Sustainability and Resiliency Issues and Objectives in Performance Building Regulations[1]

Brian J. Meacham, Worcester Polytechnic Institute, Worcester, MA, USA, bmeacham@wpi.edu

Abstract

Building regulatory agencies world-wide are grappling with how to define and implement appropriate mandatory and voluntary measures for new and existing buildings which address societal and political demands for increased environmental and resource sustainability and resiliency to the effects of climate change without lessening the historical building regulatory focus on health, safety and welfare of building occupants. It can be argued that a transition from prescriptive to performance-based building regulatory regimes, coupled with the introduction of new policy objectives for sustainability and resiliency, in a rather short period of time, without full assessment of how they interact with existing building regulatory objectives, and without broadly agreed holistic solutions, has led to the introduction of new objectives which have the potential to result in increased hazards and risks to occupants. To explore the current situation and future needs associated with performance building regulatory regimes and the inclusion of sustainability and resiliency objectives for new and existing buildings, literature was reviewed and a survey of building regulatory bodies and institutions in twelve countries was conducted to obtain perspectives on whether and how sustainability and resiliency objectives are being incorporated into their building regulations and if any challenges have been identified.

Keywords: Performance-based, building regulation, sustainability, resilience

Introduction and Context

Historically, building regulations have focused on the health, safety and welfare of building occupants. They emerged in response to widespread illness, death and destruction which occurred in urban centres as a result of unsanitary conditions and significant hazard events, and the social and political mandate to mitigate these hazards as part of urban redevelopment. A social compact (contract) developed between government and the citizenry in which it became acceptable for the government to collect taxes in return for the regulation and enforcement of minimum levels of safety and sanitary conditions. As such, early building regulations addressed such issues as minimum requirements for fire separation and resistance of materials, structural resiliency to natural hazards, and safe heating and sanitation systems for occupants. Over time, needs such as standardized testing and listing to assure minimum performance, industry standards for compatibility of systems and components, minimum competency of practitioners, and mechanisms to assure compliance of constructed buildings with stated designs gave rise to the other components within the building regulatory system, all based around a culture of facilitating a built environment that delivered minimum levels of safety and health to building occupants (Field and Rivkin, 1975; Hemenway, 1975; Cheit, 1990; Yatt, 1998; Wermeil, 2000; Geschwind, 2001; ICC, 2007; Imrie and Street; 2011; Meacham, 2014).

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Generally speaking, changes to the regulations and supporting regulatory system occurred slowly as new materials, products, systems and methods of analysis, design and construction were developed, tested, introduced and adopted as acceptable into the regulatory system. The process can take many years, as with the development and implementation of the Single Burning Item (SBI) test (van Mierlo, 2005) or even decades, such as with the development and implementation of the Eurocodes for structural design (Eurocode, 2015). In other cases, change occurred rapidly, but nearly always in response to some significant hazard event which resulted in unacceptable damage, injury or death. In these situations change was often made to the building regulations first, with changes to standards and other instruments following, with the intent of avoiding similar losses in the future. When this type of change occurred, however, it was primarily focused on new construction, and even when upgrade of some of the existing building stock was required, it was often not to the same level of new construction: a trend that continues today (e.g., IREM, 2013; Stannard, 2014). There are obvious reasons for this, primarily the cost of retrofitting all existing building stock in comparison to the overall risk and benefits. In order to provide options to legislated provisions, voluntary standards or guidelines (e.g., NFPA 101A, 2013; FEMA 356, FEMA 114) and/or market instruments (e.g., insurance industry requirements, such as FM Global Data Sheets (e.g., FM Global 1-28)) are used to encourage building owners to increase the safety performance of existing buildings.

While there have always been some challenges in addressing issues within the historical building regulatory system as outlined above, the focus on health and safety, and the development of regulatory infrastructure and generally common understanding of those issues amongst stakeholders around these topics, had created an environment where many of the issues were able to be addressed proactively and cooperatively. In recent years, however, three concurrent activities have emerged within building regulatory systems which have placed pressure on the ability of the systems to adapt and respond in as successful a manner as in the past: a relatively rapid transition to performance-based regulations, new policy objectives in the area of sustainability, some of which appear to be difficult to harmonise with traditional health and safety objectives, and a desire to address, but lack of clarity as to how to address, climate change impacts on buildings.

When the transition to performance-based (function-based) building regulatory systems and regimes began, health and safety was still the focus. The motivation for change was related to reducing regulatory burden, reducing costs to the industry and the public, increasing innovation and flexibility in design, and being better positioned to address emerging issues (BRRTF, 1991; Meijer and Visscher, 1998; May, 2003; Meacham et al., 2005; Meacham, 2009). All of this was to be achieved while maintaining tolerable levels of safety and performance.

In some cases the transition has worked reasonably well: in other cases there have been issues, including some significant system failures (May, 2003; Lundin, 2005; Mumford; 2010; Meacham, 2010). With respect to failures, contributing factors include lack of agreed performance measures (criteria) and means to predict performance in use, lack of test methods which yield data that can be used in engineering analysis, limited availability and quality of data, inadequate competency and accountability in the market and of those in oversight (compliance checking) roles, insufficient product certification / means to assure performance of products, lack of transferring knowledge between regulatory regimes, lack of having persons with the right expertise and experience involved, and challenges with insurance, liability assignment and limitation, and consumer protection mechanisms (May, 2003; Lundin, 2005; Mumford; 2010; Meacham, 2010). These shortcomings become particularly

important when one considers that buildings have been constructed under these systems for some 25 years, and now might reflect a significant contribution to the existing building stock in many countries. As such, if performance issues exist, the impact could be significant. The 'leaky building' scenario which unfolded in New Zealand is probably the highest profile example of what could happen (May, 2003), but there may be other latent problems as well.

Part of the challenge is that performance-based building regulatory systems, while similar in structure, can vary significantly in implementation. While the structure of the building code (regulation) itself follows the general format outlined by the Nordic Building Code Committee (NKB) in the 1970s (Meacham 2004, Meacham et al., 2005), there can be significant variation in the means for demonstrating compliance with the mandatory provisions (see Meacham, 2009).

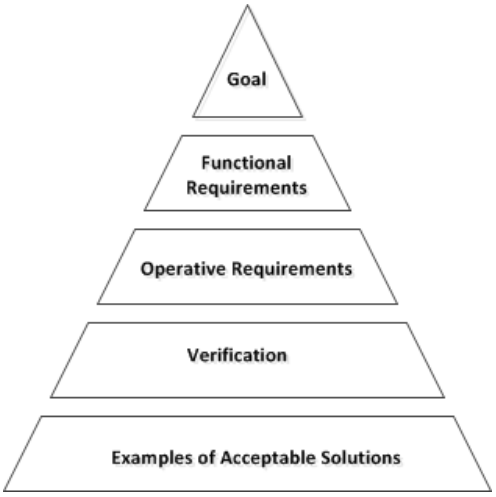

Figure 1. NKB Hierarchy (Meacham et al., 2005)

In some countries, there are no mandatory means of demonstrating compliance, and it is the designer's choice to follow 'deemed to comply' documents, which may reference national or international standards, or to take a 'first principles' (performance-based) approach. England and New Zealand are examples. In other countries, there are mandatory compliance documents, which in turn reference national or international standards, and variance from the requirements is by exception. There are also situations in which performance criteria and means of verification are built into the code (regulation). A good example here is Japan.

