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Increasing deemed to satisfy height limits for timber construction

Cost benefit analysis

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REPORT

Increasing deemed to satisfy height limits for timber construction

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Prepared for
Forest & Wood Products Australia

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THE CENTRE FOR INTERNATIONAL ECONOMICS
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1 Introduction and summary

The CIE has been commissioned by Forest and Wood Products Australia to undertake a net benefit analysis of increased height allowances for the deemed to satisfy (DTS) provisions in the National Construction Code (NCC). The analysis considers DTS provisions for timber framing up to 25 metres for building classes 2 and 3 (referred to generally as multi-residential construction) and class 5 (referred to generally as commercial construction). [1]

The analysis has been undertaken as a three stepped approach, considering:

1. The net cost savings per timber framed building (greater than 3 storeys but less than 25 metres) compared to traditional framing materials of steel and concrete;
2. The proportion of the Australian mid-rise construction market that timber framing could be expected to account for over the 10 years following DTS provisions; and,
3. The number of additional mid-rise timber framed buildings that this market share would imply – from both previously planned construction and the encouragement of new construction projects.

Discussions with industry were the primary data collection point to build the economic model. Industry representatives provided estimates of the relative costs and benefits of timber framing for construction projects that had achieved approval through the existing NCC Alternative Solutions pathways. Therefore, the net benefit analysis implicitly allows for timber construction that meets the structural, fire safety and acoustic requirements in the NCC.

The use of timber framing may provide a range of economic benefits compared to steel and concrete, including:

- direct construction cost savings;
- improved environmental performance;
- improved workplace health and safety; and,
- reduced neighbourhood disruptions through shorter construction time.

Well executed DTS provisions for height allowances above three storeys and below 25m could help to promote the use of timber framing in the Australian construction industry and in turn provide additional market benefits, including:

- reduced compliance costs for builders;
- increased diversity within the design and construction industry; and
- improved industry employment flexibility.

[1] Building classes are outlined in Appendix A

Table 1.1 summarises the net benefits estimated in the analysis. Increased height allowances for DTS provisions for timber framing in the NCC are estimated to provide approximately $103 million in net benefits to the Australian economy over 10 years.

This figure is divided across construction cost savings, compliance cost savings and environmental benefits as:

- $98.2 million in direct construction cost savings;
- $3.8 million in reduced compliance costs;
- $1 million in environmental benefits.

1.1 NPV of increasing height allowances for timber framing

	Multi-residential	Commercial
Savings per net new construction	$1,324,050	$1,717,200
Compliance cost savings per previously planned construction	$ 40,000	$ 40,000
Number of previously planned/envisaged constructions over 10 years	117	30
Number of net new constructions over 10 years	82	34
Total number of timber framed construction projects over 10 years	200	64
Discount rate	7%	7%
Net present value of DTS provisions ($m)	**$ 66.5**	**$ 36.5**

Source: The CIE

A sensitivity analysis was undertaken on selected parameters of the model to test the robustness of the findings. As the proposal for change represents an opening up of a new market segment in the construction industry, and there are no external costs being imposed on the wider Australian construction industry, all of the results indicated a net return to the Australian economy.

One caveat to this finding was raised by industry representatives who flagged the possibility of overly cautious DTS provisions potentially sending messages to the market that construction in mid-rise timber framing is more costly and risky than experience suggests. Industry representatives considered that such cautious DTS provisions could work to delay the rate of uptake of timber framing, reducing or negating any net economic benefits from the DTS provisions.

2 Net benefits of increased height limits

In the right context, the use of timber framing provides a number of benefits over more traditional building materials such as steel and concrete. These benefits fall into the categories of:

- direct construction cost savings;
- improved environmental performance;
- improved workplace health and safety; and,
- reduced neighbourhood disruptions through shorter construction time.

Through expanding the DTS height allowances within the NCC, there are additional market benefits that may be achieved, including:

- reduced compliance costs for builders;
- increased diversity within the design and construction industry; and
- improved industry employment flexibility.

This analysis integrates quantitative estimates of these benefits where possible and concludes with a qualitative discussion of the non-market benefits of timber framing.

It is important to note that the analysis has assumed that timber framing provides the same level of structural integrity and occupant safety as the current DTS provisions in the NCC.

To be able to make these assumptions, the estimates of relative costs and benefits used implicitly allow for additional provisions required in timber framing for elements of fire safety and acoustics for example. This was achieved through discussion with builders experienced in mid-rise timber framing who provided estimates of the relative cost savings they have experienced in timber-framed construction that have gained Alternative Solution approval – and therefore include structural, acoustic and fire safety requirements.

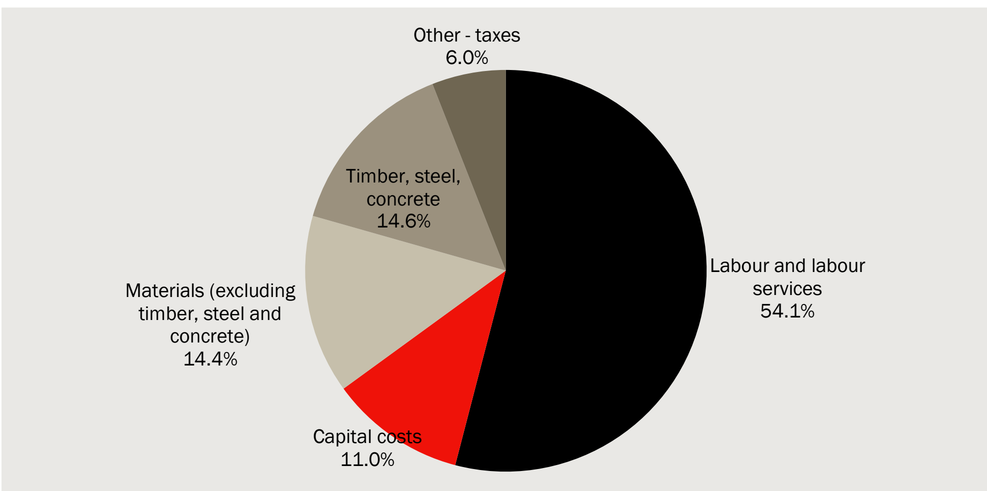
Construction costs

The most valuable benefit of timber-framed construction is considered to be shorter construction timeframes. Timber-framed construction offers reduced on site construction time through a number of avenues including:

- direct savings from faster methods of construction compared to traditional steel and concrete structures due to both:
  - increased scope for off-site prefabrication
  - lighter and more easily manipulated materials
- reduced foundation requirements due to lighter above ground structure;
- reduced need to involve additional services such as fixed cranes;
- increased accessibility of the construction site; and
- increased ability to slide in follow on trades through the construction process reducing final time to completion.

When considering construction across multi-residential and commercial buildings, broadly speaking, total costs may be divided across labour, materials, capital and other taxes as outlined in chart 2.1.

2.1 Construction cost breakdown



Data source: The CIE, CIE-REGIONS data

Notably, labour and labour services (such as design, finance, project management etc) account for more than half of the total construction costs. Total materials account for up to 30 per cent of construction costs, with framing materials (timber, steel and concrete) accounting for approximately 15 per cent of total construction costs. Where labour and labour services are variable costs, dependent on the total construction time of a project, reducing time to completion for a project will necessarily result in large savings to the overall build cost.

It is understood that cost savings from using timber framing are necessarily going to be highly project specific, just as total costs of construction are highly project specific.

Accounting for this variability, the CIE has brought together a range of industry estimates of construction project costings to present a representative range of building projects that will be used to estimate the construction costs savings possible due to timber framing. Sensitivity analyses will be used to express the importance that these assumptions have on the final net benefit results.

Table 2.2 outlines the components of the representative apartment buildings used in the analysis.

