# Appendix 1:

## Questionnaires and raw responses

### Description of the survey on new technologies in building energy codes

Within the Working Group on Building Energy Codes of IEA EBC TCP, fourteen nations participated in the questionnaires on new technologies in building energy codes. The first questionnaires including Q1 to Q9 were sent in December 2022, and follow-up questions to respondent nations were sent in February 2023. A response from Belgium was added in December 2023. This document summarizes the responses to the first questionnaires and to the follow-up questions.

### Introductory instruction to respondents

Around the world, codes are increasingly adopting innovative new technologies such as fuel cells, stationary batteries, heat pumps and smart meters, at a faster pace. In some countries and jurisdictions, this has meant a push towards whole building performance requirements instead of prescriptive requirements. For example, while some countries still have prescriptive requirements, the vast majority of stakeholders use building energy simulation to ensure that the overall building will meet the required energy targets. In jurisdictions where most users follow prescriptive or trade-off requirements, there is also evidence of technology innovation. In this questionnaire we aim to understand the processes and methodologies used to incorporate new technologies in performance and prescriptive-based building energy codes across BECWG member countries.

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

| Nation | Response |
|---|---|
| **AU** (Australia) | Yes |
| **BE** (Belgium) | Yes |
| **BR** (Brazil) | Yes |
| **CA** (Canada) | No |
| **CN** (China) | Yes |
| **ES** (Spain) | Yes |
| **FR** (France) | Yes |
| **IN** (India) | Yes |
| **IT** (Italy) | Yes |
| **JP** (Japan) | Yes |
| **NZ** (New Zealand) | Yes |
| **PT** (Portugal) | Yes |
| **SG** (Singapore) | No |
| **US** (United States of America) | Yes |
| | Yes: 12 / No: 2 |

For nations answered “Yes”, Q2, Q3, Q4, Q5, Q6 and Q7 are applicable.
For nations answered “No”, Q8 and Q9 are applicable.

**Q2.** Could you describe the institutional framework (social systems) dedicated to the approval process of new technology integration into building energy codes? (This question is applicable only when the response to Q1 is "Yes")

| Nation | Response |
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| **AU** | The National Construction Code (NCC) is updated every 3 years, although proposals to change the NCC can be submitted by anyone at any time.<br>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.<br>The NCC is given legal effect by reference from state and territory building legislation.<br>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.<br>ABCB also collaborates with Standards Australia regarding the update of Standards referenced by the Code. |
| **BE** | 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. |
| **BR** | 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 |
| **CN** | In 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.<br>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.<br>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 |

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| | 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. |
| **ES** | Proposal by officials and validation by stakeholders |
| **FR** | There is a group of experts who read and comment the proposal made by the industrial, to be sure that the proposal is consistent with the energy code. The industrial 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. |
| **IN** | 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. |
| **IT** | All the requirements included in Italian building energy codes are transposed from the European directives EPBD (Energy Performance Buildings Directive), EED (Energy Efficiency Directive) and RED (Renewable Energy Directive). Further, specific new technologies to be integrated in buildings, aiming at achieving European goals for building sector, are indicated in the National Energy and Climate Plan and, therefore, in the Italian Long Term Renovation Strategy (these Plans are mandatory for European Countries). Before their adoption, the two plan drafts are publicly available at the Italian government website for any comments by the stakeholders and citizens. |
| **JP** | 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. The website (in Japanese) of the Contact Point is as follows: https://www.ibec.or.jp/contact_point/contact_point.html |
| **NZ** | 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 work 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. |
| **PT** | 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. |
| **US** | 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 |

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| | 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.<br>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. |

In the response from **BR**, 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, according to **BR**'s response to a follow-up question, 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.

In response to a follow-up question to **CN** on the general framework of the Chinese Building Energy Codes, the following explanation has been provided:
In China, 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
In response to another follow-up question to **CN** to clarify the relationship between the output from 'building scientific research projects' organized by Ministry of Science and Technology and the role of 'the compilation or revision group', the following additional explanation has been made:
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.
As for examples of new technologies having been dealt with the **CN**'s institutional framework, the following information has been provided by the respondent:

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 have 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 renewable energy systems.

In response to the follow-up questions for clarification on **ES**'s response included in the table, **ES** clarifies as follows:
Integration of new tecnologies can happen because of new buildings codes or because an economical drive for owners and users. New Building codes are adopted because there is 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 architecs, 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.

According to **FR**'s response to this question and the website of the French system to evaluate innovative technologies (response to Q3), 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 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.

In response to the follow-up question on **IT**'s standard for building energy calculation (UNI/TS 11300), the following has been confirmed:
UNI/TS 11300 standards are constantly evolving and updated. Thus, a new technology which cannot be identified with a product standard, could be integrated in UNI/TS 11300 by requesting the Italian standardization body (CTI) to analyze the new technology and develop its energy calculation methodology. The CTI technical working group committed for UNI/TS 11300 consists of experts from universities, research centers and industrial associations.

For clarification of **PT**'s response, the number of new technologies, which have been dealt with by the working group, was asked in a follow-up question. According to **PT**'s response to the follow-up question, its definition of the new technologies is the technologies that were not included in former Portuguese regulations, but has been included in a current regulations. The working group mentioned in the response 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.

**US** mentioned the six principles for the development of international standards. According to the reference, the six principles 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).

A follow-up question on "accredited conformity assessment providers", which was mentioned in the response to Q2, was made. **US** responded as follows:
ICC-Evaluation Service (ES) is an accredited conformity assessment provider. The following link provides an overview of their Evaluation Reports Program, where you can explore an overview of the program, the directory of reports organized by construction specifications, and also a breakdown of the product testing process. Access the link: Evaluation Reports Program - ICC Evaluation Service, LLC (ICC-ES). The following website provides a directory of approved Acceptance Criteria: Approved Criteria (Search / AC # / CSI) - ICC Evaluation Service, LLC (ICC-ES). We do have a lot of reports relating to foam plastic insulation (rigid boards and spray foam). We also have quite a few reports covering Structural Insulated Panels (SIPs) and Insulated Concrete Form (ICF) Wall Systems. We also have 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).

