Fire Research Report

Analysis of the Revised Purposes of the Building Act 2004

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New regulation requires a Regulatory Impact Statement (RIS) and usually a supporting cost benefit analysis (CBA). The report reviews recent building related CBA and finds that their format and scope varies greatly, depending on the proposed measure. The Ministry of Economic Development RIS guidelines are adequate for building regulation, but it is suggested that some guidance could be given on the economic parameters to be used in building regulation CBA, and the risk factors associated with building health and safety controls.

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Analysis of the revised purposes of the Building Act

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ABSTRACT

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The main changes in the Act relate to the introduction of sustainability as a purpose of the Act. Supporting the new purpose are several new principles including maintenance requirements of housing, whole-of-life costs, sustainable materials and material conservation, conservation of energy use and water, and reduction of waste. The report discusses the connection these principles have with fire design, and specific measures that could help achieve the purposes of the Act.

The old Act had an emphasis on health and safety matters, and these are carried over into the new Act. However, the new requirements of sustainability and user well-being would appear to support a greater level of amenity, including the need to provide for property protection and for future change in building use. These could be matters for regulation.

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2. SUMMARY

This report analyses the changes to the Building Act (BA) with the aim of identifying the contribution fire safety can make to the revised purposes of the Act. A new purpose, sustainable development, and the role of fire safety in sustainable buildings, is discussed. Other changes relating to principles to be applied when regulating are also discussed. The role of regulatory impact statements is analysed, and a review was carried out on recent building related cost benefit analyses. The main findings are:

- Sustainability is a new principle of the BA 2004 and may affect fire safety design in several areas. These include, an increased emphasis on property protection; selection of sustainable materials; and the need to allow for building adaptation and future use in the initial fire design.
- Cost benefit models could be usefully developed for a range of buildings to model the trade-off between cost and property/ life protection, assisting in material conservation and contributing to sustainability.
- Change in use of existing buildings should be investigated with the aim of assessing the costs and benefits of requiring new buildings to be adaptable for future use changes.
- The Ministry of Economic Development has issued guidelines for carrying out Regulatory Impact Statements, but there could be more consistency in the choice of economic parameters used in cost benefit analysis done for building regulation changes.

3. PURPOSE AND PRINCIPLES

The purposes and principles extracted from the Building Act 2004 are in italics (the Section numbers are as per the Act) and comments follow:

3 Purpose

The purpose of this Act is to provide for the regulation of building work, the establishment of a licensing regime for building practitioners, and the setting of performance standards for buildings, to ensure that-

(a) people who use buildings can do so safely and without endangering their health; and

(b) buildings have attributes that contribute appropriately to the health, physical independence, and well-being of the people who use them; and

(c) people who use a building can escape from the building if it is on fire; and

(d) buildings are designed, constructed, and able to be used in ways that promote sustainable development.

Commentary: The purpose has been expanded/clarified compared to the 1991 Building Act (BA).

(a) The health and safety purpose was essentially already in the BA 1991 but is rewritten here in terms of 'safety and health' instead of 'safe and sanitary'.
(b) Includes the people attributes 'health, physical independence, well-being' in the purpose. Previously the BA 1991 had the "need to safeguard people from injury, illness or loss of amenity". Amenity was defined as a building attribute that contributes to the health, physical independence, and well-being of users. So the old definition has been inserted directly into the second purpose of the new Act, Clause 3(b), but in the sense of positively contributing to well-being, rather than the negative sense of avoid loss of the same. The term "well-being" is not defined, but presumably covers building features which enhance the occupants satisfaction although these features may not be essential to its use. It could be argued that features such as room size, light, ventilation, noise, thermal comfort, security, and hygiene facilities are "well-being" features, most of which are currently covered in the building regulations. It is suggested that a level of fire protection beyond that strictly necessary for safety, and providing a greater than current level of property protection is also a well-being attribute.
(c) Means of escape from fire – no significant change here from BA 1991.
(d) Promote sustainable development –this is a new purpose not mentioned in the purposes and principles of BA 1991. This is discussed later.

4 Principles to be applied in performing functions or duties, or exercising powers, under this Act
(1) This section applies to-
(a) the Minister; and
(b) the chief executive; and
(c) a territorial authority or regional authority (but only to the extent that the territorial authority or regional authority is performing functions or duties, or exercising powers, in relation to the grant of waivers or modifications of the building code and the adoption and review of policy on dangerous, earthquake-prone, and insanitary buildings or, as the case may be, dangerous dams).

(2) In achieving the purpose of this Act, a person to whom this section applies must take into account the following principles that are relevant to the performance of functions or duties imposed, or the exercise of powers conferred, on that person by this Act:
(a) when dealing with any matter relating to 1 or more household units,-
(i) the role that household units play in the lives of the people who use them, and the importance of-
(A) the building code as it relates to household units; and
(B) the need to ensure that household units comply with the building code:
(ii) the need to ensure that maintenance requirements of household units are reasonable:
(iii) the desirability of ensuring that owners of household units are aware of the maintenance requirements of their household units:

Commentary: Clause 4(2)(a) is new to the BA 2004. It emphasises the importance of housing in peoples lives and hence the need for maintenance to achieve durability. In the area of residential fire safety there is the dilemma of recognizing the potential benefits of requiring or promoting the greater use of life safety systems such as smoke alarms and fire sprinkler systems, but at the same time not burdening home owners with onerous maintenance and/or ongoing third-party inspection costs that may cause a decision to be taken not to invest in the fire protection feature in the first place. Although the reliability of the feature may be potentially reduced, assuming no mandatory third party maintenance/inspection requirements, there may still be sufficient benefits to be gained compared to the 'do nothing' option. The introduction of domestic home sprinkler systems is an example of this – once installed there is no mandatory requirement at present for ongoing inspections by an IQP, the owner takes responsibility for the continued operability of the system.

The combined Consumer - Department of Building and Housing (DBH) web-site www.consumerbuild.org.nz has information on maintenance of houses for owners, including checking smoke alarm batteries. There has been some publicity of this site so it could be argued that the regulators are starting to address (B)(iii) above. We note from the BRANZ 2005 House Condition Survey (2005) (of 565 privately owned houses) that only 15% of houses did not have a smoke detector(s). However fewer than 10% are mains connected, and 9% of houses had some or all detectors not working. When asked how often they checked the batteries, 86% said six months, or less, but 14 % said never. So with 9% not working and, 14% never checking, there is an issue of on-going maintenance, but as stated above, the current situation is much better than not promoting smoke detectors. The overall condition (envelope, linings, etc) in the survey was better than in the 1999 House Condition Survey, but deferred maintenance was still quite large at an average of $3,700 outstanding per house.

(b) the need to ensure that any harmful effect on human health resulting from the use of particular building methods or products or of a particular building design, or from building work, is prevented or minimised:

Commentary: Materials that present particularly high risks of fire spread and hazard need to be controlled. There are existing requirements in the Building Regulations 1992, clause C3 for interior and exterior spread of fire that serve this purpose. Clause 3.3.10 states that environmental protection systems shall ensure a low probability of hazardous substances release.

(c) the importance of ensuring that each building is durable for its intended use:

(d) the importance of recognising any special traditional and cultural aspects of the intended use of a building:

Commentary: Recognition of special traditional or cultural aspects of use was covered in Section 47 (BA 1991). It ensures that traditional uses can be balanced against reduced health and safety features, eg, single means of escape in wharenui (meeting houses).

(e) the costs of a building (including maintenance) over the whole of its life:

Commentary: The Act does not specify which costs, apart from maintenance, are to be considered but presumably it includes operating, renovation, demolition and disposal costs. Formal discounting methods, such as NPV, are implied by this clause, to enable consistent comparisons between measures with low initial costs and high on-going costs, and vice versa. For example, there have been instances where the introduction of performance-based codes has resulted in shifting some up-front construction costs to ongoing maintenance costs – this could happen for example by removing passive fire protection from the building and replacing with mechanical smoke control. Does this mean, given equivalent performance, that passive means of smoke control should be preferred over mechanical systems? Use of passive systems is likely to be more restrictive on architectural design while active systems generally allow greater use of atriums and other open spaces which may be desirable to enhance the user's enjoyment of the building as well as the building's functionality. We assume the meaning of this clause is that if new regulations favoured passive measures over active measures, or vice versa, a whole-life cost study would be done to quantify the impact of the regulation. In reality, fire protection systems in buildings should be a mixture of both active and passive systems working together to limit the overall risk to an acceptably low level.

The previous Act had a requirement to consider "national costs and benefits of any control…" but the new Act specifies only costs. However all regulations (building related and otherwise) already require a Regulatory Impact Statement (MED 1999), often including a cost benefit analysis. This will be discussed later.