In addition to the transition to performance-based systems, building regulations and regulatory systems have increasingly become complicated by the establishment of policy mandates and the introduction of voluntary assessment and rating instruments originating from environmental sustainability and climate change resiliency concerns, which have historically been outside the realm of building regulation. While a social compact between government and the populace has developed around the understanding that we need to do more to protect the environment, resulting in the proliferation of environmental regulation and enforcement legislation which nominally began in the 1970s, it is only recently that the connection of the built environment to negative impacts on the environment, and the need to make buildings more resilient to climate change, have come onto the political agenda. A result is new pressures on building regulations from new actors, inside and outside of government.

These new pressures pose a significant challenge – not just because the traditional building regulatory environment is itself undergoing change and has structural challenges to overcome – but because the success of recent governmental policies and market approaches aimed at increasing the sustainability of the built environment has arguably been limited (Van Bueren and de Jong, 2007; Simmons, 2015). Whereas a robust approach to engaging stakeholders in issues of health and safety developed over decades in the historical building regulatory system, new stakeholders have emerged around sustainability objectives, and the different groups are fragmented and not working effectively together (Van Bueren and de Jong, 2007; IPCC, 2007; Cole, 2011; Du Plessis and Cole, 2011; Simmons, 2015; Foxell and Cooper, 2015). In addition, the introduction of voluntary measures have resulted in inconsistent levels of performance being realized (Newsham, Mancini and Birt, 2009; Scofield, 2009), in part because it rests outside the realm of regulatory oversight. The situation is further complicated because there are incomplete building performance measures, monitoring and enforcement mechanisms for sustainability (Van Bueren and de Jong, 2007) as well as increasing liability concerns (Brinson and Dolan, 2008). As noted by Foxell and Cooper (2015), "the gap between policy intent and effective solutions remains difficult to close. This serves to increase the number of challenges that the built environment sector needs to address successfully."

This fragmented regulatory approach, not necessarily having the right persons involved, and introduction of new social objectives has led to unintended consequences being introduced, some of which could present considerable risk to building occupants. This includes structural hazards due to moisture-related failures of enclosed structural systems (May, 2003; Mumford, 2010), health hazards related to mould and indoor air-quality due to weather-tight buildings (Mudarri, 2010), fire and health hazards due to the flammability of thermal insulating materials (Simonson McNamee et al., 2011; Babrauskas et al., 2012), fire and smoke spread potential through the use of double-skinned façades (Chow et al., 2007), and fire hazards and impediments to emergency responders associated with interior and exterior use of vegetation, photovoltaic panels and other 'green' features and elements (Meacham et al., 2012).

Finding a suitable balance between sustainability and fire safety objectives can be particularly complex due to the multidimensional aspects of each. Timber is 'sustainable' but also is combustible, so if not addressed appropriately can present a significant fire safety hazard (UL, 2008; Meacham et al., 2012). High strength concrete requires less material and is more sustainable than regular strength concrete, but can be highly susceptible to spalling during a fire (Kodur and Phan, 2007). Insulation and alternative energy sources are good for sustainability, but photovoltaic panels which can cause an ignition, and flammable insulation material, can be a catastrophic combination (Meacham et al., 2012).

Tightly coupled with goals to increase environmental sustainability through better energy efficiency, reduction in / reuse of construction materials, incorporation of alternative energy sources and related measures in the built environment, are goals to increase the resiliency of the built environment to climate change effects. In recent years we have seen devastating hurricane, cyclone, flood, snowfall, drought and wildland fire events and seasons. Each has resulted in significant impacts on the built environment, including widespread building damage associated with moisture, wind, snow load and fire. This is not unexpected, as it has been predicted as a real possibility for some time (e.g., Wilby, 2007; IPCC, 2007; Steenbergen et al., 2009).

However, there are no easy answers in terms of developing comprehensive resiliency strategies, since while the problems are easy to recognise, the solutions are difficult to agree and implement. In many cases there is not a single policy area which has responsibility for avoiding or mitigating the impacts. Planning, zoning, environmental and resource legislation has a significant effect on the susceptibility of buildings to flooding and wildland fire (as is said in real estate valuation: location, location, location). In some cases, policy makers wish to avoid moving people or restricting expansion into hazard-prone areas if that has an impact on economic development. That places a burden on building regulation. Some of this can be addressed in regulations for new construction; however, affordability then becomes a concern. The challenges become even more amplified when addressing existing buildings, as there is less regulatory oversight and often less economic capacity to manage from the ownership side (i.e., older buildings, particularly residential, house a higher percentage of lower income families).

In summary, the literature suggests that advancing sustainability and resiliency objectives in the built environment is necessary, in addition to traditional occupant health and safety objectives. However, challenges exist in that sustainability and resiliency are not yet being viewed as having the same level of importance, or equivalent level of social compact between government and the public, as providing for minimum levels of health and safety in buildings. As such, the rather sudden entry of these new policy objectives has created a wide range of challenges, from regulatory development to enforcement, with potentially the most significant issues around existing building stock and trying to assure regulatory and market instruments adequately address the spectrum of policy objectives without increasing hazards, risks or costs, or decreasing building performance. As a means to begin assessing just how significant the issues are in practice, a survey was conducted of representatives of lead building regulatory agencies and research institutions in twelve countries to benchmark the situation in a number of areas. Select outcomes from the survey and preliminary analysis, along with select outcomes from a 2009 survey of the same group, are presented below. It should be noted that the information provided below represents the author's interpretation of the survey responses and materials provided in the countries cited, and do not reflect official government or organizational policies or positions.

Performance, Sustainability and Resiliency in IRCC Member Countries

In 1997, six countries which were developing or had implemented performance-based building regulations created a forum where they, and countries with similar interests, could discuss experiences, issues and opportunities associated with performance-based building regulatory systems. This forum, the Inter-jurisdictional Regulatory Collaboration Committee (IRCC), has grown considerably since then and now has members from twelve countries - Australia, Austria, Canada, China, Japan, New Zealand, Norway, Scotland, Singapore, Spain, Sweden and the USA - with affiliated organizations participating from England and the Netherlands (see www.IRCC.info). Over the years, the IRCC has hosted several workshops and published a number of documents addressing a wide range of topics related to performance building regulatory systems (e.g., see Meacham et al., 2005; Meacham, 2010). In 2009, a report was prepared which reinforced the principles underlying the need for building regulation, the benefits that IRCC members see with performance-based approaches, and the building regulatory situation in the IRCC member countries at that time (Meacham, 2009). A general conclusion is that all IRCC member countries support performance-

based building regulatory regimes, acknowledging that there are challenges with current systems and that more needs to be done to facilitate the full potential of such systems, including:

- Mechanisms are needed to better define and quantify levels of tolerable building performance, be they in terms of health, safety, welfare, risk, sustainability, or other measures;
- Quantified performance metrics must be developed and incorporated into regulations. Recognising that some metrics may be best addressed prescriptively (e.g., rise and run of a stair), there remains significant scope for performance measures, for which associated verification methods are needed; and
- Tools and methods for helping with the enforcement of performance-based building regulations are still lacking. In part related to the lack of quantified performance measures, those responsible for approval of designs and enforcement of regulations are faced with the challenge of making decisions in the face of significant uncertainty.

