BUILDING ENERGY CODES
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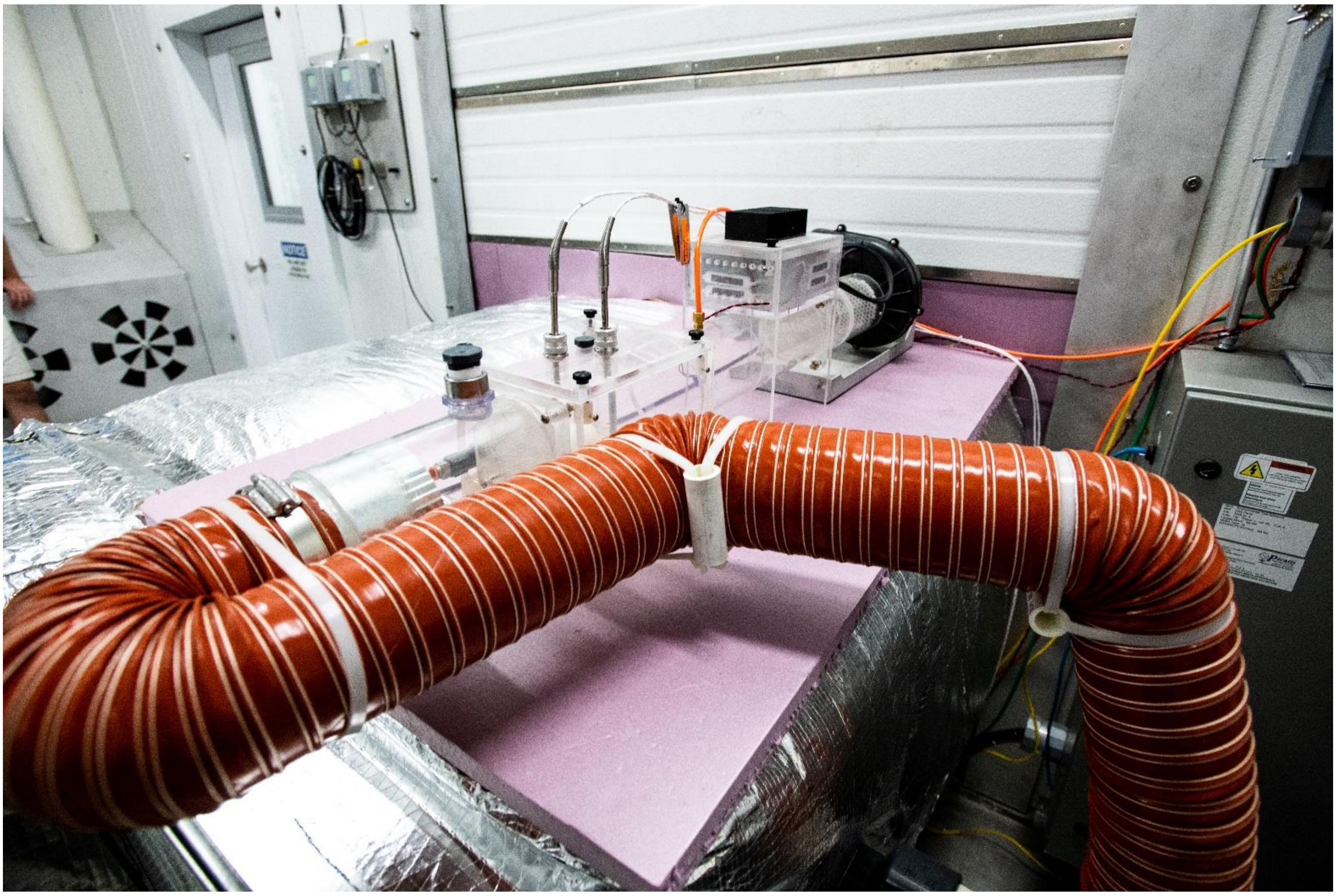
Energy in Buildings and Communities Programme

International Energy Agency

EBC Working Group Final Report: Survey on New Technology Integration in Building Energy Codes

Energy in Buildings and Communities Technology Collaboration Programme

January 2024



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January 2024

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Preface

The International Energy Agency

The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme. A basic aim of the IEA is to foster international co-operation among the 30 IEA participating countries and to increase energy security through energy research, development, and demonstration in the fields of technologies for energy efficiency and renewable energy sources.

The IEA Energy in Buildings and Communities Programme

The IEA co-ordinates international energy research and development (R&D) activities through a comprehensive portfolio of Technology Collaboration Programmes (TCPs). The mission of the IEA Energy in Buildings and Communities (IEA EBC) TCP is to support the acceleration of the transformation of the built environment towards more energy efficient and sustainable buildings and communities, by the development and dissemination of knowledge, technologies and processes and other solutions through international collaborative research and open innovation. (Until 2013, the IEA EBC Programme was known as the IEA Energy Conservation in Buildings and Community Systems Programme, ECBCS.)

The high priority research themes in the EBC Strategic Plan 2019-2024 are based on research drivers, national programmes within the EBC participating countries, the Future Buildings Forum (FBF) Think Tank Workshop held in Singapore in October 2017 and a Strategy Planning Workshop held at the EBC Executive Committee Meeting in November 2017. The research themes represent a collective input of the Executive Committee members and Operating Agents to exploit technological and other opportunities to save energy in the buildings sector, and to remove technical obstacles to market penetration of new energy technologies, systems and processes. Future EBC collaborative research and innovation work should have its focus on these themes.

At the Strategy Planning Workshop in 2017, some 40 research themes were developed. From those 40 themes, 10 themes of special high priority have been extracted, taking into consideration a score that was given to each theme at the workshop. The 10 high priority themes can be separated in two types namely 'Objectives' and 'Means'. These two groups are distinguished for a better understanding of the different themes.

Objectives - The strategic objectives of the EBC TCP are as follows:

– reinforcing the technical and economic basis for refurbishment of existing buildings, including financing, engagement of stakeholders and promotion of co-benefits;

– improvement of planning, construction and management processes to reduce the performance gap between design stage assessments and real-world operation;

– the creation of 'low tech', robust and affordable technologies;

– the further development of energy efficient cooling in hot and humid, or dry climates, avoiding mechanical cooling if possible;

– the creation of holistic solution sets for district level systems taking into account energy grids, overall performance, business models, engagement of stakeholders, and transport energy system implications.

Means - The strategic objectives of the EBC TCP will be achieved by the means listed below:

– the creation of tools for supporting design and construction through to operations and maintenance, including building energy standards and life cycle analysis (LCA);

– benefitting from 'living labs' to provide experience of and overcome barriers to adoption of energy efficiency measures;

– improving smart control of building services technical installations, including occupant and operator interfaces;

– addressing data issues in buildings, including non-intrusive and secure data collection;

– the development of building information modelling (BIM) as a game changer, from design and construction through to operations and maintenance.

The themes in both groups can be the subject for new Annexes, but what distinguishes them is that the 'objectives' themes are final goals or solutions (or part of) for an energy efficient built environment, while the 'means' themes are instruments or enablers to reach such a goal. These themes are explained in more detail in the EBC Strategic Plan 2019-2024.

