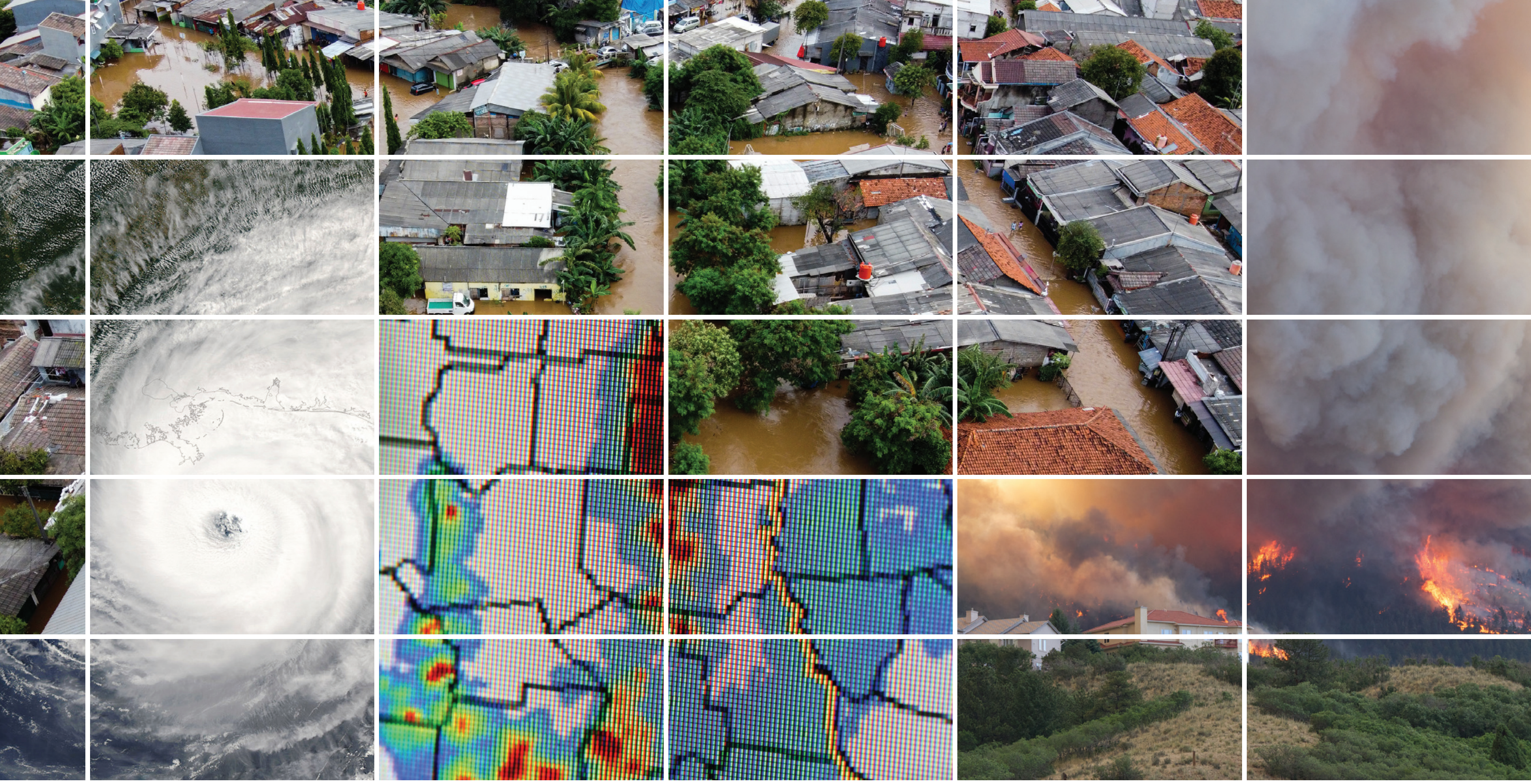

The Use of Climate Data and Assessment of Extreme Weather Event Risks in Building Codes Around the World:

Survey Findings from the Global Resiliency Dialogue

January 2021

EXECUTIVE SUMMARY

This paper is a report of the findings of a survey developed by the founding members of the Global Resiliency Dialogue[1] – the Australian Building Codes Board, the National Research Council of Canada, the New Zealand Ministry of Business, Innovation, and Employment, and the International Code Council (based in the United States).