In 2014, several IRCC members presented papers at the World Sustainable Building Conference SB14 in Barcelona, Spain, on topics related to sustainability and resiliency objectives and issues for building regulations (e.g., Dodds, 2014; Neng, 2014; Serra et al., 2014; McDonald, 2014). These were complemented by contributions of members of CIB Task Group 79, Building Regulations and Control in the face of Climate Change (e.g., Chan et al., 2014; Laubscher, 2014; and Visscher and Meijer, 2014). Collectively, these papers, as well as other literature which was reviewed, identified several issues worthy of additional investigation around this topic.

To begin exploring some of the issues in more detail, from a building regulatory perspective, a survey was conducted of the IRCC members to obtain additional information about current policies, activities and concerns around sustainability, resiliency and building regulation. The survey consisted of 30 questions within three primary topic areas:

- the relative importance / priority of sustainability and resiliency principles and policies to the government – in general and with respect to the built environment,
- how concepts of sustainability and resiliency are addressed within building regulations, and within the built environment, for new and existing buildings, and
- how well the performance- (objective-, function-) based building regulatory system has been working, with a particular emphasis on aspects which have been identified as somehow lacking (or failed, or could be significantly improved), why the challenges exist, whether actions are underway to change the system going forward, and what ‘the next generation’ of the regulatory system might include.

An open ended question to provide for additional feedback was also provided.

Surveys were sent by email to each IRCC member and affiliated organization and responses were consolidated. Due to the small sample size (12 reporting entities), no statistical analysis of the responses is provided. Rather, summary data in terms of whether or not a country addresses the issue at question is presented.

Due to space limitations, the focus of the discussion that follows is limited to feedback received as related to top-level government policy / perspective on sustainability and resiliency and how these topics are addressed within the building regulatory system. Furthermore, not all responses from each country are included, and only examples from some countries are provided. It is anticipated to present more outcomes in the future.

It should be noted that sustainability and resiliency were not defined in the survey, and countries were free to interpret the terms. This was felt to be important to gauge commonality and differences. In many countries, sustainability encompasses the management of resources (water, energy, materials, etc.), and resiliency reflects the ability to withstand and recover from impacts – from earthquake to climate change impacts, such as drought, increased storm frequency and severity, changing snow locations and amounts, and similar. While the entire paper could be focused on the definitions and broad government policy responses, it was decided to keep the focus limited to which countries have policies to address sustainability and resiliency concerns, and how it manifests within the building regulatory system.

From a top-level (over-arching) national government policy perspective, is sustainability a guiding principle for legislative / regulatory development?

Yes	No	Variable
Australia, China, England, Japan, Netherlands, Norway, Scotland, Singapore, Spain, Sweden	New Zealand	USA

The clear message here is that sustainability has become embodied as a guiding principle in most countries at the national government level. While sustainability is embodied in many legislated areas in New Zealand, there is no 'top of government' sustainability guidelines or policy. The reason that the USA is listed as 'variable' is that the priorities can change with administration, and while the Obama administration has a strong climate change and sustainability focus, subsequent administrations may not. This is not to say that other countries are not also susceptible to shifts in policy and politics, but in many countries policy guidance has been implemented, which reflects a firmer position, at least for the moment.

In Australia, it was recognised that significant benefits could be achieved through improvements in energy efficiency, so in 2004 the Australian Ministerial Council on Energy (which comprises representatives from all levels of Australian government) endorsed the National Framework for Energy Efficiency (NFEE) and agreed to the implementation of a number of energy efficiency packages. The Ministerial Council on Energy anticipated that the NFEE would comprise more than one stage, and activities under the NFEE continued for the next several years. In July 2009, the Council of Australian Governments (COAG) agreed to the comprehensive, 10-year National Strategy on Energy Efficiency (NSEE), to accelerate energy efficiency improvements and deliver cost-effective energy efficiency gains across all sectors of the Australian economy. The overarching National Partnership Agreement on Energy Efficiency (NPAEE) is the Intergovernmental Agreement that gives effect to the NSEE and sets out specific action to be taken by the Commonwealth, State and Territory Governments to maximise cost-effective energy efficiency gains across the economy.

The NSEE aims to streamline roles and responsibilities across government by providing a nationally consistent and coordinated approach to energy efficiency. The NSEE is framed around the following four key themes: assisting households and businesses to transition to a low-carbon future, reducing impediments to the uptake of energy efficiency, making buildings more energy efficient, and government working in partnership and leading the way, which was published in 2009 (NSEE, 2009).

In Japan, the Basic Environment Law sets out the overall mandate for environmental conservation and sustainability, the Purpose of which is stated in Article 1: "The purpose of this law is to comprehensively and systematically promote policies for environmental conservation to ensure healthy and cultured living for both the present and future generations of the nation as well as to contribute to the welfare of mankind, through articulating the basic principles, clarifying the responsibilities of the State, local governments, corporations and citizens, and prescribing the basic policy considerations for environmental conservation" (BEL, 1993).

The stated Purpose of the Scottish Government is to focus Government and public services on creating a more successful country, with opportunities for all of Scotland to flourish, through increasing sustainable economic growth (Scotland, 2015). The Scottish Parliament passed the world-leading Climate Change (Scotland) Act 2009 (CCSA, 2009), committing to reduce Scotland's greenhouse gas emissions by at least 42% by 2020 and 80% by 2050, compared to 1990 levels. In addition, the Scottish Government has committed to the equivalent of 100% of Scotland's electricity demand to be generated from renewable energy by 2020. Sections 63 and 64 specifically relate to making regulations for improving the energy efficiency of existing non-domestic and domestic buildings respectively (CCSA, 2009).

Sweden was the first country to adopt the goals of a global development policy in 2003 (Sweden, 2003). In brief, global development policy encompasses all political decisions that directly or indirectly affect poor people in developing countries or countries undergoing transition to a market economy, one of which is sustainable development, which encompasses sustainable use of natural resources and environmental concern, economic growth, and social development and security. Beginning in spring 2016, all Swedish ministries will develop action plans around the global development policy.

From a top-level (over-arching) national government policy perspective, is resiliency a guiding principle for legislative / regulatory development?

Yes	No
Australia, China, England, Japan, Netherlands, New Zealand, Norway, Scotland, Singapore, Sweden, USA	Spain

While the majority response to this question is also yes, the definition and interpretation of 'resiliency' varies much more than with sustainability, as well as resiliency against what hazards or events. In some cases there is a focus on specific natural hazards (e.g., earthquake), in others all natural hazards, and in some cases all disasters, including deliberate events. Only in some countries, such as Norway, is climate change resiliency a clear focus. Even in Spain, it can be argued sustainability policy is a climate change resiliency policy, even if not stated precisely as such.