- See here for a list of rigid board reports (AC12): https://icc-es.org/search-wpsolr/?q=ac12
- See here for a list of spray foam reports (AC377): https://icc-es.org/search-wpsolr/?q=ac377
- See here for a list of SIPs reports (AC04): https://icc-es.org/search-wpsolr/?q=ac04
- See below for ICF reports:
  AC15: https://icc-es.org/search-wpsolr/?q=ac15
  AC353: https://icc-es.org/search-wpsolr/?q=ac353

**Q3.** Could you provide links for any documents related to the approval process/system or the institution framework addressed in Q1 and Q2? (This question is applicable only when the response to Q1 is "Yes")

| Nation | Response |
|---|---|
| **AU** | Institutional Framework:<br>https://www.abcb.gov.au/about<br>https://abcb.gov.au/sites/default/files/resources/2022/ABCB-IGA-2020.pdf<br>Example of code update process:<br>https://www.abcb.gov.au/sites/default/files/resources/2020//NCC_2022_energy_efficiency_project_development_process.pdf<br>Example of BMM communique:<br>https://www.industry.gov.au/news/building-ministers-meeting-communique-august-2022 |

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| | https://www.nathers.gov.au/<br>Energy Efficiency Requirements: NCC2022 to be adopted in May 2023 - Refer Section J of Volume One of the National Construction Code and Part H6 of Volume Two of the National Construction Code and Housing Provisions Part 13. All available at:<br>https://ncc.abcb.gov.au/editions-national-construction-code |
| **BE** | General information (in Dutch) https://www.vlaanderen.be/epb-pedia/rekenmethode/gelijkwaardigheid#innovatieve-systemen-en-gebouwen<br>Information on procedure for innovative systems (in Dutch) https://www.vlaanderen.be/epb-pedia/rekenmethode/gelijkwaardigheid/innovatieve-systemen<br>Information on procedure for innovative building concepts (in Dutch)<br>https://www.vlaanderen.be/epb-pedia/rekenmethode/gelijkwaardigheid/innovatieve-gebouwen |
| **BR** | https://www.gov.br/mdr/pt-br/assuntos/habitacao/pbqp-h/sinat-sistema-nacional-de-avaliacoes-tecnicas-de-produtos-inovadores-e-sistemas-convencionais |
| **CN** | The following is the website of the Ministry of Housing and Urban-Rural Development for public comments on the codes.<br>https://www.mohurd.gov.cn/gongkai/fdzdgknr/zqyj/index.html |
| **ES** | No response |
| **FR** | http://rt-re-batiment.developpement-durable.gouv.fr/titre-v-r322.html |
| **IN** | https://www.bis.gov.in/share-your-comments-on-standards-wide-circulation-drafts/ |
| **IT** | Link for National Energy and Climate Plan:<br>https://energiaclima2030.mise.gov.it/index.php/consultazione<br>Link for Long Term Renovation Strategy:<br>https://www.mise.gov.it/index.php/it/normativa/notifiche-e-avvisi/strepin-2020-consultazione-pubblica-sulla-strategia-per-la-riqualificazione-energetica-del-parco-immobiliare-nazionale |
| **JP** | Documents' formats are downloadable through above-mentioned website. They include<br>1) Proposal guidelines for contact points (energy-saving standards),<br>2) Entry example, and<br>3) Handling flow. |
| **NZ** | https://www.legislation.govt.nz/act/public/2004/0072/latest/DLM306036.html<br>https://www.building.govt.nz/building-code-compliance/how-the-building-code-works/building-act-2004/<br>https://www.building.govt.nz/building-code-compliance/building-code-and-handbooks/<br>https://www.legislation.govt.nz/regulation/public/1992/0150/latest/DLM1926533.html |
| **PT** | https://www.dgeg.gov.pt/pt/areas-setoriais/energia/eficiencia-energetica/<br>https://www.adene.pt/ |
| **US** | ICC Consensus Procedures: https://www.iccsafe.org/wp-content/uploads/Revision-of-ICC-Consensus-Procedures_2-of-2-_revised-12.6.18B.pdf<br>Council Policy 12: https://www.iccsafe.org/wp-content/uploads/CP12-03.pdf<br>Consensus Policy 7: https://www.iccsafe.org/wp-content/uploads/CP07-04.pdf<br>Conformity Assessment Services: https://www.iccsafe.org/products-and-services/product-evaluation-and-testing/ |

**Q4.** Could you describe any barriers associated with integrating new technologies in building energy codes in your country/jurisdiction? (This question is applicable only when the response to Q1 is “Yes”)

| Nation | Response |
|---|---|
| **AU** | None in particular.<br>Until a new technology is fully incorporated into the NCC or referenced Standards, users |

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| | can apply a Performance Solution compliance pathway. A Performance Solution is an alternative compliance pathway that demonstrates either compliance with relevant Performance Requirements or equivalence to the Deemed-to-Satisfy Provisions. In the 2022 edition the Performance Requirements for energy efficiency are (generally) quantified and are set out in H6P1 and H6P2 (Volume Two - coverage includes detached houses, town houses, private garages or sheds) and J1P1 to J1P4. |
| **BE** | Main barrier is that the procedure for equivalence for products and systems is a slow and expensive process and requires an investment by the manufacturer.<br>Another barrier, specifically for innovative building concepts, is that the conditions for applying for this procedure are quite restrictive, the required application file is extensive, and guideline documents are not available. Consequently, this latter procedure is not well known and almost never used. |
| **BR** | Time is taken for tests, but this is ok as we have to protect the consumer. |
| **CN** | The developers of new building technologies are not the same people as the members of the building energy code team, which will result in a period of time before the new technologies are evaluated and approved by the building energy code team. Moreover, the approval process after the formation of building energy codes is long, so the comprehensive application of the new technology lags behind. |
| **ES** | Slow process: to take initiatives and deliver raw documents |
| **FR** | The model proposed as to be consistent with the energy code which sometimes can't reflect the actual operation of the system. Also, the second solution is queit expensive (around 10000 Euro) and not affordable to any industrial. |
| **IN** | The codes and standards are not technology agnostics, especially testing procedures. Hence new/upcoming technologies do not get level playing field for their performance. |
| **IT** | No response.<br>**IT** explained later when this report was reviewed by respondents why it did not respond to this question: The barrier for a technology to be integrated in the building energy code is the requirements prescribed by the law (they have to be certified according to a specific standard), but the Italian respondents do not consider the requirements as a barrier, because the requirements are necessary to guarantee the comparison between different technologies. |
| **JP** | One barrier is that poorly standardized technologies have been proposed through the contact point. In many cases, the definitions of the technologies are missed. Another barrier is the lack of energy calculation method for the proposed "new" technologies, and that the proposers are dependent on the ministry and the technical committee for developing the energy calculation methods. |
| **NZ** | The Building Code is performance-based and therefore technology-agnostic. However, many building consent applicants rely on using the acceptable solutions or verification methods provided by MBIE (Ministry of Business, Innovation and Employment). Whilst their use is not mandatory, they provide applicants with certainty that their designs comply and therefore will get consent. The acceptable solutions in particular are prescriptive. Due to resource-constraints and competing priorities it is not always possible to update these documents in a timely manner so that new technologies can be integrated and encouraged. |
| **PT** | Reference values for efficiency factors like COP and their interaction with Primary Energy Factors must be calculated and that can take time. |
| **US** | In the United States, there is differing processes and levels of building and energy code adoptions across state and local governments. In some States, building codes are adopted statewide through either a legislative or regulatory process. In other States, code adoption is the responsibility of the local jurisdiction. Building energy codes are also not recognized as 'life-safety codes' and therefore aren't uniformly adopted across the country. The |