The Executive Committee

Overall control of the IEA EBC Programme is maintained by an Executive Committee, which not only monitors existing projects, but also identifies new strategic areas in which collaborative efforts may be beneficial. As the Programme is based on a contract with the IEA, the projects are legally established as Annexes to the IEA EBC Implementing Agreement. At the present time, the following projects have been initiated by the IEA EBC Executive Committee, with completed projects identified by (*) and joint projects with the IEA Solar Heating and Cooling Technology Collaboration Programme by (☼):

Annex 1: Load Energy Determination of Buildings (*)
Annex 2: Ekistics and Advanced Community Energy Systems (*)
Annex 3: Energy Conservation in Residential Buildings (*)
Annex 4: Glasgow Commercial Building Monitoring (*)
Annex 5: Air Infiltration and Ventilation Centre
Annex 6: Energy Systems and Design of Communities (*)
Annex 7: Local Government Energy Planning (*)
Annex 8: Inhabitants Behaviour with Regard to Ventilation (*)
Annex 9: Minimum Ventilation Rates (*)
Annex 10: Building HVAC System Simulation (*)
Annex 11: Energy Auditing (*)
Annex 12: Windows and Fenestration (*)
Annex 13: Energy Management in Hospitals (*)
Annex 14: Condensation and Energy (*)
Annex 15: Energy Efficiency in Schools (*)
Annex 16: BEMS 1- User Interfaces and System Integration (*)
Annex 17: BEMS 2- Evaluation and Emulation Techniques (*)
Annex 18: Demand Controlled Ventilation Systems (*)
Annex 19: Low Slope Roof Systems (*)
Annex 20: Air Flow Patterns within Buildings (*)
Annex 21: Thermal Modelling (*)
Annex 22: Energy Efficient Communities (*)
Annex 23: Multi Zone Air Flow Modelling (COMIS) (*)
Annex 24: Heat, Air and Moisture Transfer in Envelopes (*)
Annex 25: Real time HVAC Simulation (*)
Annex 26: Energy Efficient Ventilation of Large Enclosures (*)
Annex 27: Evaluation and Demonstration of Domestic Ventilation Systems (*)
Annex 28: Low Energy Cooling Systems (*)
Annex 29: ☼ Daylight in Buildings (*)
Annex 30: Bringing Simulation to Application (*)
Annex 31: Energy-Related Environmental Impact of Buildings (*)
Annex 32: Integral Building Envelope Performance Assessment (*)
Annex 33: Advanced Local Energy Planning (*)
Annex 34: Computer-Aided Evaluation of HVAC System Performance (*)
Annex 35: Design of Energy Efficient Hybrid Ventilation (HYBVENT) (*)
Annex 36: Retrofitting of Educational Buildings (*)
Annex 37: Low Exergy Systems for Heating and Cooling of Buildings (LowEx) (*)
Annex 38: ☼ Solar Sustainable Housing (*)
Annex 39: High Performance Insulation Systems (*)
Annex 40: Building Commissioning to Improve Energy Performance (*)
Annex 41: Whole Building Heat, Air and Moisture Response (MOIST-ENG) (*)
Annex 42: The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems (FC+COGEN-SIM) (*)
Annex 43: ☼ Testing and Validation of Building Energy Simulation Tools (*)
Annex 44: Integrating Environmentally Responsive Elements in Buildings (*)
Annex 45: Energy Efficient Electric Lighting for Buildings (*)
Annex 46: Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo) (*)
Annex 47: Cost-Effective Commissioning for Existing and Low Energy Buildings (*)
Annex 48: Heat Pumping and Reversible Air Conditioning (*)
Annex 49: Low Exergy Systems for High Performance Buildings and Communities (*)
Annex 50: Prefabricated Systems for Low Energy Renovation of Residential Buildings (*)
Annex 51: Energy Efficient Communities (*)
Annex 52: ☼ Towards Net Zero Energy Solar Buildings (*)
Annex 53: Total Energy Use in Buildings: Analysis and Evaluation Methods (*)
Annex 54: Integration of Micro-Generation and Related Energy Technologies in Buildings (*)

Annex 55: Reliability of Energy Efficient Building Retrofitting - Probability Assessment of Performance and Cost (RAP-RETRO) (*)
Annex 56: Cost Effective Energy and CO2 Emissions Optimization in Building Renovation (*)
Annex 57: Evaluation of Embodied Energy and CO2 Equivalent Emissions for Building Construction (*)
Annex 58: Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements (*)
Annex 59: High Temperature Cooling and Low Temperature Heating in Buildings (*)
Annex 60: New Generation Computational Tools for Building and Community Energy Systems (*)
Annex 61: Business and Technical Concepts for Deep Energy Retrofit of Public Buildings (*)
Annex 62: Ventilative Cooling (*)
Annex 63: Implementation of Energy Strategies in Communities (*)
Annex 64: LowEx Communities - Optimised Performance of Energy Supply Systems with Exergy Principles (*)
Annex 65: Long-Term Performance of Super-Insulating Materials in Building Components and Systems (*)
Annex 66: Definition and Simulation of Occupant Behavior in Buildings (*)
Annex 67: Energy Flexible Buildings (*)
Annex 68: Indoor Air Quality Design and Control in Low Energy Residential Buildings (*)
Annex 69: Strategy and Practice of Adaptive Thermal Comfort in Low Energy Buildings (*)
Annex 70: Energy Epidemiology: Analysis of Real Building Energy Use at Scale (*)
Annex 71: Building Energy Performance Assessment Based on In-situ Measurements (*)
Annex 72: Assessing Life Cycle Related Environmental Impacts Caused by Buildings (*)
Annex 73: Towards Net Zero Energy Resilient Public Communities (*)
Annex 74: Competition and Living Lab Platform (*)
Annex 75: Cost-effective Building Renovation at District Level Combining Energy Efficiency and Renewables (*)
Annex 76: ☼ Deep Renovation of Historic Buildings Towards Lowest Possible Energy Demand and CO_2 Emissions (*)
Annex 77: ☼ Integrated Solutions for Daylight and Electric Lighting (*)
Annex 78: Supplementing Ventilation with Gas-phase Air Cleaning, Implementation and Energy Implications
Annex 79: Occupant-Centric Building Design and Operation
Annex 80: Resilient Cooling
Annex 81: Data-Driven Smart Buildings
Annex 82: Energy Flexible Buildings Towards Resilient Low Carbon Energy Systems
Annex 83: Positive Energy Districts
Annex 84: Demand Management of Buildings in Thermal Networks
Annex 85: Indirect Evaporative Cooling
Annex 86: Energy Efficient Indoor Air Quality Management in Residential Buildings
Annex 87: Energy and Indoor Environmental Quality Performance of Personalised Environmental Control Systems
Annex 88: Evaluation and Demonstration of Actual Energy Efficiency of Heat Pump Systems in Buildings
Annex 89: Ways to Implement Net-zero Whole Life Carbon Buildings
Annex 90: ☼ Low Carbon, High Comfort Integrated Lighting
Annex 91: Open BIM for Energy Efficient Buildings