The survey, which was circulated to building code development and research organizations around the world, was meant to help illuminate – in detail – how climate-based risks are currently considered within national building codes and standards. It included an exploration of the types of codes (building, fire, energy, electrical, plumbing, etc.) that rely on climate-related data to support their requirements, as well as the source of that climate data, how it is communicated, and how often it is updated.

The survey also explored the relationship between expected building life and climate projections, property protection versus life safety, land use/planning/zoning in relation to future-looking hazard assessments, and existing research related to building codes and climate-related risk.

A follow-on survey of building code stakeholders from the participating countries will focus on potential strategies to incorporate future-focused climate risk in codes and standards and the research needed for effective implementation. The results of this second survey will be presented in an additional report. Together, these two reports will inform the development of international resilience guidelines and joint research initiatives.

The findings shared in this paper indicate that the expectation of building resiliency to future weather events is largely based on historical data related to natural hazards, such as flooding, high wind, wildfire, and extreme heat, rather than on predictive data about the hazards that buildings are likely to face in the future. While some codes have begun to integrate forward-looking climate science to define select hazard measurements, these remain the exception with many questions still surrounding how to most effectively integrate appropriate climate science data into building codes. The findings support the work program defined by the Global Resiliency Dialogue and the likely relevance of the international resiliency guidelines that comprise the main deliverable of the group's work.

INTRODUCTION

The Global Resiliency Dialogue was launched in July 2019 by building code development and research organizations, along with interested government and non-governmental stakeholders, from Australia, Canada, New Zealand and the United States. As captured in the *Findings on Changing Risks and Building Codes*, the goal of this international collaboration is to collectively identify solutions to help address the global challenge posed by the impact of increasingly frequent and extreme weather events on buildings. Traditionally, building codes and standards are designed to respond to past weather events and struggle to adapt as quickly to rapidly changing global weather events (which includes anticipating events yet to be experienced), be they high wind events, flooding, wildfires or heatwaves.

The participants in the Global Resiliency Dialogue recognize that the building codes adopted in their own countries, which are largely based on historical climate and weather data, may not provide the same level of safety and resilience for future extreme weather events as they have in past years and decades. The dialogue partners agreed in principle, that it is desirable and increasingly necessary that codes and standards incorporate the latest research and data from both building/technical science and climate/environment science perspectives to maintain the expected levels of safety, amenity, sustainability and resilience. And the belief is that in working together, the participating organizations can pool resources, experience and knowledge to create guidelines that will be of both national value and global benefit.[2]

The first work item reported here, is a survey to understand in detail how climate-based risks are currently treated in national building codes and standards. In addition to input from the four founding Global Resiliency Dialogue participants – the Australian Building Codes Board (ABCB), the National Research Council of Canada, the New Zealand Ministry of Business, Innovation and Employment, and the International Code Council (based in the United States) – responses to the survey were received by counterpart organizations in Europe (Germany, the Netherlands, and Norway) and Asia (Japan), offering more of a global snapshot of the current status and approaches to integrating climate science in existing building codes.

The second work item is to identify potential strategies for the effective incorporation of climate risk in codes and standards and the research needed to support such approaches. The code development and research organizations will survey code stakeholders to gather this information for their country to identify common strategies or research needs. Results from these two work items will form the basis for an international resilience guideline and future research roadmap.

CLIMATE-RELATED DATA IN BUILDING CODES

Building codes largely rely on historical data to support requirements related to structural/atmospheric loads for wind and snow/ice, energy use/heat stress, flooding, and wildfire/bushfire protection. Climate data is frequently only updated on a 10-year cycle on average, so as weather becomes more severe from year to year, the underlying data simply does not accurately reflect the risk to the building of these extreme weather-related events.