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| | heterogeneity in energy code adoption across the country creates an imbalance in building regulation across the country and can hinder the integration of new technologies in the market that are woven into adopted energy codes. Another major barrier is created because there is not the same level of technical and resource capacities to adopt more modern energy codes and integrate innovative technologies, which limits the introduction of new technologies throughout the entire marketplace and ensure they continually become more advanced. |

A follow-up question to **CN**'s response was made on the reason why the experts independent from new technologies have to deal with the ways to integrate the new technologies in the building energy codes. **CN** replied "Building energy odes often contain a large amount of technical expertise, and new technology development teams often focus on a specific area of in-depth research. When it comes time to create a complete building energy code, a team with a large amount of expertise is needed to put it all together".

For the response from **IN** included in the above table, the respondent gave two examples in response to the follow-up question in order to explain that the codes and standards are not technology agnostics, especially testing procedures.

Example 1:

Room Air Conditions (RAC) are tested for their energy performance using IS1391 (Part I and Part II) with all amendments. This standard largely follows the process adopted by ISO. Testing conditions are suitable for only vapour compression cycle-based technologies, any new technology (such as barocaloric* cooling technology or technology that utilizes exceptionally high and selective moisture transport properties) that is non-vapour compression cycle technology will not find any place in code/standards and hence market.

* "barocaloric" is a characteristic of materials with strong, reversible thermic responses to changes in pressure.

The existing Seasonal Energy Efficiency Ratio (SEER) or its Indian derivation IndiaSEER (iSEER) provides an estimate of RAC seasonal efficiency with a focus on performance at different sensible loads; however, it does not address RAC efficiency at the different latent loads experienced in the real world. With latent loads being upwards of 30% of the total cooling loads, and even higher in humid climate zones, a significant part of the efficiency applicable to the full cooling load (enthalpy) is unaddressed.

Example 2:

Most of the building energy codes in India focuses on energy efficiency using high-performance building element or systems. This does not provide any opportunities to operate buildings in nat-vent (NV) or mixed-mode (MM). It does not give credit to the selective use of thermal mass but is biased towards, insulations for walls/roofs. It specifies the U value but not thermal mass values (specific heat), which means MM/NV operations are not on the radar, especially when the code is derivative of ASHRAE 90.1 or Title 24.

**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? (This question is applicable only when the response to Q1 is "Yes")

| Nation | Response |
|---|---|
| **AU** | Yes, testing standards would be among the issues considered by the Building Codes Committee and any Technical Reference Groups formed to advise the Board on proposed changes to the NCC. |
| **BE** | Yes, for innovative systems a technical approval with reference to test standards is required. |
| **BR** | Yes. |
| **CN** | When a new technology is developed, a strict performance test will be carried out before |

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| | the mass production. In the process of compiling building energy codes, not only the pre-production performance test report will be reviewed, but also the application effect of buildings that have been partially used will be evaluated before it can finally be included in building energy codes. |
| **ES** | No. |
| **FR** | Yes. |
| **IN** | Yes. |
| **IT** | Usually, the new technologies incorporated in the building energy code are quite known and already applied and tested in buildings. This is possible also because the Italian incentive schemes for building renovation (for private or public owners) are addressed to stimulate a more ambitious building configuration than the one required by the building code. Therefore, they allow to test the adoption of new technologies in the renovated buildings. |
| **JP** | Yes. The existence of testing standards for components or whole systems is required. Without necessary standards including testing standards, the proposed technology cannot be incorporated. |
| **NZ** | Yes. |
| **PT** | When it is possible and consistent in scientific terms, code values are taken from international standards, otherwise they must be calculated according to local climate conditions. |
| **US** | When a new or innovative product that is not adequately addressed by the code is submitted for evaluation, an Acceptance Criteria (AC) is developed by an accredited conformity assessment provider in consultation with the report applicant and with input from interested parties. ACs help ensure product compliance to relevant codes and standards, and create a level playing field for product evaluation. |

In response to a follow-up question to **CN** on the difference between 'pre-production performance test' and evaluation of 'application effect of buildings that have been partially used', **CN** further replied "In China, new technologies must pass professional testing before they can be used in batches. This is necessary to verify the applicability of new technologies and to evaluate scientific and technological achievements. Therefore, if there is no proof of performance, the standards panel will not include the technology in the standard".

**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? (This question is applicable only when the response to Q1 is "Yes")

| Nation | Response |
|---|---|
| **AU** | Commercial buildings and common areas of Class 2 apartment buildings: Energy simulation software can be used to demonstrate NCC Section J Energy Efficiency compliance through "Verification Methods" or as part of another type of Performance Solution to demonstrate compliance with the Performance Requirements in the code. However, other non-simulation-based methods of demonstrating compliance are also available (e.g. other types of Performance Solutions or elemental "Deemed-to-Satisfy Provisions").<br>The NCC does not specify any software tool(s) when following Verification Methods but sets out modelling requirements e.g., requiring a NABERS Commitment Agreement, Greenstar registration or by following a modelling specification in the Code. |

