

- **Hot works:** Employees/maintenance staff/contractors should be made aware of the danger of welding or soldering near plastic membrane materials or other combustible materials. Sparks and molten metal can easily ignite combustible materials of fall into a confined space and smoulder until a fire breaks out hours later. A common example of this is combustible engine (tractor) exhaust.
- **Heating:** Natural gas or oil heaters, CO_2 generators and any other combustion burning equipment within the greenhouse could create a fire if appropriate clearance have not been adhered to between the equipment and the combustible materials. These may include permeable/impermeable membrane. Reference should be made to the equipment manufacturer's installation and maintenance manual/documentation to mitigate risk of fire.
- **Electrical:** Deterioration and wiring problems of electrical equipment can cause sufficient sparks/heat to ignite a fire. Even professionally installed electrical work can become faulty due to overloading or physical damage.
- **Smoking:** Fires due to discarded cigarette butts usually cause a fire risk when policy and designated smoking areas are not provided by the employer.
- **Spontaneous Combustion:** This is a type of combustion which occurs by self-heating which is followed by a thermal runaway and finally ignition. Self-heating occurs when a material, such as a store of oily rags, absorbs oxygen from the air as part of a natural chemical reaction; heat generated from the oxidation then leads to a fire.

5.3.1.2 Oxygen

Oxygen has a large influence in the speed of spread of fire and the severity of the fire damage. It is common-sense knowledge that oxygen cannot be removed from the G/GS; however mechanical ventilation systems tend to exacerbate a fire if not installed correctly. Automatic ventilation systems activate when the temperature within a G/GS rises, drawing in more oxygen from outside into the G/GS, increasing the speed and damage of the fire. The installation of automatic ventilation systems that do not have fire failsafe systems installed should be an area of consultation with a professional fire engineer and or fire department official.

5.3.1.3 Fuel

Combustible components and materials stored within the G/GS act as fuel, as does the G/GS itself. Identification of which elements within or of the structure are 'fuel' for a fire –

- G/GS membrane. All polymer coverings are combustible. Some coatings on glass panes are also combustible;
- Permeable membrane, sequential curtain and ground covers;
- Timber or plastic benches, work takes and storage racks;
- Plastic/polystyrene grow containers;
- Fertilizers, typically nitrogen based;
- Dried vegetation; and
- Oils, petroleum, diesel, propane/natural gas stored inside or around the G/GS perimeter.

5.4 Fire Prevention through Farm Management Recommendations

5.4.1 Technical Standards

To most effectively reduce the risk of a fire is to have a G/GS that is well-designed. Depending on the G/GS type (i.e. retail, commercial, institutional, private), size and location, compliance to national, state and local government regulation is important. Reference can be made to Sections 2 and 3 of the Code of Practice to determine if International Standards can be imposed on your proposed G/GS. Building codes are designed and enforced for the protection of public health, safety and welfare.

It is important for you, as a grower, to identify what will be required of your new G/GS development at the conceptual stages of development, many Local Councils are not experienced in the DA/Certification of G/GS buildings, it is important that you identify resources the certifier may require while completing your DA.

Several example documents that should be brought to the attention of the certifier are –

- International Building Code – Administered by the International Code Council.
- Code of Practice (Building Codes and Greenhouse Construction) – Administered by Horticulture Australia Limited and Osborn Lane Consulting Engineers.
- Supporting Document (Building Codes and Greenhouse Construction) – Administered by Horticulture Australia Limited and Osborn Lane Consulting Engineers.

There will be other documents/ Australian Standards not listed above that are already known to the certifier.

5.4.2 Building Materials

Greenhouse and grow structure materials vary considerably. Below is listed common building materials used by the Australian G/GS Manufacturing Industry.

1. Metal Framed Buildings

Many growers wrongly perceive metal framed structures, such as greenhouses, as "fireproof". This assumption does not stand. Although flame is unable to spread over metal, an unprotected metal frame building will commonly fail more rapidly than a wooden structure. In the event of a fire, temperatures build rapidly within the G/GS, and as the ambient temperature increases so does the temperature of the metal framing, as structural steel gets hot, causing strength to decrease rapidly leading to structural failure.

2. Glazing

Plastic Glazing - Plastic glazing, such as membrane or panels, are combustible and provide a source of fuel for a fire. As such, they need to be protected from high heat sources and open flames. Research has found that the edges of plastic sheeting are more susceptible to ignition than a flat surface; it is good practice to protect sheet edges with metal or other non-combustible materials. In order to be recognised as approved light-transmitting plastics, plastic glazing must meet minimum performance criteria which are outlined within relevant Australian and International Standards and Testing Procedures.

Glass - Glass panels are non-combustible and do not spread flame. Bear in mind that glass that has been laminated with a film may be combustible; a grower should contact their selected G/GS manufacture to determine if glass has been laminated and has an additional fire risk.

Permeable Plastic Membrane/Shade Cloth – Plastic shade cloth is typically woven from plastic filament, and as such, they are extremely flammable and spread fire quickly. Once ignited, the polymers used to weave shade cloth may melt and drip; these dripping molten polymers can cause catastrophic crop damage and ignite other combustible materials below. A denser shade cloth weave provides more fuel for a more intense burn, releasing more heat and dripping more molten polymer, which in turn results in a higher damage.

Using shade cloth also has an association with potential wiring and electrical problems that can result in fires. If electrical wires are in direct contact with shade cloth at any point over the protective area, friction between the two can wear away the insulation around the wires and expose a 'live wire' against the shade cloth. Preventing this potentially hazardous situation from occurring is to have all wiring encased in metal conduit or relocating the wire to locations where friction does not occur.

Flame-retardant shade cloth can be purchased on the market and band/panels can be installed between standard polymer shade cloth to create effective fire breaks along the length of the G/GS. Consultation with a G/GS manufacturer and/ or Professional Fire Engineer should be undertaken to determine if this method is appropriate and the specifics of panel width and spacing. It should be noted that flame-retardant shade cloth is generally more costly to purchase than a standard shade cloth alternative.

Shade/Energy Curtains – Shade and energy curtains are commonly woven from polymer, similar to that of the permeable plastic membrane/shade cloth (above). Curtains are commonly closed at night to conserve energy; this creates a building length panel of highly combustible material which is a disastrous situation if a fire were to ignite. There are curtains available on the market that have a flame-retardant edge which creates an inherent fire-break between each curtain. This effectively limits the risk of fire spreading throughout the G/GS.

5.4.3 Compartmentalisation

Compartmentalization, meaning the separation of two or more sections by a fire-resistant boundary, must be adhered to through the current, relevant National Construction Code and Australian Standards. To mitigate risk it is important to prevent fires from spreading. This can be achieved in following ways –

- Separate the G/GS into compartmentalised fire zones. Use non-combustible materials as the boundary/partitions. Common fire-resistant partitions include concrete tilt panels and fire-rated cladding, for example.
- Isolate generators, heaters and boilers from the G/GS with non-combustible partitions.
- Isolate ignition sources such as heating pipes, CO_2 generators and other electrical switches/panels from combustible materials (glazing, curtains etc.).

A G/GS that has been designed well will include inherent compartmentalisation between different portions of the structure. Consider using firewalls whenever two areas with different risk levels are contained in the same building. It is important for the grower to provide the G/GS designer/manufacture with appropriate information regarding proposed layout of growing area and plant areas. From there, a manufacturer, along with a Professional Fire Engineer (if required) will determine which compartmentalisation strategy is best suited for the development.

5.4.4 Power Delivery

Many fires result from electrical faults and/ or misuse of the electricity supply. Wiring can fail due to faulty installation, physical wear/deterioration, heat, overloading and moisture. All G/GS electrical work should be undertaken by a Professional Electrician and compliant with relevant Australian Standards. If new plant or equipment is installed within a G/GS it is important to have an electrical assessment completed to determine the risk of overloading. Each circuit must be protected by a fuse or breaker that will blow if safe capacity is exceeded.

Areas of excessive, prolonged moisture should be avoided when locating electrical panels/boxes; it is good practice to have the panel located in the driest and most accessible location within the G/GS. Due to the typical environment within a G/GS, it is important to ensure the panel is corrosion resistant and weatherproof. It is also recommended, in certain situations, that a secondary power supply panel and disconnect switch is located outside of the G/GS. Key staff should be instructed on how to disconnect the power supply in the event of a fire. Make sure that power systems are installed to allow continual, uninterrupted power (even while the disconnect switch has been activated) for the retraction of energy curtains and/ or the operation of misting/spray systems (H^2O mister/spray only).

Further detail and design recommendations can be obtained through the services of a Professional Fire Engineer and or Electrical Engineer.

5.4.5 Quality of Installation

Fires sometimes occur following the installation or repair of mechanical or lighting equipment. It is therefore important to have all installation or repair work completed by a qualified, licensed professional – employing such a contractor not only reduces risk of fire but also provides the grower with shared responsibility if a fire were to occur.

5.4.6 Lights

Though not common in G/GS within Australia, lights that are installed should be protected with a non-combustible conduit (i.e. metal) wherever possible. Lights should also be maintained regularly to remove dust/debris build-up and to check electrical wiring to lights. The following general installation recommendations include:

- Maintain appropriate distance between lights and combustible materials,(plastic glazing for example.)
- Use a licenced electrician during the installation and ensure approved fittings are used.
- Faulty parts should only be replaced with original or manufacture approved components.

5.4.7 Maintenance of Equipment

1. General Maintenance

Each G/GS should have protocol in place to ensure equipment, be it mechanical or electrical, is checked and maintained to ensure that it operates properly. Manufacturers of most equipment are able to provide a routine for inspection to the purchaser of the equipment. Replacement or repair of damaged or faulty equipment should be made an immediate priority and equipment should be removed from service without delay.