The building codes in some countries, particularly in Europe and the United States, reference design standards to dictate the energy performance and structural standards that impact wind loads and snow/ice loads, and the underlying data is updated on an “as needed” basis, which could exceed the 10 year average. More specifics from each country studied can be found in Figure 1.

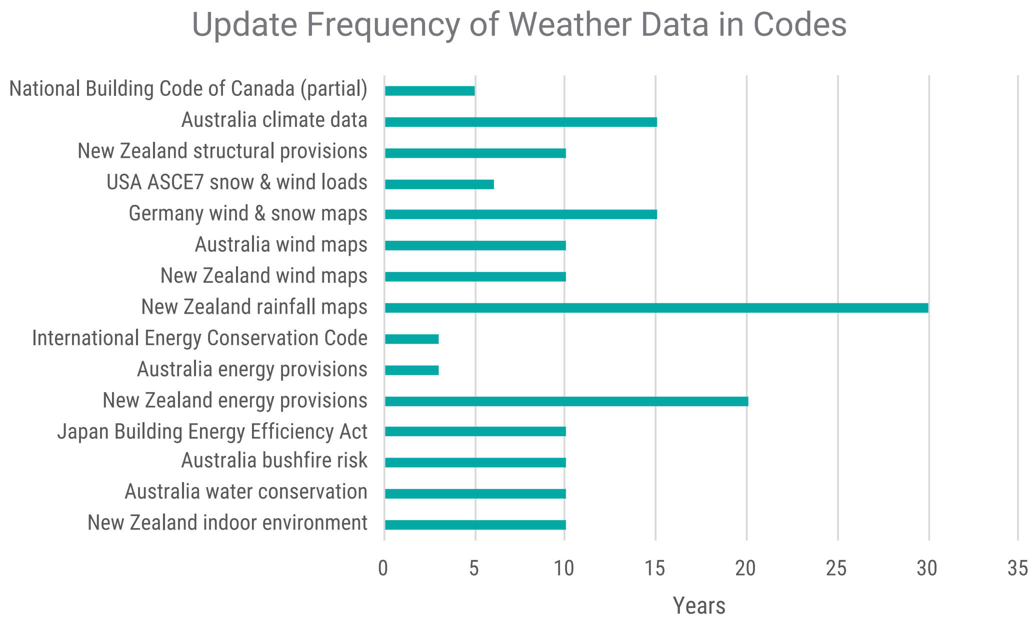

Figure 1: Sampling of the frequency of which the underlying weather/climate data in building codes is updated

The notable exception to the rule of relying on historical weather and climate data for hazard maps published in building codes is likely to be found in the 2025 editions of the National Building Code of Canada (NBCC) and the Canadian Highway Bridge Design Code (CHBDC), for which new climate change provisions are being considered. Proposed future-looking climatic design data was developed as part of the Climate Resilient Buildings and Core Public Infrastructure Initiative in 2019, and incorporates considerations of future climate scenarios, linked to degrees of global warming.[3] The design data, including temperature, precipitation, wind and ice, is currently under consideration by the committees of the NBCC and Canadian Commission on Building and Fire Codes (CCBFC). If implemented, it will result in a major shift in the way infrastructure and buildings are designed in Canada: to include consideration of a non-stationary climate.

Although Australia has not begun to integrate climate change modeling into its National Construction Code (NCC), the ABCB and the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia’s national science agency, are currently examining whether and how “future climate scenarios” can and should be used in improving building resilience. This work is still in its infancy and will involve reviewing the adequacy of natural hazard standards that exist against the potential events that buildings might encounter in their life-cycles, including for heat stress as part of regulating the energy efficiency of new buildings, currently being investigated for 2022 code development.[4]

In New Zealand, the Ministry of Business, Innovation and Employment (MBIE) has a climate change adaptation work stream in its Building for Climate Change programme. This work will examine how future climate change data can be incorporated into the Building Code. It will include a data stock take to understand how robust modeled future climate data is, what level of conservatism/redundancy is inherent in the current Building Code settings, and what changes might be required to ensure buildings are resilient for the future.