2.2 Estimated cost savings by representative multi-residential build

Storeys	Apartments per floor	Gross floor area	Traditional build cost	Timber build cost
		sqm	$m	$m
4	10	6000	10.8	9.7
5	10	7500	13.5	12.2
6	10	9000	16.2	14.6
7	10	10500	18.9	17
8	10	12000	21.6	19.4

Source: The CIE based on industry estimates

Traditional construction costs of $1800 per square metre for an apartment building have been used. These estimates were agreed by industry representatives as being useful for indicative cost calculations. They are further supported by publications from BMT quantity surveyors who report cost of construction ranges (depending on quality of finishes) of $1720 to $2650 per square metre for a 4 to 8 storey walk up apartment complex.[2]

Table 2.3 outlines the components of the representative commercial office building used in the analysis.

2.3 Estimated cost savings by representative commercial build

Storeys	Gross floor area	Traditional build cost	Timber build cost
	sqm	$m	$m
4	8000	12.8	11.52
5	10000	16	14.4
6	12000	19.2	17.28

Source: The CIE based on industry estimates

Construction costs of $1600 per square metre were used for a commercial office building, again based on discussions with industry and reference to BMT quantity surveyors. BMT reported cost of construction ranges (depending on quality of finishes) of a 4 to 8 level open plan offices, including A/C and lifts, excluding fitout of between $1620 and $2400 per square metre.[3]

2 www.bmtqs.com.au/construction-cost-table accessed on 31/10/2014

3 www.bmtqs.com.au/construction-cost-table accessed on 31/10/2014

Note that commercial buildings tend to have a higher floor to floor height and so it is assumed that six storeys might be reached for commercial buildings under 25 metres.

In general, industry representatives agreed that the use of timber framing could result in up to 10-15 per cent savings across the total constructions costs of a project – mainly through reduced construction time. Tables 2.3 and 2.4 allow for a conservative 10 per cent reduction in build costs due to timber framing.

- **Labour and labour services are the largest cost component for construction, a variable cost dependent on the total construction time for a project**
- **Where timber framing provides significant reductions in construction time, there will be resulting significant cost savings**
- **Cost savings were estimated at between 10 and 15 per cent of gross construction costs due time saved by using timber framing**

Environmental benefits

The use of timber framing in construction is well documented to have lower environmental impacts than the use of traditional building materials such as concrete and steel. Life cycle assessments of timber construction identify benefits including:

- less embodied energy;
- lower levels of air and water pollution; and,
- lower carbon footprint.[4]

In this CBA, estimates of carbon dioxide equivalent (CO_2e) have been used as a proxy to quantify the value the environmental benefits of timber framed construction. Analysis has been limited to CO_2e based on:

- accessibility of estimates from a range of studies;
- ability to convert savings in embodied energy directly to CO_2e measures; and
- increased international acceptance of CO_2e as a more general measure of environmental benefits.

When considering the carbon footprint of construction, the amount of carbon embodied in a building necessarily depends on a large range of factors including the:

- construction materials used and the energy intensity of those materials;
- carbon intensity of the energy used to fabricate the construction materials (coal or natural gas, for example); and,
- distance and type of transport required in construction.

[4] Durlinger, B., Crossin, E. and Wong, J. (2013) Life cycle assessment of a cross laminated timber building. Prepared for Forest and Wood Products Australia

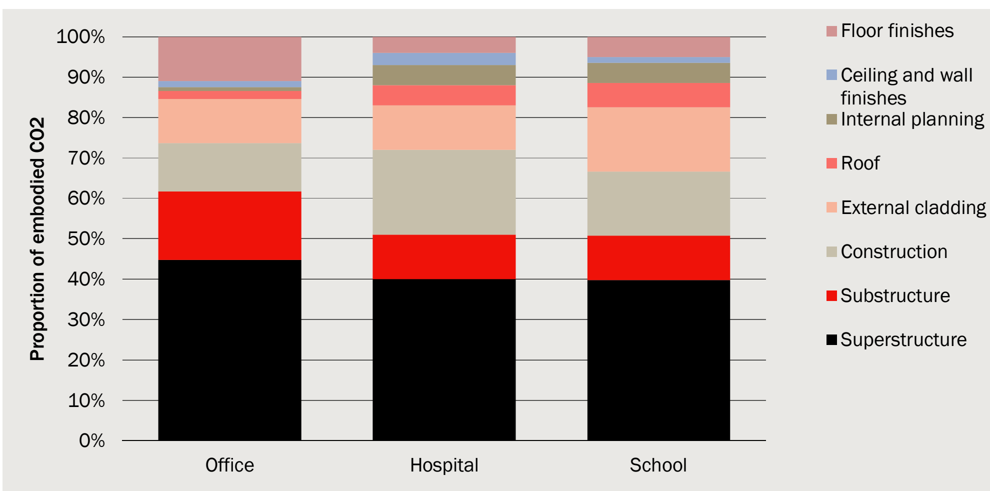
A number of international studies have been collated here to provide an overview of the amount of embodied and stored CO_2 estimated in different construction projects. By necessity, the values found in these studies are specific to the buildings being analysed, but they do provide guidance on the general scale of embodied CO_2, as well as the general proportion of reduced embodied CO_2 that may be generated from switching to timber framing. The sensitivity analysis will consider how sensitive the CBA results are to changes in the amount of embodied CO_2.

Embodied CO_2 in construction

A British study has undertaken a cradle to site assessment of the relative carbon dioxide embodied in three different building types – a commercial office building, a hospital and a school, all without basement structures. Comparisons were made between steel and concrete framing solutions across a number of different specifications for each building. The analysis included extraction and production of materials, delivery and construction but not building operation or end of life impacts of construction materials.

Chart 2.4 shows that the superstructure of all three buildings accounted for the greatest proportion of embodied CO_2 – 40 per cent for each of the hospital and school, and 45 per cent for the commercial office building. These results indicate that changes in the embodied CO_2 of structural materials, to timber for example, are likely to provide the largest gains in reducing the carbon footprint of building construction.

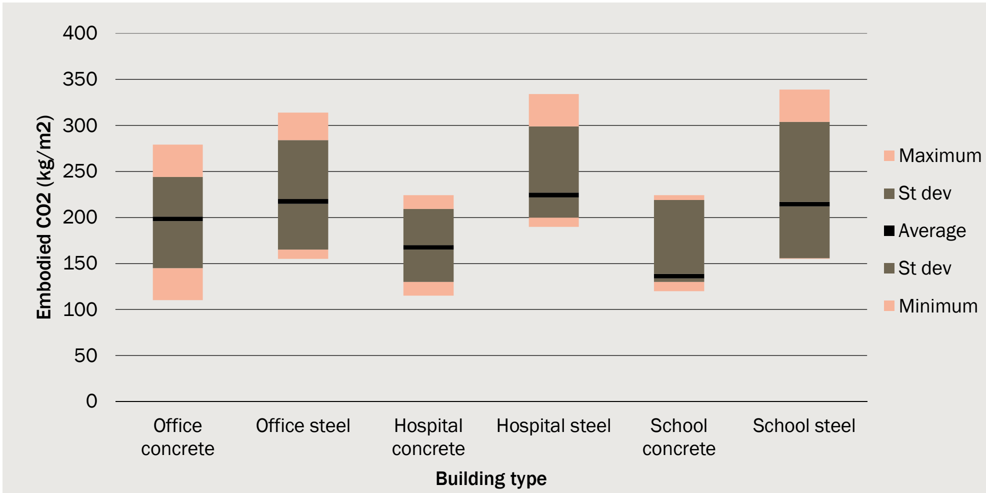
2.4 Embodied CO_2 by building component



Data source: Kaethner, S. C. and Burridge, J. A. (2011) Embodied CO_2 of structural frames. http://www.concretecentre.com/pdf/Embodied_CO2_of_Structural_Frames.pdf accessed on 26/11/2014

Chart 2.5 collates the results of analyses considering the embodied CO_2 per square metre of gross floor area. While there is deviation in the estimates, on average, steel and concrete construction results in approximately 200 kg of embodied CO_2 per square metre of gross floor area.