2. Maintenance of Fans and Motors

Motors and fans that are overheating due to a build-up of dust, overloading, sparking or poor ventilation could ignite combustible materials nearby. It is therefore important to keep the area around fans and motors clear of combustible materials. Motors should be provided with appropriate ventilation and maintained regularly to remove dust build-up.

Again, equipment including fans and motors should be wired by a licensed professional and in accordance with relevant Australian Standards. Voltages and amperage should correspond to the motor nameplate.

3. Maintenance of Appliances and Tools

One of the most common causes of G/GS fires in Australia is fire caused by faulty equipment, be it anything from a forklift to petroleum powered blower/vacuum. Over time it is common for devices to experience internal wiring failure or other electrical related issues which may result in a fire. Tools which are powered by an internal combustion engine must also be serviced and maintained as per manufacture's recommendations.

If any device is found to be not working, not performing as intended, making unusual noises/vibrations, smoke etc., it is vital that the device is immediately removed from service and replaced if required.

Vehicles, including fork-lifts and tractors, should be serviced regularly and cleaned to ensure dust and oil does not build-up around the engine block and electrical connections. A vehicle fire is extremely dangerous and difficult to extinguish. It is therefore important to ensure all reasonable maintenance is undertaken to reduce the risk of ignition.

Tools and vehicles that may be hot from operation should not be stored near combustible materials and should have an appropriate clear radius for ventilation.

5.4.8 General Housekeeping

1. General Guidelines

The following general guidelines are recommendations made by the National Greenhouse Manufactures Association of America. Note: The recommendations are not applicable for all G/GS buildings.

- Test fire and smoke alarms on regular intervals.
- If installed, flush private fire hydrants at least once a year or as instructed by the designer/manufacturer/installer.
- Check that fire doors are performing adequately, are unobstructed and in good condition.
- Regularly check all water control valves and the air and water pressures of automatic sprinkler/misting systems.
- Have a licenced electrician check all wiring, power boards and electrical equipment for faults or determination.
- Check and maintain all boilers and heating systems to ensure they are in prime operating condition.
- Clean dust and debris from fans and motors regularly; two to three times a year is advised but may be more if deemed necessary.

2. Fire Extinguishers & Fire Hose Reels

Fire extinguishers must be installed in locations as instructed by the relevant Australian Standards or Professional Fire Engineer.

Extinguisher placement is important. It is generally appropriate to installed extinguishers at locations close to potential hazards (i.e. gas storage tanks, boilers and CO_2 generators), in the middle of long aisles and near exterior doorways. More specific detail can be found in relevant Australian Standards and through consultation with the Fire Department or Professional Fire Engineer.

Fire hose reels should be installed where recommended by the relevant Australian Standards and or as directed by the Fire Department or Professional Fire Engineer. Fire hose reels typically require a minimum inlet pressure of 220 kPa and a maximum inlet pressure of 1,000 kPa (confirm with a specific manufacturer). A fire hose is only appropriate when fighting an ordinary combustible fire, (wood, paper, plastic and fabric) and is not suitable for any other type of fire. Staff should be educated in how and when it is best to use a fire hose and that they should ensure they maintain a path of egress between themselves and the nearest exit while fighting a fire.

There are different types of fires; each require a particular extinguisher to combat the flames. Types of fire extinguishers commonly found within a G/GS are identified in the below table (see Table 5.2).

Table 5.2
Fire Extinguisher Classes

Class	Type of Fire	Appropriate Extinguishers
A	Ordinary Combustibles (i.e. wood, paper, fabric, plastic)	Water, Foam, Dry Chemical, Vaporising Liquid, Halon, Wet Chemical
B	Flammable Liquids	Foam, Dry Chemical, Carbon Dioxide, Vaporising Liquid, Halon
C	Flammable Gas	Dry Chemical, Vaporising Liquid
E	Electrical	Dry Chemical, Carbon Dioxide, Vaporising Liquid, Halon

It is important to educate staff in how to effectively identify and use each type of fire extinguisher and also when to attempt to combat the fire or to evacuate. Ensuring all staff know what to do and where to go during the event of a fire is vital in minimising confusion, panic and the risk to life.

3. Storage of Combustibles

Flammable and combustible liquids and gasses are renowned fire hazards. Reference must be made to the National Code of Practice for the Storage and Handling of Workplace Dangerous Goods. Determining an appropriate location to store these combustibles should be a top priority. The ideal location for storage of such substances is in a large open outdoor area which is well separated from buildings, streets and property boundaries; its location should also have appropriate emergency access in the event of an emergency. If a large quantity of stored combustibles is required within the G/GS, it is vital that the storage is separated from the remainder of the building through the use of a firewall or similar. Fire resistance times of a fire wall are typically 30 minutes to 60 minutes – exact resistance times can be obtained through the services of a Professional Fire Engineer.

The following points should be enforced regardless of type or location of the combustibles stored:

- The storage room should be labelled and secured;
- Locations of combustible storage areas should be documented in the farm's Fire Prevention and Emergency Response Plan;
- An inventory should be kept of the type, quantity, date of purchase and location of the chemicals/combustibles;
- The inventory should be kept safe and available for inspection from emergency personnel;
- Flammable liquids should only be stored in approved containers; and
- Chemical storage rooms should have appropriate ventilation and spill contaminate design in accordance with Australian Standards (where applicable).

4. Fire Prevention and Emergency Response Plan

It is commonplace for a farm within Australia to have Workplace Health & Safety programs in place; these include evacuation plans, First Aid Kits and what to do if a dangerous situation is observed. However many farms do not have Emergency Response and Emergency Preparation protocol. The Emergency Response Plans ensure that, in the event of a fire or other emergency, all staff know what to do in order to preserve human safety and reduce loss and damages. It is the grower's responsibility to provide staff with a written Emergency Response Plan and to appropriately train all employees in how to follow the Response Plan. For assistance on how to write a Response Plan the grower should refer to State Workplace Health and Safety Commissions.

Alerting all employees to a fire emergency is vital. Common alarm systems include PA Systems, sirens or bells that are clearly audible anywhere on the farm. Protocol must be in place to ensure that management and foremen know where the alarm system is and how to activate it.

Exit routes from buildings must be clearly identified on emergency exit plans. Exits must be clearly marked with an approved EXIT sign (illuminated signs not required in a typical G/GS). If stipulated by a fire authority it is important to install 'knockout panels' in the greenhouse sidewalls and gable ends. Knockout panels must be labelled appropriately to ensure staff can identify the egress panels during an emergency. Staff should be educated as to how to evacuate the building in the event of an emergency; education should include the practice of kicking through a knockout panel.

Australian Standard 3745-2010 stipulates that workplaces are required to have a minimum of one onsite fire and evacuation drill per year. An announced fire drill should be conducted regularly so employees know what they should do in the event of a fire. A meeting should be held after the drill to discuss improvements in procedure and equipment.

The Emergency Plans Fact Sheet published by Safe Work Australia (www.safeworkaustralia.gov.au) provides quality resources for business owners in relation to Emergency Response Plans. It is recommended that G/GS growers download the document and complete the checklist; this checklist will identify any areas of immediate concern of human safety and loss/damage of property. Fire Departments and Professional Fire Engineers are also able to provide fire prevention and emergency response protocol for a fee.

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Supporting Documentation for Code of Practice

Building Codes and Greenhouse Construction

VG13055 (August 2014)

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Research Provider: **Osborn Lane Consulting Engineers**

Funding Provider: **Horticulture Australia Limited**

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SUPPORTING DOCUMENT

HAL Project Number: VG13055

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Table of Contents

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Glossary of Abbreviations

AS	**Australian Standards**
ASTM	**American Society of Testing and Materials**
BA	**Building Approval**
BCA	**Building Code of Australia**
CPM	**Compartmentalised Plastic Membrane**
DA	**Development Application**
FPM	**Film Plastic Membrane**
FRP	**Fibre Reinforced Plastic**
G/GS	**Greenhouse and Grow Structures**
HAL	**Horticulture Australia Limited**
IBC	**International Building Code**
ICC	**International Code Council**
NCC	**National Construction Code**
OLCE	**Osborn Lane Consulting Engineers**
PM	**Plastic Membrane**
SPM	**Sheet Plastic Membrane**

1.0 Introduction

1.1 Document Utilization

This document is to be referenced in conjunction with VG13055: Building Codes and Greenhouse Construction – Code of Practice. The document has been separated in the following four (4) sections. These are:

- **Section 1: Introduction**
  Outlines the objectives of the project and what methodology has been undertaken to achieve project objectives.
- **Section 2: Literary Review**
  Documents findings made from national and international resources.
- **Section 3: Ethics and Risk Assessment of Completing Project**
  Outlines the ethical risk of providing measures to reduce the cost of compliance for G/GS buildings.
- **Section 4: Consultation and Field Investigations**
  Consultation with experts and growers underpin all recommendations made in the Code of Practice. Experts have provided technical information, and growers have provided insight into issues facing the industry.

Research, information and field investigation case studies documented within this document will make direct reference to the accompanying Code of Practice. Identification of linking references can be found in the right-hand column of this document. An example of such a reference has been provided to the right. "REF: CoP 1.1" makes reference to "Code of Practice Section 1.1".

REF: CoP 1.1

1.2 Project Methodology and Timeframe of Programme

1.2.1 Research Methodology

Much of the research accomplished throughout this project has been completed via online channels, these mainly being IEEE Database, EBSCO Host and SAI Global; other research tools used include internet search engines (such as google.com, google.scholar.com.au). All research used directly or indirectly within the document has been referenced using the Harvard Reference System with footnote references and an end of document reference list.