Working Group - Energy Efficiency in Educational Buildings (*)
Working Group - Indicators of Energy Efficiency in Cold Climate Buildings (*)
Working Group - Annex 36 Extension: The Energy Concept Adviser (*)
Working Group - HVAC Energy Calculation Methodologies for Non-residential Buildings (*)
Working Group - Cities and Communities (*)
Working Group - Building Energy Codes

Acknowledgements

It has been stressed that building energy codes currently provide the most effective way to push construction and renovations of more energy efficient buildings. This is partly because many experts, businesses and stakeholders are engaged in decision making during the building lifecycle and they need rules and guidance to help them as professionals and building owners. The contents of national building energy codes are not simple and need deep expertise to be understood. This questionnaire survey and analysis was possible through the support of the national respondents listed in the Appendix 1, who are knowledgeable on building energy codes. The author expresses his deep gratitude to those respondents. He also appreciates the guidance by Ms. Meredydd Evans, the Operating Agent of IEA EBC Working Group on Building Energy Codes and supports by Mr. Siddarth Durga.

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Acronyms

ANSI American National Standards Institute
ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers
BEC-WG Building Energy Codes Working Group
CIBSE Chartered Institution of Building Services Engineers
COP Coefficient of Performance
DOE Department of Energy
EBC TCP Energy in Buildings and Communities Technology Collaborattion Program
EN Euronorm, European Standards
EPBD Energy Performance of Buildings Directive
HVAC Heating, Ventilation and Air Conditioning
ICC International Code Council
IEA International Energy Agency
IEA BESTEST International Energy Agency Building Energy Simulation Test and Diagnostic Method
IPMVP International Performance Measurement and Verification Protocol
ISO International Standard Organization
UNI Unificazione Italiano, Italian Standardization Body
WTO World Trade Organization

Executive Summary

The primary objective of this survey is to learn about experiences around the world on how to deal with new technologies in building energy codes.

The building energy codes are defined as public rules on how energy efficiency and performance of buildings and/or their components shall be evaluated in order to promote buildings with higher efficiency. The rules are called differently in country to country such as codes, laws, standards or regulations. In some countries, the rule may not be a national law, but it could be used for policies to promote buildings with higher energy efficiency. In this report, all relevant rules mentioned above are considered building energy codes.

The issue of inclusion of new technologies in building energy codes has been prioritized in the Building Energy Codes Working Group (BEC-WG) of the Energy in Buildings and Communities Technology Collaboration Program (EBC TCP) of the International Energy Agency (IEA). Here, 'new technologies' are defined as technologies that are new to building energy codes. If there is a technology, which has already been used in buildings but has not yet been evaluated in building energy codes, the technology is considered a new technology in this report.

This survey was carried out using questionnaires and analyses of documents on national building energy codes and processes examing how new technologies are integrated in the codes.. It should be noted that after the questionnaires were received, follow-up questions for clarification were sent to some of the respondents.

Conclusions of this survey and problems to be tackled in the near future are summarized as follows.

1. In this survey, in addition to direct replies to questions from national respondents, the official documentsdescribing the building energy codes and the processes for new technologies have been introduced by the respondents and referred to in the analyses for this survey. This is indicative that not only possibly subjective information provided by respondents was used, but also the descriptions in the documents are the basis for the analyses.
2. The processes to deal with new technologies in building energy codes vary country to country to some extent, but there seems to be common recognition among respondents or experts engaged in building energy codes. They also seem to share common problems when new technologies are to be integrated into the building energy codes by using their characteristics as performance-based codes. As most of the existing building energy codes have basic structures as performance-based codes not with fixed requirements for specifications of components, some applicants of new technologies may misunderstand that their new technologies can be easily integrated into the building energy codes. However, in reality, the process for the integration needs significant effort such as for developing testing standards and new energy calculation methods for the new technologies.
3. New technologies could be recognized differently between homogeneous materials/single-products and new technologies at the system level, which consist of different components that are computer controlled (i.e., CO_2 demend control ventilation, natural cooling by ventilation, etc.). For the former

new technologies (materials/single-products), development of testing procedures can be done by referring to existing testing standards for similar materials/single-products with similar functions. For the latter new technologies at the system level, clear definitions of control algorithms and requirements of components characteristics have to be clarified, and new energy calculation methods have to be developed and validated. This kind of validation for new technologies cannot be done by using existing standards or guidlines for the validation of simulation programs, and the developers of the new technologies need to carry out experiment or field measurement to obtain data for the validation.

4. Liability for public organizations to maintain building energy codes reliable and scientifically sound has been clearly recognized among participating countries to this survey, and the protection of consumers (building owners, tenants, etc.) has become an important role through building energy codes.
5. The energy simulation programs are being used for performance-based building energy codes in many countries. The lack of bases for validating the energy simulation programs has been highlighted especially for new technologies. In the R&D projects for the new technologies, it is critical to include the development of energy calculation programs and necessary data to validate the programs, because existing standards and other documents for validation naturally cover only some of existing technologies and basic structures of the simulation programs.
6. In current R&D projects, awareness of the process through which the new technologies shift from products of R&D projects to integration in building energy codes is frequently lost. The characteristics and philosophy of the building energy codes are rarely shared by the developers of new technologies. This may be a reason why it takes time and additional resources to make the new technologies integrated in building energy codes.

1. Introduction

Building energy code, standard and regulation (hereafter, ‘building energy code’) is the most effective tool for governments to promote buildings of higher energy efficiency toward decarbonized society in 2050 (Ref. 1). The building energy codes are huge systems of knowledge on building and energy system technologies, and they may be expected to cover most practical energy-saving technologies. However, although the building energy codes have been revised constantly in most countries and areas, it has not been easy to change substantially their structure, because they must maintain existing capabilities to cover key technologies for energy-saving and usability/convenience for applicants and examiners.

On the other hand, there is a need to make it possible to cover new technologies in building energy codes. For that purpose, there is a need to fully utilize performance-based rules for the new technologies.

This survey has been done in IEA EBC TCP’s Building Energy Codes Working Group (Ref. 2) to share the information on the current situation in participating countries on how they deal with new technologies in their building energy codes.

The results show participating countries face similar requests from industries and academic societies and have pathways for the new technologies to be integrated in building energy codes, while they try to maintain reliability and scientific soundness of evaluation methods for the building energy codes.

Energy simulation programs are promising as methods to integrate new technologies and are used with trials to request validation of the programs to be used. However, when new technologies are evaluated by energy simulation programs, the logic, and data for its validation specific to the new technologies is indispensable since such data for validation could not be found in any existing standard and documents. It is highly recommendable for R&D projects, which intend to develop new technologies, to include the development of the logic for energy calculation and data for its validation so that the new technologies will be more smoothly integrated into building energy codes.

This survey was supported by experts from fourteen countries (Australia, Belgium, Brazil, Canada, China, Spain, France, India, Italy, Japan, New Zealand, Portugal, Singapore and United States of America) as respondents to the questionnaires.