2.5 Estimated range of embodied CO_2 by building type and frame material



Data source: Kaethner, S. C. and Burridge, J. A. (2011) Embodied CO_2 of structural frames. http://www.concretecentre.com/pdf/Embodied_CO2_of_Structural_Frames.pdf accessed on 26/11/2014

Relative embodied CO_2 in timber framing

Three studies have been collated to estimate the reduced CO_2e emissions from using light timber framing compared to concrete and steel. These studies are summarised in table 2.6. All of the studies considered switching building structure materials from predominantly steel and concrete to a light weight timber frame.

2.6 Summary of selected studies estimating CO_2e savings

Authors	Location	Building details	Avoided emissions (kg CO_2e/m2)
Buchanan, A. and Levine, S.	New Zealand	Five storey commercial office block	240.5
		Six storey hostel	
			159.1
Gustavsson et al	Sweden and Finland	Four storey apartment building 16 apartments, 1190m2	208.0
		Four storey apartment building 21 apartments 1175m2	477.0a
John, S. et al	New Zealand	Five storey office block of 4200m2	
		Timber compared to	
		concrete	193.0
		steel	214.0

a No explanation was provided for the large difference in estimates between apartment buildings apart from a statement that different designs and materials will generate different results.

Note: Results based on gross floor area of the buildings, and are based on a lifecycle assessment of the building where operational CO_2e was similar across the construction materials

Source: Buchanan, A. and Levine, S. (1999) Wood-based building materials and atmospheric carbon emissions. Environmental Science & Policy 2(6) p427-437 and Gustavsson, L., Pingould, K. and Sathre, R. (2006) Carbon dioxide balance of wood substitution: comparing concrete and wood framed buildings. Mitigation and Adaptation Strategies for Global Climate Change (2006) 11:667-691, and John, S. et al (2008) Environmental impacts of multi-storey buildings using different construction materials.

These results are driven by the high proportion of embodied CO_2 in the superstructure of a building, and are importantly dependent on the relative embodied CO_2 in the chosen timber alternative (light timber framing, glue laminated timber or cross laminated timber).

The studies summarised in table 2.6 specifically consider light timber framing, and not glue laminated or cross laminated timber. Due to the relatively minimal transformation in production, light timber framing is known to have the lowest embodied energy and therefore the lowest embodied CO_2 measure of alternative timber building materials.

Where switching to light timber framing may provide reductions in embodied CO_2e of around 200 kg per square metre of gross floor area (anywhere up to 75 to 90 per cent of total embodied emissions), life cycle assessments of CLT note that CO_2e savings are in the region of 25 per cent compared to traditional construction methods.[5] Further, the embodied energy (and embodied CO_2e) in in glue laminated timber is estimated to be approximately 50 per cent higher than standard timber.[6] However, the relative carbon balances of light timber framing compared to CLT and GluLam will be influenced by changes in both the embodied carbon and the stored carbon of the product.

- **Timber framing is assumed to save 200 kg of embodied CO_2e per square metre of gross floor area**
- **Switching to CLT could provide up to 25 per cent reduction in embodied CO_2e and switching to glue laminated timber could provide 30 to 75 per cent reduction in embodied CO_2 e where substituted for steel or concrete.**

Costs of Alternative Solution pathways

Currently in Australia, all timber framed construction above three storeys is required to apply for an Alternative Solution compliance pathway through the NCC. Industry representatives have observed new interest in timber framed construction above three storeys from developers, however, once the additional time and resources required to achieve an Alternative Solution compliance pathway are factored in, interest declines sharply. That is, the current Alternative Solution requirements are considered prohibitive to many developers who either revert to traditional steel and concrete construction, or remain under the three storey DTS height limits.

There are however, mixed estimates of the additional costs that these Alternative Solution requirements place on new construction. These costs divergences are predominantly determined by the size of the developer and the amount of previous experience they have in timber framing. Developers new to the timber framing market

[5] Durlinger, B., Crossin, E. and Wong, J. (2013) Life cycle assessment of a cross laminated timber building. Prepared for Forest and Wood Products Australia

[6] Hammond, G.p. and Jones, C.I. (2008) Embodied energy and carbon in construction materials. Proceedings of the Institution of Civil Engineers – Energy, 161(2) p87-98

tend to view the Alternative Solution pathway as prohibitive, where more experienced developers absorb the costs.

Overall, generating confidence in the design community is considered to be one of the greatest hurdles for developers and builders looking to utilise timber frame construction. There is a perception that for each new designer brought on board, there is a need to “re-invent the wheel” in bringing the team up to speed on the characteristics of a timber frame build job and the requirements necessary to meet Alternative Solution pathways.

For those large developers and builders that persist with the design community, it was considered reasonable to estimate the cost of Alternative Solution pathways at approximately one month of lead time lost for medium rise developments, costed at $2000 per day for designers and head office staff. This equates to approximately $40 000. Over a medium scale development of $7 million gross costs, this is not a large proportion. Alternative Solution pathways can represent approximately 0.5 per cent of total build costs, or 4 per cent of the cost savings expected from using timber framing.

It should be noted that these cost estimates are applicable only to those developers that choose to proceed with an Alternative Solution pathway. Unaccounted for costs, unquantifiable costs and risk premiums of attempting Alternative Solution pathways are anecdotally prohibitive to a portion of the market that chooses not to proceed with an Alternative Solution.

The nature of the DTS provisions is an important factor in estimating the cost savings from avoided Alternative Solutions pathways. In particular, if DTS provisions are overly conservative, requiring significant additional engineering to meet them, cost savings may be limited. Meeting fire and acoustic requirements are the major components of design and construction of timber-framed buildings and are expected to remain the most prominent components of a DTS pathway.

Industry representatives were divided on their opinion of the role that the first stage of DTS measures might play in the market. On the one hand, representatives expressed concern that overly conservative DTS provisions could introduce redundant structural integrity or fire safety elements, further constraining the market by providing indications that timber framed construction was more risky and more costly than experience suggests. In addition, where timber framed construction tends to be used in conjunction with other innovative construction methods that also require Alternative Solution pathways, the marginal costs associated with the Alternative Solution for the timber frame could be quite minimal, therefore a DTS provision would provide minimal cost advantage.

On the other hand, conservative DTS provisions were not considered a binding constraint to all industry representatives and instead were viewed as a pragmatic step process of introducing timber framed construction to the industry. Where currently all timber framed construction requires Alternative Solution pathways for the majority of the design, some industry representatives mused that even conservative DTS provisions would provide a stepping stone to reduce costs. That is, where timber framed construction would likely still require an Alternative Solution from conservative DTS provisions, it is hoped that these marginal costs are less than those currently being faced.

- **Costs for Alternative Solutions are considered prohibitive by a portion of the market, but larger building companies are absorbing these costs and continuing mid-rise timber framed construction**
- **For builders progressing with timber construction, Alternative Solutions were estimated to cost approximately $2000 per day, for a delay of one month – a total of $40 000**
- **The value of compliance cost savings generated from DTS provisions would necessarily depend on how conservative or onerous the provisions were**

Unquantifiable benefits

There are a number of unquantifiable benefits identified in the use of timber framing for mid-rise construction. These benefits are not traded in a market place and therefore do not have a market price that can be included in the net benefit analysis. They are discussed here to provide an indication of the wider benefits that timber framing may have on the Australian economy.

Workplace health and safety

Workplace health and safety is comprised of two components: the time spent on a construction site, and the complexity of the construction process. A simplified construction process, combined with a faster construction pace will necessarily provide reduced workplace health and safety risks.