Literary Reviews of national and international standards, consultation with building certifier(s), fire engineer(s) and field visits are the basis of all recommendations in the investigation to reduce the cost of compliance in the investigation into the classification of G/GS's and to provide guidelines for consistent building approval around Australia.

Field investigation has been completed by Osborn Lane Consulting Engineers (OLCE) to answer questions that remain unanswered after the literary review process and consultation with building and design professionals. The field visits also gave a good understanding of what fire and egress regulation has been imposed on existing G/GS structures. Where appropriate, the economic burden of these imposed systems has also been documented within the report.

Field investigations were an integral aspect of this project. Six (6) field investigations were undertaken to meet growers and investigate their protective structures/canopies around Australia. Grower concerns and recommendations were also documented and made available through the case studies provided in Section 4 of this document. The investigations were vital when determining:

- The success and failures of existing G/GS infrastructure;
- What fire, egress and structural requirements have been imposed on existing G/GS's;
- How the growers/owners feel the planning, design and construction were implemented – are there areas for improvement;
- Existing structural performance under extreme loading events (i.e. severe storms);
- What code recommendations do the growers/owners make; and
- Feedback on our research and recommendations over the project timeframe.

The following avenues of research methodology were utilised for this project.

- Research existing theories and concepts to help identify proposed improvements to the approval process through a literary review process.
- Complete research on the needs and desires of the industry and on the potential decrease in the cost of compliance.
- Economic research on industry and business to determine cost of compliance and reductions.
- Carry out social and communicational research to find answers to questions not discovered in point three – social research is the easiest means to determine industry perception of a specific issue.

Social and communicational research consisted of the development of a grower questionnaire. This questionnaire was completed by all growers who agreed to a site investigation and also to growers who had a particular interest in sharing their G/GS experiences. Protective Cropping Australia assisted in the questionnaire distribution.

Questionnaires that provided useful feedback and recommendations have been adapted into case studies which can be found in Section 4.0.

1.2.2 Project Staffing Resources

The following table shows those who have been utilised throughout the projects history and a description of association has also been given. Growers and G/GS manufacturers have also been utilised throughout the project.

Table 1.1
Utilised Staff

Name	Association to Project
Marcel Olivotto	VG13055 Project Leader
Eric Peter Osborn	VG13055 Project Administrator
Chris Millis	Vegetable Industry Grower Partner
Chris Lee	FERM Engineering – Fire Consultant
Milton Stennett	Acacia Building Approvals – Certifier Consultant

1.2.3 Timeframe of Programme

The below table contains programme objectives that are considered as crucial elements of the project; each element requires individual research, analysis, and documentation. Any additional unforeseen time restrictions, elements that require additional attention or regressions shall be incorporated into the existing timeframes.

Table 1.2
Timeframe of Programme

Element	Begin (month after start)	End (month after start)
Start of project communication summary	0	0
Literary review of current documentation and industry standards	0	1
Consultation with building certifier/fire engineer	0	2
Fire engineering and egress	1	5
Structural criteria	1	1
Case study of success and failure of past G/GS	2	5
Literary review on materials and new innovative systems	3	4
Determine cost reduction techniques	5	7
Field investigations	2	6
Development of final HAL report	6	9
End of project communication summary	9	9

2.0 Literary Review

2.1 G/GS Classification

2.1.1 In Australia

Reducing cost of compliance for structures, be it through regulation or design parameters, is not a new idea; the exponentially increasing availability of new technology and growth in design experience has led to greater design efficiency. Growers have benefited greatly from the progress made in structural efficiency by the design of lighter and stronger G/GS systems. National, State and Local Council regulation however often lacks efficiency, decisiveness and relevance to the expanding G/GS industry.

REF: CoP 1.2

Issues streamlining the process of government approval for G/GS originate largely from the interpretation of the National Construction Code (NCC) - Building Code of Australia (BCA) and its classification of G/GS. Further reference to the Building Code of Australia (BCA) in this project means Volume One of the National Construction Code Series (NCC) unless noted otherwise. Construction requirements for every building type are primarily associated with their classification in accordance with clauses A3.2 and 1.3.2 of the BCA. A3.2 of the BCA stipulates [1]"The classification of a building or part of a building is determined by the purpose for which it is designed, constructed or adapted to be used."

REF: CoP 2.0

In the individual States and Territories, appropriate authorities (such as local councils) may classify G/GS or other 'farm buildings' as Class 10a, which covers non-habitable buildings. A classification of 10a would only be made if Class 7 and Class 8 within the BCA were not appropriate.[2] When making the decision a certifier considers the buildings size, operations, purpose and occupation/utilization by people.

There are three basic types of Class 7 buildings. The first is Class 7a a carpark, the second, Class 7b, a building for storage and thirdly Class 7c, a building for the sale of wholesale goods. 'Wholesale' is the business of selling goods in large quantities and at low prices, typically to be sold on by retailers at a profit.[3] A G/GS structure would not fit into these categories easily without considerable interpretation of the word 'wholesale' and 'storage.' The primary use of G/GS are for growing produce. Once the produce is ready for sale, the product is picked (collected) and transported to another storage facility for wholesale. Hence, Class 7 is inappropriate for G/GS.

REF: CoP 2.3.2.1

Class 8 buildings are commonly described as a 'factory.' More specifically, this class includes buildings used as a "laboratory, or building in which a handicraft or process for the production, assembling, altering, repairing, packing, finishing, or cleaning of goods or produce is carried on for trade,

REF: CoP 2.3.2.1

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[1]NCC 2013b. Part A3.1 Building Code of Australia: Volume One. *In:* SERIES, N. C. C. (ed.).
[2]NCC 2013a. A3.3. *In:* CODE, N. C. (ed.) *Guide to the BCA Volume One.*
[3]OXFORD 2014. Oxford Dictionary. *Word Definition, Oxford Dictionary*

sale, or gain."[4] Use of the word 'production' has been problematic when decisively classifying G/GS structures in a unified category around Australia. If a certifier does not classify a G/GS as Class 10a he/she would usually classify the structure as Class 8 as people are likely to be employed to feed, clean or collect produce from animals or plants within a building. However, this can be seen as an inaccurate classification.

Practice Note 2013-64 by the Victoria Building Commission (issued January 2013) gives information on the process animal shelter buildings are required to comply with BCA requirements. [5]

2.1.2 Internationally

Europe, Canada and the United States of America have codes and standards that can either be specifically used for G/GS structures or can be adapted for the unique function and occupancy of a particular G/GS. The International Building Code that includes exceptions and specific requirements for agricultural buildings, such as, greenhouses or grow structures.

The International Building Code is published by the International Code Council in the United States. The IBC is a comprehensive building code which establishes the minimum regulations for building systems using prescriptive and performance-related provisions. The document is founded on broad-based principles that make possible the use of new materials and new building designs.[6]

REF: CoP 2.3.2

Agricultural buildings, which include G/GS, are classified as Group U buildings under the IBC.[7] Group U (Utility and Miscellaneous) buildings and structures are of an accessory nature or miscellaneous structures. The IBC specifies, structures not classified in any specific occupancy shall be constructed, equipped and maintained to conform to requirements of this code commensurate with the fire and live hazard incidental to their occupancy.

REF: CoP 2.3.2.2

Appendix C of the IBC provides exceptions and provisions for Group U buildings. These exceptions and provisions include allowances for Group U building heights and areas, distances between other buildings and exits. Exceptions for exits are as follows:[8]

REF: CoP 2.3.2.5

1. The maximum travel distance from any point in the building to an approved exit shall not exceed 91,440 mm; and
2. One exit is required for each 1,393.5 m^2 of area or a fraction thereof.

REF: CoP 2.3.2.4

[4] NCC 2013c. Part A3.2 Building Code of Australia: Volume One. *In:* SERIES, N. C. C. (ed.).
[5] VBC 2013. Practice Note: Classification of buildings. *In:* COMMISSION, V. B. (ed.). Victoria, Australia.
[6] ICC 2012c. International Building Code, Preface.
[7] ICC 2012b. International Building Code, Chapter 3.
[8] LEE, C. April 2014, ICC 2012a. International Building Code, Appendix C: Group U Agricultural Buildings.

2.2 Fire and Egress

Growing produce in greenhouses and grow structures often takes place in rural, remote locations zoned for agricultural use; due to this remoteness the buildings are almost always far from firefighting assets/stations. This means longer reaction time that gives an advantage to the spread of the fire. G/GS fires usually start in a discrete point and can quickly spread through the combustible materials. Although there have been relatively few documented serious greenhouse fires, each occurrence has taken place where there was high potential fire risk. This high fire risk leads to a high fire consequence, consequences including loss of life and serious property damage. Risk factors commonly associated with G/GS fires are as follows:

- Size of the operation;
- Structural materials used;
- Glazing/covering materials used;
- Machinery and equipment maintenance;
- The use of automation including production;
- Lighting, and
- Environmental control systems.

2.2.1 Material Use and G/GS Fires

Materials used within greenhouses are chosen for their useful growing properties and features, however, the same materials may have unforeseen risks associated with fire susceptibility and/or exacerbation. Combustible materials commonly used in G/GS are plastic glazing materials, shade cloth, energy curtains, containers, packaging products, stored chemicals and fertilizers, and plant materials.

It is a common misconception that metal-framed buildings, which is a common greenhouse construction method, are "fireproof"[9]. Unlike timber, metal has a negligible fire spread rating. It is however common for an unprotected metal framed building to fail much sooner than its hardwood timber counterpart in the event of a fire. Strength of steel decreases rapidly when a structural element becomes hot; this can result in a complete structural collapse long before actual flames spread through the building.