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Most building code development and research organizations rely on outside organizations with expertise in natural environmental sciences to develop the climactic and hazard maps that are included in the codes. Table 1 provides a listing of the organizations that contribute to the climate data in each of the surveyed countries, as well as standards that are referenced. Many countries also rely on published standards developed by national standards bodies or private organizations such as ASHRAE, along with input from academia and industry experts serving on standards committees, or on studies undertaken by commissioned consultants.

COUNTRY	SOURCE(S) OF WEATHER/CLIMATE RISK DATA	REFERENCED STANDARDS
Australia	Bureau of Meteorology (BOM), Geoscience Australia (GA), Commonwealth Scientific and Industrial Research Organisation (CSIRO).	AS/NZS 1170.2 ASHRAE 140 (2007) AS 3959:2018 ABCB Bushfire Standard
Canada	Environment and Climate Change Canada (ECCC)	CSA CS478
Germany	German Weather Service (DWD)	DIN-EN 1991-1-3/NA DIN-EN 1991-1-4/NA
Japan	Japan Meteorological Agency, Architectural Institute of Japan	
Netherlands	Royal Netherlands Meteorological Institute	NEN-EN 1990 NEN-EN 1991-1-3/NA NEN-EN 1991-1-4/NA NTA 8800
New Zealand	National Institute of Water and Atmospheric Research (NIWA), Universities, Resilience to Nature's Challenges and The Deep South Science Challenges and local Councils	AS/NS 1170 E1 VM1, E1 AS1 NZS 3604 NZS 4218: 2009 NZS 4243.1: 2007 NZ G5 AS1
Norway	Norwegian Meteorological Institute	NEN-EN 1990 NEN-EN 1991-1-3/NA NEN-EN 1991-1-4/NA NTA 8800
United States	U.S. Department of Energy, National Weather Service, National Oceanic and Atmospheric Administration (NOAA), National Flood Insurance Program, Federal Emergency Management Agency, Applied Technology Council, U.S. Forest Service, U.S. Department of Agriculture, local jurisdictions	ASCE 7 ASHRAE 90.1 ASHRAE 169

Table 1: Sources of data and standards pertaining to climate and weather-related risks currently referenced in building codes

For the most part, climate risk data is communicated through the use of maps with zones or contour line maps, and in some cases, tables. New Zealand has an online tool developed by the National Institute of Water and Atmospheric Research (NIWA) that is used by building designers to assess surface water and flood risk.[5] Germany has the intention of replacing its postal code-based maps to geocoordinate-based climate risk zones, particularly in the area of wind loads.

The quality and coverage of weather and climate data incorporated into building codes – especially in larger countries with diverse physical geography and climates – is variable and imperfect. Smaller countries such as the Netherlands are able to employ a large number of weather stations across a relatively small area, resulting in better and more accurate data collection.

Most of the surveyed countries are able to gather good overall data, especially for temperature, and to a lesser extent for wind, rainfall/snowfall, and even less for wildfire/bushfire, which is very localized. A common difficulty is seen in gathering strong underlying data from more rural and less populated areas with fewer resources and less advanced technology. Australia in particular has sought to improve the quality of the data through national arrangements and the use of nationally-owned weather satellites with devolved and automated weather stations.

WEATHER HAZARD DATA BEYOND BUILDINGS

The climate data used to inform provisions of building codes is generally not limited to the building safety industry, and has the potential to impact other sectors of society, particularly because the key science agencies are often national bodies that service the diverse needs of state, provincial, tribal/indigenous, and local jurisdictions. In Australia and Canada there is overlap in data usage such as in the infrastructure sector, relating to roads and bridges, water management and energy supply.

The data is also used in the surveyed countries by a variety of other industries including agriculture, insurance, utility authorities, transport (particularly aviation and shipping), health, emergency services and forestry. Despite the wide applicability of the data, in Canada it was discovered that the specific needs of the engineering community are unique, particularly in the area of building and infrastructure where the need for extreme values of climatic parameters for buildings and bridges (not mean values), and quantifying the uncertainty associated with future climatic data, are required to advise decisions on structural design.