Where timber framing uses lighter construction materials, with reduced use of heavy machinery and allowing for a faster construction process, significant improvements in workplace safety have been reported.

Encouragement of small and medium sized businesses

It is expected that the majority of additional mid-rise timber framed construction will be undertaken by large project builders that are currently using timber frames under the three storey height limits. That is, larger project builders will likely look to expand their operations, rather than larger construction companies currently using steel and concrete moving in to timber construction.

An expansion in use of timber framing could provide market encouragement for the design and distribution of a greater range of fire and acoustic related products.

The domestic wood manufacturing industry would also experience growth to the extent that domestic plantations can meet the demand. The 25 metre height allowances considered in this analysis is likely to cover predominantly light timber framing which can be supplied through the domestic markets. Cross laminated timber would only be economic at the very top end of this height allowance and therefore, it is not expected that the current proposal for change would have a discernible impact on encouraging domestic production of CLT within the 10 year time horizon of this analysis.

Greater integration of the timber industry with the construction industry would also be achieved with the timber industry will continue to provide through the WoodSolutions program Technical literature and training materials to support the construction systems proposed in this NCC change.

Employment market effects

The construction methods used in timber framing are similar to those utilised in the residential industry. This is the predominant reason why it is likely to be larger project builders expanding into the increased height allowances of timber framing. The advantage of this interchangeability is that it would allow for improved employment opportunities for trades people shifting from detached housing construction to medium density construction. Increased integration of the labour force across detached residential construction and mid-rise construction would be particularly beneficial due to the counter-cyclical nature of the two construction markets.

Design and visual amenity,

Increasing the materials available for construction will necessarily produce benefits to the design community, allowing for an increase in diversity in design, layout and general amenity of developments. Increased diversity in materials will likely provide for increased design innovation and therefore a broader and more competitive environment for consumers.

Nuisance factor of construction

Through reduced construction time, reduced need for heavy machinery and the ability to increase off site prefabrication, timber framing can dramatically reduce site impacts and neighbour disruption through the construction process. These reduced disruptions can increase public acceptance of medium density developments and potentially increase the completion rate of infill developments that achieve modern goals of increased density and mixed use developments that integrate with existing transport, retail and service centres.

3 New timber framed constructions

The economy wide benefits of increasing height allowances for timber framed buildings necessarily depends on the number of new construction projects that would be developed directly because of the DTS provisions. The two main factors that will influence the number of new constructions are:

- the reasons that timber framing is not currently used above three storeys; and,
- the level of demand for mid-rise buildings in general.

Industry discussions have indicated that DTS provisions are expected to provide encouragement to the market to use timber framing to meet known demand for mid-rise, medium density developments around Australia.

Current impediments to timber framing

The effect that introducing DTS provisions above three storeys may have on development across Australia depends critically on the current impediments to mid-rise timber framed construction in Australia. In particular, it is important to identify whether construction using timber framing is limited because of one or more of the following.

- The prohibitively costly process or perceived increased risks of applying for Alternative Solution construction approval;
- A lack of information or understanding of the product and technique where designers and developers consider it to be too risky and “unproven”; or
- Timber not being a preferred product.

Through discussions with industry representatives it is apparent that there is a mix of all three opinions working together to limit the use of timber currently in Australia.

Where new interest in timber framing is piqued, there is anecdotal evidence that the uncertainty in gaining approval and the certainty of additional time and resource costs of applying for Alternative Solutions can often more than take up the expected time and cost savings from using timber construction. In particular, smaller developers looking to experiment with expanding their operations are deterred.

Developers currently constructing using mid-rise timber frames acknowledged a learning curve required in the design community, with expectations that greater information, understanding and marketing could provide significant encouragement. A similar result has been observed in the United States. A survey of architects found that when considering the use of cross laminated timber, compatibility with the building code (the availability of a DTS provision, for example) was considered to be a large barrier to adoption by 22 per cent of respondents with only 5 per cent of respondents not considering code compatibility to be a barrier. Further, the results indicated that those practitioners that were more aware of the product were also more likely to utilise it and were more comfortable with the structural integrity and overall positive perceptions of the product.[7]

Finally, there is, and there will remain, a large proportion of both the design and the construction markets that are not interested in the potential uses of timber framing. While this segment will not be affected by any potential DTS provisions, this is not to be considered an impediment to the expanding timber framing market and introducing DTS provisions at greater height allowances. The large proportion of the market that is unlikely to be moved by DTS provisions does however provide an indication that timber framing, at least for the short to medium term, will remain a small portion of total mid-rise construction in Australia.

Assessments indicate that should DTS height allowances be increased for timber framing:

- **there is likely to be a positive effect on the market through reduced costs and uncertainty of gaining alternative solution approval and increased information and exposure to timber framing construction options; and**
- **while medium rise timber framing is unlikely to gain a significant proportion of the market, the increased DTS height provisions will not place any restrictions or additional costs on the traditional construction market.**

Demand for medium density construction

There are two potential avenues through which allowing timber framed construction may benefit the Australian economy.

1. Allowing for cheaper, environmentally efficient construction on land that would have been developed anyway, thereby reducing the costs of construction – economic benefits will be purely through changing construction materials; and
2. Allowing construction to go ahead where it was previously uneconomic to do so - that is the costs and benefits are to be calculated against an empty block, or a reduced value development, such as lower height, different scale, different land use, increasing economic activity in the Australian economy.

Industry representatives have considered that both avenues will be likely to be evident in the future of timber framing in Australia. In particular, Australand's Kase Jong has been quoted as saying that hybrid construction makes sites viable that weren't previously viable from an economic point of view. This indicates that not only are there construction cost benefits, there are also land planning benefits possible if the expansion

[7] Mallo, M. and Espinoza, O. (2014) Awareness, perception and willingness to adopt cross-laminated timber in the United States, presentation made to University of Minnesota

of timber framing allows for developments that would previously not have been undertaken.

There is also current evidence of unmet demand for medium density development in Australia. In reviewing Australian housing desires, the Grattan Institute found evidence of significant unmet demand for medium density multi-residential developments within the 25m height limits in both Sydney and Melbourne. [8]

- In Sydney this unmet demand was predominantly in areas outside of the central metropolitan area and in the Western region
  - 50 000 apartments in buildings 4 storeys and above in the south eastern regions, and areas westwards out to Parramatta (zone 2)
  - 70 000 apartments in buildings 4 storeys and above in Western regions around Liverpool, Hornsby, Blacktown and up to Sackville (zone 3)
  - 60 000 apartments in buildings 4 storeys and above in the wider western ring from Picton to Penrith and further north (zone 4)
- In Melbourne, this unmet demand was predominantly located in areas bordering the greater metropolitan areas to the north, and south east
  - 55 000 apartments in buildings 4 storeys and above in the outer metropolitan areas north to Greensborough, north east to Doncaster and west to Rowville (zone 2)
  - 45 000 apartments in buildings 4 storeys and above in further regions south to Frankston and north to the outskirts of the city, west along the bay to Geelong (zone 3)
  - 25 000 apartments in buildings 4 storeys and above in furthest regions but most likely in localised regional centres (zone 4)

Further, across both Sydney and Melbourne, the Grattan Institute survey identified Construction issues – including separate residential and commercial labour forces, access to materials, building standards and innovation in construction methods – as an important disincentive (Sydney) and a critical disincentive (Melbourne) to development. Similar conclusions have been reached in other studies of Australian development. For example, considering infill construction specifically, Rowley and Phibbs (2012) identified high construction costs above three storeys as a key prohibitive factor in the development industry providing medium density development in infill areas.

Increased availability of light timber framing up to 25 metres would be able to help alleviate a number of identified constraints on development and begin to meet current, and increasing future, demand for medium density developments.