REF: CoP 3.3

Consultation with fire engineers has determined that a solid hardwood timber column/post will typically remain structurally sound for a longer period of time in the event of a fire than its steel counterpart.[10]

All plastic materials used as greenhouse glazing or shade cloth are combustible and need to be protected from high heat sources and open flames. Edges of glazing tend to be more susceptible to ignition than a flat surface. As such, the edges should be protected with a non-combustible material. When shade cloth or glazing is ignited or exposed to flame the polymers melt and drip. Dripping polymers cause damage to protected crops and can have the serious potential of igniting other flammable materials.

REF: CoP 3.3.2 & 5.4.2

[9] JONES, E. 2011. Preventing Greenhouse Fires. *Greenhouse Management*.
[10] LEE, C. April 2014.

Fire-retardant glazing and shade cloth has market availability and several manufacturers have had Australian testing complying with AS 1530.2.1993 and USA Standards. Manufacturers, such as Polyfab Australia, use new-generation technology that enables flame resistant additives to work with ultraviolet stabilisers to ensure maximum flame resistance while still offering long-term UV protection.[11] Fire-retardant shade cloth is generally more costly than standard shade cloth. As such, several G/GS designs within the USA have taken to effectively creating greenhouse divisions by installing wall and roof panels of flame-resistant glazing, this act as firebreaks and compartmentalisation[12]. These fire-resistant panels discourage fire to spread throughout the entire G/GS, through compartmentalisation. This compartmentalisation reduces the severity of the fire and losses. It should be noted that there were no identified laboratory tests to verify the effectiveness of this procedure, but field tests indicate that it can be an effective fire precautionary measure.

REF: CoP 3.3.2 & 5.4.2

REF: CoP 5.4.3

2.2.2 Fire Extinguishers and G/GS Fires

Fires start small and grow larger with the availability of time and fuel; an appropriate fire extinguisher in the hands of an experienced person can often prevent a small fire from becoming a major loss. Each workplace building (including G/GS) should have the appropriate types of fire extinguishers for all possible fire hazards. Extinguisher placement is stipulated within the relevant Australian Standard or by the instruction of a Professional Fire Engineer.

REF: CoP 5.4.8

Fires can be categorised into the following four (4) groups. These are:

- **CLASS A:** Paper, Wood, Cardboard
- **CLASS B:** Solvents, Paint, Petroleum, Methylated Spirits
- **CLASS E:** Electric fires
- **CLASS F:** Cooling oils and fats

Extinguishers can be categorised into the following five (5) main groups[13]. These are:

- **Carbon dioxide fire extinguisher**
  Carbon Dioxide fire extinguishers are recommended for Class 'E' electrical hazard fires, but also have limited capabilities for extinguishing small, indoor Class 'A' paper and Class 'B' flammable liquid fires.
- **Water fire extinguisher**
  Air/Water Fire Extinguisher contains water under pressure and is

[11] POLYFAB. 2014. *Polyfab Australia - FR Comshade* [Online]. Available: http://www.polyfab.com.au/11683.htm [Accessed Feb 2014.

[12] NGMA 2010. National Greenhouse Manufacturers Association Fire Safety. *In:* ASSOCIATION, N. G. M. (ed.) *3.C Fire-Retardant or Fire-Safe Screens.*

[13] EXTINGUISHERS. Unkown. *Types of Fire Extinguishers in Use* [Online]. Available: http://www.typesoffireextinguishers.com.au/typesoffireextinguisherstouse.html [Accessed Feb 2014.

to be used in an upright position. It is designed for use on solids such as wood, paper, rubbish or textiles, and has a discharge period of 60 - 100 seconds. Water extinguishers are unsuitable for flammable liquid fires.

- **Foam fire extinguisher**
  Air/Foam Fire Extinguisher contains an aqueous film-forming foam additive and is to be used in an upright position. It is designed for use on flammable liquid fires such as petrol, oils and paint. This extinguisher must not be used on fires involving live electrical equipment.
- **Dry chemical fire extinguisher**
  A 'BE' dry chemical fire extinguisher can be effectively used on fires involving live electrical equipment or flammable liquids and cooking oil. The 'ABE' fire extinguisher is recommended for fires where wood, paper, flammable liquid or live electrical equipment are involved.
- **Wet chemical fire extinguisher**
  Wet Chemical Fire Extinguisher contains a liquid alkaline extinguishing agent and is specifically designed for use in commercial kitchens on deep fryer fires involving fat and cooking oil. These extinguishers must never be used on fires involving live electrical equipment

Determining the most effective extinguisher location is important; it is a general rule to locate extinguishers close to the potential hazards (be it greenhouse C02 generator, fans and motors and areas of stored combustibles and accelerants), in the middle of long aisles and near external doorways.

2.2.3 Water Storage for Fire Fighting Purposes

State/Local Government applies policy in relation to above ground water storage tanks for firefighting purposes. Policies are in addition to the requirements found in the relevant Australian Standards for water storage tanks for firefighting purposes. The services of a Professional Fire Engineer may need to be sought to determine appropriate water storage for each particular G/GS.

2.2.4 Egress

The concept of occupant egress implemented through building regulations involves the provision of a designed and designated means of egress for a building. Egress should be an unobstructed path from any point in the building to the outside. Proper design includes the width of the spaces and doors, direction of door swing, lighting and marking, protection from the fire and its effects, and also the geometry of stairs or ramps. Limiting travel distances to reach a means of egress or common paths of travel, dead ends, and the provision of alternate means of egress, if the primary path is blocked by fire, are basic concepts of egress design. Part D of the NCC 2013 Building Code of Australia – Volume One provides Provisions for the aforementioned.

REF: CoP 3.3.3 & 3.3.12

Assuming a G/GS is classified as a Class 10 building the following Deem-to-Satisfy Provisions are imposed when referring to Part D1 'Provision for Escape' within the BCA. These are:

- All buildings (any Class) – Every building must have at least one exit from each story.[14]
- Minimum exit travel distances are not specified. [15]

However, if the G/GS is classified as Class 8 the following Deem-to-Satisfy Provisions are imposed when referring to Part D1 'Provision for Escape' within the BCA:

- Every building must have at least one exit from each story; a minimum of two (2) exits must be provided is the building has an effective height of more than 25 m. [16]
- No point on the floor must be more than 20 m from an exit, or a point from which travel in different directions to two exits is available, in which case the maximum distance to one of those exits must not exceed 40 m. [17]

The International Building Code provides the following egress provisions. These egress provisions are specifically for agricultural buildings that are of a compliant building type; G/GS are a compliant building type.

The means of egress for a G/GS building shall comply with the applicable provisions of Chapter 10 of the IBC, based on an occupant loading factor of 1 person per 30 m2 of the gross floor area. Both statements below must be adhered: [18]

- The maximum travel distance from any point in the building to an approved exit shall not exceed 91,440 mm.
- One exit is required for each 1390 m2 of area or a fraction thereof.

[14] NCC 2013d. Part D1.2 Building Code of Australia: Volume One. *In:* SERIES, N. C. C. (ed.).
[15] NCC 2013e. Part D1.4 Building Code of Australia: Volume One. *In:* SERIES, N. C. C. (ed.).
[16] NCC 2013d. Part D1.2 Building Code of Australia: Volume One. *In:* SERIES, N. C. C. (ed.).
[17] NCC 2013e. Part D1.4 Building Code of Australia: Volume One. *In:* SERIES, N. C. C. (ed.).
[18] ICC 2012a. International Building Code, Appendix C: Group U Agricultural Buildings.

2.3 Structural Design: G/GS Design and Construction Materials

2.3.1 Existing Construction Materials

There are two types of greenhouses commonly used around Australia. These are:

- Steel frame with glass cladding, these are also known as glasshouses, and
- Steel frame with polycarbonate (impermeable plastic membrane)

Greenhouse frames (support structure) may be constructed of timber, steel, aluminium or concrete. Modern greenhouses are usually constructed of steel or aluminium. Aluminium generally provides a stronger, rust resistant, lightweight frame but can be significantly more expensive than steel and timber. Timber is typically used for low technology G/GS. Timber can be difficult and expensive to maintain as it needs to be treated with a preservative and may require periodically painted to prevent rotting.

REF: CoP 3.0

Floors may be constructed of porous concrete, reinforced concrete, gravel or compacted clay covered with a strong polypropylene fabric. Porous concrete is usually strong enough to bear most loads encountered in greenhouse situations and allows for drainage through the surface. Reinforced concrete is more expensive and does not allow drainage through the surface.

However, reinforced concrete might be desirable in traffic areas where heavy loads occur. Concrete floors (unless used as part of the irrigation system) should have a slight grade to promote drainage and prevent puddling of water. Gravel is low cost and allows drainage, but can allow the growth of weeds and may not accommodate all types of equipment. Polypropylene fabric (weed mat) can be a low-cost alternative and can be combined with gravel, but the floor can become uneven over time, can cause puddling and algae growth.

As shown above there are three cladding systems commonly used on G/GS in Australia, these are glass panes, polycarbonate panels and poly-films or netting.

Polycarbonate panels are made from clear, rigid plastic that transmits light almost as well as glass. Panels are typically available as flat twin-wall panels, these contain two flat polycarbonate panes separated by an air space. The air space between panes improves the insulation properties of the panels.

REF: CoP 3.0

Though more expensive than poly films, polycarbonate panels are cheaper than glass within a greenhouse application. The benefit of polycarbonate is that it is almost as durable as glass while its weight is considerably less. This makes it much easier to handle and install. However, polycarbonate panels have a tendency to yellow over time which can reduce the light transmitting efficiency of the panel.