This clause could theoretically be interpreted as enabling a maximum lifecycle $/sqm rate to be set for various types of buildings. But this is considered very unlikely, and instead its purpose, as stated above, is to cost the impacts when comparing alternative measures to achieve the purposes of the Act. Note that there does not necessarily need to be net dollar benefits from, for example, increased fire safety, just that the net cost of any new measure needs to be quantified, so that decision makers can trade off costs against achieving other aims such as greater life safety or higher sustainability in buildings.

(f) the importance of standards of building design and construction in achieving compliance with the building code:

(g) the importance of allowing for continuing innovation in methods of building design and construction:

(h) the reasonable expectations of a person who is authorised by law to enter a building to undertake rescue operations or firefighting to be protected from injury or illness when doing so:

Commentary: The mention of standards is new to this revision, and reminds regulators that standards are an efficient way to achieve compliance, in contrast to the alternative of specific design solutions. However, the reference to innovation is a reminder to regulators that the regulations should not be unduly prescriptive and that the main thrust of controls is performance orientated, despite the recent addition of prescriptive solutions for weathertightness to the building code.

There have been no economic studies in New Zealand on the benefits or otherwise, of the performance oriented building code. In Australia, the Australian Productivity Commission (APC 2004) provided examples of cost savings, and reported on a survey of building surveyors which showed 80% believed the introduction of performance orientated regulation has had a positive impact on overall performance including cost savings. However some concerns were expressed about maintenance costs with 64% disagreeing with the statement that maintenance costs had reduced.

There is no change from BA 1991 with respect to providing for fire fighters.

(i) the need to provide protection to limit the extent and effects of the spread of fire, particularly with regard to-
(i) household units (whether on the same land or on other property); and
(ii) other property:

Commentary: No change from BA 1991 with respect to protection of household units and other property.

(j) the need to provide for the protection of other property from physical damage resulting from the construction, use, and demolition of a building:

(k) the need to provide, both to and within buildings to which section 118 applies, facilities that ensure that reasonable and adequate provision is made for people with disabilities to enter and carry out normal activities and processes in a building:

(l) the need to facilitate the preservation of buildings of significant cultural, historical, or heritage value:

Commentary: The old Act had requirements under the principles in Section 6 for protection of other buildings, and disabled access. Consideration of special cultural or historic buildings was covered in Section 47 (BA 1991). As in the old Act, the new Act wording implies a higher level of protection/consideration for some buildings. This does not translate into the regulations anywhere. Maybe there should be a new objective under Clause C3.1 of the Regulations that acknowledges this principle. The could be along the lines of "(e) Protect buildings of significant cultural, historical, or heritage value from the effects of fire". There would also then need to be corresponding functional and performance requirements in Clause C3.

This principle of protection of significant buildings links back into the new 'sustainability' purpose in the Act in the social /cultural aspects of sustainability.

(m) the need to facilitate the efficient use of energy and energy conservation and the use of renewable sources of energy in buildings:

Commentary: Given two fire protection options, this clause suggests that the designer may favour the one requiring the lower energy inputs. This clause seems to advantage passive methods over active systems. However the analysis would need to also consider embodied energy, as well as operating energy. The reference to renewable energy is new to the BA 2004 and supports passive solar design, solar water heaters, photovoltaic, and other renewables, none of which appear have a direct link with fire safety.

(n) the need to facilitate the efficient and sustainable use in buildings of-
(i) materials (including materials that promote or support human health); and
(ii) material conservation:

Commentary: This is a new principle. Sustainable use of materials includes both life-cycle environmental analysis and cost benefit analysis. Environmental analyses are discussed later. However looking at material conservation from a cost-benefit viewpoint there is potential for reduced fire losses (building and its contents) in the event of fire. Buildings that are provided with minimal fire protection may have large reasonably foreseeable losses in the event of a fire. There is a need to develop a cost-benefit model to understand the value of an increased level of fire protection for a range of building types. How much should be invested in fire protection to satisfy this principle in the BA?

(o) the need to facilitate the efficient use of water and water conservation in buildings:

Commentary: It takes much less water to control/extinguish fire with a fire sprinkler system compared to water applied by fire-fighters using hoses. On the other hand, fires are such a rare event in the life-cycle of a building that the quantity of fire-fighting water used over the life of the building may be of no consequence, except as it might affect the provision of infrastructure. It may be feasible to reduce the cost of providing fire-fighting water supplies (or Fire Service infrastructure) to a new community if that community was fully sprinkler protected.

Water conservation measures could result in reduced main water pressures or flow rates if pipe sizes were reduced due to lower water demand. This could adversely affect fire protection systems.

(p) the need to facilitate the reduction in the generation of waste during the construction process.

Commentary: Some fire protection systems will involve more waste than others. For example passive methods including fire resistant sheet linings tend to have a greater volume of off-cuts than active systems which have a high pre-fabricated content.

Clause (p) above is the final purpose in the 2004 Act, and the appendix contains extracts from the 1991 Act to enable comparisons with the new Act's provisions.

4. SUSTAINABILITY

Promotion of sustainable development is one of the four main purposes of the Building Act. It is new to the 2004 revision and is line with the overall thrust of Government policy to introduce sustainability measures into the economy. The Ministry for the Environment launched the Sustainable Development Programme of Action in 2003 to encourage developers and territorial authorities (TAs) to include urban design issues in their work. Some of the actions in the Programme are:

- Urban Design Protocol (March 2005) advising TAs of the sustainability issues in city planning and design.
- Sustainable Cities, in which Government agencies are working with Auckland TAs in the areas of urban form, development and design.
- Govt3, to advise Government departments how to build their infrastructure more sustainably.
- Profiting for Environmental Initiatives, seminars for property owners stating the business case for sustainable buildings.

The term 'sustainable' is not defined in the Building Act. What is sustainability and what is the link to building fire protection and risk management?

The most common definition for sustainability is as per the Brundtland Commission - "*development which meets the needs of the present without compromising the ability of future generations to meet their own needs*." It is generally accepted that it can be likened to a tripod with three legs that support sustainable development, namely environmental, economic, and social/ cultural sustainability.

Locally, the Ministry for the Environment (MfE) suggests a definition for sustainable buildings - *"Sustainable building includes sustainable construction, life cycle analysis of materials and methods, architecture (including historical and cultural heritage/buildings), and physical infrastructure provision and engineering. It can be described as construction that meets current building needs, minimizes adverse affects on occupants and the environment, and reduced impacts on future generations."* – Urban Sustainability in New Zealand: an information resource for urban practitioners, Ministry for the Environment 2003.

The MfE definition does not specifically include economic sustainability, which is the requirement that expenditure be allocated efficiently and with due regard for future costs and benefits. Life cycle analysis is sometimes confused with life cycle cost analysis. The former is a measure of the environmental impact of a building, from extraction of the raw materials for the components, through to final disposal of the materials, whereas the latter is about minimising whole life costs. However we consider that economic sustainability is an integral part of overall sustainability and that due weight needs to be given to economic considerations when interpreting and implementing the sustainability principle of the Act. Already there is a Government requirement that all new regulation have a Regulatory Impact Statement (RIS), which often includes a cost benefit analysis, and the new Act reinforces the need to ensure that building controls contribute to economic sustainability.

The new principle of sustainability also implies that the RIS processes will need to include the wider indirect environmental and social/community 'benefits' as well as the direct benefits derived from any expected reductions in death/injury rates and any savings in physical property losses.

It is apparent that a number of the purposes of the Building Act directly relate to sustainable buildings, namely maintenance requirements, clause 4(2)(a), healthy buildings 4(2)(b), traditional/cultural uses 4(2)(d), whole life costs 4(2)(e), preservation of cultural/heritage buildings 4(2)(l), energy efficiency 4(2)(m), material sustainability 4(2)(n), water efficiency 4(2)(o), and waste minimisation 4(2)(p).

Research the Fire Service has commissioned is related to some of these areas. For example, protecting heritage buildings (NZFSC 2004, Report No 48), and ecotoxicity of fire water run-off (NZFSC 2001, Reports 17, 18 and 19). These are not currently subject to building regulation, though the first study has useful advice on protecting heritage buildings when renovating, altering or making additions, and the second study discusses pollution prevention plans for high risk sites, (though not mitigation measures, e.g. run-off storage which could be incorporated in design for buildings likely to contain toxic materials.) The US National Fire Protection Association has work in progress on the environmental impacts of fire, but has not reported as yet. Their work is expected to include cost data as well as environmental impacts.

4.1 Measurement of sustainability

How are sustainable provisions in buildings measured? The most common method is a sustainability index, or a "green building index". For buildings these score on impacts such as energy use (operational, embodied), proximity to transport, pollution (indoor and outdoor), materials (renewable and recycled, construction waste management), water use, land use, health and well-being (comfort, daylighting, sound proofing, private spaces, security, etc). There are a wide variety of indexes available overseas (Ecohome, Breeam, LEED, BASIX, etc) and in New Zealand the BRANZ Green Home Scheme (GHS), and the Tool for Urban Sustainability used by some territorial authorities. The GHS includes energy use, transport, type of smoke detectors, materials and water efficiency only, and most indexes are limited in the number of impacts they consider. They allow designers to trade-off between the various measures, to suit the particular house location and owner.