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| | Residential buildings (houses and apartment units): Compliance with energy efficiency requirements can be demonstrated using simulation-based or other approaches such as by following elemental provisions. Simulation-based approaches include using:<br>・ House Energy Rating Software accredited under the National House Energy Rating Scheme (NatHERS).<br>・ Verification Using a Reference Building, which compares the modelling of the proposed building with an elementally-compliant "reference building". Calculation method must be ANSI/ASHRAE Standard 140 compliant and the software used must be other than House Energy Rating Software (currently or previously NatHERS-accredited). |
| **BE** | The regulatory calculation method is based on a quasi-steady-state monthly energy use calculation, for which one official software is available from the authorities (VEKA).<br>For new technologies the building energy simulation software is not specified. Applicants can propose any software, but it needs to be approved by the authorities.<br>For some specific applications, already integrated in the regulatory framework, the use of specific software is allowed and described: for calculation of linear and point thermal transmittance of building envelope junctions:<br>https://assets.vlaanderen.be/image/upload/v1661522053/MB_van_28_december_2018_Bijlage_5_voor_bouwaanvragen_vanaf_1_januari_2019_zfywjd.pdf |
| **BR** | In Brazil EnergyPlus is widely used. |
| **CN** | Dest and IBE software independently developed by a Chinese research team can simulate building energy consumption and evaluate the effects of different new technologies using hourly and monthly mean simulation methods, respectively. And simulation software such as EnergyPlus, PKPM, TRNSYS and DesignBuilder are also frequently used in building energy simulation. |
| **ES** | e-quest alike |
| **FR** | The simulation of the code itself |
| **IN** | EnergyPlus or ASHRAE 140 compliant and sometimes CIBSE AM11 |
| **IT** | DOCET (https://www.efficienzaenergetica.enea.it/servizi-per/cittadini/docet.html) e SIRE (https://sire.enea.it/), ICARO (https://www.anit.it/icaro/)<br>Further, the products found in the market are certified according to the UNI EN ISO 52016:2018 |
| **JP** | In Japan, there are two approved simulation programs for total energy use by buildings. The algorisms are fully opened, and the proposers of new technologies can propose new algorisms to be replaced or added with an existing part of the algorisms. Any independent simulation software can be used if it is validated of its reliability (the way of validation is described in the response to the next question) in order to calculate key input parameters in the approved simulation programs. |
| **NZ** | The Verification Methods H1/VM1 and H1/VM2 for Building Code clause H1 Energy Efficiency are compliance pathways that are based on building energy modelling. They permit the use of any building energy simulation software that complies with AHRAE 140 and/or BESTEST. |
| **PT** | Software must be compliant with ASHRAE Standard 140. Mostly used software is Energy Plus in order to calculate Useful Energy and Final Energy. Primary Energy is calculated based on Primary Energy Factors defined by national regulations for each energy carrier, according to national features. |
| **US** | The U.S. Department of Energy's (DOE) Pacific Northwest National Laboratory (PNLL) also developed and continually updates COMcheck and REScheck software to improve consistency in code compliance. The free tool allows helps clarify trade-offs and prescriptive requirements and aids in interpretation of the code by calculating fan power, lighting power, and envelope minimum requirements based on building/space type and climate zone.<br>In addition, DOE is required by law, under the Energy Conservation and Production Act, to issue |

| | |
|---|---|
| | a determination as to whether the latest editions of the nationally recognized model energy codes will improve in energy efficiency and carbon emissions reduction compared to the previous edition of the corresponding code. The determination is supported by technical energy savings analysis performed by PNNL, which calculates the impacts of changes to the energy code including the integration of new products and technologies. The determination analysis is based on an established DOE Methodology, which entails a combination of qualitative and quantitative components to identify changes that have a direct impact on residential energy efficiency, and which can be reasonably quantified in estimating overall national average saving impacts. The determination and accompanying technical analysis serve as useful guidance to state and local governments as they review and update their building codes. |

In response to the follow-up question on the limits of ASHRAE Standard 140 and CIBSE AM11 that all aspects of simulation programs cannot be covered even by those distinguished standards, **IN** added the following comments:
It can be fully agreed that ASHRAE standard 140 could be the minimum requirement but could not be the only one. The calibration of the model, the development of national-level archetypes, the ability to simulate heat and mass, and the integration of advanced control are some of the challenges that need to be addressed. But referring to ASHRAE standard 140 at least will filter out homegrown tools or black box tools.

In **US**, there are three options to show building energy code compliance. They are 1) prescriptive option, 2) Trade off option, and 3) Energy Cost Budget Method by using performance simulation. For the second option, COMcheck and REScheck software have been provided. When applicants for the building energy code compliance wish to make new technologies, which they are going to install in buildings, to be evaluated, they have to use the third option by using EnergyPlus or other DOE energy modelling tools.

**Q7.** Are there any procedures and processes in place to validate the energy simulation software for new technologies in building energy codes? (This question is applicable only when the response to Q1 is "Yes")

| Nation | Response |
|---|---|
| **AU** | Software validation processes include ANSI/ASHRAE Standard 140 or<br>House Energy Rating Software accreditation:<br>https://www.nathers.gov.au/publications/software-accreditation-protocol<br>However, these are general accreditation processes rather than specifically relating to new technologies - until new technologies are represented in the simulation packages they may need to use a Performance Solution to demonstrate compliance.<br>In addition to accrediting software tools, NatHEWRS includes a case-by-case peer assessment for inclusion of new technologies in the scheme and determining performance characteristics for modelling purposes. |
| **BE** | No. |
| **BR** | No, we only ask for the software to comply with ASHRAE 140. |
| **CN** | At present, the verification of simulation software is usually based on the comparison of simulation and experimental results conducted by scholars, and no official channels have been used to verify the simulation software. |
| **ES** | No. |
| **FR** | Yes, the experts will look at the modelisation in the simulation of the code |
| **IN** | No. |
| **IT** | According to Article 7 of the Ministerial Decree of 26 June 2015, the so-called 'Minimum |

| | |
|---|---|
| | Requirements', the CTI performs a verification activity of commercial software and tools for calculating the energy performance of buildings. For details on the purposes and methods of verification, see the aforementioned Ministerial Decree of 26 June 2015, Legislative Decree 192/05 as amended, as well as the Verification Rules for the procedure in force (https://www.cti2000.it/index.php?controller=sezioni&action=show&subid=62) |
| **JP** | It can be said that there are two requirements. One is an openly fully described algorism of the software. Theory behind the calculation shall be checked with the algorism. Another requirement is validations of theories and parameters in the algorism by using the results of field measurements and/or laboratory tests for the technologies. |
| **NZ** | If the application for which the software is to be used has been documented according to the ANSI/ASHRAE Standard 140 procedure, then the method shall pass the ANSI/ASHRAE Standard 140 test. If the application for which the software is to be used has not been documented according to the ANSI/ASHRAE Standard 140 procedure, the method shall be tested to BESTEST and pass the BESTEST. |
| **PT** | Yes. When an update for a new requirement for the code is needed a dispatch from Director General for Energy and Geology can be published with that update |
| **US** | No response |