In Australia, the Council of Australian Governments (COAG) agreed in 2007 to the National Climate Change Adaptation Framework (NCCAF). The NCCAF covered a range of cooperative actions between all Australian governments to begin to address key demands from business and the community for targeted information on climate change impacts and adaptation options (NCCAF, 2007). In 2009, the COAG agreed to adopt a whole-of-nation resilience-based approach to disaster management, which recognises that a national, coordinated and cooperative effort is needed to enhance Australia's capacity to prepare for, withstand and recover from disasters. The National Emergency Management Committee subsequently developed the National Strategy for Disaster Resilience (NSDR, 2009), which was adopted by the COAG in 2011. The purpose of the NSDR is to provide high-level guidance on disaster management, with a focus on priority areas necessary for building disaster resilient communities across Australia.

In China there are several policies and laws related to resiliency against natural hazards, including protection and mitigation of earthquake disasters and meteorological disasters, and on disaster prevention and planning. While earthquake and meteorological disasters are important in Japan as well, the Fundamental Plan for National Resilience speaks to being committed to promoting initiatives for building national resilience with the aim of creating safe and secure national lands, regions and economic society that have strength and flexibility in the event of any disaster (NRPO, 2015). The guiding principles include prevent human loss by any means, avoid fatal damage to important functions for maintaining administration as well as social and economic systems, mitigate damage to property of the citizenry and public facilities, and achieve swift recovery and reconstruction.

New Zealand has a long standing focus on resiliency to earthquakes, with renewed thinking and discussion following the Canterbury earthquakes, and is also a signatory to the international Sendai framework (formerly Hyogo), monitoring and reporting on the disaster risk reduction objectives of the framework. In the Netherlands, climate change resiliency has been a focus for a long time, given the potential susceptibility to sea level rise. There is also a focus on infrastructure and security resiliency. This is also the case in the USA, which under the Obama administration there are Executive Branch initiatives on climate change resiliency and on infrastructure resiliency, with several government departments and agencies having legislation and guidance on these topics.

A national assessment of the impacts of climate change on Norway has been produced and published as an Official Norwegian Report, Adapting to a changing climate (NOU, 2010). As noted in the report, the Norwegian government appointed a committee to study society's vulnerability and the need to adapt to the effects of climate change. Various climate change effects were identified, including higher temperatures, increased precipitation and potential sea level rise and effects on the coasts and fjords. Impacts to infrastructure and buildings were identified as needed to be addressed, and the committee recommended that adaptation considerations be incorporated into new regulations associated with the Planning and Building Act.

From a building regulatory policy perspective, is sustainability addressed within the building regulations?

All countries report some aspects of sustainability being embodied in building regulations. In Australia, sustainability was included as a specific objective of the Building Code of Australia (BCA) in 2007. In the European Union (EU), the Energy Performance of Buildings Directive (EPBD, 2010) and

the Energy Efficiency Directive (EED, 2012) provide common direction and expectations, which in general are adopted in member states' legislation, although other legislation may be promulgated as well.

In New Zealand, even though sustainability is not an overarching objective of the current government, it is one of four purposes of the Building Act, so that "buildings are designed, constructed, and able to be used in ways that promote sustainable development." The Act also requires certain principles to be taken into account, including: the need to facilitate the efficient use of energy and energy conservation and the use of renewable sources of energy in buildings, the need to facilitate the efficient and sustainable use in buildings of material … and material conservation, the need to facilitate the efficient use of water and water conservation, and the need to facilitate the reduction in the generation of waste during the construction process. The Building Code has a specific code clause related to energy efficiency, H1 (DBH, 2011).

In Scotland, sustainability was first explicitly addressed in the Building (Scotland) Act 2003, which speaks to 'furthering the achievement of sustainable development.' However, sustainability has been a focus of the national building regulations since the Building (Scotland) Act 1959, predating the term 'sustainable development.' The current approach to development of standards and guidance within the Scottish building regulations framework looks to embed sustainability into the minimum measures that apply to new building work. However this is always tempered by cost, as it could be considered unsustainable to have new buildings that are very environmentally friendly and accessible but the capital construction cost is elevated to such a level that means they become unaffordable. As such, within the Scottish system, a sustainability labeling system (with clearly defined measures) exists that enables those who wish to go further and demonstrate their 'green' credentials to do so (Dodds, 2014).

In 2005, Singapore's Building and Construction Authority (BCA), a statutory board under the Ministry of National Development, kick-started its drive to green Singapore's physical landscape by launching the BCA Green Mark: a rating system to evaluate a building's environmental impact and recognise its sustainability performance (Neng, 2014). The BCA Green Mark scheme forms the backbone of the first Green Building Masterplan (GBMP) which was introduced in 2006 to encourage, enable and engage industry stakeholders to step up efforts in environmental sustainability, with a first focus on greening new buildings. This included legislation, financial incentives, industry training programs and a public outreach campaign to place green buildings in the forefront of industry and consumer awareness. Under the legislation, Singapore' Building Control Act was amended in April 2008 to impose minimum standards on environmental sustainability for buildings (BCESR, 2008). In January 2008, an Inter-Ministerial Committee on Sustainable Development (IMCSD) was also set up to formulate a national strategy for Singapore's sustainable development. A Sustainable Development Blueprint was developed by the IMCSD and released in 2009 to outline key targets and initiatives to improve resource efficiency and enhance Singapore's urban environment for the next 10 to 20 years. One of the key targets set by the IMCSD for Singapore's built environment, is to green at least 80% of the buildings in Singapore by 2030. This would reduce the city-state's carbon footprint in the long term, whether in terms of energy and water efficiency, waste reduction or the use of sustainable materials.

In the USA, 13 states and the District of Columbia have adopted the *International Green Construction Code* (IgCC, 2015). The IgCC is the first model code to include sustainability measures for the entire construction project and its site — from design through construction, certificate of occupancy and beyond. This code is expected to make buildings more efficient, reduce waste, and have a positive impact on health, safety and community welfare. It is in addition to other codes, such as the *International Energy Conservation Code* (IECC, 2015), which focuses of energy efficiency measures in new buildings.

From a building regulatory policy perspective, is resiliency, as reflected in general government policy, addressed within the building regulations?

Yes
Australia, China, England, Japan, Netherlands, New Zealand, Norway, Scotland, Singapore, Spain, Sweden, USA

While it is noted that 'resiliency' is addressed in building regulations in all countries, the situation here is somewhat complex, as with the case of national resiliency policy. In all countries, resiliency against 'normal' loads such as wind, snow, earthquake and the like, as appropriate to the country, is included. However, fewer countries have explicit infrastructure and security resiliency clauses beyond these, and countries addressing resiliency to climate change impacts through building regulations are even fewer. In some cases, this is not because of lack of interest, but more related to lack of knowledge and data from the experts.