[8] Kelly, J. (2011) The housing we'd choose. Grattan Institute

Estimates of new constructions

Larger developers in Australia have already shown an interest in timber framed construction, and have acknowledged that they will continue to expand their activities in timber framing irrespective of any DTS provisions. For these developers, should DTS provisions be included in the NCC, they would affect the process of applying for Alternative Solutions, not necessarily affecting the number of timber framed construction projects in the short term.

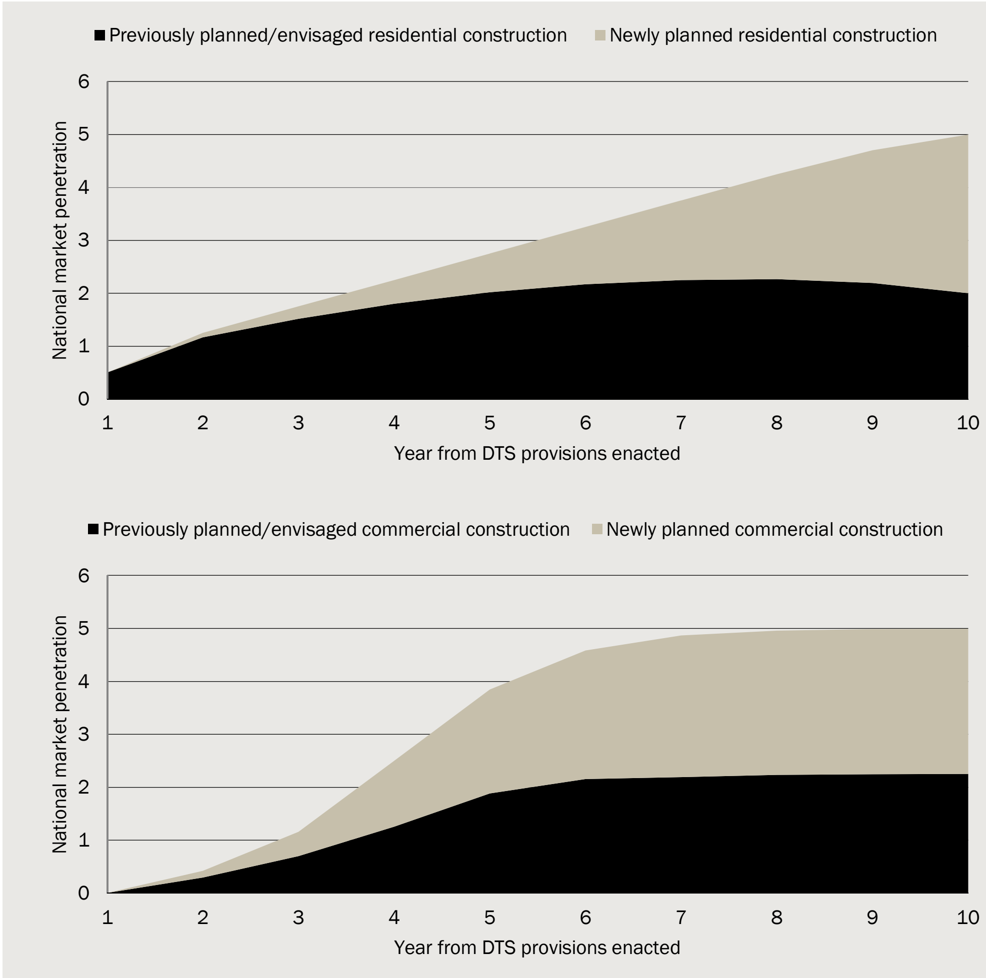
When considering the potential for wider growth in the market for timber framing, industry representatives noted that there was a lag before effects were observed from the introduction of three storey height limits for timber framing. A similar lag, potentially ten years, is expected following the introduction of any DTS provisions up to 25 metres before maximum market penetration might be reached. Industry representatives indicated that maximum market penetration for timber framed construction would not be expected to be more than approximately 5 per cent of total construction in this height market.

Chart 3.1 outlines the national market penetration assumed for both residential and commercial timber framed construction for the ten years following any DTS provisions. In the years immediately following DTS provisions, previously planned construction (that is, construction by the major market participants) is assumed to account for the bulk of construction. By ten years, previously planned construction is assumed to account for 40 per cent of the residential and commercial timber framed construction market in this height category.

Note that the differences in the rates of market penetration for residential and commercial construction projects reflect the current market observations that there are no light weight timber framed commercial office construction projects either started or completed. While commercial construction is expected to be taken up in the future, there is likely to be a more prominent proportion of newly encouraged development.

Beyond DTS provisions, State government planning policies will have a strong influence on the pattern of uptake of mid-rise timber framing across Australia. For example, planning policies in Victoria are currently providing significant encouragement for developments in the five to six storey height bracket in outer areas of Melbourne in particular which would further help to promote timber framing in this market.

3.1 National market penetration of timber framed construction



Data source: The CIE

It is estimated that timber framed construction under 25 meters would reach maximum market penetration of five per cent within ten years of the DTS provisions being enacted.

4 Net impact analysis

The current proposal for change looking at the expansion of DTS timber-framed height limits provides an opportunity to open up a new market segment within the construction industry. There are no costs imposed on the wider construction industry from the new provisions. Further, as the cost savings outlined in Chapter 3 are net of additional costs required to support structural, acoustic and fire ratings of the buildings, the current analysis is taking a net benefits approach as a whole.

The important point here from a regulatory review standpoint is that introducing the DTS provisions are not going to impose costs on the wider construction market that are not involved in timber framing.

While it is likely that well-defined DTS provisions will provide encouragement and facilitation of increased uptake of timber framing in Australia, some industry representatives have raised concerns that highly conservative DTS provisions could have the potential to discourage market uptake of timber framing. This is important from a regulatory assessment point of view as it raises concerns that overly conservative DTS provisions could be worse than redundant for the industry, working to discourage uptake that might have occurred over time through merely maintaining Alternative Solution requirements. This should be kept in mind for any Regulatory Impact Statement work that might be undertaken.

A sensitivity analysis has been included here to provide a high-level indication of how discouraging market signals might affect the net benefits calculation.

The results in this section are presented as net present values over ten years at a discount rate of 7 per cent.

Market analysis

Estimation of economy wide benefits from increased timber framing height allowances depends on:

- the benefits achieved per new building constructed;
- the number of new buildings that might be constructed because of the DTS provisions; and,
- the reduced compliance costs of avoided Alternative Solutions pathways for buildings that were planned for construction.

Distribution of construction

Where tables 2.2 and 2.3 outlined the representative buildings to be analysed, an assumed construction distribution of these buildings is required to calculate the expected annual cost savings that might be expected across the industry.

Discussions with industry identified a reasonably coherent range of expectations on the distribution of heights in timber-framed apartment buildings that might be constructed following the DTS provisions. It was expected that lower rise apartment buildings, at four and five storeys would form the majority of the market, with six, seven and eight storey apartment buildings accounting for perhaps 20 per cent of the market (table 4.1).

Discussion around the distribution of commercial buildings was more limited, but it has been assumed that six storey complexes would account for half of the market, with fewer four and five storey complexes. This assumption has been made on the understanding that construction in commercial areas tends to be at greater mid-level height allowances than multi-residential developments in general (table 4.1).

4.1 Distribution of construction heights for building classes

Multi-residential buildings, classes 2 and 3		Commercial buildings, class 5	
Storeys	Proportion of the market	Storeys	Proportion of the market
4	50%	4	20%
5	30%	5	30%
6	10%	6	50%
7	5%		
8	5%		

Source: The CIE

Value of environmental benefits

The value of reduced CO_2e emissions depends on the price of carbon. With the removal of the Australian carbon price, there is currently no domestic measure of the value of carbon emissions. Under the Gillard-Rudd Labor government, the price of carbon reached approximately $23 per tonne of CO_2e. This price was expected to have continued to increase over time. While the revocation of the emissions trading scheme and the announcement of direct action polices by the current government has created some uncertainty around the future price of CO_2e in Australia, there is a reasonable degree of consensus that these policies will not generate prices nearly as high $23 per tonne.