Approximately 30 new houses have been rated in the GHS, but it is mainly used by designers as a design assist tool without going through the formal rating by BRANZ. There are at least this number of other "green homes" designed by architects specialising in environmental friendly residential design. A consortium called Beacon Pathway (Fletcher Building, Waitakere City, Scion, Building Research, and NZ Steel) is researching sustainable houses and has recently build a trial house with sustainable features called the NOW house (www.nowhouse.co.nz). It is currently tenanted and is being remotely monitored to assess performance. Green features of the NOW house are energy and water use, health, well-being, comfort, durability of materials, and overall functionality. The consortium's goal is to introduce sustainability in all new housing before 2012. There is currently no consensus on exactly what is a minimum standard for a sustainable house, but experience from the Beacon programme, plus the work of others will facilitate a better understanding of NZ conditions and what can be reasonably achieved in mainstream housing.

None of these schemes measures fire protection as an issue to be scored in an overall sustainability impact index, apart from a small weighting for smoke detectors, usually with extra points for hard wired and /or linked detectors. There is the possibility that recycled fire safety equipment, (e.g. sprinklers, pipes and pumps), would receive a credit in some schemes. It is also likely some passive fire resistant materials would score better than others. For example, the embodied energy content of a firewall made from concrete would differ from a similar performance wall made from plasterboard on timber frame. However the level of life or property fire protection inherent in a design is not included in any of these indexes, though it could be argued these are occupant well-being type issues, and should be measured in "green" building indexes.

The main sustainability issues already covered in the building code are, healthy buildings (through ventilation requirements), traditional/cultural/ historic buildings discussed earlier, and energy efficiency. The latter was in the old Act but has been expanded to include energy conservation and use of renewable resources. Energy efficiency is in the Building Regulations as Clause H1. To achieve broader sustainability the regulators could possibly rename section H, as Sustainability, and introduce other measures. This has occurred in the Building Code of Australia (BCA) where Victoria and NSW use sustainability trade-offs. In Victoria this is limited to a choice between a rain water tank or a solar water heater, plus a 5 star energy rating, for new houses. The latter allows various combinations of ceiling, wall, floor and window insulation. In NSW (Sydney area only) they use a more comprehensive sustainability index, the BASIX, which applies to the land development and housing consents. The three main issues measured are energy efficiency, water use and thermal comfort, and a minimum overall score is required.

In New Zealand it is not known if an index type approach would be considered by DBH. As mentioned, some local indexes are available, consensus on what should be included appears to be achievable, and the regulations could refer to an industry developed standard. However in the immediate future it is more likely that DBH will decide on specific measures for the regulations under a general sustainability section H. Clause H1 could remain as the energy efficiency clause. The next easiest issue to address is water efficiency and this could be a new clause H2. Other impacts, such as use of materials and waste minimisation, are harder to measure and regulate. We have not found these regulated through building controls in any other country, and where Governments have intervened they have used information and education programmes, recycling development grants, and landfill controls, rather than building regulation. Overseas interventions for sustainability in buildings are discussed further in the Appendix.

4.2 Property protection

The Australian Productivity Commission study on the aims and outcomes of building regulation reform in Australia found several issues relating to property protection. These were:

- There was uncertainty about the level of the building and contents protection embodied in the Building Code of Australia (BCA).
- There was insufficient focus on property protection in the BCA, and this was not in line with community expectations.
- The BCA and the legislation governing the fire authorities had different objectives relating to property protection.
- Owners were not aware that a BCA compliant building may require additional fire protection measures to get property and contents insurance cover.

In NZ some of these issues are relevant. Some owners may not be aware that insurance companies may require above code fire protection measures for some buildings. In the old Act it was clear that the regulations' objectives were limited to occupants' protection, and not the contents, however the concept of sustainability and well-being of occupants, in the new Act, appears to go beyond this. As in Australia it may also be the case that owners expect a higher degree of property protection, though we are not aware of any studies into this for New Zealand.

The NZFSC has as two of its five objectives "to reduce the consequences of fire for property" and "to reduce the consequence of fire for communities and the environment". This is more explicit regarding property than the Building Act and appears to be based on an interpretation of the Fire Service Act 1975, Clause 20 (2c) "Reduce continually the incidence of fire and the attendant risk to life and property". So the Fire Service already has a mandate to protect property and the question is should property protection measures be introduced through building regulations, and if so, to what extent?

The justification for a degree of property fire protection, beyond health and safety requirements, would be the need to appeal to the new sustainability aspects of the Act, plus the reference to well-being of people. The latter is the second purpose of the Act, to ensure that "buildings have attributes that contribute appropriately to the health, physical independence, and well-being of the people who use them" (Clause 3(b)). Well-being and physical independence would seem to imply some degree of assurance to occupants that design and materials will protect or mitigate owners from property loss in the event of fire loss.

4.3 Building adaptation

The sustainability purpose in the Act reads "buildings are designed, constructed, and able to be used in ways that promote sustainable development", Clause 3(d). The adaptation of buildings to new uses, and the appropriate design of new buildings so that they can be readily adapted to new use is an obvious measure to promote sustainability. If we are to reduce impact on 'future generations', then building designers should be more accommodating of reasonable foreseeable changes in the way buildings are used. Adaptable building design is not an objective in itself but one method to address resource conservation, and it also makes it easier to modify for people with disabilities and/or the needs of old persons.

An adaptable design may cost more initially; for example, the provision of long span roof trusses so that interior walls can be readily shifted may cost more than lighter trusses supported at internal walls. But other flexible measures would have a low cost, for example, arranging the pipework in a new house so that fire sprinklers, or solar water heating panels, can be readily accommodated at a future date, assuming the first owner decided not to install these features.

4.4 Sustainable fire design examples

Fire protection choices that would promote "sustainability" are:

- Stop fires from starting or keep them small. Fires destroy buildings and its contents creating wastage, due to the re-building of what was an existing asset.
- Smaller fire compartments will reduce the maximum foreseeable loss due to fire. Currently firecell floor areas can be unlimited in many unsprinklered buildings.
- Require greater use of fire sprinklers to keep fires smaller.
- Gas suppression systems using 'clean extinguishing agents' in preference to water in some situations, avoiding possible water-runoff concerns. Water mist sprinkler systems would also reduce run-off.
- Choosing mains-powered smoke detection systems or long-life batteries – in preference to disposable stand-alone alarms.
- Building materials, fittings, and furnishing choices that minimise toxic by products.

- Encourage greater use of photoelectric detectors in preference to ionisation detectors which include radioactive material.

Two examples of potential new regulation for fire design follow, based on property protection and designing for building adaptability.

4.4.1 Firecell area

As an example of fire design regulation for the promotion of sustainability consider firecell areas. Should firecell area limits be placed on unsprinklered buildings to limit the effects of the fire on the surrounding environment and to limit the losses?

In many cases, firecell floor areas are unlimited in unsprinklered buildings. For example, an industrial building remote from a site boundary (for which an s-rating does not apply) requires no internal fire-rated compartmentation (see extract from C/AS1 below). Large fires in industrial buildings of this type pose difficulties for fire-fighters who may have no choice but to let the building burn. There could also be potential problems with contaminated fire-fighting water runoff.

"C/AS1 4.2.3
Except as permitted by Paragraph 4.2.4, the floor area of an unsprinklered firecell to which an S rating applies, shall not exceed the maximum firecell floor area given in the following table.

Fire hazard category (from Table 2.1)	*Maximum firecell floor area (m2)*
1	*5000*
2	*2500*
3	*1500*
4	*Specific fire engineering design required*

COMMENT:
Firecell floor area limits assist fire-fighting operations, and are set to limit total fire load to approximately 2,000,000 MJ in unsprinklered firecells."

"C/AS1 4.2.4
In an unsprinklered single floor building where the building elements supporting the roof are not fire rated, the firecell floor area may be unlimited provided that no less than 15% of the roof area (distributed evenly throughout the firecell) is designed for effective fire venting."

4.4.2 Design Flexibility

Another example of fire design regulation which assists sustainability is to require the initial design to allow for a 'reasonably foreseeable' future change of use.

In a fire design context, building fire protection may be specified for a low hazard fire load because that is all that is required for the initial use anticipated, at least cost. But when the occupancy changes or even the commodity changes in a warehouse – the cost of upgrading the fire protection to meet Building Code or insurance requirements is more expensive/wasteful than if the original construction/specification had allowed for a reasonably foreseeable change in use.