In Australia, for example, the Australian Building Codes Board (ABCB) recognises that they are not the experts on climate change, but need input from experts and other stakeholders, and released a Discussion Paper in 2014 to inform and seek feedback from stakeholders on the resilience of new buildings to extreme weather events (ABCB, 2014). Some of the issues are identified by McDonald (2014) as including the fact that the National Construction Code of Australia (NCC) currently does not cover hail, storm tide or have specific requirements relating to heat stress, but that some of the largest insurance property losses result from hail damage, and that storm tide is potentially a very high risk in low lying coastal communities, especially those subject to the risk of cyclones. However, it is acknowledged that any proposed changes would need to pass regulation impact analysis, and it is unlikely that requiring all external building materials to resist hail impact would be cost effective, and it would be very costly and restrictive to design and construct buildings to resist storm surge because of the significant water forces involved. Ultimately, the feedback to be obtained from stakeholders is expected to inform the ABCB on strategic advice it provides to governments in identifying future areas to focus its activities.

In the Netherlands, which has a significant coastal flooding concern, flooding is not regulated within the Building Regulations, but is part of the Act "Deltawet waterveiligheid en zoetwatervoorziening," which addresses flood protection and care of fresh water in relation to the expected climate change, under the responsibility of the Ministry of Infrastructure and the Environment. However, potentially surprising to some, the Building Decree will be addressing earthquake in the future, to address man-induced earthquakes which occurs frequently in the Northern part of the Netherlands due to gas production for many decades.

The examples from Australia and the Netherlands are reflective of challenges that other countries face as well – with numerous stakeholders providing input and various regulatory bodies having jurisdiction over resiliency, it can be difficult to craft holistic policies and legislation for the built environment. Climate change science is still developing. People live in areas of changing hazards. As will be highlighted later, it is challenging to upgrade existing buildings. These are but a few areas which need to be addressed.

Are building regulations in your country applicable to existing buildings?

Building regulations have traditionally been developed to apply to new construction. As a growing percentage of the construction activity is with the renovation, transformation, extension and upgrading of existing buildings more countries are engaged in developing regulatory tools for existing buildings (Meacham, 2009). In 2007, the IRCC conducted a survey of member countries with respect to building regulation and existing buildings. A summary of the 2007 survey results was published by Bergeron (2007).

Building Regulation Not Applicable to Existing Buildings	**Building Regulation has Provisions for New and Existing Buildings**	**Application to Existing Buildings Determined by Regional Government**	**Application to Existing Buildings for Major Alteration or Renovation**	**Separate Regulation for Existing Buildings**
Austria	China, England, the Netherlands, Singapore, Sweden[2]	Australia	Canada, Japan, New Zealand, Scotland, Spain,[3] Sweden[1], USA	USA

Some of the key outcomes of the survey include the following:

- An important aspect of regulation for existing buildings is the determination of the performance level required from building upgrades. In many countries this is achieved by comparing existing building upgrades to the performance levels required for new construction;
- A fundamental difficulty encountered is the unavailability of sufficient knowledge to express the performance target of building regulations in quantified measurable terms that can be verified. Developing tools and methods to help develop these performance parameters is essential to the success of this approach; and

[2] In Sweden, essentially the same requirements shall be applied for both the construction of a new building as well as the alteration. For alterations, however, one shall always take into account the scope of the alteration in accordance with Chapter 8, Article 7 of the Planning and Building Act and Chapter 3, Article 23 of Planning and Building Ordinances as well as the building's conditions, when the requirements apply. The requirements for new constructions are never directly applicable to alterations. However, one can often get some guidance from these for assessing the implications of the requirements for the alterations. For alterations, however, the requirements are often met through other solutions than for the construction of new buildings. (see Boverket, 2011)

[3] To comply with EU regulations on energy efficiency as part of the 20/20/20 plan, a system of energy certification of buildings for both new construction and for existing buildings that are sold or rented has been implemented in 2013.

- In some countries the regulations make allowance for risk-based approaches for determining what constitutes an acceptable level of performance. With the rapid expansion of the scope of regulations from the traditional fire and safety issues, to emerging social objectives such as accessibility and resource conservation, new decision-making tools need to be developed to support this approach.

From the 2015 survey, the situation appears to be generally unchanged. It was reiterated by several countries that regulations for new buildings are applicable to existing buildings, but whenever any intervention takes place in an existing building (expansion, renovation or change of use) due consideration should be given to proportionality, flexibility and no worsening of the conditions. How this is done, however, varies, and tools are sought to help make reasonable risk-cost-performance decisions.

The challenges have become highlighted when considering building retrofit for energy performance, which can have an impact on other building performance objectives (e.g., see Sanchez et al., 2014; Meacham, 2012). This is especially true given that most countries have voluntary (market-based) mechanisms aimed at helping to increase sustainability in buildings, for which regulatory oversight may not occur.

Challenges are also highlighted for existing buildings within areas impacted by climate-related events, such as drought and subsequent wildland (bush) fire (e.g., Australia and parts of the U.S.), coastal storm surge and flooding (e.g., Netherlands, Australia, U.S,), increased snow load (e.g., New Zealand) and more. In concept the challenge is not new – we have to deal with earthquake and other hazards, and adjust the building regulations as needed. However, in this case, numbers of buildings / people at risk may be higher, while ability to predict impact is not as reliable. Data, tools and methods for predicting a broad range of impacts, at a regional level to a building level, remain needed.

In your country, have any sustainability measures been mandated for existing buildings through regulation?

Yes	No	Variable
Netherlands, Scotland, Singapore, Spain, Sweden	China, England, New Zealand, Norway	Australia, Japan, USA

While the summary indicates significant movement in addressing sustainability measures in existing buildings, many of the legislated requirements are associated with energy performance certification, or are only triggered if significant renovation is being undertaken (see above section on existing buildings).

In Australia the Department of Industry, Innovation and Science delivers the Commercial Building Disclosure (CBD) Program which mandates the disclosure of energy efficiency information for commercial office spaces of 2000 square meters or more (CBD, 2015). Disclosure of this information before sale or lease assists prospective buyers and tenants to make informed decisions. The CBD Program is an initiative of the Council of Australian Governments (COAG). The Australian Capital Territory (ACT) introduced under the ACT's House Energy Rating Scheme (ACTHERS) in 1999 a requirement for the disclosure of an existing dwelling's energy rating in all advertisements for sale,

and that the contract of sale includes information about the buildings Energy Efficiency Rating. Minimum Energy Performance Standards (MEPS) Regulations apply in Australia for individual domestic appliances. MEPS is regulated through Commonwealth legislation, i.e. the Greenhouse and Energy Minimum Standards (GEMS) Act 2012. . It allows consumers to make informed decisions regarding the performance of individual domestic appliances.

As noted earlier in the paper, for EU member countries, the *2010 Energy Performance of Buildings Directive* and the *2012 Energy Efficiency Directive* are principal pieces of legislation. Under the *Energy Performance of Buildings Directive*:

- Energy performance certificates are to be included in all advertisements for the sale or rental of buildings.
- EU countries must establish inspection schemes for heating and air conditioning systems or put in place measures with equivalent effect.
- All new buildings must be nearly zero energy buildings by 31 December 2020 (public buildings by 31 December 2018).
- EU countries must set minimum energy performance requirements for new buildings, for the major renovation of buildings and for the replacement or retrofit of building elements (heating and cooling systems, roofs, walls, etc.).
- EU countries have to draw up lists of national financial measures to improve the energy efficiency of buildings.