Analysis is included in Chapters 4, 5 and 6, and raw data (replies from participating countries) is included in Appendix 1.

2. Study Objectives

The building energy codes are defined as public rules on how energy efficiency and performance of buildings and/or their components shall be evaluated in order to promote buildings with higher efficiency. The rules are called differently in country to country such as codes, laws, standards or regulations. In some countries, the rule may not be positioned as a national law, but is used for policies to promote buildings with higher energy efficiency. In this report, all relevant rules mentioned above are called as building energy codes.

In the Building Energy Codes Working Group (BEC-WG) of Energy in Buildings and Communities Technological Collaboration Program (EBC TCP) in International Energy Agency (IEA) has identified the issue of new technologies for building energy codes as a priority.

Here, ‘new technologies’ are defined as technologies, which are new to building energy codes. If there is a technology, which has already been used in buildings but has not yet been evaluated in building energy codes, the technology is considered a new technology in this report.

Although newly developed advanced technologies may capture more attention especially in industries and academic societies, there seems almost no difference between existing technologies and such newly developed technologies when the ways how they should be dealt with in building energy codes are studied.

There is a distinction between prescriptive and performance-based building energy codes, but most or all respondents from participating countries reported that the performance-based rules for evaluation have been included in their building-energy-code systems. The performance-based rules are useful when comparing different combinations of adopted technologies for trade-off, and they are also expected to be helpful when evaluating the performance of new technologies.

The primary objective of this survey is to learn from experiences in different countries on how to deal with new technologies in building energy codes.

3. Methodology

This survey was carried out using questionnaires and analyses of documents on national building energy codes and processes on how to integrate new technologies, which were introduced by respondents in the questionnaires. After the first questionnaires, follow-up questions for clarification were sent to some of respondents.

The following questions formed part of the questionnaire sent to the participants:

Q1. Does your country/jurisdiction have a process or a national/local system to approve the integration of new technologies in building energy codes?

The following questions Q2 to Q7 were asked only to respondents, who answered "Yes" to Q1.

Q2. Could you describe the institutional framework (social systems) dedicated to the approval process of new technology integration into building energy codes?

Q3. Could you provide links for any documents related to the approval process/system or the institution framework addressed in Q1 and Q2?

Q4. Could you describe any barriers associated with integrating new technologies in building energy codes in your country/jurisdiction?

Q5. Before a new technology is incorporated into the building energy code, are testing standard(s) for the new technology taken into consideration in the approval process/system?

Q6. What building energy simulation software or other methods are available to assess the energy or emissions reduction resulting from new technologies integrated into the building energy codes?

Q7. Are there any procedures and processes in place to validate the energy simulation software for new technologies in building energy codes?

The following questions Q8 and Q9 were asked only to respondents, who answered "No" to Q1.

Q8. Could you describe any barriers associated with integrating new technologies in building energy codes?

Q9. Does your country/jurisdiction have plans to produce a process/system to approve the integration of new technologies in building energy codes? If yes, please elaborate and provide links to any sources if available.

Appendix 1 includes all the raw responses to Q1 to Q9, as well as responses to follow-up questions.

4. Key Findings

4.1 Overview of building energy codes or regulations in respondents' countries

The following is an overview of the frameworks of building energy codes in participating countries. The following background information may be useful for readers of this report when they try to understand the characteristics of nations' system to integrate new technologies in building energy code. The information is based on answers to the questionnaires and on documents, of which URLs were provided by respondents (see Q3 Section of Appendix 1).

4.1.1 Australia

The National Construction Code (NCC) is updated every 3 years, although proposals to change the NCC can be submitted by anyone at any time.

Australian Building Codes Board (ABCB) is the standards writing body responsible for making the changes, including both technical changes and changes that implement government policy. ABCB is an initiative of Commonwealth, State and Territory governments.

The NCC is a national standard that is given legal effect when state and territory governments adopt it into their building legislation as per local policy requirements and timing.

Proposed updates to the NCC are subject to technical review (Building Codes Committee, Plumbing Codes Committee, both comprising industry and jurisdictional representatives), Regulatory Impact Analysis, public consultation, and approval by the Board and consideration by Commonwealth, State and Territory Building Ministers.

ABCB also collaborates with Standards Australia regarding the update of Standards referenced by the Code.

4.1.2 Belgium

The regulation 'energy performance and indoor climate of buildings' in the Flemish Region of Belgium (Flanders), allows an alternative calculation method instead of the regulatory standard calculation method, in case an 'innovative' product, system or building concept cannot be assessed using the regulatory method. For this purpose, the applicant (product or system manufacturer, or builder) needs to submit an application for equivalence with the Flemish Energy and Climate Agency (VEKA). If approved, the alternative calculation method will then receive an equivalence decision. That decision determines that the innovative system or building achieves equivalent performance as the established systems and concepts. It allows certain corrections to input values so that the regulatory calculation method can estimate the performance of the system or concept correctly. When there is more experience with the innovative system, or when it has become a more established technology on the market, the regulatory calculation method may be updated based on the alternative calculation method, to allow direct assessment of the innovative system. After integration, it is no longer possible to request equivalence for that system or product. This was for instance the case with demand controlled ventilation systems for which equivalence decisions were issued in between 2010 and 2015. Later a calculation method for the demand controlled ventilation was included in the regulatory method.

4.1.3 Brazil

When a building component or system for housing is not covered by a standard, they pass through tests established by the government in the SINAT at PBQP-H.

There is a possibility for building components and systems, which are not covered by a standard, to be evaluated through the tests in the SINAT at PBQP-H, which has been established by the government. However, the SINAT system is mainly to evaluate new building construction systems, especially envelope part, and if the construction system has a better thermal performance, it will be reported in the SINAT. Steel frame construction systems, which may be considered as new technologies, have been evaluated by using the SINAT.

4.1.4 Canada

The National Energy Code of Canada for Buildings 2020 (NECB) has been developed as the latest version by the Canadian Commission on Building and Fire Codes. It is an objective-based national model code that can be adopted by provincial and territorial governments, which have the authority to enact legislation that regulates building design and construction within their jurisdictions.

The code comprises three Divisions: Division A, which defines the scope of the Code and contains the objective, the functional statements and the conditions necessary to achieve compliance; Division B, which contains acceptable solutions deemed to satisfy the objective and functional statements listed in Division A; and Division C, which contains administrative provisions.

Division B contains requirements for minimum energy efficiencies and specifications for components of buildings (prescriptive requirements) as well as Building Energy Performance Compliance Path (Part 8), which prescribes requirements for annual energy consumption calculation.

The compliance with the NECB shall be achieved by complying with the acceptable solutions in Division B or by using alternative solutions that will achieve at least the minimum level of performance required by Division B. To do something different from the acceptable solutions described in Division B, a proponent must show that their proposed alternative solution will perform at least as well as the acceptable solutions it is replacing.

4.1.5 China

The Ministry of Science and Technology and the Ministry of Housing and Urban-Rural Development are usually responsible for the integration of new technologies into building energy codes. The Ministry of Science and Technology will set up different building scientific research projects every year, among which the most common goal is to develop new technologies and incorporate them into building energy codes. In this process, new technologies need to pass expert review and professional testing for several times before they can pass the assessment.