**Q8.** Could you describe any barriers associated with integrating new technologies in building energy codes? (This question is applicable only when the response to Q1 is "No")

| Nation | Response |
|---|---|
| **CA** | 1) Performance of new technologies often not well understood; test and rating standards are requisite requirements before new tech can be integrated in codes. But it is often hard to justify the cost of standard development if technologies have limited market uptake. And market uptake of new technologies is often limited before they are recognized by codes.<br>2) Builders and code officials are often skeptical that new tech will achieve performance goals.<br>3) Builders and code officials are often worried that new technologies will introduce unintended consequences, causing issues for occupants and liabilities for builders / code authorities. |
| **SG** | Availability of sufficient performance data across different environmental conditions where the technologies were deployed, as well as availability of fire codes to ensure that safety is addressed. |

A follow-up question was made to **CA** on a technology, which has already been widely used in buildings, but has not yet been evaluated of its contribution to improving energy efficiency of buildings due to the lack of sufficient data and theory to support the value of the technology. In addition, the role of government, industry and academia was asked. The response of **CA** is as follows:

In respondent's experience, rapid market update creates a strong mandate for government labs and program authorities to intervene. Those interventions may include bench testing and field trials, publishing evaluation procedures, developing standards for performance rating & installation; issuing labels (e.g., EnergyStar) to best-performers. If government does not do these things, industry may self-organize into a consortium that attempt to fill this gap. However, the respondent has observed that such industry led initiatives are less effective without engagement from government because they are often unwilling to commit the resources for effective standards development, and they understandably put competitive interests ahead of public interests. The respondent does not see a clear role for academic researchers in situations like this. In respondent's experience, their contributions are most valuable earlier in the innovation chain.

**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. (This question is applicable only when the response to Q1 is "No")

| Nation | Response |
|---|---|
| **CA** | No such process is contemplated. New technologies are approved using the same process and committees that develop codes. |
| **SG** | While we do not have building energy codes, we have a process to involve fire safety regulators (as well as other economic agencies) to address the safety concerns of innovative technologies. New technologies are also tested for performance in our testing facility (BCA Skylab) to gather performance data, and schemes to support the demonstration of these technologies requiring IPMVP reports to validate the performance for the technologies. |

A follow-up question was made to **SG** on the number of technologies, which have been tested in BCA Skylab (Figure 9-1). SG did not clarify the number of technologies, but informed four examples of the technologies. They are 1) a building-integrated photovoltaic system (BIPV), 2) an anti-thermal paint for facades, 3) an air balancing method for air-conditioning systems with a multi-terminal duct system, and 4) a desk product with personalized ventilation system. The test results cannot be disclosed due to the agreements with the companies.

Figure 9-1 BCA's Skylab in Singapore (a rotatable test facility)
https://www1.bca.gov.sg/buildsg/sustainability/bca-skylab

IPMVP, which was mentioned in **SG**'s response to the original question, stands for International Performance Measurement and Verification Protocol. According to the latest document on IPMVP's core concept, the purpose of the IPMVP is to reduce barriers to the energy and water efficiency industries, and the IPMVP is now used by utilities and government agencies for their demand-side incentive programs and by building, manufacturing, and industrial managers to assess and improve their facilities' performances. The IPMVP is owned and maintained by Efficiency Valuation Organization (EVO®). EVO's mission is to ensure that the savings and impact of energy efficiency and sustainability projects are accurately measured and verified.

List of respondents

| Nation | Name | Affiliation |
|---|---|---|

| | | |
|---|---|---|
| **AU** (Australia) | Dev Bhardwaj | Department of Industry, Science, Energy and Resources |
| **BE** (Belgium) | Arnold Janssens | Ghent University |
| **BR** (Brazil) | Roberto Lamberts | Department of Civil Engineering, Federal University of Santa Catarina |
| **CA** (Canada) | Alex Ferguson | Natural Resources Canada |
| **CN** (China) | Shicong Zhang | China Academy of Building Research, Institute of Building Environment and Energy |
| **ES** (Spain) | Francesc Bonvehí | ASOLBA Engineering & Architecture |
| **FR** (France) | Constance Lancelle | CEREMA (Centre for Studies on Risks, the Environment, Mobility and Urban Planning) |
| **IN** (India) | Rajan Rawal | CEPT University |
| **IT** (Italy) | Francesca Hugony | ENEA (National Agency for New Technologies, Energy and Economic Development) |
| **JP** (Japan) | Takao Sawachi | Building Research Institute |
| **NZ** (New Zealand) | Christian Hoerning | MBIE (Ministry of Business, Innovation and Employment) |
| **PT** (Portugal) | João Mariz Graça | DGEG (The General Directorate of Energy and Geology) |
| **SG** (Singapore) | Noel Chin | Building and Construction Authority |
| **US** (United States of America) | Joseph W. Sollod | International Code Council |

# Appendix 2:

## Presentations of a session on 'New Technology Integration in Building Energy Codes' in EBC Building Energy Codes Working Group Annual Symposium in November 2023

The 5th Annual Symposium of Building Energy Codes Working Group was held on 14th November 2023 in Beijing. In the symposium, a session on 'New Technology Integration in Building Energy Codes' was organized and presentations from three countries (CA, CN and US) were made.