Under the *Energy Efficiency Directive*:

- EU countries make energy efficient renovations to at least 3% per year of buildings owned and occupied by central government
- EU governments should only purchase buildings which are highly energy efficient
- EU countries must draw-up long-term national building renovation strategies which can be included in their National Energy Efficiency Action Plans

In Japan, Article 11 of the *Act for the Improvement of the Energy Saving Performance of Buildings* states that the owner of a building undergoing major renovations exceeding a certain size is obliged to make them comply with the energy consumption performance standard. In the USA, existing buildings undergoing major renovations are required to meet current building codes, including for energy performance.

Are there market based approaches to enhance sustainability in existing buildings?

Yes
Australia, China, England, Japan, Netherlands, New Zealand, Norway, Scotland, Singapore, Spain, Sweden, USA

As one might expect, all countries have voluntary mechanisms to help enhance sustainability in existing buildings. A representative sampling includes:

- **Australia**: *Green Star* is a national, voluntary, industry-developed sustainability rating system for buildings and communities. The National Australian Built Environment Rating System (NABERS) is a government-developed national rating system that measures the environmental performance of Australian buildings, tenancies and homes. NABERS is mandatory where required to comply with the Commercial Building Disclosure (CBD) Program.

- **England**: *BREEAM* is voluntary, sustainability rating system for buildings, and is used mainly in commercial buildings. The Code for Sustainable Homes ceases to have effect in October, to be replaced by the Home Quality Mark system.

- **Japan**: Energy saving performance can be indicated in *BELS: Building Energy-efficiency Labeling System*, overall environmental performance can be indicated in *CASBEE: Comprehensive Assessment System for Built Environment Efficiency*, and energy saving performance of housing can be indicated in the housing performance indicator system.

- **New Zealand**: The New Zealand Green Building Council (NZGBC) promotes several green star rating systems, including *greenstar*, *homestar* and *NABERS/NZ*.

- **Singapore**: The BCA *Green Mark* is a rating system to assess a building's environmental impact and recognise its sustainability performance, designed specifically for buildings in the tropics.

- **Sweden**: *Miljöbyggnad* is a voluntary Swedish environmental assessment system developed by Boverket a few years ago and now managed by the Sweden Green Building Council.

- **USA**: There are several systems, including *LEED*, a green building certification program that recognises best-in-class building strategies and practices and the *Energy Star* system for homes and businesses.

Have any resiliency measures been mandated for existing buildings through regulation?

Yes	No	Variable
Australia, China, Japan, Netherlands, New Zealand, Scotland,	England, Norway, Singapore, Spain, Sweden	USA

The answer to this question closely tracks the responses with national resiliency policy and existing building policy outlined above. In most cases, mandated resiliency upgrades are for specific hazards, such as earthquake, with upgrades associated with resiliency requirements associated with climate change effects less prevalent. This seems likely due to the complexity of the problem. As noted by Thompson et al. (2015, as cited in Foxell and Cooper, 2015), "climate change is the prime example of a well-recognised but still intractable policy issue for almost all sectors and certainly for the built environment."

As an example of earthquake upgrade requirements for existing buildings, New Zealand focuses on 'earthquake-prone buildings,' which are defined as those having one third the capacity of a new building at that location. While some changes are underway to the legislation, most seismic assessment of buildings is conducted by following New Zealand Society for Earthquake Engineering (NZSEE) guidelines (NZSEE, 2015). These too are currently undergoing a major revision based on the new proposed legislation and the lessons from Canterbury. In addition, New Zealand is also reviewing requirements for snow loading and flooding, based on recent events.

Are there voluntary regulatory measures, or voluntary market mechanisms, to enhance resiliency in existing buildings?

Yes	**No**
New Zealand, Norway, Scotland, Sweden	Australia, China, England, Japan, Netherlands, Singapore, Spain,

Here again, the mechanisms are largely related to long-known natural hazards, such as earthquake. However, there are some mechanisms for flooding, which is a potential climate change effect.

For example, in Japan, voluntary seismic retrofitting under the Law for Promotion of Seismic Retrofitting of Buildings exempts the owners from application of other requirements. In New Zealand, NZSEE has a rating scheme to encourage building owners to upgrade to a higher level, which has seen an uptake in use since the Canterbury earthquakes. This is having a significant impact on the market, particularly in Wellington where the seismic hazard is greater.

In Scotland there are a number of guidance documents available for flood protection, as well as industry guidance and advice. The same is the case in the USA, where guidelines on seismic rehabilitation of buildings, flood protection and protection against other hazards is available from the Federal Emergency Management Agency (FEMA), the American Society of Civil Engineers (ASCE) and others.

Have there been any failures of / gaps in / challenges to your system, particularly as related to sustainability or resiliency policies or issues?

Yes	No
Australia, England, Netherlands, New Zealand, Scotland, Spain, USA	China, Japan, Norway, Singapore, Sweden

This question is actually quite complex, and a yes or no answer is not that simple. Many countries have identified existing buildings as presenting building regulatory policy challenges for sustainability and resiliency. Existing buildings are not specifically a new challenge, but the new objectives, and assessment of actual versus intended performance, is providing new focus.

In Australia, the Commonwealth Scientific and Industrial Research Organization (CSIRO) was contracted to evaluate the effectiveness of the 5-star energy efficiency standard for houses introduced in 2006, compared to the previous 3.5 to 4 star standard. The resulting report, *The Evaluation of the 5-Star Energy Efficiency Standard for Residential Buildings*, is the first evaluation of energy efficiency standards for houses in Australia based on comparison of actual energy use

(Ambrose et al., 2013). The study monitored the energy use of more than 400 houses (with around half the houses undergoing more detailed monitoring of heating and cooling) in Brisbane, Melbourne and Adelaide, from June 2012 to February 2013. One of the findings was that the expected energy ratings of the houses in the sample have not increased in line with the changes in building regulation. This tracks with published research about the how well voluntary rating schemes do at actually delivering cost savings and expected performance (e.g., Newsham et al., 2009; Scofield, 2009; Oates and Sullivan, 2012), the point being that both mandatory and voluntary approaches appear to have difficulty in delivering on projected outcomes.

Comments from England and Scotland suggest growing concern that increasing the energy efficiency of buildings will lead to problems of poor air quality in homes, moisture damage to fabric, and overheating in summer. The moisture and indoor air quality issues were seen with New Zealand's 'leaky building' problem (May, 2003; Meacham, 2010), and similar issues have been observed in Sweden and the USA as well (Hagentoft, 2011; Odom et al., undated). In Scotland, survey feedback indicates that there is evidence that either poorly designed or extremely well built air tight buildings are causing poor indoor air quality and leading to the increase in respiratory diseases. With the ever increasing drive to improve energy efficiency this is likely to acerbate the IAQ issue. There is also evidence that poorly executed energy efficiency retro-fitting projects have led to fire and moisture issues with existing buildings. There are numerous reports of fires related to energy retrofits and alternative energy installations on buildings (Meacham et al., 2012), which supports these concerns.