The Ministry of Housing and Urban-Rural Development regularly sets up a compilation or revision group for building energy codes in a specific field. Members of the compilation group are required to evaluate the feasibility of the promotion and application of existing new technologies, and integrate the technologies that can be promoted into building energy codes by evaluating the technology maturity, economy and use effect. When the text of building energy code is formed, it will be submitted to the Department of Standard Quota of the Ministry of Housing and Urban-Rural Development for review. After the review, the Ministry of Housing and Urban-Rural Development will solicit opinions from the whole society to confirm the feasibility of implementation in the whole society. Finally, the new technology can be formally implemented as part of the building energy code after it has been reviewed by the research project, reviewed by the Ministry of Housing and approved by the whole society.

In China, the building energy code are divided into mandatory and guiding standards. The mandatory energy codes specify the technical parameters of buildings, and design drawing inspectors verify whether the buildings meet the prescribed parameters, which all buildings are required to meet. The guiding standard is a performance-based index, and the building can voluntarily choose whether to apply for a higher level of building. For example, in the "Technical Standard for Nearly Zero Energy Buildings" GB/T 51350-2019, the building can be certified as a near-zero energy consumption building only if it achieves a certain energy saving rate, so the energy usage needs to be calculated

Expert reviews and professional testing were conducted after new technology is developed by the project. After having confirmed that new technologies have been tested, the group for building energy codes conducts simulation studies to assess their energy savings contribution before incorporating them into the codes.

During the "13th Five-Year Plan" period, China has carried out a lot of research in building energy conservation, renewable energy application and other aspects. At present, the integrated technology of building photovoltaic, photothermal utilization technology and ground source heat pump technology has become more and more mature. In the newly released General Code for Building Energy Efficiency and Renewable Energy application GB55015, it is clearly stipulated that all new buildings must have the renewable energy systems.

4.1.6 Spain

Integration of new tecnologies can happen because of new building codes or because of an economical drive for owners and users. New Building codes are adopted because there is a need to transpose new European Directives to Spain. The spanish government prepares and issues a draft document to be rewiewed by different civil organisations such as Builders Associations, professional associations such architects, engineers, planners, local administrations, equipment manufacturers and distributors. The government takes the comments into account or not and issues the final law or code. Lately only charging devices for e-cars have been adopted. Also domestic hot water systems with heat pumps can be prepared and considered as ecological or clean.

Not all energy certificates based on projects are being reviewed by the Spanish administration. Furthermore only 1/1000 of new completed buildings are being physically inspected. This seems to be the common way in most European Union countries.

4.1.7 France

There is a group of experts who read and comment the proposal made by industries, to be sure that the proposal is consistent with the energy code. The industries can propose either a model for a single operation (i.e., for one building) or a model for the system to be completely introduced into the code (i.e., for any buildings).

There is a procedure called "Title V", by which the energy performance of construction products or innovative energy systems not explicitly dealt with in relevant regulations (the 2012 thermal regulation (RT2012)) can be evaluated.

RT2012 includes three performance requirements, which are 1) envelope performance such as thermal insulation, solar heat gain, etc., 2) primary energy consumption, and 3) comfort in summer in non-air-conditioned buildings. The requirement of maximum primary energy consumption covers the consumption of heating, cooling, lighting, domestic hot water and auxiliaries (pumps and fans). There is the calculation method of the primary energy consumption, which is called "Th-B-C-E".

In the specific case where an energy product or system is not included in the Th-B-C-E calculation method, RT2012 offers the possibility of taking it into account. Articles 49 and 50 of the Order of 26 October 2010 and Annex V set out the procedure dealing with the specific cases. Applications submit in accordance with this procedure is referred as Title V system. The applicants have to provide calculation models and necessary data. Approvals for applications for Title V system are issued through an order of the Minister in charge of construction, and published in the official journal.

According to the list of Title V system, since March 2012 and until December 2022, there have been 65 approved applications.

4.1.8 India

Technical members of Committees constituted by Bureau of Indian Standards (BIS) and/or Bureau of Energy Efficiency proposes the amendments. The proposals also get circulated for wider circulation beyond technical committees. This happens over emails. The email list consists of academicians, industry experts, researchers and administrators.

4.1.9 Italy

All the requirements included in Italian Building Energy Codes are based on the European directives EPBD (Energy Performance Buildings Directive), EED (Energy Efficiency Directive) and RED (Renewable Energy Directive). Criteria and methodologies for the calculation of energy performance of buildings, including the use of renewable sources, are presctribed by the Italian Ministerial Decree of 26 June 2015. The calculation tools and commercial software shall guarantee that the values of the energy performance indices have a maximum deviation of more or less 5 percent compared to the corresponding parameters determined with the application of the national reference tool, which the CTI (the Italian Standardization Body) prepares.

4.1.10 Japan

The ministry in charge of the Japanese building energy code (Ministry of Land, Infrastructure, Transportation and Tourism, MLIT) commissions an organization to run "Contact Point", through which requests for new technologies can be conveyed to the ministry and the technical committee, which was mandated by the Ministry to develop calculation procedures for residential and non-residential buildings, and is still mandated to check feasibility of proposals on new technologies and to develop additional calculation procedures for mainly existing but not yet evaluated energy-saving technologies. It is frequently observed that applications of new technologies to be integrated in the building energy code do not come with concrete proposals on how they should be modelled for energy calculation and with data, which can be used for the validation of the models.

4.1.11 New Zealand

The Building Act 2004 sets out the rules for the construction, alteration, demolition and maintenance of new and existing buildings in New Zealand. The Building Act 2004 requires all building works to comply with the Building Code. The Building Code is contained in Schedule 1 of the Building Regulations 1992. The Building Code sets performance standards for all New Zealand building work. This includes requirements for the energy efficiency of buildings. The Ministry of Business, Innovation and Employment (MBIE) is New Zealand's building regulator and also issues documents called acceptable solution or verification method for use in establishing compliance with the Building Code. These documents describe compliance methods and requirements that New Zealand's building consent authorities must accept as complying with the Building Code. MBIE regularly reviews and updates acceptable solutions and verification methods, following the procedural requirements set out in section 29 of the Building Act.

4.1.12 Portugal

Usually, a working group is set by Government including Directorate General for Energy and Geology (DGEG), and Energy Agency among others like universities and National Laboratories. A report will be delivered for future approval by Political entities.

Portuguese definition of new technologies is the technologies that were not included in former Portuguese regulations, but has been included in current regulations. The working group is not set in response to any specific request from industries, but is set for the revision of Portuguese regulations for energy performance of buildings.

For example, a certain ordinance was issued on 1 July 2021, and requirements for building envelope, technical systems for ventilation, hot water production and fixed lighting, and electricity production systems were updated. This ordinance also defined the requirements for Building Automation and Control Systems (BACS). Those updates were based on the report, which was prepared by the working group and was approved by political entities.