Using the European emissions trading scheme as a guide, a price of $10 per tonne of CO_2e has been assumed in this analysis to value the environmental benefits of timber framing.

Net economic benefits per average construction project

Tables 4.2 and 4.3 provide a summary of the expected benefits of increased height allowances for timber framing, per construction project, bringing together expected:

- cost savings by building height (tables 2.2 and 2.3);
- environmental returns by square metre of construction; and
- height distribution of expected construction (table 4.1).

4.2 Collated benefit values for multi-residential timber construction

Storeys	Gross floor area	Construction cost savings	Environmental cost savings	Proportion of the market
4	6000	$ 1,080,000	$ 12,000	50%
5	7500	$ 1,350,000	$ 15,000	30%
6	9000	$ 1,620,000	$ 18,000	10%
7	10500	$ 1,890,000	$ 21,000	5%
8	12000	$ 2,160,000	$ 24,000	5%
Estimated average building cost savings				**$1,309,500**
Estimated average building environmental savings				**$ 29,100**
Estimated average building benefits in construction of timber framing				**$1,338,600**

Source: The CIE

4.3 Collated benefit values for commercial timber construction

Storeys	Gross floor area	Construction cost savings	Environmental cost savings	Proportion of the market
4	8000	$ 1,280,000	$ 16,000	20%
5	10000	$ 1,600,000	$ 20,000	30%
6	12000	$ 1,920,000	$ 24,000	50%
Estimated average building cost savings				**$ 1,696,000**
Estimated average building environmental savings				**$ 42,400**
Estimated average building benefits in construction of timber framing				**$1,738,400**

Source: The CIE

Where the average multi-residential (class 2 or 3) timber framed building is estimated to save the Australian economy approximately $1.3 million, the average commercial (class 5) timber framed building is estimated to save the Australian economy approximately $1.7 million. These differences are driven largely through the assumed difference in the relative size of a multi-residential construction project compared to a commercial construction project. Discussions with industry did not indicate any structural difference in cost savings that would be expected across multi-residential and commercial build projects (that is, both were expected to achieve savings of 10 to 15 per cent).

Market value of timber framing

The residential construction market of four storeys and above was estimated to be worth $13.2 billion in the 2013-14 financial year (ABS cat no 8731.0, table 21). Cross tabulating this with information from the Cordell's construction database, it was estimated that the market value of multi-residential construction between four and eight storeys is approximately half of the high rise market, or $6.6 billion in 2013-14. Based on information from the Cordell's database, there were estimated to be 470 multi-residential apartment buildings within the height category in the twelve months to September 2014.

Over the ten years following implementation of DTS provisions, the multi-residential market was assumed to grow at an average of 5 per cent per year.

Using this average annual growth rate and the market penetration figures outlined in chart 3.1, the value of lightweight residential timber framed construction was modelled to rise to $510 million in ten years' time.

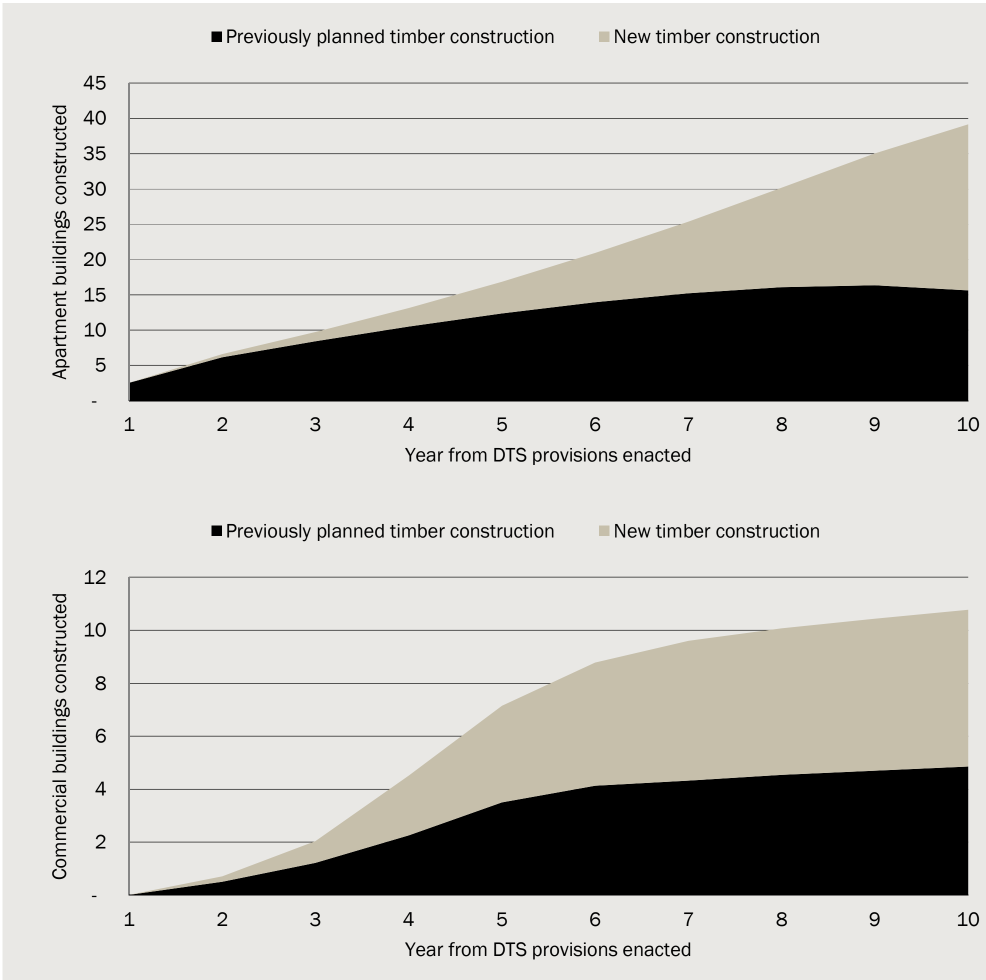
The value of office building construction work completed in Australia was estimated to be worth approximately $5.6 billion in 2013-14 (ABS cat no 8752.0, table 71). It was assumed that office blocks within the 4 storeys to 25 meter height bracket account for 50 per cent of this market, or $2.8 billion annually.

Over the ten years following implementation of DTS provisions, the office construction market was assumed to grow at an average of 3 per cent per year.

Using this average annual growth rate and the market penetration figures outlined in chart 3.1, the value of lightweight commercial timber framed construction was modelled to rise to $182 million in ten years' time.

Chart 4.4 combines this market value information, the market penetration rates (total new and previously planned) modelled in chart 3.1 and the average cost savings per average residential and commercial construction project, to illustrate the modelled estimates of timber framed residential construction. In ten years' time, well developed DTS provisions could contribute approximately 82 new light timber framed construction projects and approximately 34 new commercial projects to the Australian economy.

4.4 Modelled number of light weight timber framed buildings constructed



Data source: The CIE

Table 4.5 summarises the net benefit results of the model.

4.5 NPV of increasing height allowances for timber framing

	Multi-residential	Commercial
Savings per net new construction	$1,324,050	$1,717,200
Compliance cost savings per previously planned construction	$ 40,000	$ 40,000
Number of previously planned/envisaged constructions over 10 years	117	30
Number of net new constructions over 10 years	82	34
Total number of timber framed construction projects over 10 years	200	64
Discount rate	7%	7%
Net present value of DTS provisions ($m)	**$ 66.5**	**$ 36.5**

Source: The CIE

Increased height allowances for DTS provisions for timber framing in the NCC are estimated to provide approximately $103 million to the Australian economy over 10 years. This figure is divided across construction cost savings, compliance cost savings and environmental benefits as:

- $98.2 million in direct construction cost savings;
- $3.8 million in reduced compliance costs;
- $1 million in environmental benefits.