For several countries, issues associated with how to address sustainability and resiliency in existing buildings – to what level should they perform, what is the basis of the performance analysis, and what is an appropriate regulatory instrument – was identified as a significant concern. Tied closely to this is the need for quantitative performance metrics in the building regulations, which several countries identified as well. This is not only for sustainability and resiliency, but across regulation. It becomes focused when new objectives, such as energy performance of buildings, compete with safety objectives, such as fire performance of buildings.

Conclusions

Review of the literature and responses to survey of IRCC members reflect that challenges exist with performance-based building regulatory systems due to lack of clear performance criteria, verification methods, and related issues. Outcomes also indicate that challenges exist in incorporating sustainability and resiliency into building regulation, for both new and existing buildings, because these social objectives are not yet being viewed as having the same level of importance, or equivalent level of social compact between government and the public, as providing for minimum levels of health and safety in buildings.

While review of the literature and responses from the survey reflect sustainability objectives are being included in building regulations, it has also been found that their inclusion has been triggered from outside of the 'traditional' building regulatory system actors, and it appears that holistic or integrated performance has not been fully assessed (i.e., making sure that adding a new objective does not result in an unanticipated impact somewhere else). This failure to fully assess potential impacts has resulted in observable, if not fully measured, reduction in performance for some areas, such as fire safety, structural safety and occupant health.

Table 1. Summary Responses to Selected Survey Questions (Note: Please look at notes in appropriate section above for assistance in interpreting responses)

	Australia	China	England	Japan	Netherlands	New Zealand	Norway	Scotland	Singapore	Spain	Sweden	USA
From a top-level (over-arching) national government policy perspective, is sustainability a guiding principle for legislative / regulatory development?	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	V
From a top-level (over-arching) national government policy perspective, is resiliency a guiding principle for legislative / regulatory development?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
From a building regulatory policy perspective, is sustainability, as reflected in general government policy, addressed within the building regulations?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
From a building regulatory policy perspective, is resiliency, as reflected in general government policy, addressed within the building regulations?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Are building regulations in your country applicable to existing buildings?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
In your country, have any sustainability measures been mandated for existing buildings through regulation?	V	N	N	V	Y	N	N	Y	Y	Y	Y	V
Are there market based approaches to enhance sustainability in existing buildings?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
In your country, have any resiliency measures been mandated for existing buildings through regulation?	Y	Y	N	Y	Y	Y	N	Y	N	N	N	V
Are there voluntary regulatory measures, or voluntary market mechanisms, to enhance resiliency in existing buildings?	N	N	N	N	N	Y	Y	Y	N	N	Y	Y
Have there been any 'significant' failures of / gaps in / challenges to your system? If so, what are / were they, how did they come about?	Y	N	Y	N	Y	Y	N	Y	N	Y	N	Y

While the literature suggests that resiliency to climate change effects, narrowly viewed as resulting in hazards such as drought, increased rain, wind and snow loads, sea level rise and storm surge, should be addressed at all levels of government, survey results indicate that such objectives are generally not explicitly addressed in the building regulations of the responding countries.

Overall, the literature review and survey responses suggest that addressing sustainability and resiliency objectives for existing buildings is the greatest challenge, since regulatory oversight is low, building modifications associated with increasing sustainability (e.g., more insulation, alternative energy sources) is becoming a concern, and it is extremely costly to increase the overall performance of existing buildings to that expected for new construction.

To address these issues, research suggests that a better understanding of holistic building performance is needed, along with the data and tools to assess performance, and more integrated regulatory and market measures are needed to achieve societal expectations for safe, healthy, sustainable and resilient buildings.

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Annex A – Survey Questions

The purpose of this survey is to gather input for two papers to be submitted to the journal *Building Research & Information*. The first will be an international comparative survey of regulatory provisions and market instruments aimed at increasing sustainability and resiliency in existing buildings, and the second will be on challenges with existing (performance) building regulatory systems and desired attributes for 'next generation' systems. Part A of this questionnaire relates to gaining an understanding of government policies for sustainability and resiliency, in general. Part B relates to sustainability and resiliency policies and instruments for new and existing buildings. Part C focuses on issues with current regulatory systems and desires for next generation systems. Thank you for answering these questions as best you can. Please feel free to provide links to documents which provide additional information pertinent to the issue(s) in your country. Note that while names and contact information are requested, information provided by you will not be attributed to you or any other person without your approval. If you have questions regarding the survey, please contact (____). Please respond by July 15, 2015.

Name:	
Organization:	
Address:	
Email:	

Part A

To understand the relative importance / priority of sustainability and resiliency principles and policies to the government in your country – in general and with respect to the built environment – a few benchmarking questions are posed. It is understood that these questions may be difficult to answer (or that you may not be able to answer them). However, any information which helps illustrate the situation will be beneficial.

From a top-level (over-arching) national government policy perspective, is *sustainability* a guiding principle for legislative / regulatory development? If so, how is it defined and what does it encompass? (E.g., in the USA, presidential initiatives on sustainability can be found at https://www.whitehouse.gov/blog/2015/03/19/leading-example-climate-change-our-new-federal-sustainability-plan.)
Which national government departments / agencies have a role in promulgating regulation related to *sustainability*, and which aspects are addressed by those departments / agencies? (E.g., in the USA, US Environmental Protection Agency (USEPA) efforts in the area of sustainability practices and approaches include labeling green products and promoting green chemistry and engineering, managing materials rather than creating waste, using green infrastructure to manage storm water runoff, and supporting the sustainable design of communities (http://www.epa.gov/sustainability/). The US Department of Energy sustainability activities relate to reducing greenhouse gas emissions associated with energy production and use (http://energy.gov/eere/spo/goals-and-requirements). Etc.)