4.1.13 Singapore

To advance sustainable development, the Building Control (Environmental Sustainability) Regulations requires a minimum environmental sustainability standard for new buildings and existing buildings that undergo major retrofitting. All new buildings and additions/extensions that involve increasing the gloss floor area of 5,000 m^2 are applied the Code for Environmental Sustainability of Buildings Edition 4.0 in 2021. The code includes prescriptive requirements for building envelope and components of building services for energy efficiency, as well as prescriptive requirements for other aspects of sustainability than energy efficiency.

4.1.14 United States of America

The International Codes (I-Codes) are updated every three years and developed through a consensus-based process, bringing together expertise from the public and private sector to capture the latest science and technology. The process used to develop the I-Codes is aligned with the six Principles for the Development of International Standards, Guides and Recommendations agreed upon by the World Trade Organization (WTO) Technical Barriers to Trade Committee. The International Energy Conservation Code (IECC), recognized as the model energy code for new residential construction in the U.S., is developed through the International Code Council's standards development consensus procedures. The IECC is developed by the combined efforts of a Residential Energy Code Consensus Committee and a Commercial Energy Code Consensus Committee that are appointed consistent with International Code Council Consensus Policy-12 and Consensus Policy-7 and the Code Council's Consensus Procedures. Requirements contained in the code include both prescriptive and performance-based pathways, which allow for flexibility in the use of technologies that comply with the code. The energy code is updated on a three-year cycle with each subsequent edition providing increased energy savings over the prior edition.

The IECC is intended to provide flexibility to permit the use of innovative approaches and techniques. New products and technologies are evaluated by accredited conformity assessment providers to ensure adherence to performance requirements contained in building codes and provide assurance around other important attributes including structural, mechanical, chemical, and other properties. Product evaluations examining these performance attributes help assure that newly formulated products do not compromise safety and verify that new and innovative building products comply with code requirements. Products may also be evaluated through environmental product declarations (EPDs) to understand the environmental attributes of products. Thus, products and technologies become recognized for their code compliance and safety and may be integrated into construction projects to meet energy code requirements.

According to the reference of the six principles by WTO (Ref. 3) are 1) Transparency, 2) Openness (without discrimination with respect to the participation at the policy development level and at every stage of standards development), 3) Impartiality and consensus, 4) Effectiveness and relevance (whenever possible, international standards should be performance based rather than based on design or descriptive characteristics), 5) Coherence (international standardizing bodies avoid duplication of other the work of other international standardizing bodies), and 6) Development dimensions (Constrains on developing countries should be taken into consideration).

ICC-Evaluation Service (ES) is an accredited conformity assessment provider. It has published a lot of reports relating to foam plastic insulation (rigid boards and spray foam). It also has quite a few reports covering Structural Insulated Panels (SIPs) and Insulated Concrete Form (ICF) Wall Systems. It also has criteria developed for BIPV roof systems (AC365; Tesla had a couple of ESRs for their solar roof system at one point, but they are no longer active) and for Photovoltaic Mounting Systems (AC428; again, we don't have any active reports for this criteria).

4.1.15 EPBD (The Energy Performance of Buildings Directive) as a background of European building energy codes

Five European countries (**BE**, **ES**, **FR**, **IT** and **PT**) participated to this survey. As broadly noticed, as a background of European countries' building energy codes, there is a directive of the European Parliament on the energy performance of buildings. The energy performance of a building is defined as the calculated or measured amount of energy needed to meet the energy demand associated with a typical use of the building, which includes energy used for heating, cooling, ventilation, hot water and lighting. In the directive, it is stated that member countries shall apply a methodology for calculating the energy performance of buildings in accordance with the common general framework, which is partly prescribed by some ISO 52000 series (Ref. 4). It is also stated that member countries shall lay down the necessary measures to establish a system of certification of the energy performance of buildings to be shown to owners and tenants of the building, and member countries shall ensure that the energy performance certification is carried out in an independent manner by qualified and/or accredited experts.

4.2 Existence of any system to integrate new technologies in building energy codes

Among fourteen countries responding questionnaires, twelve answered they have systems to integrate new technologies in building energy codes. However, all of those countries have strict rules and systems to deal with proposed new technologies. That is a reason why it takes time and cost to make new technologies integrated in building energy codes.

On the other hand, two countries answered they do not allow new technologies to be integrated, except for when the countries revise evaluation methods used for building energy codes or any other policies. Those two countries clearly explain why they have strict rules to integrate new technologies.

4.2.1 Barriers when new technologies are to be integrated in building energy codes

From the twelve countries having systems to integrate new technologies, the following difficulties were identified.

- The current codes and standards are not 'technology agnostic', and new technologies do not get a 'level playing field' for their performance. These statements seem to mean that building energy codes are prescribed taking characteristics of mainly already-evaluated technologies for energy saving into consideration and that building energy codes do not easily incorporate unevaluated new technologies.
- It takes time to test and to integrate new technologies. Because it is necessary to protect consumers, the process has to be cautious and slow. The model (i.e., evaluation tool to check the consistency with the building energy code), which is proposed by the developer, sometimes does not reflect the actual operation of the system, and the cost to check the model and to make corrections is quite high and is not affordable for any industries.
- In the United States (US), there is different processes and levels of building energy code adoption across states and local governments. This heterogeneity and imbalance in building energy regulations

can hinder the integration of new technologies. Another major barrier is created because the level of technical and resource capacities is not equivalent in different jurisdictions.

- In New Zealand (NZ), the code is performance-based and therefore ‘technology agnostic’, but when building consent applicants like to get approval for their new technologies, many of them rely on two methods (‘acceptable solutions’ or ‘verification methods’) provided by the government. The acceptable solutions in particular are prescriptive, and it is not always possible to updates these documents in a timely manner so that new technologies can be integrated and encouraged.

4.2.2 Needs for testing standards and other standards when evaluating new technologies

- In many countries, testing standards for new technologies would be the issue, which is considered by authorities.
- In China (CN), before the mass production of new technologies, strict performance tests are carried out not only as the pre-production performance tests but also as the tests in real buildings installed with the new technologies. In Italy (IT), the energy calculation and certification is made on the basis of laboratory tests of components, while new technologies (more ambitious technologies) not yet integrated (evaluated) for the certification are prometed to be adopted in renovated buidlings by Italian incentive schemes for building renovation and the tests for the new technologies can be done in the incentivize renovated buildings. The results from the tests can be utilized when the new technologies are to be integrated in the Italian certification system. In the responses from CN and IT, they assumed new technologies not like new single product nor material but like a new system consisted of various components, of which behaviors are controlled as a system (e.g., new HVAC system, new façade system like double skin, natural ventilation system, etc.)
- In Japan (JP), the lack of necessary standards that define the new technologies poses difficulties. Capacities of components and their control method must have impacts on the technologies’ energy efficiency, but the prescription of the components and control method sometimes is not provided. The lack of testing standards for key components included in the new technologies also makes their energy efficiency unstable and unreliable.
- In the response from the US, Evaluation Service by International Code Council is introduced. New products or materials, which have not been addressed by the code, can be evaluated by Acceptance Criteria (AC) to be prepared by ‘accredited conformity assessment provider’. As an example of the AC, AC for spray-applied foam plastic insulation was introduced to the survey team of this WG. It seems that the AC plays a role like product standards (including testing methods) of ANSI, ISO, EN, etc. However, in this survey, new technologies focused on may not be just one new homogeneous product or material, but a system composed of various parts and provided with its control, such as parts of HVAC systems and double skin façade systems.