Whole program and presentations will be provided through the website of the Working Group, and only presentations from three countries having participated to this survey are included in this Appendix. It is hoped that more countries will be able to meet in future symposiums of the Working Group to exchange technical information on new technologies integration. https://iea-ebc.org/working-group/building-energy-codes

EBC
Energy in Buildings and Communities Programme

**EBC Building Energy Codes Working Group Annual Symposium**

**IEA EBC Building Energy Codes Working Group (BECWG)**

**14 November 2023**
13:30 – 18:00 Beijing (5:30 – 10:00 UTC/GMT)

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**Venue:** Room F, the "Third Blast Furnace", Shougang Park, Beijing
**Remote Access:** https://teams.live.com/meet/9519053945463?p=3frIlLF7VRwVgiQn

***Times below are in Beijing Time (CST)**

| **Introduction** | | |
|---|---|---|
| ***13:30 – 13:35*** | Welcome and introduction | Xudong Yang, Tsinghua University |
| ***13:35 – 13:45*** | Meeting goals and overview of BECWG accomplishments and planned activities | Meredydd Evans,<br>Pacific Northwest National Laboratory (BECWG Operating Agent) |

| **Session I. New Technology Integration in Building Energy Codes** | | |
|---|---|---|
| **Moderator: Takao Sawachi, Building Research Institute, Japan** | | |
| ***13:45 – 14:45*** | How 'New Technologies' are dealt with in Building Energy Codes: Case Studies from 13 Countries | Takao Sawachi,<br>Building Research Institute |
| | Performance Approaches Paving the Way for Innovative Technologies | Michael Tillou,<br>Pacific Northwest National Laboratory |
| | Developing Emission factors for Carbon Codes during a Clean Energy Transition | Alex Ferguson,<br>Natural Resources Canada |
| | From Energy Code to Carbon Standard | Zhang Shicong,<br>Institute of Building Environment and Energy |
| ***14:45 – 15:30*** | **Panel Discussion** | Moderator: Takao Sawachi,<br>Building Research Institute |
| ***15:30 – 15:45*** | **Break** | |

# Appendix 3:

## References


1. IEA: Technology and Innovation Pathways for Zero-carbon-ready Buildings by 2030, All countries targeted for zero-carbon-ready codes for new buildings by 2030, September 2022, https://www.iea.org/reports/technology-and-innovation-pathways-for-zero-carbon-ready-buildings-by-2030/tcps-strategic-vision-on-iea-net-zero-by-2050-s-buildings-milestones-to-2030

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3. World Trade Organization (WTO), Principles for the Development of International Standards, Guides and Recommendations, 2000, https://www.wto.org/english/tratop_e/tbt_e/principles_standards_tbt_e.htm

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6. Pacific Northwest National Laboratory, Technical Support Document for Version 3.9.1 of the COMcheck Software, September 2012, https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-21880.pdf

7. IEA Energy in Buildings and Communities TCP, IEA EBC Working Group Final Report: HVAC Energy Calculation Methodologies for Non-residential Buildings, November 2020, https://www.iea-ebc.org/Data/Sites/1/media/docs/working-groups/ebc_wg_hvac_final_report_november_2020.pdf

# Presentation 1 (United States of America)

EBC
Energy in Buildings and Communities Programme

Performance Approaches Paving the Way for Innovative Technologies

Michael Tillou
Pacific Northwest National Laboratory

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Pacific Northwest
NATIONAL LABORATORY

**Performance Approaches Paving the Way for Innovative Technologies**

EBC BECWG 5th Annual Symposium
November 14, 2023

ENERGY BATTELLE

PNNL is operated by Battelle for the U.S. Department of Energy

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Topics

- Roadblocks facing new technologies in US Energy Codes
- Performance based compliance solutions
  - Appendix G PRM
  - TSPR – system performance
  - Energy Credits

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## Challenges Facing New Technologies

- Prescriptive Compliance is the dominant compliance pathway
  - Establishes criteria for individual building components that apply to all buildings. (ie. Heating efficiency, fan power, lighting power)
  - Does not consider interactive system effects
  - Favors mature technologies that are broadly available from multiple vendors and applicable across all building types.
- Development process
  - Three-year code development cycle
  - Consensus based process requires multiple rounds of industry stakeholder input, public comment and development
  - Prescriptive requirements must be shown to be cost-effective

## Solution: Shift to Performance Based Compliance

**Performance based compliance pathways offer an opportunity for new technologies to be more widely adopted.**

Performance based compliance pathways

1. Increase flexibility
2. Capture interactive effects of system components
3. Allow the impact of new technologies to be captured without specific prescriptive requirements.
4. Allow establishment of whole building energy efficiency targets.

## Performance based solutions currently adopted under United States energy codes

- **Appendix G** – Performance Rating Method – whole building simulation compliance option
- **HVAC Total System Performance Ratio (TSPR)** – integrated, HVAC only, system performance compliance option
- **Energy Credits** – additional efficiency requirements based on whole building energy use or energy cost reduction.

## Appendix G - Whole Building Performance Rating Method

## Appendix G – Performance Rating Method (PRM)

### What is PRM?

- Whole building code compliance pathway
- A proposed building design must demonstrate lower energy use or cost than an equivalent baseline building.
- Independent Baseline - varies by building type and climate zone.
- Captures energy impacts of **all** proposed equipment and systems.
- Introduced for beyond code programs (e.g. LEED) in 2004 and approved for code compliance in 2016.

### Why PRM?

- The benefits of new technologies are fully captured.
- Allows supplemental energy calculations to be used where a new technology is not yet included in whole building simulation software.

### Challenges

- Requires detailed whole building simulation of a proposed design
- Requires additional time for development and review of compliance documentation.

## HVAC Total System Performance Ratio

---

## HVAC Total System Performance Ratio (TSPR)

### The Basic TSPR Idea

- Forget the question; "does it comply prescriptively?"
- Instead; how much Heating, Cooling can be delivered and at what cost per HVAC service? – This is TSPR
- Compare the proposed TSPR to a target TSPR
- Allows equivalent tradeoffs within HVAC prescriptive requirements

### Why HVAC Performance?

- A particular building may have trouble with a prescriptive requirement
  - Trouble meeting fan power limits
  - Economizer difficult
- TSPR allows trade off within HVAC system
  - Higher cooling or heating efficiency
  - Pumping power reductions
  - More DCV area where not required
- TSPR results in equivalent energy input for a "good" system selection
- Reduces complexity of a whole building analysis

---

## HVAC Total System Performance Ratio (TSPR)

### HVAC Performance Metric: Total System Performance Ratio

$$TSPR = \frac{\text{Heating + Cooling Loads Delivered}}{\text{Annual HVAC Operating Input*}}$$

* HVAC operating input can be in terms of energy cost (ECI), use (site or source Btu's), or carbon emissions. The higher the HVAC loads output relative to HVAC input, the more efficient the total HVAC system is.