The data usage circumstances for the United States differs slightly, in that the building safety industry is the beneficiary of floodplain data that was originally designed for use by the insurance industry. However, this data, which forms the basis for the flood maps in the building codes, is used for building safety as well as for land use planning and zoning purposes.

Planning, including land use and zoning policies, which is typically the responsibility of the agency having jurisdiction over building code implementation and enforcement, but not necessarily referenced in the building code, can likewise be guided by the same climate and weather data that is used in developing building codes. In the United States, the National Flood Insurance Program maps are used for zoning and planning as well as to rate flooding hazards, although some jurisdictions have adopted more sophisticated mapping programs that use LIDAR[6] for planning, which are not referenced in building codes.

In Australia and Canada, some hazard mapping for land use planning is more localized than the national data incorporated in the building codes. In Australia this is because of the nature of the federation and also that certain hazards like bushfires and flooding are normally quite local/regional in nature. National building codes are based on amalgamated data from the various geographical regions – so localities will have more specific information that would inform the application of the relevant standard via areas designated by land use planning. In Canada, where national wildfire hazard mapping is done through the Canadian Wildland Fire Information System (Natural Resources Canada)[7] a federal flood mapping program that formerly existed was defunded in 1996, passing the responsibility for flood mapping to local jurisdictions, without common standards. In order to strengthen flood mapping across the country, the Canadian federal government has recently funded the development of a series of federal flood mapping guidelines[8] and introduced the National Disaster Mitigation Program to fund some local flood mapping and flood-risk assessments.

Some countries utilize different underlying data to inform the building codes and the planning/land use/zoning regulations. In Japan, for instance, the zoning regulations include the regulation of disaster risk areas, but those regulations do not directly use climate data. In New Zealand, the oversight is split with the building codes considering risks related to wind, rain and snow loads, while the planning regulations cover inundation and flooding, land prone to liquefaction and slips, etc. utilizing different data. The Netherlands, with its long tradition of managing water, regulates flooding through the Dutch Water Act rather than through building regulations. The comprehensive Dutch Water Act is designed to consider climate change in the regulation of project plan review, issuance of permits, and administrative agreements related to water management.[9]

EXTREME WEATHER PROVISIONS IN BUILDING CODES

Most building codes that address extreme events do so as part of the design standard and based on the probability of the occurrence of the specific event, with the design requirements changing based on the potential severity of the event, location or the importance of the building. Design events are frequently measured in probabilities, with the ratios varying greatly by country with no apparent international consistency.

For instance, the Australian codes utilize an annual probability for a wind event at 1:500 while the Canadian building codes utilize a 1:50 annual probability measure. Some standards have been published that specifically address designs for extreme natural hazard events, such as the ICC Standard 600: Standard for Residential Construction in High-Wind Regions or the German and Dutch national annexes to Eurocode EN 1991-1-4, which addresses exceptional snow events and snow loads on buildings.

The International Code Council's International Wildland-Urban Interface Code similarly focuses on areas that have higher risk for wildfires. This code, like bushfire provisions in the Australian National Construction Code, are adopted by individual local jurisdictions based on their relative risk level.

It is not unusual for building codes to not address extreme events at all. In Japan, extreme events are not addressed by building codes. Norway's performance-based building code addresses protection against acts of nature, particularly flooding/storm surge and landslides/avalanches, but with probability ranges that dictate safety classes based on historical data (although the underlying data on precipitation intensity, duration and frequency is updated annually). The National Model Codes in Canada do not currently address flooding, wildfire or extreme heat, however, efforts are underway to develop national guidance in these areas. The New Zealand building code does not address extraordinary flooding, drought, bushfires and extreme heat.

In some cases, certain extreme weather events have been determined as difficult to address through building codes due to either the localization of an event or the severity of the natural forces involved. Two such examples are hailstorms and storm surge impacting coastal regions.