Twin-wall polycarbonate panels include a rating, in mm, that indicates the size of the separation between the individual polycarbonate panels (e.g. 4mm twin-wall panels have a 4mm air space between the panels). A larger gap between the panels provides better heat insulation properties. The lowest-price option, poly film can be a good option for G/GS where budgets are small and long-term useful life is not as important. Poly films are easy to work with, but they are the least permanent option for G/GS.

Poly films are often rated in terms of the number of useful growing seasons (e.g. 1 year useful life, 4 year useful life), this is the films life expectancy. The useful life of poly film is determined by a number of factors. These are:

- Climate;
- Film thickness;
- UV treated/stabilised;
- Installation quality; and
- Chemical attack from horticultural spray.

If a UV stabilizer has been applied to the film, it is important to check if the stabilising agent has been applied to both sides of the film. If treatment has only been applied on one side it is important to install the treated side facing the sun.

Glass is the highest-quality, highest-price option for G/GS. It is the heaviest material and so can be the most difficult to install. If installed correctly and protected from shattering, glass outlasts any other plastic option in terms of useful life. It must be noted that not all glass is the same. Annealed glass can be dangerous for greenhouse applications. When it breaks, annealed glass shatters into long, sharp shards which may cause injury. Tempered glass is four to six times more shatter-resistant than annealed glass, and when it breaks it breaks into small square pieces, making it unlikely to cause injury. There are different varieties of tempered glass (single tempered, double tempered, and more) with various tensile strengths.

2.3.2 New/Innovative Construction Materials

New and innovative construction materials show promise as future structural and glazing materials in the greenhouse and grow structure industry. Fibre composites are a prime example of this. Fibre composites are materials made from two or more constituent materials with significantly different physical and chemical properties, that when combined, produce a material with different characteristics from the individual components.[19]

Composite materials are not a new discovery, nor do they remain a costly and unrealistic alternative to existing construction materials. Concrete, for example, is one oldest and most commonly used composite which is reinforced by particles. More recent developments in composites include:

- Composites reinforced by chopped strands;
- Unidirectional composites;
- Laminates, timber ply sheeting is one such example;
- Fabric-reinforced plastics;
- Honeycomb composite structure.

Fibre-reinforced plastic (FRP) has become a notable material in structural engineering application over the past decades. Studies by academic institutions are continuing to document the potential benefits in construction. Cost-effectiveness has also been modelled against traditional concrete, masonry, steel, cast iron, and timber structures and found to be encouraging in future predictions. The fibres are usually glass, basalt, carbon or aramid while the polymer usually consists of epoxy, polyester thermosetting plastic or vinylester.[20]

Though promising, fibre-reinforced plastics are not currently being produced at a rate, consistency and controlled quality to be applicable as an alternative to steel or timber within a G/GS.

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[19] DURAND, L. P. 2008. *Composite Materials Research Progress*.
[20] SPRINGER, G. 2014. Fibre and Plastic - Stanford University. *Journal of Reinforced Plastics and Composite*.

2.4 Structural Design: Wind Loading

2.4.1 Existing Loading as per AS/NZS 1170.2

AS/NZS 1170.2:2011 Wind Actions (incorporating amendment numbers 1, 2 and 3) set out procedures for determining wind speeds and resulting wind actions to be used in the structural design of structures subjected to wind actions. The processes of determining wind actions on structures as per AS/NZS 1170.2 are as follows:

a) Determine site wind speed (AS/NZS 1170.2 Clause 2.2).
b) Determine design wind speed from the site wind speeds (AS/NZS 1170.2 Clause 2.3).
c) Determine design wind pressures and distributed forces (AS/NZS 1170.2 Clause 2.4).
d) Calculate wind actions (AS/NZS 1170.2 Clause 2.5).

REF: CoP 4.1

Determining the correct/most appropriate annual probability of exceedance for each structure is also very important for structural safety and economic viability. Obtaining annual probability of exceedance is a two-step process.

Firstly, the importance levels of a structure shall be determined in accordance with Table F1 of AS/NZS 1170.0. Importance levels for G/GS are defined by the proposed use of each structure. It's common for low technology G/GS (steel hooped frames with plastic membrane) to have an Importance Level of 1 'LOW' consequence of failure; this low importance level is associated with a low consequence for loss of human life, or small or moderate economic, social or environmental consequences. Medium to high technology G/GS tend to have an Importance Level of 2 'ORDINARY' consequence of failure; definition of this is medium consequence for loss of human life, or considerable economic, social or environmental consequences.

Table 2.1
Structure Types for Importance Levels[21]

Consequence of failure	Description	Importance Level	Comment
Low	Low consequence for loss of human life, or small or moderate economic, social or environmental consequences	1	Minor structures (failure not likely to endanger human life)
Ordinary	Medium consequence for loss of human life, or considerable economic, social or environmental consequences	2	Normal structures and structures not falling into other levels
High	High consequence for loss of human life, or very great economic, social or environmental consequences	3	Major structures (affecting crowds)
		4	Post-disaster structures (post disaster functions or dangerous activities)
Exceptional	Circumstances where reliability must be set on a case by case basis	5	Exceptional structures

[21] AS 2002a. AS/NZS 1170.0 General Principals, Table F1. *In:* AUSTRALIA, S. (ed.).

Once the importance levels have been identified the annual probability of exceedance can be found through Table F2 in AS/NZS 1170.0.[22] The BCA requires that regional wind speeds of specific probability be used for building design. The more important the building, the less the allowable risk that the design speed will be exceeded in any one year and the higher the speed required in the design. Regardless of their importance level or classification, buildings should not fail when subjected to the wind event for which they are certified to withstand. Common engineered design working life of wind loading for low technology G/GS's is 25 years while high technology G/GS's tend to have a design working life of 50 years.

REF: CoP 4.1 & 2.1

2.4.2 Potential for Loading Reductions

AS/NZS 1170.2:2011 Wind Actions (Incorporating Amendment Nos 1, 2 and 3) notes in 1.1 SCOPE that: "The standard is a stand-alone document for structures within specified criteria. It may be used, in general, for all structures but other information may be necessary." And "Further advice, which may include wind-tunnel testing, should be sought for geometries not covered in this Standard, such as unusual roof geometries or support systems, very large roofs, or the roofs of podium at the base of tall buildings." [23]

REF: CoP 4.2.2

Where appropriate, engineers have the option to utilise AS 1170.2 in conjunction with European Standard numbered EN 13031-1 Greenhouses – Design and Consideration.

EN 13031-1 provides an engineer with external pressure coefficients c_{pe} for common greenhouse structural geometries which are not documented within AS 1170.2. [24]

REF: CoP 4.2.1

[22] AS 2002b. AS/NZS 1170.0 General Principals, Table F2. *In:* AUSTRALIA, S. (ed.).
[23] AS 2011. AS/NZS 1170.2: Wind actions, 1.1 Scope. *In:* AUSTRALIA, S. (ed.).
[24] ES 2001. EN 13031-1 Greenhouses - Design and construction. *In:* STANDARDS, E. (ed.).

3.0 Ethics and Risk Assessment of Completing Project

3.1 Consequential Effects / Implications / Ethics

As a single entity, Osborn Lane Consulting has an ethical responsibility to itself, its clients, staff and the wider community. Osborn Lane also needs to control how it responds to unforeseen circumstances and how that response will affect parties it has a responsibility to. During the process of this project the firm and its contributing consultants must consider the effects (both ethical and consequential) the recommendations within this report may have on all involved.

Consequential effects can be analysed through two opposing channels, the first being “effects without recommending change” and the other being “effects when recommending change”. Recommending changes can have many positive effects on the G/GS industry; the main objectives of this project being reducing cost of compliance for construction of G/GS’s and provide guidelines for a consistent building approval approach across Australia.

Recommending changes can also have serious negative effects on the G/GS industry – making large, unsubstantiated recommendations without providing supporting research and thorough consultation with professionals could prove to be very dangerous. Fire and egress is one such area which requires systematic and exhaustive analysis into consequential effects and risk assessment.

Osborn Lane Consulting Engineers’ Workplace Health and Safety and Environmental Policy can be found in Appendix B and C respectively.

3.2 Risk Assessment

Risk assessment in an important factor in protecting staff, clients, the company and the wider community from danger; risk assessment can be described as an in-depth analysis of what could cause physical, emotional or financial harm to any effected group – protective and preventative measures have been taken by the company in relation to this project in the aim to control risk associated with the recommendations given.

Each individual recommendation given in the Code of Practice has had an associated risk assessment completed.

Recommendations given by Osborn Lane within this project are the result of research, interpretation of National and International Codes and consultation with professionals in the field of investigation. Osborn Lane Consulting does not take responsibility for action taken upon the documented recommendations; construction, design and/or approval upon the recommendations given within this project is not endorsed without obtaining specific, independent professional advice in respect of the matters set out in this document and associated appendices.

4.0 Consultation and Field Investigations

4.1 Professional Consultation

Consultation with professional fire engineers and building certifiers during the project underpins most recommendations made within the Code of Practice document.

Fire Engineer

Fire engineers have provided comments and feedback regarding Section 3 of the Code of Practice document – feedback included general risk assessment alterations, technical specifications for materials, information regarding behaviour of materials in the event of a fire, and general farm management protocol that has the potential to reduce risk and spread of fire.

Building Certifier

Recommendations made in Section 2 of the Code of Practice have been reviewed by a building certifier.

Greenhouse Manufacturer

Several G/GS manufacturers have made general comment about the G/GS industry in Australia – they identified that it was important to work with certifiers and engineers who have experience in dealing with the unique issues facing the protective cropping industry.