Do you also have state / province / territory government departments / agencies with a role in promulgating regulations related to *sustainability*, and, if so, which aspects are addressed by those departments / agencies? (E.g., in the USA, each state has environmental, planning and related legislative and regulatory responsibility for the built environment. In Massachusetts, for example, the Executive Office of Energy and Environmental Affairs (EEA), among other activities, enforces pollution laws to protect public health and natural resources; reviews the environmental impact of major real estate and infrastructure developments; and enhances the state's role in energy conservation and production (http://www.mass.gov/eea/), and the Executive Office for Administration and Finance focuses on energy efficiency and sustainable practices for state-owned facilities (http://www.mass.gov/anf/property-mgmt-and-construction/facilities-mgmt-and-maintenance/energy-and-sustainability/).
Is there a hierarchy at either the national or state / provincial / territorial level with respect to *sustainability* policy? (E.g., does one particular ministry / department / agency have actual power to direct other groups' efforts in sustainability, or have *de facto* power to direct or influence others significantly, or does each group work independently, or…) If there is a hierarchy, how is it structured? (E.g., in the USA, states are required to follow federal environmental and energy regulations, but depending on state, can also promulgate their own (varies by state).)
From a top-level (over-arching) national government policy perspective, is *resiliency* a guiding principle for legislative / regulatory development? If so, how is it defined and what does it encompass? (E.g., In the USA, presidential initiatives on climate change resiliency can be found at https://www.whitehouse.gov/administration/eop/ceq/initiatives/resilience, and presidential policy on infrastructure and security resiliency can be found at https://www.whitehouse.gov/the-press-office/2013/02/12/presidential-policy-directive-critical-infrastructure-security-and-resil).
Which national government departments / agencies have a role in promulgating regulations / policies related to *resiliency*, and which aspects are addressed by those departments / agencies? (E.g., in the USA, several entities have 'resiliency' portfolios, including Department of Homeland Security (DHS) for flooding, earthquake, terrorism (http://www.dhs.gov/topic/resilience) and the National Oceanic and Atmospheric Administration for hurricanes, tornados, and large storms (http://www.noaanews.noaa.gov/stories2014/20141117_climateresiliencetoolkit.html), with the Department of Housing and Urban Development addressing related impacts (http://www.huduser.org/portal/periodicals/em/winter15/highlight1.html).
Do you also have state / province / territory government departments / agencies with a role in promulgating regulations related to *resiliency*, and, if so, which aspects are addressed by those departments / agencies? (E.g., in the USA, there are state Emergency Management Agencies, which operate much like the Federal Emergency Management Agency (FEMA), a part of DHS.)
Is there a hierarchy at either the national or state / provincial / territorial level with respect to *resiliency* policy?

Part B

This series of questions aims to identify how concepts of sustainability and resiliency are addressed within building regulations, and within the built environment, for new and existing buildings.

Are building regulations developed and promulgated at a national level? If so, which ministry / department / agency is responsible? Note: no need to update if information in the 2010 IRCC Guidelines document is still accurate.
If building regulations are not developed and promulgated at a national level, how does your system work? Note: no need to update if information in the 2010 IRCC Guidelines document is still accurate.
From a building regulatory policy perspective, is *sustainability*, as reflected in general government policy (see A1 above), addressed within the building regulations? If so, how? (E.g., stated in the Building Act (or similar), stated goal or objective of the regulations (Code), through specific provisions (such as energy usage / efficiency, insulation requirements, glazing requirements, embodied carbon limits, etc.).) Note: As stated above, please feel free to provide documents / links to documents which may have details.
From a building regulatory policy perspective, is *resiliency*, as reflected in general government policy (see A5 above), addressed within the building regulations? If so, how? (E.g., stated in the Building Act (or similar), stated goal or objective of the regulations (Code), through specific provisions (such as specific mitigation for earthquake, high winds, high snow loads, flooding (riverine / coastal), wild land fire, etc.)) Note: As stated above, please feel free to provide documents / links to documents which may have details.
Are building regulations in your country applicable to existing buildings? If so, when are the regulations applicable, and to what extent? (E.g., in the USA, existing buildings are not required to meet current building codes unless there is an imminent hazard to occupants, or if the building is undergoing a change in use, major renovation or expansion.)
In your country, have any sustainability measures been mandated for existing buildings through regulation? If so, what precipitated the action, how were the measures implemented, and to what extent (e.g., as a result of the Kyoto Agreement and IPCC reports and associated pressures on government, through Ministerial Order (or equivalent), addressing energy efficiency targets, etc.).
If there are no mandatory regulatory requirements to enhance sustainability in existing buildings, are there voluntary regulatory measures? If so, what are they and how are they used? (E.g., creating an energy use label when a building is sold.)
If there are no voluntary regulatory requirements to enhance sustainability in existing buildings, are there voluntary market based approaches? If so, what are they and how are they used? (E.g.,

LEED is a voluntary approach to rating sustainability performance of buildings, where points are assigned to various building features.)
In your country, have any resiliency measures been mandated for existing buildings through regulation? If so, what precipitated the action, how were the measures implemented, and to what extent (e.g., following an earthquake / hurricane / cyclone / wildland fire / flood, by decree / Ministerial Order / stakeholder input, addressing earthquake rehabilitation of XXX type buildings, addressing YYY type buildings in flood zones, by changing hazard maps (peak/sustained winds, snow loads, rainfall, flood levels, ground motion, etc.)).
If there are no mandatory regulatory requirements to enhance resiliency in existing buildings, are there voluntary regulatory measures (voluntary standards, other regulatory instruments)? If so, what are they and how are they used? (E.g., ASCE/SEI 41-06 is available in the USA for seismic rehabilitation of existing buildings.)
If there are no voluntary regulatory requirements to enhance resiliency in existing buildings, are there voluntary market based approaches? If so, what are they and how are they used? (E.g., FEMA 547 is available in the USA for techniques for seismic rehabilitation of existing buildings.)

Part C

This section is aimed at understanding how well the performance- (objective-, function-) based building regulatory system has been working in your country, with a particular emphasis on aspects which have been identified as somehow lacking (or failed, or could be significantly improved), why you think the challenges exist, whether actions are underway to change the system going forward, and what 'the next generation' of the regulatory system might include (or that you would like to see it include). Again, please feel free to send documents / links if there is material on this already available for the situation in your country.

What is working well with respect to your performance- (objective-, function-) based building regulatory system?
What <u>is not</u> working so well with respect to your performance- (objective-, function-) based building regulatory system?
Have there been any 'significant' failures of / gaps in / challenges to your system? If so, what are / were they, how did they come about? (See also 4 below.)
Can any of these failures / gaps / challenges be related to *sustainability* or *resiliency* policies or issues ? (E.g., a focus on insulation for energy led to moisture failures, or inattention to wind (snow, …) loads, which are potentially related to climate, change led to building failures, or…)

If there have been failures of / gaps in / challenges to the system, what have been the major implications for government, your agency, the industry and other stakeholders? (See also 6.)
If there have been failures of / gaps in / challenges to the system that can be related to *sustainability* or *resiliency* policies / activities / issues, what have been the major implications for government, your agency, the industry and other stakeholders? (E.g., failure to address increased wind speeds in cyclones resulted in $XXXX in property damage, leading to changes to the building regulation and increased insurance costs.)
If the implications have affected the building regulatory system, what action has the government / your agency undertaken to address them and to prevent / mitigate similar challenges in the future?
Are the building regulatory system stakeholders generally accepting of the current system, or would they like to see changes? If they want changes, what would they like to see?
Are there any activities underway to modify, reduce or enhance any aspect(s) of the building regulatory systems (regulation, education, certification, …) to address failures / gaps / challenges, either resulting from an event, or resulting from stakeholder feedback, or from new 'high level' policy objectives? If so, what are they?
Even if there are no changes to the system underway, what types of changes would your country be interested in with respect to delivering a 'next generation' building regulatory system?

Part D

If you have information, data, comments, ideas or suggestions relative to the two papers which are being prepared, which are not addressed in the above questions, please provide your comments below. Thank you for your participation in this survey.