PROPERTY PROTECTION AND DURABILITY

The primary function of building codes universally is to protect life/human safety. Often this requires structural durability, resistance to fire, adequate means of egress and other related functions to ensure that lives are protected. However, in discussions of natural hazard mitigation and community resilience, particularly as risks continue to become more severe and impact different geographic locations, the question of greater levels of property protection and 'bounce back' recovery of function following an event is increasingly debated by key decision makers. For instance, in a high wind or flood event, building codes are designed to protect the lives of the occupants for the duration of the event, but not necessarily to enable those occupants to return to a building that has been damaged by an event.

Beyond this, the German building code aims to ensure the intactness of the structure over the building life, with the exception of fire events (the codes are designed such that a building must protect life safety for the duration of the evacuation, after which point the building may be considered to have served its purpose). Building life is also something that is treated differently by different countries. In the EU, the Eurocode standard EN 1990 provides five classes of building life from 10 to 100 years, with the typical building life being 50 years. In Norway, the economic lifetime of buildings is normally anticipated to be 60 years.

The codes in the United States, Canada, Australia and Japan do not specifically define the life of a building, although the standards referenced by the National Construction Code in Australia often refer to a building life of 50 years for durability and design (excepting temporary buildings) and the Canadian standards developer CSA Group has published a durability standard for buildings, CSA S478, which specifies an expected service life of 50 years. New Zealand has a durability clause in its building code, which requires the structural elements of a building to last for no less than 50 years, unless it is specifically designed for a shorter intended life after which period the building must be demolished or removed.

Following the unprecedented bushfires in Australia in its summer of 2020, a Royal Commission into National Natural Disasters Arrangements reported, amongst other things, that *"where the National Construction Code can be expanded in a proven, cost-effective way to improve the ability of a structure to withstand damage and destruction of property from natural hazards, it should be."*[10]

It is also worth noting that there have been policy discussions in Canada over the decades on the role of the National Building Codes in addressing durability and property protection. Though not explicitly stated in the codes, durability is a consideration in the development of building code provisions in order to ensure healthy indoor conditions and structural sufficiency. For the 2025 edition of the Code, committees have received a request to consider moving the standard on durability in buildings (CSA S478) to the main body of the code, which if implemented would enable regulation for durability.

ANTICIPATION OF FUTURE RISK

Currently, none of the building codes in use in the surveyed countries addresses future climate risk – all are focused on addressing risk based on past weather experiences and extreme events. However, not surprisingly given the nature of this project, discussions are underway about how to include future focused risk in building codes – with some countries further along than others.

In Australia, the National Construction Code does not address future climate change risks, although a 5% climate change multiplier to the regional wind speeds in cyclonic wind regions is proposed for the national wind code in 2022. Additionally, in Australia the National Disaster Risk Reduction Framework[11], includes an action for codes to improve the resilience of buildings to extreme weather events. Consequently, the ABCB is engaged with building code development agencies from around the world, with support from the CSIRO, Geoscience Australia, Standards Australia, the Australasian Fire and Emergency Services Authorities Council, the Australian Institute for Disaster Recovery and the Department of Industry, Science, Energy and Resources, to support research and identify future climate risks and adaptation solutions to enhance building resilience.

In New Zealand, a programme is being developed as part of the country's National Adaptation Plan, which would include provision for future climate change in relevant building code clauses. The current approach is based on modeled climate data.

Under the Canadian Climate Resilient Buildings and Core Public Infrastructure Initiative (CRBCPI), funded by Infrastructure Canada, the National Research Council of Canada has been working with partners to develop future climatic design data and climate change provisions for consideration by the committees of the Canadian Commission on Building and Fire Codes. The effort involves generating a series of climate model results for the different design data elements currently referenced in the National Building Code for different degrees of global warming. Some measure of uncertainty is also included, as calculated based on the variation between the results of different climate model runs. Under the CRBCPI initiative, research has also been undertaken to understand potential climate change impacts on rainfall intensity-duration-frequency curves, wildland fire hazard, and urban heat islanding.