Sensitivity analysis

The net benefit model developed here has drawn primarily on data from discussions with industry representatives and international literature. All sources agreed that the parameters were highly specific to the nature of the construction projects being considered, as well as assumptions on rates and patterns of development across Australia over time.

While not all of these factors can be accounted for in a baseline analysis, a sensitivity analysis can outline how the base results change given specific changes in different parameters. Table 4.6 provides an example of the effects that changing parameters have on the net present value results.

4.6 Sensitivity analysis

	Multi-residential	Commercial	Economy wide
Base line results	67	36	103
15 per cent construction cost savings	97	54	150
$20 per tonne price for CO_2e	67	37	104
Early uptake	113	47	161
Late uptake	36	26	62
5 per cent discount rate	77	42	119
10 per cent discount rate	54	30	84

Source: The CIE

Changes in construction cost savings from timber framing

Industry representatives were not able to be explicit in the value of savings that could be attributed to the use of timber framing. This is because the total costs of any construction project are highly specific to each job, and are dependent on project specific factors such as location, accessibility to site, availability of suppliers and services, interactions with planning agencies and local communities, just to list a few.

Keeping this caveat in mind, industry representatives were comfortable with the assertion that timber framing could provide between 10 and 15 per cent cost savings on gross project costs, not accounting for additional innovative construction materials and techniques that often accompany mid and high rise timber construction.

Where the baseline analysis of 10 per cent construction cost savings resulted in national economic benefits of $103 million over 10 years, increasing this assumed rate of cost savings to 15 per cent results in increased net benefits of approximately $150 million over 10 years.

Note that the net benefit results are heavily influenced by the assumed rate of construction cost savings due to:

- Construction cost savings making up the vast majority of national net benefits; and
- An assumed linear rate of cost savings across different project scales, as industry representatives were not comfortable estimating more complex distributions of cost savings – this could be considered in a wider Regulatory Impact Statement.

Increasing value of carbon

The analysis has found that environmental benefits from timber framing account for 1 per cent of total national benefits ($1) expected from timber framing. A value of $10 per tonne of CO_2 was used in the base line analysis. Doubling the price of carbon used to $20 per tonne of CO_2 also doubles the expected value of environmental benefits to $2 million over ten years.

National net benefits of $104 million could be expected with a $20 per tonne price on CO_2.

Market optimism

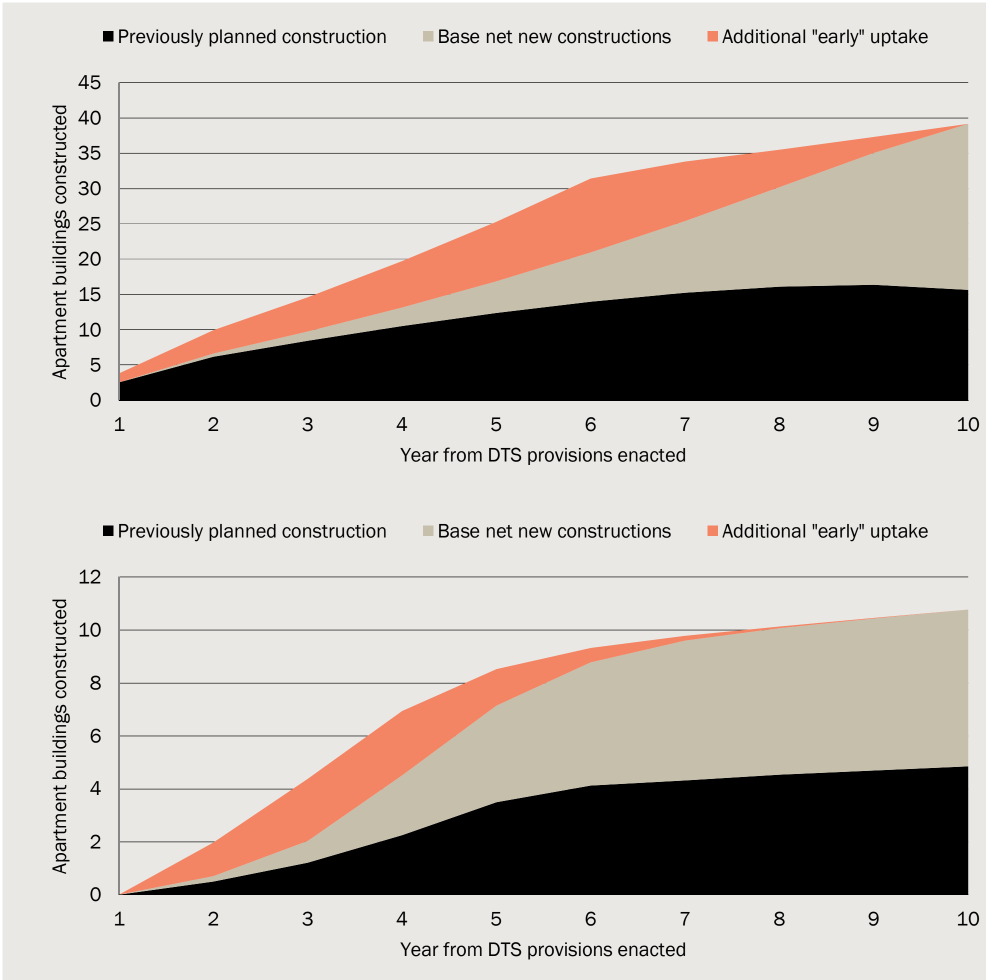
Where the vast majority of net benefits are derived from newly encouraged timber framed developments, the level of optimism generated in the market due to the new DTS provisions will necessarily have a significant effect on the national net benefits calculation.

One degree of market optimism that could have a greater effect on national net benefits is the assumed lag before maximum market penetration is reached. As shown in chart 3.1, a lag of two to three years is assumed before newly encouraged timber framed developments are expected from the DTS provisions.

If this lag effect was shorter, encouraging immediate new constructions, larger national net benefits could be expected. Chart 4.7 outlines assumptions on the rates of early uptake that could be expected from wider market encouragement. This level of early uptake could increase national net benefits to approximately $161 million, as summarised in table 4.8.

Conversely, less than encouraging signals to the market on the benefits of timber framing due to changed DTS provisions, could reduce the expected national net benefits by increasing the delay before construction picks up. Chart 4.9 outlines assumptions on delayed rates of uptake that might be expected. An increased lag before net new timber framed constructions are observed could result in net benefits of approximately $62 million – just over half the otherwise expected national net benefits. The results are summarised in table 4.10.