This issue is already recognized in C/AS1 para 1.3.1 where the following comment is provided –
"COMMENT:
Future flexibility. It is very likely that a building, over its lifetime, will undergo one or more changes in use. Even under the same use, floor layout and furnishing will alter to accommodate changes in technology and occupant practices. Owners should therefore consider the advantages, at initial construction time, of providing for fire safety precautions to suit

alternative occupancies. These could be difficult or excessively expensive to install at a later date."

The Acceptable Solution C/AS1 classifies buildings into purpose groups. For industrial/warehouse type buildings there are four purpose groups that could apply – WL, WM, WH, or WF. Since these all are applicable to buildings used for storage, do they have the effect of constraining future use? Would it not be more 'sustainable' to design warehouses assuming more hazardous contents to allow for future flexibility without the need for fire protection re-design?

5. REGULATION OR THE MARKET

For many sustainability type interventions the existing markets do not fully reflect the environmental and social costs (and benefits). For example, building material costs do not include environmental costs such as greenhouse gas emissions (though the Kyoto energy surcharge from 2007 will begin to address this), and the issue of intergenerational access to non-renewable resources is not reflected in prices.

Apart from these "externalities", there is doubt whether price signals in the building industry are clear due to the complex supply chain of tenants, owners, builders, developers, and designers. There are also information costs as many transactions are one-off and owners may not have previous experience to guide them, and buildings tend to have long lives. Deficits may take years to appear and the potential for failure may not be apparent at the time of purchase. Property developers may have incentives to minimise capital costs because on-going costs, such as water and energy charges, are borne by the tenants.

Due to this mix of price distortions and information gaps there may be a case for intervention by Government in terms of regulation.

Previous sections described sustainability issues relating to property protection, and adaptability/ change of use of buildings. However, is regulation needed or would the market efficiently address these issues? The case for regulation depends on whether there is a market failure, the effectiveness of other interventions, and whether the benefits of intervention exceed the costs. If regulation was not used other interventions available are:

- voluntary standards and certifications,
- information and education campaigns,
- economic instruments (taxes, subsidies, grants).

Voluntary standards arise when market providers develop a standard of performance for voluntary compliance. Education campaigns could be industry or Government funded. Economic instruments are usually Government measures. Taxes include such measures as taxes on resources (energy, water, landfill, etc) to encourage efficient use. Subsidies and grants are used to establish markets on the supply side (e.g. recycling, solar panel manufacturing), which hopefully become self-funding.

The purported market failures in earlier sections include:

- The level of property protection for home owners may possibly be lower than expected by them due to information failures of owners' expectations.
- The level of property protection in a range of building types may be insufficient due to inadequate understanding of the costs, risks and benefits.

- The level of property loss from fire is at a level which may be causing damage to the environment and does not demonstrate conservation of materials.
- Designers/ owners are not specifying buildings that can be readily adapted to changing use, due to initial cost concerns and information failure.

In the first example the issue is how important residential property protection is in terms of owners feelings of well-being. Most, but not all, housing owners carry fire insurance, so the market operates in terms of financial loss, but to what extent owners expect better property protection is not known. Also the uninsured "free ride" on the public fire service, which is paid by the insured at the time they renew their private insurance. The incentives for voluntary insurance would seem to be overwhelming for most owners, so regulation for compulsory insurance would seem to be unnecessary. New Zealand has a fairly low domestic fire fatality rate (Wade, Duncan 2000) in comparison with other developed countries, suggesting that property damage may also be comparatively low and acceptable to owners, but it may be worthwhile to explore owners perceptions on the level of property protection afforded in the NZBC.

In the second example, the trade-off between fire protection measures and property loss needs to be better understood, particularly for non-residential buildings. Insurance companies are not proactive on this as their focus is on balancing premiums with historic losses, rather than a first principles assessment of fire protection measures (with some exceptions). To some extent this is understandable because the risk data usually has a significant margin of error, and refinement of fire design may be swamped by other factors such as occupant behaviour. So there may be a case for an increased level of regulated fire protection from a property protection perspective, but further studies need to be done. These studies would also consider injury/ life protection benefits since these arise as part of property protection.

In the third example, environmental costs of fire damage such as toxic run-off and smoke pollutants are not covered in the insurance premiums charged. The Building Regulations have building performance requirements for release of hazardous substances, (C3.3.10) but an Acceptable Solution may need to be referenced or developed for this.

Last, it is possible that buildings are not being designed to a suitable level of adaptability, including provision for change of use from a fire protection view. Inadequate design probably arises because the extra initial cost is not always recovered in the re-sale price due to information failures. The Acceptable Solution C/AS1 has a comment for designers on future flexibility, but owners need to be educated on the cost advantages of designing for change of use. In office buildings owners are becoming aware of the advantages of energy efficiency built into the initial design, and it seems likely provision for adaptability is another feature that would enhance the re-sale value. To some extent the market will value buildings designed for enhanced fire adaptability if an education programme is used, however regulation may still be required if further research showed that lack of adaptability of existing buildings has large economic costs.

6. COST BENEFIT ANALYSIS

Cabinet instructions require all policy proposals that result in government bills or regulations to be accompanied by a Regulatory Impact Statement (RIS). Where a proposal has business compliance cost implications, a Business Compliance Cost Statement (BCCS) should be incorporated into the RIS. The RIS needs to contain:

- Statement of the nature and magnitude of the problem and the need for government action.
- Statement of public policy objectives.

- Statement of feasible options (regulatory or non-regulatory).
- Statement of the net benefit of the proposal.
- Statement of consultation undertaken.
- BCCS (if applicable).

Generally the RIS is no more than 3 pages, but it may refer to a cost benefit analysis (CBA), and other documents. MED documents (MED 1999, 2001) provides guidance for RIS, and the BCCS, and includes techniques for carrying out the CBA.

Points to note from the cabinet guidelines are that measures other than government regulation may be an option, as mentioned in the previous section. However, where these, and market forces, will not provide a solution then regulation may be the only option.

The Australian/ New Zealand standard on life cycle costing provides guidance on the technical aspects of undertaking financial comparisons and is a useful supplement to the MED documents.

Table 1 lists recent CBA done to support changes in regulations and for new legislation. The extent of the analysis varies greatly, depending on the scope of the regulation. For example, the PriceWaterhouseCoopers report on the new Building Act included an extensive study of the impacts on the cost of materials, labour, training and licensing of building practitioners, territorial authority costs, and increased design and supervision costs. The benefits of the new measures namely reduced building failure rates were not quantified. Another extensive report prepared by NZIER attempted to quantify the benefits of specific measures relating to improved cladding systems and timber treatment. (NZBC Clauses E2 and B2). Assumptions were made for reductions in weather-tightness failures, and this enabled an NPV to be calculated for various scenarios.

At the other end of the scale the BIA have published a number of Consultation Documents which have no CBA, and in which the costs are identified as minor, but not quantified. These include fairly minor changes to regulations relating to NZBC clause changes relating to Safety from Falling, Emergency Lighting, and Structure (steel re-bars strength changes).

It is apparent the stringency of the analysis is tailored to the extent of the change, with minor changes having a fairly cursory examination of impacts. The more significant changes generally had the benefits quantified, usually as a reduction in costs of operation or repair of the building, but in one case as assessment of amenity improvement (Firecon sound attenuation study).

The techniques used in the CBA vary somewhat. The most common method is simply to identify cost impacts and quantify these, usually as additional new building costs. Some reports have the results expressed as a benefit cost ratio, and some sensitivity analysis is done by changing discount rates, failure rates, injury rates, etc. Assigning the benefit is quite difficult in many cases. In fire design we need to estimate fire injury and death rates both with and without the ‘proposed change’. Existing fire death and injury rates are usually derived from fire incident reporting data such as that collected by the New Zealand Fire Service.

For example, BRANZ carried out an analysis to estimate the cost per life saved of installing combined home fire sprinkler/plumbing systems (Wade and Duncan 2000). It was necessary to estimate the number of fire deaths expected each year with a home sprinkler system to determine the expected reduction in the number of deaths compared to the current situation. The current situation can be represented by historical fire incident data for fire deaths in houses. The fire deaths in houses with home sprinklers could not be estimated from the New Zealand Fire Incident records because it is a new technology and there is no historical fire incident data to call on. In this case, overseas (USA) fire incident data for conventional sprinkler systems in houses was used but adjusted to maintain sprinklered vs non-sprinklered ratios between countries, and using authors judgement on the expected performance and reliability of the proposed new system compared to conventional fire sprinkler systems. Thus, the absence of historic data for a new technology may require expert judgement to aid in the estimate of future benefits.

Even when data on risk is available it often has limitations. For the case of fire incidence data the limitations include:

- The incident is only recorded when the fire service has been called out, thus many small fires that are extinguished by occupants or self-extinguish are not included in the statistics.
- Data is collected by fire-fighters, who may not be motivated to ensure the data is accurate
- Some deaths and injuries may not be apparent until some time after the fire event and may be missed by the incident statistics.
- New Zealand is a small country and fire is a rare event. Often the number of incidents relevant to a particular fire protection feature are small and may not be statistically significant.