The International Codes (I-Codes) used throughout the United States are developed through a consensus-based process that is a public-private partnership, so the ultimate path to include future-focused risk is unclear. Because changes to the I-Codes cannot be unilaterally mandated, the International Code Council, which facilitates the development of the I-Codes, is considering potential strategies that align with the current format of the codes. These include an overlay document (standard or guideline) that communities wishing to address future climate risk can adopt alongside their code, or the development of a stand-alone standard that addresses the process that jurisdictions can use to factor climate change into their codes. Some local jurisdictions including New York City and Southeast Florida have developed design guidance that addresses climate risk. In New York this guidance currently applies to municipal buildings but may be extended to all buildings in the future. Local governments in southeast Florida have developed common sea level rise projections which can be incorporated into zoning or building code requirements.

In European countries, discussions are also underway. The German design rules do not currently use any predictive forecast models but the weather data will be updated on an ongoing basis and the uncertainties of models are incorporated in a "safety concept."[12] In the Netherlands and Norway, the building code development and research organizations have not yet made any decisions about how to account for the effects of climate change and corresponding implications for natural hazard risks. The initial focus in Norway has been on surface water, which could be impacted by a new proposed regulation.

While the building codes in Japan do not directly address future climate risk, the wind load calculations are made with consideration of forward-looking safety factors.

As countries consider modeling scenarios to incorporate future climate-related risk in building codes, one option under wide consideration are Representative Concentration Pathways (RCPs) – scenarios that consider the emissions and concentrations of the full suite of greenhouse gases, aerosols and other chemically active gases, along with land use by the year 2100, based on the radiative forcing limit reached on earth before emissions begin to decline.[13] One of the most severe and high impact scenario pathways is RCP 8.5. This is the one most commonly referenced by countries as the most likely basis for assessment of future climate risks in building codes, although no countries have confirmed use of RCP scenario data in future modeling.

Canadian experts have proposed the RCP 8.5 scenario for the design of buildings and are considering more moderate and less extreme RCP scenarios for the design of bridges, but separately linked climate design data to degrees of global warming (making the data agnostic to RCP scenarios), while New Zealand is considering a Dynamic Adaptive Pathway Planning Process. The Global Resiliency Dialogue founding partners are hoping that participation in this collaborative effort will help to identify a common path forward through appropriate benchmarking.

If climate modeling is used, building codes and referenced standards will need to be updated to replace historical weather data with future-focused climate data. In most countries, this type of change will follow the standard code revision process. In Australia this process involves including the work on the ABCB work program after approval from the ABCB Board and Building Ministers, engaging consultants to research and develop draft code provisions, technical review, public consultation, regulatory impact assessment, and finally Board approval with public comment before the next version of the code (updated every three years) can include any new provisions.

Similarly, the International Codes are updated on a three year cycle, which involves the consideration of code change proposals (which are generally submitted with data/research to support them) by a committee of subject matter experts, followed by a public comment period and finally a vote by governmental public safety officials who make the final determination of the content of the codes. In New Zealand, any changes can potentially be incorporated much more quickly as the codes are updated annually, based on research, impact analysis, and urgency, following the building code review work programme. However, climate data are usually contained in national standards referenced in building code compliance pathways and these have their own development and consultation timeframes. Canada's codes are updated on a five-year cycle, with changes considered by the committees and generally supported by research and input from stakeholders.

The timelines for codes and standards updates are not as clearly delineated in Europe and Japan. In Europe, the relevant clauses that would need to be updated are primarily in the form of referenced standards and would therefore follow the standards updating process, often on an as-needed basis upon the receipt of a proposal to the standards committee. In Japan, the proposed code changes, along with relevant research, are considered by a council of experts and then incorporated as a revision to the building code.

Assuming that code provisions can be adjusted to address future climate risk assessments, countries will need to have a process in place to ensure that the changes are not only adequate, but equally suitable and proportionate in scope. This work will fall primarily to the building code development and research organizations in each country, where they utilize their own internal processes. Some entities may develop new standards to assist with regulatory impact analysis. For its part, New Zealand already has committed to doing a national climate change risk assessment and consequential National Adaptation Plan every six years, taking into account the latest IPCC reports and climate modeling.