4.7 Possible rates of early uptake of timber framing



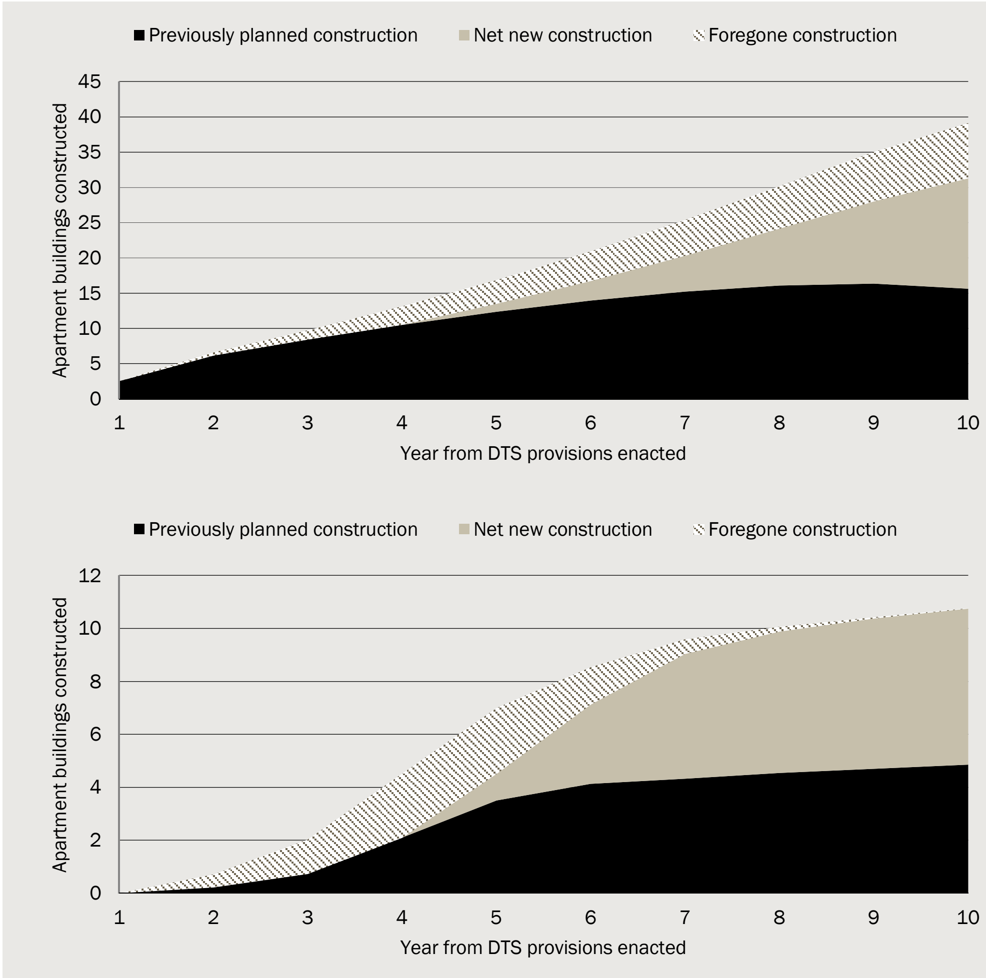
Data source: The CIE

4.8 Effect of greater market optimism

	Multi-residential	Commercial
Savings per net new construction	$1,324,050	$1,717,200
Compliance cost savings per previously planned construction	$ 40,000	$ 40,000
Number of previously planned/envisaged constructions over 10 years	117	30
Number of net new constructions over 10 years	133	42
Total number of timber framed construction projects over 10 years	251	72
Discount rate	7%	7%
Net present value of DTS provisions ($m)	**$ 113.7**	**$ 47.4**

Source: The CIE

4.9 Possible rates of delayed uptake of timber framing



Data source: The CIE

4.10 Effect of reduced market optimism

	Multi-residential	Commercial
Savings per net new construction	$1,324,050	$1,717,200
Compliance cost savings per previously planned construction	$ 40,000	$ 40,000
Number of previously planned/envisaged constructions over 10 years	117	29
Number of net new constructions over 10 years	44	26
Total number of timber framed construction projects over 10 years	162	55
Discount rate	7%	7%
Net present value of DTS provisions ($m)	**$ 35.9**	**$ 26.2**

Source: The CIE

Discount rate

The discount rate provides an indication of the eagerness of the Australian economy to generate immediate savings. A high discount rate places a higher value on immediate savings, and a lower value on savings that might be generated in the future. Alternatively, a low discount rate implies that the value of savings is similar irrespective of whether we need to wait to achieve them.

The baseline analysis has used a discount rate of 7 per cent to value future savings. This is in line with requirements of the Office of Best Practice Regulation (OBPR).

A higher discount rate of 10 per cent (indicating a need for more immediate savings) reduces the net present value of the net benefits to approximately $84 million. This is because a large majority of the construction cost savings are expected from new construction projects five to ten years after the implementation of any new DTS provisions.

A lower discount rate of 5 per cent (indicating a greater patience towards future savings) increases the net present value of the net benefits to approximately $119 million.

5 Conclusions

There is scope for considerable net economic benefits to the Australian economy from increased use of timber framing in mid-rise developments. Increasing the DTS height allowance from three storeys currently to 25 metres could provide approximately $103 million worth of net economic benefits through reduced construction costs, reduced business compliance costs and environmental returns. Increased market optimism around timber framing could see this figure rise to $161 million.

The net benefit analysis draws heavily on discussions with industry representatives and the modelling results show a heavy reliance on the estimated rate of construction cost savings per project and the estimated rate of new construction projects. However, due to the nature of the proposal for change, increasing height allowances for timber framed construction does not impose costs on the wider construction market and therefore, sensitivity analyses show consistent positive net economic returns to the Australian economy from the proposed change.

6 References

Buchanan, A. and Levine, S. (1999) Wood-based building materials and atmospheric carbon emissions. Environmental Science & Policy 2(6) p427-437

Construction costs table http://www.bmtqs.com.au/construction-cost-table

Durlinger, B., Crossin, E. and Wong, J. (2013) Life cycle assessment of a cross laminated timber building. Prepared for Forest and Wood Products Australia

Gustavsson, L., Pingould, K. and Sathre, R. (2006) Carbon dioxide balanceof woor substitution: comparing concrete and wood framed buildings. Mitigation and Adaptation Strategies for Global Climate Change (2006) 11:667-691

Hammond, G.P. and Jones, C.I. (2008) Embodied energy and carbon in construction materials. Proceedings of the Institution of Civil Engineers – Energy, 161(2) p87-98

John, S. et al (2008) Environmental impacts of multi-storey buildings using different construction materials.

Kaethner, S. C. and Burridge, J. A. (2011) Embodied CO_2 of structural frames.

Kelly, J. (2011) The housing we'd choose. Grattan Institute

Mallo, M. and Espinoza, O. (2014) Awareness, perception and willingness to adopt cross-laminated timber in the United States, presentation made to University of Minnesota

Rowley, S. and Phibbs, P. (2012) Delivering diverse and affordable housing on infill development sites. Australian Housing and Urban Research Institute

A Building classes

Class 1: one or more buildings which in association constitute -

a) Class 1a - a single dwelling being -

   i. a detached house; or

   ii. one of a group of two 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; or

b) Class 1b –

   i. a boarding house, guest house, hostel or the like –

      1. with a total area of all floors not exceeding 300 m2 measured over the enclosing walls of the Class 1 b;

      2. and in which not more than 12 persons would ordinarily be resident; or

   ii. 4 or more single dwellings located on one allotment and used for short-term holiday accommodation,

which are 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 building of Class 1 or 2, which is a common place of long term or transient living for a number of unrelated persons, including -

a) a boarding house, guest house, hostel, lodging house or backpackers accommodation; or
b) a residential part of a hotel or motel; or
c) a residential part of a school; or
d) accommodation for the aged, children or people with disabilities; or
e) a residential part of a health-care building which accommodates members of staff; or
f) a residential part of a 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, including -

a) an eating room , cafe, restaurant, milk or soft-drink bar; or
b) a dining room, bar area that is not an assembly building, shop or kiosk part of a hotel or motel; or
c) a hairdresser's or barber's shop, public laundry, or undertaker's establishment; or
d) market or saleroom, showroom, or service station.

Class 7: a building which is -

e) Class 7a - a carpark; or
f) Class 7b - 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 -

a) Class 9a - a health-care building, including those parts of the building set aside as a laboratory; or
b) 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; or
c) Class 9c - an aged care building.

Class 10: a non-habitable building or structure -

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 freestanding wall, swimming pool, or the like; or
c) Class 10c - a private bushfire shelter.

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