Among the major parameters are the values placed on human death and injury. Not surprisingly these vary quite widely across different countries, and the richer the country the higher the value. For purposes of allocating scare resources it is important that a country use consistent values for the same categories of risk. Involuntary risk, such as that involved with transport, or use of buildings, would tend to have a higher life value than voluntary risks, such as those associated with some sports activities. One measure of value is the expected average earnings life of the person at risk. On this criteria old persons (e.g. in a aged-care home) would be valued differently from young persons (e.g. in schools). These examples illustrate the difficulty of defining an appropriate value for human life.

In some reports the costs are expressed in terms of $ per life saved, which avoids the need to assign a value per human life. However at some stage a judgement is still required on whether the implicit value so derived justifies the expenditure. Other reports use the commonly accepted Land Transport Safety Authority human life value and derive a net present value (NPV). The Firecon report for changes to the Approved Documents C1 to C4, calculated the required percentage reduction in the injury and death rates when the costs exactly equal the benefits of the proposed changes. It then asked whether these percentage reductions in injury/ death were likely to occur, and concluded they were for some of the options.

Generally most reports are restricted in the benefits and costs that are considered, most being narrowly focussed to the costs and benefits of the proposed measure. We have not found any studies that analyse the follow-on economic effects, except for the BERL report which considered lost wages and employment throughout the economy due to fire damage of businesses. In one study BRANZ commissioned BERL (2003) to quantify the economy wide flow on effects for hypothetical residential energy savings. This was a scoping study done for EECA, rather than any particular proposed code change. It found that a 10% reduction in energy use in the residential sector due to increased insulation would have a 0.2% increase in GDP after 10 years of new housing to the higher standard. These type of studies use macroeconomic models and they can readily model the flow-on effects to the rest of the economy.

In recent times EECA has become interested in trying to quantify the non-energy benefits of energy efficiency. These include improved comfort, less mould growth on interior surfaces, and health improvements. These are difficult to quantify and researchers usually find the best they can do is to flag the benefit without any number attached, so decision makers are aware of it even if it has not been quantified.

In terms of reporting the results of CBA a variety of measures are used. Where NPV analysis is carried out the discount rates vary between 5% and 8% and the analysis period also varies from 8 years up to 40 years. The MED guideline provides no advice on this. However, a Treasury paper (Young 2002) suggest that the discount rate to be used is the social opportunity costs, proxied by the capital asset pricing model (CAPM). This requires a knowledge of the financial parameters used to calculate the CAPM rate of return, and could result in different discount rates for different types of measures, see the Appendix.

Table 1 Recent CBAs and building regulation

Recent cost benefit studies relating to building regulation					
Author	**Title**	**Report for**	**Date**	**Method and coverage**	**Comments**
BRANZ	Cost effective domestic fire sprinkler systems Report No 1.	NZFSC	Aug-00	Cost per life saved	Combinations of sprinklers/ smoke detectors. NPV analysis, 6% discount rate.
Caldwell Consulting	Risk assessment & CBA of corridor smoke detectors in rest homes. Report No. 4.	NZFSC	Aug-00	Cost per life saved	Various combinations of sprinklers and smoke detectors. No discounting.
BERL	An economic assessment of industrial fires in New Zealand, Report No. 28.	NZFSC	Jan-02	Direct/ indirect costs, I/O.	Includes building, contents, business disruption, reduced income costs.
BRANZ	CBA of regulating fire safety performance of upholstered furniture. Rprt No 35.	NZFSC	Mar-03	Cost per life saved	Sensitivity analysis on the discount rate. NPV analysis.
BERL	Peer review of Report No. 35.	NZFSC	Aug-03		Suggests results should also include the PV of costs and benefits seperately.
PWC	Social and economic impact study of changes to building regulations.	MED	May-03	Direct and indirect costs	Assesses cost impacts of new Building Bill. Benefits identified but not quantified.
NZIER	CBA of proposed changes to Clause E2 and Approved Docs B2/AS1 and E2/AS1.	BIA	Jun-03	Costs and estimated benefits	Weather-tightness measures. NPV analysis, 5% discount rate.
BIA	Consultation Document, Clause F4 Safety from Falling.	BIA	Aug-03	No cost data.	Some injury stats - swimming pool drownings, injuries from falling.but not costed.
Rider Hunt, Firecon	Cost analysisof changes to Clause G6 Airborne & Impact Sound.	BIA	Nov-03	Costs and estimated benefits	NPV 7.5% discount rate. Values noise attenuation in $/dB./household/yr.
BIA	Consultation Document. Clause F6 Lighting for Emergency.	BIA	Feb-04	Approximate costs	Costs are approximate $/sqm rate. No benefits quantified.
BRANZ	Economic analysis of window insulation, Clause H1.	BIA	Feb-04	Costs and benefits	Double glazing. Benefits are reduced energy use. NPV, 5% and 8% discount rate.
BIA	Changes for B1/VM1 (NZS3109, relating to Grade 500 steel and hollow core floors)	BIA	Jun-04	No cost data.	Costs expected to be minor. Value of safer buildings are not quantified.
Rider Hunt, Firecon	CBA of proposed changes to NZBC Approved Documents C1, C2, C3 & C4.	BIA	Sep-04	Breakeven injury/death rate.	Assumes $4m life value, no discounting.
BIA	Changes to Approved Documents for B1 (NZS3109 Concrete Construction).	BIA	Dec-04	No cost data.	Costs minor, no benefits. Change reflects relocation of technical clauses.
Forest Research	CBA of Amendment No 4 to NZS3603 (related to timber grading).	DBH	Apr-05	Costs and estimated benefits	NPV. Discount rate used is not apparent.

6.1 Details of building related cost benefit studies

This section amplifies the summary in Table 1 of the types of CBAs carried out in recent years.

Cost effective domestic fire sprinklers, NZFSC Research Report No. 1.

The sprinklers are inexpensive domestic sprinklers connected to the normal domestic plumbing. The initial cost is estimated at about $1,000 for a single storey 3 bedroom house. The cost per life saved was about $900,000, and an estimated 22 lives are saved per year. When combined with 4 battery smoke alarms the cost per life saved is about $2.8 million and 25 lives are saved per year. Zero maintenance costs are assumed. Sensitivity analysis is carried out for installation, design and maintenance costs. When quite small maintenance costs are included the cost per life increased significantly. The costs allow for reduced injury and property losses. A real discount rate of 6% is assumed and the analysis period was 20 years. The expected number of fatalities per year per household with no fire protection is 0.00048. Given the subsequent years that have passed since this research was conducted and the installation of a number of these systems into houses – the initial cost is now estimated to be in the range $1500-$2000 leading to a corresponding increase in the cost per life saved.

Risk assessment & CBA of corridor smoke detectors in rest homes, NZFSC Research Report No. 4.

Various combinations were analysed for smoke detectors and standard and fast response sprinklers, one or two staff per occupant, and a standard or ultra fast fire. The base case assumes a sprinkler system is already installed, since that was required at the time, and the study is assessing the enhancements on the basic sprinkler system. The best two combinations gave a cost per life saved of $450,000, and $1.69 million. The first was for replacing standard sprinklers with fast response sprinklers. The second case is for adding smoke detectors to a standard response sprinkler system The analysis period was 8 years, the assumed life of smoke detectors, and future costs were not discounted, i.e. a zero discount rate was used. The value of property saved, an assessment of reduced injury costs, and maintenance of detectors was not included. The expected number of fatalities per year is 0.0025 per rest home per year, or about 20 times higher than in households. Adjusting for the different number of persons, the rest home fatality rate is about 5 times higher, and is a “believable” difference.

Cost effective fire safety measures for residential buildings in New Zealand, BRANZ Study Report No. 93.

Seven combinations of smoke alarms were considered, ranging from a single battery powered alarm, up to 4 interconnected mains wired alarms. Fire sprinklers were also considered separately, with three cases; a system for a new house to the then current NZS4515, the same standard retrofitted to an existing house, and the revised NZS4515 system applied to a new house. Installation and maintenance costs were considered including an allowance for the owner’s time for checking alarm batteries. Estimates of reduced fatalities, injury and property losses were made and included in the economic analysis. The inflation adjusted discount rate was 6%, and the analysis period was 20 years. The main findings were that all alarm combinations were cost effective, with the cost per life saved ranging from -$142,000 up to about $3.0 million per life saved. A number of sensitivity analyses were carried out, and the significant variables were the fire death rate with smoke alarms, and the maintenance costs. The former relied on data from Australia since there is no comparable history in NZ. If the NZ rates turn out to be say 50% higher than assumed then the cost per life saved moves into the $4 to 6 million range for the 4 alarm systems, but does not greatly change for the single alarm systems. If the owners time for maintenance/ checking is not included then the cost per life saved drops to close to zero for most combinations.