4.2.3 Reasons why Canada (CA) and Singapore (SG) do not need procedures to integrate new technologies

- CA states that performance of new technologies is often not well understood. Even though testing and rating standards are requirements before the new technologies can be integrated in codes, they are often lacking. It is partly because the cost of standard development cannot be borne by the developers, before the new technologies obtain market uptake. But the new technologies cannot easily obtain the market uptake without being integrated in building energy codes. Builders and code officials are often skeptical that new technologies will achieve performance goals. Builders and code officials are often worried that new technologies will introduce unintended consequences, causing issues for occupants and liabilities for builders and code authorities. New technologies should be approved using the same process and committees that develop codes.

- SG states that while SG does not have building energy codes, SG has a process to involve fire safety regulators to address the safety concerns of innovative technologies. New technologies are also tested for performance in Building and Construction Authority (BCA)'s testing facility to gather performance data. The schemes to support the demonstration of the new technologies require IPMVP reports to validate the performance of the new technologies.

The IPMVP, which is mentioned by SG, stands for 'International Performance Measurement and Verification Protocol', which was published by EVO (Efficiency Valuation Organization) in 2018 (Ref. 5). Its principles are (a) Accurate, (b) Complete, (c) Conservative, (d) Consistent, (e) Relevant and (f) Transparent. The EVO was founded in 1994 by U.S. DOE and industry and is supported by seven organizations in North America and Europe. They say that the purpose of the IPMVP is to reduce barriers to the energy and water efficiency.

- US mentioned another set of principles, which World Trade Organization (WTO) published. Its six principles are (a) Transparency, (b) Openness, (c) Impartiality and Consensus, (d) Effectiveness and Relevance, (e) Coherence and (f) Development Dimension. They say that these six principles should be observed when international standards, guides and recommendations are elaborated.

4.2.4 Energy simulation programs used in the evaluation of new technologies

- In AU, for commercial buildings and common areas of a category of apartment buildings, energy simulation software can be used for compliance checking through 'Verification methods' or another type of method to demonstrate compliance. The National Construction Code Serie (NCC) does not specify any software tools, but sets out modelling requirements. For residential buildings (houses and apartment units), simulation-based approaches can be used for demonstrating compliance with energy efficiency requirements. The simulation-based approaches include a) House Energy Rating Software accredited under the National House Energy Rating Scheme (NatHERS), and b) Verification Using a Reference Building, of which calculation method must be validated with ANSI/ASHRAE Standard 140.
- In NZ, the Verification Methods are compliance pathways that are based on building energy modellings, which need to be compliant to ANSI/ASHRAE 140 Standard and/or IEA BESTEST.
- In CN, Dest and IBE software independently developed by a Chinese research team can be used to simulate energy consumption and to evaluate the effect of different new technologies, using hourly and monthly mean simulation methods, respectively.
- In FR and JP, the simulation programs developed for the codes themselves can be used for code compliance.
- In JP, another program can be used for the building energy standard (code), but the comparison of results by the two programs had been strictly checked and corrections had been made for the second program. The full documentation of the algorisms of the second program had been requested for

transparency, so that any stakeholders and experts can check scientific correctness and unbiasedness of the energy simulation programs. The full documentation for transparency is expected to be the ground for future technological development for both programs.

- In US, COMcheck and REScheck softwares areused for free to check compliance covering trade-offs and prescriptive requirements (Ref. 6). In addition, when DOE carries out its duty to compare the improvement of energy efficiency between the previous and the latest editions of model energy codes, the analysis is based on an established DOE Methodology, which can evaluate new products and technologies. To show building energy code compliance, there is the third option, which is called 'Energy Cost Budget Method' in addition to prescriptive option and trade-off option by COMcheck and REScheck. In the Energy Cost Budget Method, new technologies can be evaluated by using EnergyPlus or other DOE energy modelling tools.
- ANSI/ASHREA Standard 140 'Standard method of Test for the Evaluation of Building Energy Analysis Computer Programs' is mentioned by plural national respondents as a tool to validate energy simulation programs. CIBSE TM33 'Tests for software accreditation and verification' (2006) and CIBSE AM11 'Building performance modelling' (2015) are also mentioned as tools of the same purpose. However, portions of buildings focused for verification by those documents are still very much limited, and it can be said those valuable documents and works are used as filters to screen simulation programs, which should not be used for building energy codes. It means that there are still various portions of buildings and variety of energy aspects of buildings, which need data for their validation and verification of energy simulation programs. It should be also pointed out that common and existing technologies have been especially focused in those technical documents, but unknow new technologies have not been considered enough. It was expected that energy simulation programs could be useful to evaluate new technologies, which have not been evaluated by more ordinary evaluation methods for building energy codes such as prescriptive specification-based methods, but existing documents for validating simulation programs do not contain any validation methods nor data for the new technologies.

5. Discussion

5.1. Understanding of 'new technologies' varied among respondents

It seems that respondents to this survey may have assumed two different kinds of new technologies:

1) New technologies of component or material level

In fire protection codes and standards, new building materials have been tested for incombustibility. In the same way, thermal conductivity, solar heat gain coefficient and other characteristic values of materials and components are evaluated by a pathway for new technologies under building energy codes. This kind of new technologies for component or material level does not need a fundamental change of logic for evaluation in building energy codes.

2) New technologies of system level which combine different components and a control system and device

Another type of new technology is new systems of facades or energy systems in buildings, which are not single components nor materials but consist of different components with different sub-functions. The different components are usually controlled by computers and software. For example, outdoor air intake volume control systems with CO_2 concentration consist of components such as fan(s), motor dumper(s), airflow measurement device(s) and CO_2 sensor with a computer system to control the components. This outdoor air control system is a conventional energy-saving technology rather than a newly developed advanced technology, but it is not so easy for building energy codes to be able to evaluate (integrate) this technology that some country is trying to develop an evaluation technique for its building energy code. First, a requirement for this technology, which can surely contribute to energy saving, shall be clarified. Second, a method to evaluate a reduction of energy consumption shall be developed. In the method, a design outdoor air intake volume and assumed occupancy density for the targeted building probably need to be taken into consideration. This kind of new technologies for system level may require a fundamental change of logics for evaluation in building energy codes.

5.2 New technologies for system level which are expected to have higher energy efficiency

In order to reach the international and national targets in 2030 or 2050 towards zero carbon emissions from the buildings sector, the combinations of already evaluated technologies by building energy codes may be enough. In other words,taking decarbonization of electricity by renewables and replacement of fossil fuels with hydrogen-based fuels into consideration, necessary reduction of energy consumption in buildings such as by 40 to 50% seems to be feasible by fully deploying already practical and cost-effective energy technologies. If so, why are new technologies as other options needed to be developed and to be integrated into building energy codes?