Unlike a '**Mechanical Power Density**' limit, TSPR accounts for part load performance

**TSPR is the HVAC system performance for the whole building HVAC system**
(more like a seasonal heat pump rating than boiler efficiency)


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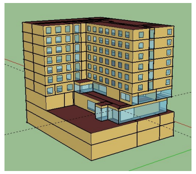
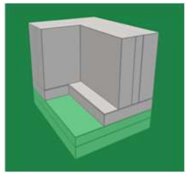
## HVAC Total System Performance Ratio (TSPR)

### Compliance Calculation Tool

- Software tool provided by United States Department of Energy (free)
- Simplified tool, requiring limited user input, to assess building HVAC system efficiency.
- Automatically generates compliance report
- Lighting, equipment and envelope loads same as reference
- Does not predict actual whole building energy performance of a proposed design



Detailed Energy Model



Block Based Simplified Model

Energy Credits

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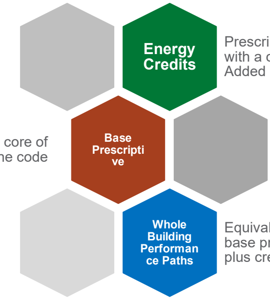
## Energy Credits

### How Do Energy Credits Fit?




Prescriptive Plus: with a choice; Added Savings

The core of the code

Equivalent to base prescriptive plus credits

New energy credits language requires projects to select additional energy efficiency and load management design features to improve overall building energy efficiency.

### Energy Credit Characteristics

- Wide range of credits
- May be experimental / new / load management
- Instead of prescriptive exceptions, pick an alternative savings target
- Equivalency across the different credits
- Can support above code or incentives
- Each energy credit measure is assigned points based on it's energy impact in different building types and climate zones.



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## Current Energy Credit Measures

Over 30 energy credit measures are included in the latest versions of both the Commercial and Residential energy code in the United States.

**Energy Credit Measures**

*Efficiency Measures*
- Envelope performance
- UA reduction (15%)*
- Envelope leak reduction*
- Add roof insulation*
- Add wall insulation*
- Improve fenestration*

*HVAC Measures*
- HVAC performance
- Heating efficiency
- Cooling efficiency
- Residential HVAC control
- Ground source heat pump*
- DOAS/fan control

*Water Heating Measures*
- SHW preheat recovery
- Heat pump water heater
- Efficient gas water heater
- SHW pipe insulation
- Point of use water heaters
- Thermostatic bal. valves
- SHW heat trace system*
- SHW submeters
- SHW flow reduction
- Shower heat recovery


*Lighting Measures*
- Lighting dimming & tuning
- More occupancy sensors
- Increase daylight area
- Residential light control
- Light power reduction

*Power & Equipment Measures*
- Energy monitoring
- Efficient elevator
- Efficient commercial kitchen equipment
- Residential kitchen equipment
- Fault detection
- Guideline 36 controls**

*Renewable & Load Management Measures*
- Renewable energy
- Lighting load management
- HVAC load management
- Automated shading
- Electric energy storage
- Cooling energy storage
- SHW energy storage
- Building mass/night flush

*Only in IECC;
**Only in Standard 90.1

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## Energy Credits

### Benefits of "Energy Efficiency Credits"

- Credit measures can offer more flexibility
  - Do not need to apply to all buildings
  - Niche oriented savings opportunities can be included
  - Does not require a custom performance analysis
  - Provides flexibility of choice to each project
- Can mix options to achieve a target savings
- Can include choices that may not be strictly cost effective
- Deal with large-saving strategies that may not be appropriate for all buildings
- Lays groundwork for future performance tradeoffs and target for smaller simple buildings
- Each Credit represents ~1/10 % whole building energy cost

## Summary

**Performance based compliance approaches allow new technologies a pathway for energy code integration.**

**Appendix G PRM –** Allows greatest flexibility for capturing the benefit of new technologies, adds additional time and cost to a project.

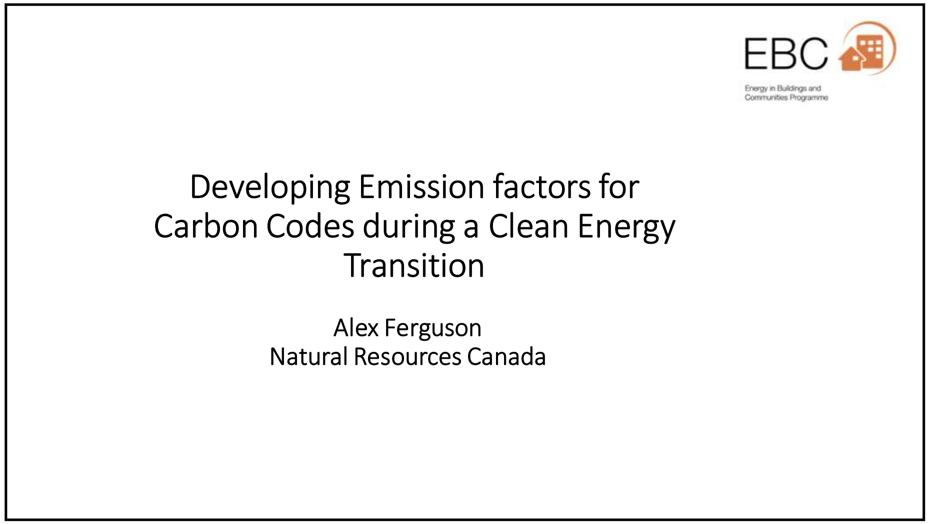
**System Performance (TSPR)** – a simplified alternative to PRM for capturing the impact of new technologies. System performance pathways are also being developed for lighting and service water heating systems.

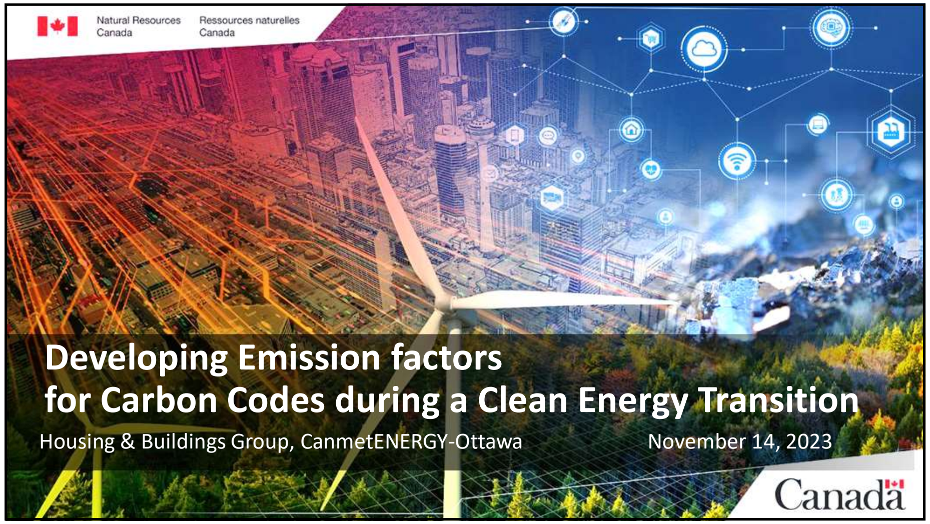
**Energy Credits –** allows credit for systems designed to exceed minimum prescriptive criteria. Credits for new technologies can be added that are based on the