4.2 Field Investigations

A project questionnaire was completed by known interested growers. The document was also disseminated over the Protected Cropping Australia database – ten (10) responses were received over the length of the project, these responses provided invaluable insight and experience when determining what issues most affect growers.

Below are summaries of each completed questionnaire. The identification of each grower has been kept confidential to ensure anonymity of the grower, their farm and farming processes.

4.2.1 Site One: Regional Victoria, Australia

Grower Identification: Grower VICa

Typical crops being produced: Hydroponic seedlings, tomatoes and capsicums
Type of G/GS: Glass and steel Dutch Venlo
Technology level: High
Total area under G/GS: 26 ha

Site visit undertaken: Yes

Field Investigation Findings:

Grower VICa has identified that they are HAL levy paying growers.

Glasshouses are imported from Netherlands through the Dutch Venlo company. The greenhouses are provided with frameworks, fastening elements, glazing and steel zinc-coated metalware. Frameworks and gutters are made of aluminium, metalware for fixation and aluminium construction. Construction meet European standard EN 13031. [25]

Grower VICa's history with DA (Development Approval) and council compliancy is as follows. The first Dutch Venlo greenhouse constructed onsite required fire and egress requirements; these requirements were hydrant booster pumps, a fire ring suppression system and illuminated exit signs. Before construction of successive glasshouse structures Grower VICa approached a building surveyor and a fire engineer to investigate and engage in reducing cost of compliance. The fire engineer completed a risk assessment in relation to the possible outcomes in the event of a fire – this risk assessment was presented to local council and CFA officials which delivered an outcome that was acceptable to the grower.

DA concessions are directly related to fire and egress requirements applicable to all future glasshouse structures constructed on the growers property. Some practical fire and egress requirements were still imposed on new developments after the concession was implemented. One such requirement was the installation of fire hose reels at locations specified by the fire engineer. Other imposed requirements were the construction of concrete fire rated walls (60 minutes) between the plant equipment room and the growing areas. The installation of break-glass sensors that activate the H^2O misting/fog system which remains active till disengaged is an alternative to the fire ring suppression system that has been approved by CFA and local Council. Misting/fog fire suppression systems utilise existing infrastructure used during daily operation of the glasshouse and therefore do not require layout of dedicated fire suppression systems that may never be used. Fire extinguishers are also located at each exit and control panels.

[25]VENLO. 2010. *Venlo Greenhouse Construciton* [Online]. Available: http://www.venloprojecten.com/en/index.php?page=1 [Accessed March 2014.

Exits and egress in all glasshouses are approved by Council and CFA; exits are at the end of each row and provide a maximum escape path of 126 meters. Glass wall panes could also be shattered in the event of a fire if alternative escape is required. Emergency evacuation plans and procedures are conveyed to all staff and site visitors.

Grower VICa has not experienced structural failure due to extreme natural events nor has there been documentation of fire in any of the glasshouses onsite. Glasshouses are maintained meticulously and are kept clear of combustible materials.

4.2.2 Site Two: South-East Queensland, Australia

Grower Identification: Grower QLD

Typical crops being produced: Cucumbers
Type of G/GS: Impermeable plastic membrane on hooped steel structure
Technology level: Low
Total area under G/GS: 5.4 ha

Site visit undertaken: Yes

Field Investigation Findings:

Grower QLD has identified that they are HAL levy paying growers.

Greenhouses are imported from Adelaide, SA and constructed from steel hoops, timber/steel column supports and are covered with an impermeable plastic membrane. The greenhouses have been in operation for 20+ years and mainly produce cucumbers year round. All sides of the greenhouses remain operable throughout the growing season. There has been no extreme natural event (storm/hail etc.) that has caused structural failure documented on Grower QLD's property, nor has a fire.

The property is in a semi-rural area with houses all around. Grower QLD has had issue with residential complaints regarding noise pollution from tractors and other farming machinery, spraying and visual pollution.

Grower QLD has recently had to apply for a DA through the Logan City Council for the existing greenhouses. The process of obtaining BA has been a problematic, protracted occurrence which has caused the grower economic and emotional hardship. Grower QLD accepted that DA would have to be completed however it was the unknowingness and professional inexperience throughout the process which caused issues. These issues were:

- Local Council was unable to provide the grower with a uniform response to what process was required to complete the DA efficiently. Council was also unable to provide council fees associated with the DA process. After meeting with Grower QLD, Marcel Olivotto from Osborn Lane Consulting contacted a member of Logan City Councils Planning Department to request further information regarding the process of BA for greenhouse structures. The response from Council that was received was "DA requirements are a case-by-case issue and are dependent on the council certifier. Council does not have documented guidelines that outline what is required [for the completion of greenhouse DA]."
- To obtain structural certification of the existing greenhouses a large Brisbane based engineering firm was engaged – This resulted in the apparent noncompliance of the existing structural columns [presumably for wind loading], the only remediation measure that was offered to the grower was to replace all existing columns with a

larger size. Grower QLD was unpleased with this result and acquired a second opinion through an alternative engineering firm. The second firm was much more experienced in the design of low technology greenhouses and found the greenhouses were structurally adequate for both strength and service loading and as such no additional work was needed. Through experience it is evident that applying wind loading to low technology greenhouses, specified in AS/NZS 1170.2 Wind Loading Code can be unnecessarily conservative if the entire structural system is not understood.

Fire and egress regulation was not imposed during the DA process though Grower QLD has identified that several other growers in the area were required to comply with fire and egress during BA of new and existing greenhouses.

Grower Project Recommendation:

Produce design and classification guidelines for local councils to adhere to.

4.2.3 Site Three: West Sydney, New South Wales, Australia

Grower Identification: Grower NSWa

Typical crops being produced: Hydroponic Tomatoes and Cucumbers
Type of G/GS: Impermeable plastic on hooped/sawtooth steel structure
Technology level: Low
Total area under G/GS: 0.68 ha

Site visit undertaken: Yes

Field Investigation Findings:

Grower NSWa has identified that they are HAL levy paying growers.

Greenhouses were constructed onsite from steel hoops, steel columns and are covered by impermeable plastic membrane. The property is in a semi-rural area with several new housing subdivisions expected within the area over the next decade. Grower NSWa began building greenhouses on his property 20+ years ago and had not had any issue with design or council approval processes and outcomes.

Grower Project Recommendation:

Though Grower NSWa has not experienced an issue with design or council approval processes, he has provided recommendations in regards to G/GS approval processes. Grower NSWa has concerns that BA is not being completed homogeneously throughout the local regulatory body; he and other growers in the area are well aware of which certifiers within council are more or less stringent with approvals. Without documented regulatory/approval guidelines certifiers are left to determine compliance on the basis of previous knowledge and/or simply applying non-realistic pro forma which would otherwise be relevant for permanent industrial Class 8 buildings. Grower NSWa has identified several cases where local council has requested that growers reduce the height of pre-purchased greenhouse from France by removing 0.5m to 1.0m from the column lengths to ensure the building does not exceed a height of 4m, this height reduction has had negative impacts on quality and quantity of produce under such G/GS's.

4.2.4 Site Four: Tasmania, Australia

Grower Identification: Grower TAS

Typical crops being produced: Hydroponic Tomatoes and Seedlings
Type of G/GS: Pitched Glasshouse and Impermeable plastic on hooped/sawtooth steel structure
Technology level: High
Total area under G/GS: 1.1688 ha (excl. seedling structure)

Site visit undertaken: Yes

Field Investigation Findings:

Grower TAS has identified that they are HAL levy paying growers.

Two hydroponic tomato growing G/GS's are located onsite. The greenhouse constructed in 2007 is fabricated from steel and glass with a pitched roof profile while the greenhouse constructed in 1998 is fabricated from steel and impermeable plastic with a hooped roof profile. The first greenhouse was imported from France (Richel Greenhouse) while the second was imported from New Zealand (Faber Greenhouses).

Grower Project Recommendation:

Grower TAS recommended that this project documents design and classification guidelines for local councils to adhere to. This grower also recommended the development of a risk assessment protocol which would be used when determining fire and egress risk on individual G/GS buildings.

4.2.5 Site Five: South Australia, Australia

Grower Identification: Grower SA

Typical crops being produced: Hydroponic lettuce
Type of G/GS: Steel cable flat roofed panel system, permeable netting
Technology level: Low
Total area under G/GS: 4.0 ha

Site visit undertaken: Yes

Field Investigation Findings:

Grower SA has identified that they are HAL levy paying growers.

Grower has been in operation for approximately 20 years, during this time the farm has produced hydroponic lettuce and Asian greens for a dominantly domestic market. The steel cable with permeable membrane structure did not require specific fire and/or egress requirements other than an appropriate WH&S policy which includes an emergency response plan. The structure has not experienced failure due to winds, fire or other extreme environmental events other than localised hail damage which is expected with this type of construction.

Grower Project Recommendations:

Grower SA identified the following two (2) recommendations for the project, these are:

1. Material Usage – Grower SA encourages manufactures and growers to use materials best suited for the desired application.
2. Netting Replacement – Grower SA also recommended that growers only replace severely damaged or degraded netting; smaller areas of netting that require repair can be easily patched.

4.2.6 Site Six: New South Wales, Australia

Grower Identification: Grower NSWb

Typical crops being produced: Fresh culinary herbs
Type of G/GS: Venlo double gable
Technology level: Mixed
Total area under G/GS: 1.0 ha

Site visit undertaken: No

Questionnaire Findings:

Grower NSWb has identified that they are HAL levy paying growers.