One reason may be that any new technology, which is much more cost-effective, practical and has a larger potential to reduce energy consumption, should be developed in order that building owners and designers can find solutions more easily and cost-effectively. Another reason may be that it is indispensable, for a particular industry competing with another industry providing a common service to buildings, to develop more energy efficient technologies and products in order to survive against the competition. The integration of their new technology in building energy codes can be a matter of life and death for the industry. Not only for the industry, but also for governments, economic competitive capabilities of industries can be a part of preferential policies.

5.3 Prescriptive requirement and performance-based requirement

In prescriptive codes, for each building component, requirements are given as specifications. For example, thermal resistance of insulation material or heat transmission coefficients of walls, roofs and floors are prescribed. For equipment, minimum energy efficiencies of heat sources are prescribed, for example. However, energy consumption for space heating and cooling is influenced by both specifications of the building envelope and the equipment. Therefore, there is a need for flexibility on which component shall be more focused to be improved of its energy efficiency. Even among different equipment, the flexibility may be required such as between HVAC systems and lighting systems. This is an origin of the performance-based codes, which allow the flexibility for trade-offs among energy efficiencies of different components of buildings. Another origin of the performance-based codes is a demand for using new technologies, which have not yet been included among specifications nor evaluated according to indices in prescriptive codes. This demand may require much more substantial changes to the performance-based codes. For example, hourly energy calculation and more detailed assumptions on building use such as occupancy schedules may be indispensable. It seems to be one reason why integration of new technologies sometimes needs a large amount of time and resources, and why the integration cannot be accomplished only by developers of new technologies.

5.4 Performance-based codes and standards are commonly searched for in building energy codes

All respondents to the survey expressed directly or indirectly their concerns for a necessity to enhance performance-based building energy codes in order to make them truly ‘technology-agnostic’. There seems to be strong requests from industries and academic societies to accept a broader range of technological solutions for improving a total building energy efficiency. At the same time, even if the performance-based codes are searched for by making them technology agnostic as much as possible, the current structure of the codes in many countries do not allow easily to integrate new technologies due to a limitation for being technology-agnostics.

The problem is not only due to building energy codes. The applicants of new technologies are not necessarily familiar with the building energy codes and their evaluation methodologies. However, they need their technologies to be evaluated by the building energy coeds so that their technologies can be authorized publicly by public organizations like governments. Certifications by such public organizations may be indispensable for promoting the technologies in the market.

5.5 Evaluation of new technologies by using energy simulation models

The above-mentioned new technologies of system level tend to need energy simulation models to estimate energy consumption reduction, which depends on how a new technology is designed and installed taking design conditions into consideration. Usually, each building technology can vary with its design parameters when it is optimized for the building in which it is to be installed. Therefore, not only the development of hardware of the new technology but also the development of the logic on how to estimate energy consumption taking its design parameters and design conditions (e.g., climatic conditions, building use, shape, dimensions) into consideration is a critical process for the R&D project.

By using the logic and the simulation model, a design guide for the new technology can be prepared. The design parameters of the technology also have to be clearly defined sometimes with testing standards for key parameters of the technology. In addition, the background data, which proves the validity of relevant standards and the logic for energy calculation, has to be documented in a transparent manner. If these knowledge and tools for the new technology has been prepared though its R&D project, it can be easier for the new technology to be integrated in building energy codes.

As already stated in chapter 2 'objectives', new technologies are not necessarily newly developed advanced technologies. There are some important energy-saving technologies, which have not yet been evaluated in building energy codes. For such existing key technologies, it must be necessary to develop relevant standards to define more clearly the technologies and the logic for energy calculation.

5.6 Relationship between R&D projects of new technologies and building energy codes

The Working Group of Building Energy Codes has been launched in EBC TCP because building energy codes are the most dependable tool to promote buildings of higher energy efficiency, and the research outputs from the Working Group are expected to form the fundamental knowledge as a guidance for other R&D projects including Annexes in EBC TCP.

The EBC TCP's Annexes are developing mainly practical guidelines and design tools for targeted technologies. It is strongly recommended that the targeted technologies are to be integrated in building energy codes, and the outputs of this survey on new technologies for building energy codes could be contributing to the enhancement of Annexes' activities and research strategies. It is highly recommendable that the research plans of Annexes cover the development of relevant standards and the logic for estimating energy consumption by the technologies, so that the standards and logic can be utilized when the technologies are integrated in building energy codes.

6. Conclusions

Conclusions of this survey and problems to be tackled in the near future are summarized as follows.

General issue:

1. In this survey, in addition to direct replies to questions from national respondents, the official documents describing the building energy codes and the processes for new technologies (shared by the respondents) have also been referred. The basis for the analysis therefore inlcudes not only subjective information provided by respondents but also the information contained in the documents. Nowadays, different languages can be translated more easily than before, and future works for building energy codes could be more thorough than the past.

Common issues building energy codes have in the integration of new technologies:

2. The recognition that existing building energy codes are not fully technology agnostic to new technologies is identified by some country respondents. They are struggling to provide a level playing field for various energy-saving technologies. The processes to deal with new technologies in building energy codes vary depending on the country to some extent, but there seems to be an issue identified by respondents and experts engaged in building energy codes. They also seem to share common problems when new technologies will be integrated into the building energy codes by using their characteristics as performance-based codes. As most of the existing building energy codes have basic structures as performance-based codes not with fixed requirements for specifications of components, some applicants of new technologies may misunderstand that their new technologies can be easily integrated into the building energy codes. However, in reality, the process for the integration needs significant effort similar to that for developing testing standards and new energy calculation methods for the new technologies.
3. New technologies could be recognized differently between homogeneous materials/single-products and new technologies of system level, which consist of different components computer controlled (i.e., CO_2 demend control ventilation, natural cooling by ventilation, etc.). For the former new technologies (materials/single-products), development of testing procedures can be done by referring to existing testing standards for similar materials/single-products with similar functions. For the latter new technologies of system level, clear definitions of control algorithms and requirements of components characteristics have to be clarified, and new energy calculation methods have to be developed and validated. This kind of validation for new technologies cannot be done by using existing standards or guidlines for the validation of simulation programs, and the developers of the new technologies need to carry out experiment or field measurement to obtain data for the validation.
4. Liability for public organizations to maintain building energy codes reliable and scientifically sound has been clearly recognized among participating countries to this survey, and the protection of consumers (building owners, tenants, etc.) has become an important role through building energy codes.

R&D activities to produce new technologies and building energy codes:

5. The energy simulation programs are being used for performance-based building energy codes in many countries. The lack of basis for validating the energy simulation programs has been highlighted especially for new technologies. In the R&D projects for the new technologies, it is critical to include the development of energy calculation programs and necessary data to validate the programs, because existing standards and other documents for validation naturally cover only some of existing technologies and basic structures of the simulation programs.
6. In current R&D projects, awareness of the process through which the new technologies as the products from the R&D projects are integrated in building energy codes is frequently lost. The characteristics and philosophies of the building energy codes are rarely shared by the developers of new technologies. It may be a reason why it takes much time and additional resources to make the new technologies integrated in building energy codes.

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