In the U.S., a National Climate Assessment is conducted every four years by the U.S Global Change Research Program, a joint effort of 13 federal agencies. To date, the assessment has only focused on the built environment at a relatively high level. As the fifth assessment gets underway, there may be increased focus on the needs of the design and construction industry.

APPENDIX 1: RESEARCH REPORTS ON BUILDING CODES AND CLIMATE-RELATED RISKS

American Society of Civil Engineers (USA):

- Manual of Practice Climate-Resilient Infrastructure: Adaptive Design and Risk Management
- Adapting Infrastructure and Civil Engineering Practice to a Changing Climate

Australian Building Codes Board:

- Resilience of Buildings to Extreme Weather Events

German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety:

- Climate Action Plan 2050

German Weather Service (DWD):

- German Climate Atlas

International Code Council:

- Resilience Contributions of the International Building Code
- The Important Role of Energy Codes in Achieving Resilience
- Wildland Urban Interface Codes Support Community Resilience

Klima2025 Research Center (Norway)

- Website with links to research

National Research Council of Canada:

- Climate-Reslient Buildings and Core Public Infrastructure Initiative
- Assessment of the Impact of Climate Change on Climatic Design Data in Canada
- Canadian Centre for Climate Services: Developing Climate Resilient Standards and Codes
- Climate Change Adaptation Solutions within the Framework of the CSA Group Canadian Electrical Code Parts I, II and III
- CSA Group: How Consensus-Based Standards can Help Communities Build Resiliency and Adapt to Climate Change

New Zealand Ministry of the Environment

- National Climate Change Risk Assessment
- Adapting to Climate Change in New Zealand: Recommendations from the Climate Change Adaptation Technical Working Group

APPENDIX 2: STAKEHOLDER GROUPS COMMONLY INVOLVED IN DEVELOPMENT OF BUILDING SAFETY CODES AND STANDARDS

- Academia
- Architects
- Building owners/managers
- Building safety professionals & industry associations
- Conformity assessment bodies, such as product evaluation services
- Consumers or consumer advocacy groups
- Contractors
- Developers
- Energy efficiency advocates
- Engineers
- Fire safety professionals
- Government entities: federal/national, state, provincial, tribal, territorial, local
- Home builders
- Insurance industry representatives
- Manufacturers of building products
- Professional societies
- Plumbing professionals & industry associations
- Subcontractors
- Subject matter experts
- Supply chain/distributors

[1] For more information about the Global Resiliency Dialogue, please visit www.globalresiliency.org
[2] See https://www.iccsafe.org/wp-content/uploads/Findings_ChangingRisk_BldgCodes.pdf
[3] See report available at https://climate-scenarios.canada.ca/?page=buildings-report-overview
[4] See report available at https://www.energy.gov.au/publications/climate-change-impact-building-design-and-energy-final-report-2020
[5] The NIWA interactive map is available online at https://hirds.niwa.co.nz/
[6] LIDAR refers to Light Detection and Ranging, a remote sensing method used to examine the surface of the earth.
[7] https://cwfis.cfs.nrcan.gc.ca/home
[8] Canadian Flood Mapping Guidelines can be downloaded here: https://www.publicsafety.gc.ca/cnt/mrgnc-mngmnt/dsstr-prvntn-mtgtn/ndmp/fldpln-mppng-en.aspx
[9] A summary of the Dutch Water Act can be downloaded here: https://puc.overheid.nl/rijkswaterstaat/doc/PUC_135574_31/
[10] https://naturaldisaster.royalcommission.gov.au/publications/royal-commission-national-natural-disaster-arrangements-report
[11] The National Disaster Risk Reduction Framework sets out the foundational work required nationally, across all sectors, to reduce disaster risk, new disaster risk, and deliver better climate and disaster risk information. https://www.homeaffairs.gov.au/emergency/files/national-disaster-risk-reduction-framework.pdf
[12] The safety concept refers to the choice of probability density function ("PDF"), the selection of the parameters of the PDF and the partial safety factors. For more information see http://www2.ing.unipi.it/dic/snowloads/Final%20Report%20I.pdf
[13] https://www.ipcc-data.org/guidelines/pages/glossary/glossary_r.html