Grower NSWb have G/GS constructed of both steel and glass and steel and impermeable membrane on their site. Structural engineering certification was obtained for the G/GS through Faber Greenhouses and the building was required to be inspected independently by the Lismore City Council as part of the final certification of occupancy. The development application required the following:

1. A certificate from a consulting engineer, certifying the footings and structural steel framework;
2. A copy of the geotechnical report, certifying the bearing capacity and compaction of the glasshouse pad with attention to the bearing pressure of the footings;
3. Certificates to be provided from the glazing provider, certifying that the glazing complies with Australian Standards;
4. Additional exit points, as indicated from a Fire Service Engineer;
5. A copy of a fire safety statement, certifying the following is in place:
    a. Emergency evacuation plan;
    b. Emergency exit operation;
    c. Portable fire extinguishers.
6. Adequate staff toilet amenities required to be provided prior to occupation of the Glasshouse.

The structure(s) have not previously failed due to winds, fire or other extreme environmental events.

Fire and egress requirements were imposed on the G/GS during the design and approval stage; escape doors/kick-out panels were required on walls at 25 meter maximum apart. Evacuation plans, staff education and procedures were also required. Evacuation plan was a minimal cost and an invaluable asset to the safety of staff and protection of the G/GS.

Certification of G/GS glass was a major issue when completing the local council development application information request. Roof glass needed to be toughened so that it shatters into small pieces. Wall glass is typically ‘float glass’ which is dangerous if broken, especially if broken by a person jumping through it.

Grower NSWb was happy with the development application approach taken by the local Council.

4.2.7 Site Seven: Regional Victoria, Australia

Grower Identification:	Grower VICb
Typical crops being produced:	Fresh culinary herbs
Type of G/GS:	Steel and impermeable membrane
Technology level:	Mixed
Total area under G/GS:	0.6 ha (3 structures)
Site visit undertaken:	No

Questionnaire Findings:

Grower VICb has identified that they are HAL levy paying growers.

Structural engineering certification, local government approval and fire/egress requirements were obtained for the steel and impermeable membrane G/GS structures. Grower VICb noted that cost reduction of G/GS could occur though the design of G/GS to enable staff to work at heights; this will be used when replacing impermeable membrane covers.

Grower VICb has identified membrane/covering failure in the event of storm events with winds exceeding 130 km/hr and 170 km/hr.

4.2.8 Site Eight: South Australia, Australia

Grower Identification: Grower SAb

Typical crops being produced: Herbs
Type of G/GS: Sawtooth, Steel and Glass
Technology level: Mixed
Number of G/GS: Approximately 13 structures onsite

Site visit undertaken: No

Questionnaire Findings:

Grower SAb has identified that they are HAL levy paying growers.

Structural engineering certification and local government approval was required though fire and egress requirements were not – Grower SAb utilised an experienced engineer who was able to reduce classification of the structure which enabled the exception of fire and egress requirements.

Minor structural failure has been documented for the site, this was due to wind events. Grower SAb believes the only preventive measure would have been installing wind breaks.

4.2.9 Site Nine: New South Wales, Australia

Grower Identification: Grower NSWc

Typical crops being produced: Raspberry's
Type of G/GS: Tunnel profile, steel and impermeable membrane
Technology level: Mixed
Number of G/GS: Approximately 8 structures onsite

Site visit undertaken: No

Questionnaire Findings:

Grower NSWc is <u>not</u> a HAL levy paying grower. Questionnaire has been included due to issues with Local Council. Grower NSWc indicated that he will soon become a levy paying member of HAL.

Grower NSWc found dealing with Local Council very difficult – Council was not experienced in the certification of G/GS structures. The structure was purchased from a Chinese manufacturer, structural certification was also difficult as Local Council required detailed plans and steel specification before approval.

4.2.10 Site Ten: Regional Victoria, Australia

Grower Identification: Grower VICc

Typical crops being produced: Tomatoes, herbs, lettuce, eggplant and Lebanese cucumber
Type of G/GS: Sawtooth profile, steel and impermeable membrane
Technology level: Mixed
Number of G/GS: 3 structures onsite

Site visit undertaken: No

Questionnaire Findings:

Grower VICc has identified that they are HAL levy paying growers.

Structural engineering certification, local government approval and fire/egress requirements were not obtained for the steel and impermeable membrane G/GS structures. Grower VICc has identified that they are required to maintain a 250,000 litre water tank for firefighting purposes, a separate tank is also installed onsite with a CFA approved hose coupling attached in preparedness for a fire event.

Grower VICc has stated that the local government approval was difficult.

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Appendix A

Example Risk-Point Matrix Assessment

The following Risk-Point Matrix Assessment has been completed as a process example. This example should only be used as an assistive guide to the steps identified in Section 3.3 'Simplified Method of Risk-Point Matrix Assessment.'

The following parameters have been selected from an existing G/GS which was site investigated during the completion of this document. Site location shall remain anonymous to protect the grower's anonymity.

Example G/GS parameters are as follows:

- G/GS Size 1.2 ha
- Glazing/Covering Type Film Plastic Membrane
- Value of Crop & G/GS Crop = $40,000/year; G/GS = $60,000
- Location of G/GS Semi-rural
- G/GS Height 3.5 m
- Distance from Buildings 17 m
- G/GS Tech Low

Making reference to Section 3.3 of the Code of Practice, results for each step are documented below.

3.3.1 STEP 1 – Determine G/GS Size

The G/GS is 1.2 ha and therefore falls within Band 2 of Table 3.1.

Answer = Band 2

3.3.2 STEP 2 – Glazing/Covering Type: (Flammability)

G/GS glazing is Film Plastic Membrane (FPM), FPM falls within the Plastic Membrane category.

Answer = Plastic Membrane (PM)

3.3.3 STEP 3 – Grazing Type: (Egress)

As per STEP 2, glazing is FPM.

Answer = FPM

3.3.4 STEP 4 – Glazing Type: (Smoke)

As per STEP 2 & 3, glazing is FPM.

Answer = FPM

3.3.5 STEP 5 – Lighting

There is no assimilation lighting installed in the G/GS

Answer = N.A.

3.3.6 STEP 6 – Value of Crop & G/GS

Value of the crop per year is $40,000 while the value of the G/GS is $60,000. As per Table 3.2, value of both the crop and G/GS are within the 'Average' category.

Answer = Average

3.3.7 STEP 7 – Other Flammable/Combustible Items

This G/GS has the following combustible items. These are:

- Cardboard growing containers;
- Combustible pallets; and
- Dry vegetation.

Answer = Flammable/combustible items are present.

3.3.8 STEP 8 – Environmental Control Systems

No environmental control systems are installed in this G/GS

Answer = Low Tech, N.A.

3.3.9 STEP 9 – Location of G/GS

The G/GS is located in a semi-rural zone as per the Local Government planning scheme.

Answer = Semi-rural

3.3.10 STEP 10 – Distance from other buildings

The G/GS has a minimum distance of 17 metres from all buildings and boundaries. As per Table 3.4 (building height less than 6 metres) the G/GS is within 'Distance 1.'

Answer = Distance 1

Now that STEP 1 to STEP 10 has been completed under Section 3.3 it is appropriate to proceed to Section **3.3.11 STEP 11 – Risk-Point Matrix**.

Using relevant tables and information, determine the Risk-Points for each of the elements outlined in Table 3.6. Tally, through addition (+), the Risk-Points for each element to give a Total Risk-Point for the STEP 1 through to STEP 10.

The example completed above give the following risk points per step. These are:

Example Risk Points Obtained

STEP	Answer	Table 3.6 Risk Point
1	Band 2	3
2	PM	5
3	FPM	4
4	FPM	2
5	N.A.	0

6	Average	3
7	Flammable/combustible items	5
8	Low Tech, N.A.	0
9	Semi-rural	3
10	Distance 1	3
	TOTAL	**28**

The tallied Risk-Point has given a value of **28**.

Proceeding to 3.3.12 STEP 12 – Risk-Point Assessment Result and making reference to Table 3.7 determines that this specific G/GS can be classified as a 'Medium Risk' G/GS.

Section 3.3.12.2 'Medium Risk' of the Code of Practice specifies the following recommendations for a medium risk G/GS.

3.3.12.2 Medium Risk

A G/GS that falls within the 'Medium Risk' Risk-Point Result Bracket (see Table 3.7) exhibits a medium risk of a catastrophic fire event. This assessment is dependent on the following conditions:

- That good farm practices and management are implemented within the farm (see Section 5.0 Farm Management and General Practices);
- Relevant Codes are adhered to, especially in relation to Egress (See Section 2.0);
- All electrical work has been installed in strict accordance with Local, State and Federal Standards by a qualified professional electrician;
- The Grower is aware of the heightened fire risk and has incorporated appropriate measures within the farm's Occupational Health and Safety Procedure; and
- Maintenance is carried out to the manufacturer's recommendations and all electrical equipment is tested and tagged 6 monthly.

Expectation of Fire Engineers Consultation: Though not recommended for all G/GS within the 'Medium Risk' bracket, it is at the discretion of the certifier to request the services of a Professional Fire Engineer. Growers should be made aware of this consultation and the associated fees. Common Professional Fire Engineer recommendations for a G/GS with Medium Risk are as follows:

- Emergency operation manual is produced and maintained to ensure all staff are aware of any risk and evacuation procedures that are to be followed in the event of an emergency.
- Emergency equipment such as extinguishers and hose reels are tested at intervals as required by AS 1851-2012.