Sprinklers to the revised DZ4515/CD3 were not cost effective, and had a cost per life saved of about $17.8 million. Note that the sprinkler requirements for DZ4515 are more stringent that the simplified system discussed in NZFSC Research Report No1.

An economic assessment of industrial fires in New Zealand. NZFSC Research Report 28.

An Economic Impact assessment was done and the total economic and social costs in 2000 was estimated at $86 million. The costs include building and business losses, injuries and fatalities, operation readiness costs for the Fire Service attributable to industrial fires only, and the indirect effects of reduced consumption due to reduced incomes. Business losses (material damage and business interruption) was obtained from a survey of the major insurers. Input/ output analysis was used to estimate the flow-on effects to other industries of a reduction in industrial activity due to fire. In addition there are induced losses because incomes and spending are reduced. The LTSA value of life saved number was used ($2.47 million). An investigation of whether a higher level of fire protection measures would be justified in terms of cost savings was not part of brief.

Costs and benefits of regulating fire safety performance of upholstered furniture in NZ. NZFSC Research Report No. 35.

The estimated cost of improved flammability standards for furniture was about $9.8 million per life saved. Assumptions were made on the reduction in fire deaths and injury, furniture replacement rates, and the additional furniture cost if it had improved fire safety performance. The discount rate was 5% and sensitivity analysis was done on this and other variables.

Social and economic impact study of changes to building regulations. PriceWaterhouseCoopers for MED, May 2003.

This report was produced before the Building Bill was drafted, so the specific changes where not known. However costs were estimated for administering and training of licensed building practitioners, additional initial building costs to improve weathertightness, and increased compliance costs. The estimates were for an establishment cost of licensing of about $20 million, on-going licensing costs of $5 million per year, plus an increase in building costs of about 2.9% per house in materials and labour. The benefits of a lower failure rate were not calculated.

CBA of proposed changes to Clause E2 and Approved Documents B2/AS1 and E2/AS1. NZIER for BIA, June 2003.

This report covers some of the measures in the PWC report, namely the weathertightness provisions, specifically control of external moisture, and durability of the materials, for the residential sector. It found an NPV over 25 years which was positive (up to $700 million) or slightly negative for the "medium" scenarios of assumed failure of claddings, and the degree of protection. Benefit cost ratios were about between 0.7 to 2.0 for the medium range of scenarios. A 5% discount rate was used, and a 25 year analysis period. Good data was not available on pre-existing failure rates, or the costs of failure, so the benefit calculations were based on assumptions.

CBA- NZBC Clause G6 Airborne and Impact Sound. Rider Hunt and Firecon for BIA, July 2004.

One apartment was cost modelled, for both timber framing and concrete walls. The report discusses how to value benefits, in this case the value people place on reduced exposure to noise. They are typically very difficult to quantify. The two basic types of these analyses are: Hedonic price studies - correlate the hazard (eg noise, flooding, electro-magnetic radiation exposure) with market prices (e.g. houses prices, rents); Contingent valuation studies – use surveys to determine how much people are willing to pay to reduce the hazard. Firecon used both methods (from overseas studies, converted to NZ dollars) and found the benefit to cost ratios varied greatly (0.23 to 1.12), depending on the assumptions. The conclusion was that the net benefits are likely to be negative, but may be slightly positive, and are small. A discount rate of 7.5% was used, and the analysis period was not given.

Economic analysis of NZ window insulation in new housing. BRANZ DC0790 EZ01 for BIA, February 2004.

One house in three climate zones, and two heating regimes were modelled. The report contains charts of NPV against the type of glazing, where the costs considered are initial window costs, and space heating energy use. Options with the lowest NPV are the preferred window arrangements. The analysis was from two perspectives, the owners, and the "national" perspective. The former used the mortgage interest rate (8%) to discount future energy savings, since the measure adds to the owners house cost. The latter used a lower discount rate, 5%, to reflect the "national good" perspective. The analysis period was 20 and 40 years respectively. Real energy price escalation of 1.5% pa was assumed.

CBA- proposed changes to Approved Documents for Clauses C1, C2, C3, and C4 of the Building Code. Rider Hunt and Firecon for BIA, November 2004.

Three buildings representative of the affected building types were modelled for the cost increases due to the upgraded fire ratings. It proved difficult to quantify the level of benefit from the reduced risk or death and injury, because data was not available to estimate the change in risk. Instead the analysis assigned a value of human life of $4 million, (up from the $2.2 million used by LTSA) and calculated what the change in risk would be at the break-even point. This showed there would need to be at least a 40% reduction in fatalities and injuries, before the benefits outweighed the cost. Sensitivity analysis was done. No discount rate or analysis period is provided, and it appears that a 0 % discount rate was used.

CBA- Changes to Approved Document NZS3603, Amendment No. 4, (i.e. changes to design stress of framing timber) . NZ Forest Research Institute, for BIA, April 2005.

The methods for grading of sawn timber is to change, meaning that visually graded timber is downgraded in strength, and millers will need to install machine grading equipment to continue to supply the traditional No 1 framing timber. There was extensive information in the report on the structure of the milling industry, testing of the strength of timber, and sawmilling and merchant cost structures. The factors modelled in the CBA were the cost to sawmillers to upgrade equipment to more reliably measure strength of sawn timber, and the benefits were reduced building failures (cracked linings, springy floors, sagging roofs, etc) costed at an average of $3,000 per house. No data was provided to support this cost estimate of current failures. The analysis period was 8 years and future benefits were discounted in a NPV analysis, but the discount rate was not provided.

7. DISCUSSION

Revised purposes of the Act. The main changes relate to the introduction of the sustainability purpose, which is not defined in the Act. However, it is generally accepted that sustainable construction includes the meeting of current user needs, minimising adverse effects on occupants and the environment, and having regard to future generations. Some of the new principles in the Act that promote sustainability are:

- The need to consider the role household units play in the lives of people.
- Maintenance requirements for housing are reasonable.
- Whole-of-life costs are considered.
- The importance of standards, but there is need to allow for innovation in design and materials.
- Material conservation.
- Water use efficiency and conservation.

The relationship of these to fire safety are:

- The role of household units in peoples lives, and the material conservation principles imply a degree of property protection. The well-being purpose of the Act also supports this, and cost benefit models should be developed to better understand the relationship between fire safety and property protection for various building types.
- Domestic mains wired smoke alarms and integrated sprinkler systems are low maintenance, the CBA that have already been undertaken are generally favourable, and these measures could be considered for regulation.

- Water efficiency measures may lead to lower demands on new water supply infrastructure. This is generally a favourable outcome but planners need to be aware that sufficient capacity (i.e. water volumes and pressure) remains for fire fighting.
- Protection of historic buildings is unchanged in the new Act, however as under the old Act there are no regulations giving effect to this purpose. Some wording was suggested earlier, and possibly a standard for fire protection of historic buildings could be developed, based on NZSFC Report No.48.

Scope of RIS and CBA. The factors considered in the building related RIS and CBA vary greatly, ranging from an estimate of the initial cost impact, up to a detailed assessment of expected benefits, and flow-on effects into the general economy. The scope obviously depends on how much of the building industry the proposed change will affect, and the magnitude of the impact. It is considered the current MED guidelines provide appropriate help in deciding on the scope, and on the earlier stage of whether intervention is needed and if so what type of intervention.

Some RIS and CBA have a lot of technical information in the form of models of the effect of the proposed changes on buildings, e.g. fire design models, changes to timber strength, thermal space heating model, etc. This information can dominate the CBA and care is need to ensure the economic analysis drives the process rather than the technical aspects. This means that at the start the reasons for the proposed intervention are clearly stated, then all options are identified (which may or may not include regulation), and then the technical solution options need to follow.

In the reports analysed in Chapter 6 this separation of process usually, but not always, occurred. Most studies had a separate section devoted to the CBA, and in some there was an additional section devoted only to the initial building cost effect of the proposed change. Finding an optimum technical solution is often an iterative process, so the financial and technical analyses will need to work together, but as stated earlier the economics should drive the options considered rather than the other way around.

Economic parameters in CBAs. The parameters used in recent studies have varied somewhat, with the implication that decisions on which regulations proceed could be inconsistent, and economically inefficient. The range of discount rates used in recent studies is from 5% up to 8%. In the appendix we discuss the selection of an appropriate rate and suggest 6% for most building related regulation, based on the CAP model. However there needs to be some flexibility, as discussed in the Appendix, because for resource saving regulations (such as energy or water conservation) a lower rate could be justified. The analysis period has varied in recent studies, in part because of different durability requirements of the components being considered. Usually it does not greatly affect the answer because, for example, the NPV does not change greatly after about 20 years for discount rates in the 5 to 8% range. Many analysts consider that uncertainty about future prices and technical developments make it unjustified to extend cost benefit analysis beyond 20 years.

In Australia the ACBC developed the Economic Evaluation Model (ABCB 1997), which meets requirements of their Office of Regulatory Review. It covers the range of impacts to be considered, the types of financial and economic analyses to be used, and methods of consultation with stakeholders. It is not suggested that this is duplicated in New Zealand, because the MED RIS guidelines covers much the same content and is applicable to building regulation.

However it is suggested that DBH issue some guidelines on the parameters to be used in CBA. These would cover the discount rate, period of analysis, value of human life saved, and sources of information on risk factors for safety, building failure, etc. A narrow range for the parameters, rather than specific values are preferable, and also advice on what parameters to include in a sensitivity analysis would be helpful.

8. RECOMMENDATIONS

NZFSC commissions work on the development of cost benefit models of property fire protection (as well as injury/ life protection) in a range of buildings, including institutional, commercial and industrial buildings.

NZFSC commissions further study on the 'value of human life' to be used for 'fire' related CBA. Does society have a different tolerance to 'fire' deaths compared to road-accidents? And does this justify a higher or lower value of human life to be used in fire-related CBA?

NZFSC recommends that DBH investigate the trends in change of use of existing buildings, and the costs and benefits of appropriate design for new buildings that anticipates change.

NZFSC recommends to DBH that improved fire safety can contribute to the sustainability purpose of the Act. These include:

- Greater use of mandatory mains-wired smoke detectors, and mandatory integrated domestic sprinkler system for new housing.
- Smaller fire compartments and greater use of sprinklers in non-residential buildings to reduce property loss.
- The development of objective, functional and performance requirements in the regulations for protection of historic buildings.

NZFSC recommends that DBH commission a study on what attributes of housing contribute to the feeling of well-being, as one of the purposes of the Act. As part of this study owners should be surveyed on the level of property fire protection expected in the residential sector.

NZFSC recommends to DBH that they issue supplements on the MED RIS Guidelines, containing data on discount rates, analysis periods, value of human life, sensitivity analyses, and where to obtain data on building related heath and safety risks factors.

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10. APPENDIX

This appendix contains:

- The Building Act 1991 extracts.
- Overseas sustainability interventions in building.
- Capital asset pricing model
- The client brief.

10.1 Building Act 1991

This appendix provides an extract from Building Act 1991, for comparison purposes.

Building Act 1991

6. Purposes and principles

(1) The purposes of this Act are to provide for—

(a) Necessary controls relating to building work and the use of buildings, and for ensuring that buildings are safe and sanitary and have means of escape from fire; and

(b) The co-ordination of those controls with other controls relating to building use and the management of natural and physical resources.

(2) To achieve the purposes of this Act, particular regard shall be had to the need to—

(a) Safeguard people from possible injury, illness, or loss of amenity in the course of the use of any building, including the reasonable expectations of any person who is authorised by law to enter the building for the purpose of rescue operations and fire fighting in response to fire:

(b) Provide protection to limit the extent and effects of the spread of fire, particularly with regard to—

(i) Household units and other residential units (whether on the same land or on other property); and

(ii) Other property:

(c) Make provision in a building used for the storage or processing of significant quantities of hazardous substances to prevent significant adverse effects on the environment (whether within the immediate locality or otherwise) arising from an emergency involving fire within that building:

(d) Provide for the protection of other property from physical damage resulting from the construction, use, and demolition of any building:

(e) Provide, both to and within buildings [to which section 47A of this Act applies], means of access and facilities that meet the requirements of that Act to ensure that reasonable and adequate provision is made for people with disabilities to enter and carry out normal activities and processes in those buildings:

(f) Facilitate the efficient use of energy, in the case of new buildings, during the intended life of those buildings.

(3) In determining the extent to which the matters provided for in subsection (1) of this section shall be the subject of control, due regard shall be had to the national costs and benefits of any control, including (but not by way of limitation) safety, health, and environmental costs and benefits.

10.2 Overseas sustainability interventions in building.

This section reports on a survey that the OECD (2003) undertook of its members in 2002 on sustainability measures. The report noted that while the private sector has a role to play in promoting sustainability, it is often better done in partnership with Government policy measures. The instruments available to Government and/or the private sector were divided into three categories;
Regulation - building regulations, and other regulations relating to waste disposal, and energy and water use;
Economic instruments - energy efficiency subsidies, tax exemption schemes, cheap loans, energy taxes, virgin material taxes, capital subsidies for waste process plant;
Information - environmental guidelines and labelling schemes, energy and sustainability audits, waste information exchange schemes, promotion and demonstration of sustainable buildings and retrofits.

Most OECD countries have energy efficiency requirements in building regulations. However these are generally for new buildings only, and intervention for upgrading existing buildings is modest. Some countries have included sustainability criteria in building regulations. For example, the Scottish Executive passed building legislation in 2003 "The Scottish Ministers may for any of the purposes of …... furthering the achievement of sustainable development, make regulations with respect to the design, construction, demolition and conversion of buildings …" In Australia the Future Building Code (under development) will have specific reference to sustainability, and the Australian Building Codes Board has consulted with the industry about what the code could include.

The responses, from 20 OECD members, are summarised below. The numbers in brackets are the number of countries reporting the measure. The reporting is for buildings in general, but most responses apply equally to residential and non-residential buildings. The measures were reported in three main target areas; mitigation of CO2 releases, reduction of construction and demolition waste, and prevention of indoor air pollution.

Regulation – new building regulation for mandatory energy efficiency performance of the envelope (19), mandatory energy labelling of buildings(5), obligations for utilities to improve the energy efficiency of their customers (UK), landfill bans (5), mandatory separation of waste (8), demolition licensing (6), ventilation regulations (15), regulation of building materials to reduce indoor air pollution (6).

Economic instruments - energy efficiency/ renewable energy subsidies (7) and tax exemption schemes (5), cheap loans for energy efficiency measures (6), environmental energy taxes (5), landfill taxes (10), virgin material taxes (4).

Information - voluntary environmental labelling of buildings (7), environmental labelling of materials and products (6), environmental guidelines for designers (10), embodied energy data (3), waste information exchange schemes (2), labelling schemes for recycled material (6), voluntary guidelines for concentration of pollutants (13).

Water efficiency and conservation measures were not surveyed by the OECD. However it is a component of most of the environmental labelling tools developed by the OECD countries, and several countries have mandatory water efficiency measures. Since the above report, produced in early 2003, some countries have further developed sustainability measures. For example, one area of expansion is in environmental labelling and green home schemes, and 9 countries are members of the World Green Building Council (Australia, Brazil, Canada, India, Japan, South

Korea, Spain, Mexico and US). Other schemes are under development in Scandinavia and Hong Kong.

The following are selected interventions, mainly Government sponsored, that indicate the types of measures being implemented:

Australia

Your Home – A set of consumer and technical guide materials and tools to encourage sustainable new homes and retrofits. The website is run by the Australian Greenhouse Office and there is a wide "buy-in" by industry organisations including state government environmental and building agencies, designer organisations, master builders, Housing Industry Association, and window associations.

In NSW builders and developers are required to use BASIX, an environmental impact assessment tool, for new housing planning approval processes. There are nine measures of performance and it shows developers how their project rates on the aggregate sustainability index.

In Victoria the state government has amended regulations requiring all new homes to have a 5 star energy rating (uses FirstRate software from SEAV) for the building fabric and water saving devices. In addition, all new homes now require a rain water tank or a solar hot water system.

United Kingdom

The UK Government has brought forward the review of energy efficiency measures Part L of the Building Regulations by two years because of the EC Directive on the Energy Performance of Buildings, which is a major driver for energy efficiency in Europe. (Office of the Deputy Prime Minister, 2002). The UK draft includes mandatory energy labelling for all new dwellings, and mandatory energy performance upgrading of existing dwellings when making additions over a certain value. Also included is the provision of the energy rating of existing commercial buildings at the time of resale.

The Government commissioned Sustainable Buildings Task Group reported in 2003 and its main recommendation was a single national Code for Sustainable Buildings be established. (Office of the Deputy Prime Minister, 2004). It recommends indicators based on BREEAM and Ecohomes, and incorporation of clearly specified minimum standards in energy and water efficiency, and waste and use of materials. The standard would have a performance level above that required in the Building Regulation, and as the latter are upgraded over time the Standard would also be upgraded above the statutory minimum.

The Building and Social Housing Foundation (2002) held a conference of industry participants in 2002 which developed an agenda for action in 4 main areas: use of regulations and standards, use of financial incentives, creating demand for sustainable housing (positive promotion, raising awareness, stakeholder analysis, eco-labelling), and creating capacity (demonstrate the business case, incentives, training, public/ private partnerships, back-up/ support).