Appendix B

A Partnership of
Osborn Lane Pty Ltd A.C.N 061 799 979
& Gremfield Pty Ltd A.C.N 073 121 258
A.B.N: 51 132 296 754

A QUALITY ASSURED SUPPLIER

OSBORN LANE
CONSULTING ENGINEERS

HEALTH AND SAFETY POLICY

Osborn Lane Consulting Engineers considers workplace health and safety as an integral part of the success of the organisation and is committed to providing a safe and healthy work environment for all employees, contractors, clients and members of the public.

Osborn Lane Consulting Engineers will do this by eliminating or, where this is not practicable, managing workplace health and safety hazards to prevent all injuries, illnesses and dangerous events.

The responsibility for managing workplace health and safety ultimately rests with management, but employees also have important responsibilities that must be met.

Management is responsible for:

- Ensuring the company complies with all legislation relating to workplace health and safety
- Eliminating or minimising all workplace hazards
- Providing adequate information, procedures and training to enable all employees and contractors to do their job safely
- Encouraging and respecting the involvement of all employees in the improvement of workplace health and safety
- Providing appropriate safety equipment and personal protective equipment whenever required

All employees are responsible for:

- Following all safe work procedures, instructions and rules
- Participating in the management of workplace health and safety
- Encouraging other employees, contractors and members of the public to act in a healthy and safe way
- Participating in safety training
- Reporting health and safety issues
- Using the safety equipment and personal protective equipment provided

Our goal is to have zero work-related injuries and illnesses to employees, contractors and members of the public. This will only be achieved through the participation, co-operation and commitment of everyone at the workplace.

P. Osborn

Signed by: **ERIC PETER OSBORN**
Date: 1st July 2014

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Appendix C

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A QUALITY ASSURED SUPPLIER

ENVIRONMENTAL POLICY

Osborn Lane Consulting Engineers considers the protection of the environment to be a matter great importance both personally and commercially. Osborn Lane Consulting Engineers will do this by eliminating or, where this is not practicable, managing environmental risk.

The responsibility for managing environmental risk ultimately rests with management, but employees also have important responsibilities that must be met.

Management is responsible for:

- Ensuring the company complies with all legislation relating to the environment
- Eliminating or minimising all environmental risk
- Provide training in environmental practices as appropriate to the engineering scope of the practice
- Ensure that staff are aware of the environmental management plans of all major clients

All employees are responsible for:

- Encouraging other employees, contractors and members of the public to act in a way that minimises environmental risk
- Participating in relevant training
- Reporting breaches of environmental legislation to the relevant authority
- Identify environmentally sensitive issues at commencement of a project in the design phase
- Where applicable carry out risk analysis and identify means to reduce or eliminate potential environmental dangers
- Recommend to clients the engagement of specialist environmental professionals when environmental design issues are outside our capability
- Project drawings and specifications are to note environmental risks and design solutions where applicable. Specifications are to bring to Contractors attention their legal responsibility with regard to environmental matters
- Project management and engineering supervision procedures are to include the inspection of environmental design solutions incorporated in the project documents

Our goal is to have zero negative effect on the environment as a result of our services. This will only be achieved through the participation, co-operation and commitment of everyone at the workplace.

P. Osborn

Signed by: **ERIC PETER OSBORN**
Date: 1st July 2014

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Appendix E: Letters of Support

DOYLES

CONSTRUCTION LAWYERS

* SYDNEY
* BRISBANE
* MELBOURNE
* PERTH

9 June 2017

BY EMAIL
anthony.kachenko@horticulture.com.au

Dr Anthony Kachenko
R&D Lead
Horticulture Innovation Australia Limited
Level 8, 1 Chifley Square
Sydney NSW 2000

Dear Sir,

RE: PROJECT VG16004
'DEVELOPING TECHNICAL GUIDELINES AND A BEST PRACTICE EXTENSION TOOLBOX FOR GREENHOUSE CONSTRUCTION AND SAFE OPERATION'

We are pleased to provide our support for Osborn Consulting Engineers Ltd (**OCE**)'s Proposal for Change dated 12 June 2017 in relation to Project VG16004 (**Project**).

Our firm is a project partner of OCE and has been engaged from project commencement to deliver legal services and advice targeted to help the project's twin objectives of: (1) developing technical guidelines based on the findings of VG13055 – Building Codes and Greenhouse Construction for inclusion in the National Construction Code; and (2) developing a best practice extension toolbox for greenhouse construction and safe operation - building on Section 5: Farm Management and General Practice of VG13055.

Doyles specialises in providing legal services, advice and representation to government, statutory bodies and private sector participants in the construction, engineering and development industry.

As a construction law specialist with extensive experience in planning and development law, our firm advised OCE on broad aspects of this Project including on the general methodology for conducting the relevant research and on the various summary of process documents generated in the course of carrying out the Project.

DOYLES

Broadly Doyles provided project planning and legal advice and conducted research regarding local government approval processes and difficulties experienced in relation to greenhouse planning and construction.

Specifically, Doyles advised on the following matters:

1. Grower survey questions and consultation documents;
2. Definitions and classification system for greenhouses/grow structures;
3. Advising on industry consultation;
4. Disclaimer requirements and intellectual property protection;
5. Investigation of indicative local government approval processes;
6. The extension toolboxes;
7. Ethics in data collection;
8. Risk review framework for development of the guidelines and toolbox documents;
9. Development of a test website containing blogs to support the justification for the technical guidelines;
10. Technical guidelines documents and recommendations.

We are confident that the PFC contains recommendations that achieve the Project's desired outcomes of developing clear and comprehensible technical guidelines to implement the findings of VG13055 and the generation of toolboxes to assist growers and other key stakeholders in the construction and safe operation of greenhouses/grow structures.

We are pleased to have been part of a project that will hopefully provide greater certainty to the crop protection industry in the way their applications for greenhouse/grow structure applications are processed and assist key stakeholders in designing, assessing and certifying such structures.

CORRESPONDENCE

Should you have queries, please do not hesitate to contact our Mr Jim Doyle or Ms Celina Fado.

Yours faithfully,

DOYLES

Doyles

Appendix F: End-of-Project Consultation Article

Greenhouse technical guidelines and best practice extension toolbox

Osborn Consulting Engineers and Horticulture Innovation Australia
28 April 2017 – Industry consultation article

Horticulture Innovation Australia, Osborn Consulting Engineers, FERM Engineering, RMCG and Doyle's Construction Lawyers are nearing the completion of the project 'Developing technical guidelines and best practice extension toolbox for greenhouse construction and safe operation' (VG16004).

In Part 1 of this project the team developed technical guidelines for greenhouses and grow structures for inclusion in the National Construction Code (NCC). The project team has developed measures for horticultural building classification and a provisional framework to reduce classification ambiguity and irrelevant NCC provisions. This particularly relates to the areas of fire and egress. While Part 2 developed a toolbox containing vital information and resources relating to the design, approvals, construction and safe operation of greenhouses in Australia; a tool specifically designed for growers and the protected vegetable cropping industry.

The Proposal for Change to the NCC and the toolbox fact sheets will be open for comment from 1st of May to the 19th of May 2017. The toolbox fact sheets are available at www.greenhousetoolbox.com, while the Proposal for Change will be provided to AUSVEG, Protected Cropping Australia and previous survey participants as part of the project. The Proposal can also be obtained through request using the below contact details. Please note that the Proposal for Change is currently being reviewed by the Fire and Building Surveyor Industry, as such the final proposal may vary to what is shown in the provided documentation.

A webinar has been scheduled to provide an overview of the project findings, recommendations and resources for growers and industry stakeholders. The details for this interactive session with the project team are:

Date: Friday 12th May 2017
Time: 12:30-1:30pm (AEST)
Registration: https://attendee.gotowebinar.com/register/4122479732847979 53

Requests, comments and feedback on the project will be greatly appreciated. To provide feedback please use the contact form at www.greenhousetoolbox.com or forward correspondence to:

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The team thanks you for your continued participation in this important industry project.

Appendix G: Flammability Index of Fabric Covering Material

AWTA PRODUCT TESTING

Australian Wool Testing Authority Ltd - trading as AWTA Product Testing
A.B.N 43 006 014 106
1st Floor, 191 Racecourse Road, Flemington, Victoria 3031
P.O Box 240, North Melbourne, Victoria 3051
Phone (03) 9371 2400 Fax (03) 9371 2499

TEST REPORT

Client : [redacted]

Test Number : [redacted]
Issue Date : [redacted]
Print Date : [redacted]
Order Number : [redacted]

Sample Description

Clients Ref : "14mm Q-Net"
Warp knit net/shade textile
Colour : Black
Nominal Composition : HDPE

AS 1530.2-1993

Methods for Fire Tests on Buildng Materials, Components and Structures.
Part 2: Test for Flammability of Materials

	Length	Width	
Date Tested		07/04/2016	
Flammability Index		1	
Spread Factor	0	0	
Heat Factor	1	1	
Maximum height (d)			
Mean	2.8	2.6	
Coefficient of Variation	90.0	34.2	%
Heat (a)			
Mean	3.3	3.4	°C.min
Coefficient of Variation	39.6	41.3	%
Number of Specimens Tested	9	9	

Observation: Smoking, melting and flaming debris of specimens.

These test results relate only to the behaviour of the test specimens of the material under the particular conditions of the test, and they are not intended to be the sole criterion for assessing the potential fire hazard of the material in use.

[redacted] [redacted]

NATA
Accredited for compliance with ISO/IEC 17025
- Chemical Testing : Accreditation No. 983
- Mechanical Testing : Accreditation No. 985
- Performance & Approvals Testing : Accreditation No. 1356

AWTA LIMITED

APPROVED SIGNATORY

MICHAEL A. JACKSON B.Sc.(Hons)
MANAGING DIRECTOR

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