The World Wildlife Fund (WWF, 2004) addressed the barriers they see in the UK context, and they recommended a number of strategies, including reduced VAT on EcoHomes, benchmarking of the sustainability performance of major listed builders, studies on reducing sustainable material costs, and no consensus on measurement of sustainability in housing.

Continental Europe

Mandatory energy labelling for new buildings is required in Denmark, France (dwellings only), Germany, Greece, and the Czech Republic. Denmark, and France also have mandatory energy labelling for refurbishment of buildings. Four countries have general obligations for recycling and reuse of materials during construction, but there are no specific standards. At the demolition stage the requirements are more frequent. Belgium, Denmark, Germany, Netherlands and Sweden have bans (on unsorted, or combustible waste) on demolition waste in landfills. Some of these countries, and others, also have mandatory separation, mandatory delivery of waste to specific sites, licensing of demolition contractors, and mandatory reporting of where waste is to be delivered. To minimise indoor air pollution Czech Republic, Denmark, Finland, Germany, and Norway have formaldehyde limits for building materials.

Canada

Mandatory insulation is required in most provinces and cities. Subsidies are supplied for renewable energy and insulation retrofit (the Energuide programme is very successful). The LEED labelling scheme is widely used in commercial buildings.

USA

Most states have mandatory thermal insulation requirements for new buildings. Several states and utilities offer low or zero interest loans for energy efficiency upgrades in existing buildings. A number of states and municipalities have enacted residential energy conservation ordinances (RECOs, Thorne 2002). They are designed to bring existing housing stock (mainly focussed on multi-unit blocks and rental housing) up to a minimum standard of performance. The various policy approaches in the US for existing buildings are assessed in Thorne, see the table below:

The LEED labelling scheme (Leadership in Energy and Environmental Design) is well known and is in operation for commercial buildings. New versions are being developed for new homes, existing buildings, and neighbourhood developments (transport, stormwater, urban sprawl, infrastructure, health, safety, economic communities), see Howard (2003). Some North American cities have supplements to the LEED Rating System, e.g. Seattle Capital Improvement Projects.

Approach for existing buildings	**Advantages**	**Disadvantages**
Residential subsidies	Cost-effective for large jurisdictions. Leverage is greater in combination with some private funding.	Expensive. Free rider unless targeted. Needs extensive marketing and education.
Residential regulation	Low cost to implement. Mandatory compliance.	Politically difficult. Small savings per household as the regulations are for the lowest common denominator.
Residential tax credits	Stimulates investment in large projects.	Free rider. Difficult to design effectively. Difficult to administer.
Home energy labelling.	Uniform national approach. Leverage is greater with private funds. Large savings potential.	High start-up costs for programme and marketing. Cost-effectiveness is uncertain.

OECD

Despite the considerable effort undertaken by the above countries the OECD has identified a number of problems and barriers, including:

- Market mechanisms are insufficient on their own to promote a significant increase in sustainable buildings, and regulation, economic instruments and information tools are important.
- In rental housing the incentives for owners to incorporate sustainability measures are often quite low, or zero, as the tenant bears the costs of not having sustainability measures.
- Energy efficiency measures often have a short payback period and are attractive to owners. However the benefits of other sustainability measures may not be immediately

apparent to owners. Often owners are reluctant to invest in other measures as the improved performance will not necessarily be reflected in the building resale price.

OECD has the following policy recommendations:

- Establish a national strategy for improving the environmental performance of buildings. It should include quantified goals within set time-frames.
- Set up a framework to regularly monitor the environmental performance of the building sector. It needs to be based on good data, updated at regular intervals, and it is suggested environmental labelling schemes are a good data source.
- Support environmental R&D and diffusion of technologies across the construction sector, and support government and industry partnerships.
- Direct public building procurement toward environmental friendly buildings. This supports the demand side by demonstration of sustainable technologies, and supports the supply side by helping reduce unit costs.
- Regulation is the most effective way to upgrade energy performance of new buildings at the "bottom end" of the scale, but for a large percentage of buildings further improvements are effective.
- As new buildings are upgraded the existing building stock becomes increasingly important. Since there is no regulatory framework to cover existing buildings in most OECD countries, non-regulatory instruments are expected to play a greater role than for new buildings.

10.2.1 Bibliography for sustainability

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10.3 Capital Asset Price Model (CAPM)

A key parameter when carrying out CBA is the discount rate. In the past, a real (before inflation) rate of ten percent was used as the public sector discount rate. Current Cabinet Office circulars do not refer to the 10% discount rate as a standard. Instead circular CO(00) 12 Annex One requires that the business case should identify and detail the discount rate used and its derivation. When government departments decide where to spend money they often use the department capital charge rate in the financial analysis, which has varied from 7.5% to 9% in recent years. This is based on a weighted average cost of capital to the departments and is often used as a defacto discount rate for departments for evaluating alternative policy options. It is set to be a similar rate to those in the private sector with the same investment risk level.

Government regulation in the building sector impacts on owners and it could be argued that the appropriate discount rate is their real cost of capital, which for home owners is the mortgage interest rate less inflation, (about 6.5%) or for businesses their cost of capital.

As an alternative to the weighted cost of capital a Treasury paper[3] suggest the use of the social opportunity cost rate (SOCR) for discounting the costs and benefits of Government policy measures. Further the paper suggest using the Capital Asset Price Model (CAPM) to find the SOCR. The formula is
$R = R_f (1\text{-}t) + \beta (R_m\text{-} R_f (1\text{-}t))$

Where R = SOCR
R_f = risk free rate of investment (i.e. Government bonds)
t = company tax rate.
β = measure of the volatility (i.e. variance) of the returns in the market of interest (eg housing), compared to the volatility of returns in the overall market.
R_m = Overall market rate of return for businesses.

Assume R_f = 6.5% (for 10 year government bonds.).
t= 0.33
β = 0.2
R_m = 12%

The above gives R = 5.9%, the discount rate to be used for assessing building related regulatory measures.

The main uncertainty in this method is what is the beta value (β)? In the share market construction companies commonly have a beta of about 1.3. i.e. their returns are more volatile than the market as a whole (the market as a whole has by definition a beta of 1.0). However the returns from building regulation measures accumulate year by year and the actual market situation (i.e. the number of buildings constructed) in any one year does not greatly affect the net benefits arising from the regulation. Also, since the measures are mandatory the net benefit is more likely to arise, than if the measures were voluntary. So the beta value is likely to be quite low, and we have assumed a value of 0.2.

For some building regulations it could be argued the beta value is negative. For, example, energy efficiency measures may have a negative beta. This arises because generally energy price increases are negative for the overall market, but have a positive effect on energy efficiency measures. With, for example, a $\beta = -0.2$ we get a R of 2.8% which would be a possible discount rate to use for energy efficiency regulatory measures. The same argument applies for some other efficiency measures, such as water conservation.

In summary the appropriate discount rate to use in building related regulation is not straight forward and in theory different rates could be used for different types of measures. However for simplicity it is probably best to use the same rate for all regulations (6% is suggested) but to carry out a sensitivity analysis to identify the effect of the discount rate on the net benefit calculations.

10.4 Client Brief

RESEARCH DESCRIPTION	
RESEARCH TOPIC	**Analysis of the revised Purposes of the Building Act 2004**
OBJECTIVES/ OUTCOMES OF RESEARCH	Identify and analyse the purposes and principles of the Building Act.
	Analyse the meaning of sustainable development and identify how fire safety in buildings contributes.
	Analyse the principles to be used in achieving the Acts purposes, including principles relating to traditional/cultural aspects of building use, whole life costs, importance of continuing innovation in design and construction, protection of property, preservation of significant cultural/historic/heritage buildings, and sustainable use of materials. Identify and analyse the role of improved fire safety in application of these principles.
	Identify the types of CBA undertaken in the past for fire safety measures, the parameters assumed, impacts considered, and the data limitations. Identify overseas types.
	Analyse MED's RIS guidelines and interpretations in past fire safety CBA and other building code changes.
	Produce recommendations for fire safety, for the revision of the building code, and on the related RIS process, parameters and impacts to be included in CBA.

RESEARCH DESCRIPTION cont.	
HOW RESEARCH WILL BE DONE	Identify the changes in the Building Act and the purposes and principles that related to fire safety measures.
	Analyse the meaning of sustainable development in the context of Building Act and impact of sustainability on fire safety measures.
	Analysis the influence improved fire safety could have on the other purposes and principles of the Act. Analyse which of the existing code clauses and Approved Documents would need amendment.
	Review cost benefit studies relating to fire safety measures for assumptions, parameters used and types of impact considered. An analysis of the types of data required and their availability. Recommend whether there is a need for a common set of parameters and assumptions.
	Review the RIS process and whether there is a need for a common approach for building regulation measures.
	Prepare suggested recommendations for the NZFSC to use in its presentation to DBH on the building code review.
	Preparation, editing and review of the project report.