# Thank you

# Presentation 2 (Canada)





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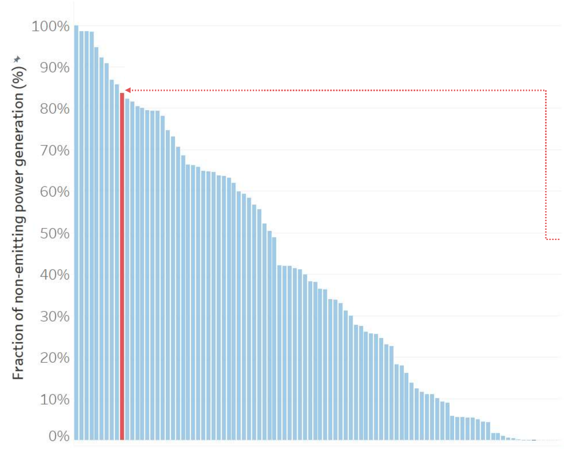
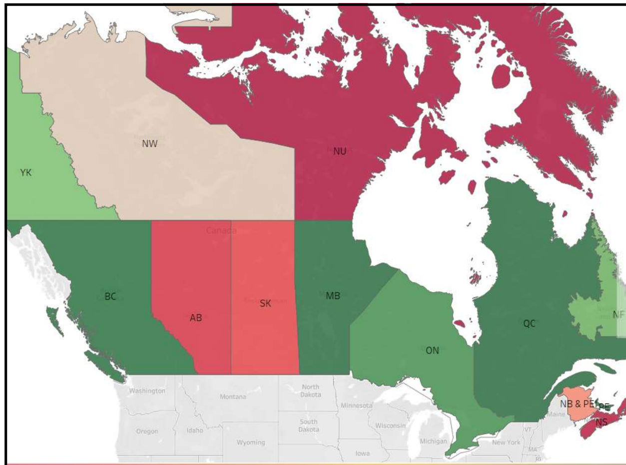



| # | Country | Non-emitting Share |
|---|---|---|
| 1 | Iceland | 100% |
| 2 | Norway | 99% |
| 3 | Sweden | 99% |
| 4 | Costa Rica | 98% |
| 5 | Switzerland | 95% |
| 6 | Kenya | 92% |
| 7 | France | 91% |
| 8 | Brazil | 87% |
| 9 | Finland | 86% |
| 10 | Canada | 84% |

We appear well-positioned for this transition. In 2020, Canada sourced 84% of its electricity from non-emitting sources.



6




But Canada's non-emitting generation is not evenly distributed. Some provincial grids have very low carbon intensity.

In others, electricity is several times more carbon-intensive than natural gas.



7

Like other countries, we have a plan to decarbonize our electric grids. That plan includes increased renewable generation


**1) More Solar!** **2) More Wind!** **3) Enhanced Distribution!**

**4) Carbon Capture ?** **5) Bio-energy ?** **6) Small-scale nuclear ?**

Low-carbon technology is expected disrupt other energy supply infrastructure as well. In Canada, renewable natural gas (sourced from biogenic or waste resources) is already blended into our gas networks. Hydrogen-blending pilots are also operating in some parts of the country.

**GHG Intensity Factor:**

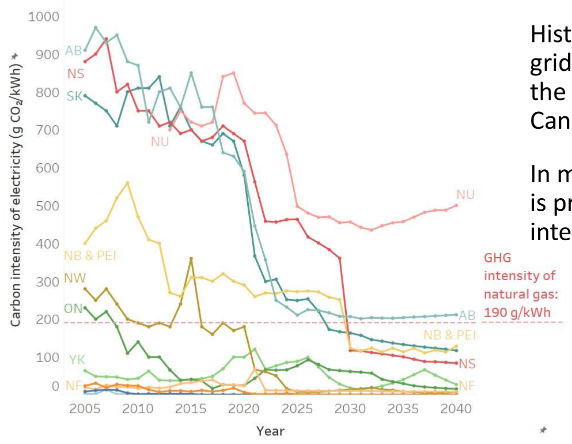
g $CO_2$-equivlent / kWh

These technologies don't have to be attached to buildings to affect the building code.

Most jurisdictions abstract utility emissions using a GHG intensity factor. Those factors reflect the mix of electricity supplied from fossil-fired and non-emitting sources.








Historical and projected data for grid-emission factors highlight the changes expected during Canada's clean energy transition.

In most regions, electric heating is projected to be less carbon intensive than natural gas.

Natural Resources Canada Ressources naturelles Canada Canada

## Timelines for Code Impacts

2030 Onwards: Building Operation

2023 — 2025 — 2030 — 2035

**2023:** Carbon code requirements designed

**2025:** Model Code Published

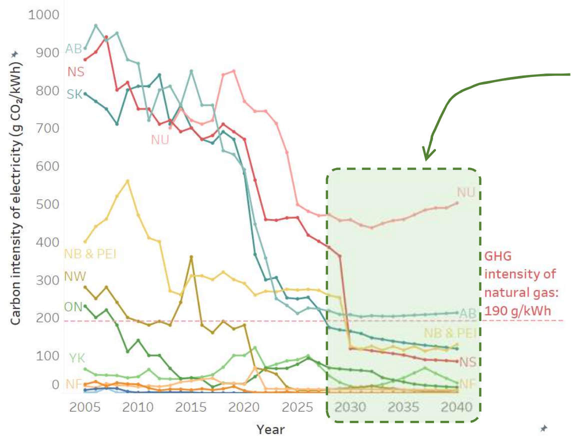
**2027:** Provinces, Territories begin to adopt the code

**2028:** First buildings designed to code

**2029:** First buildings break ground

Natural Resources Canada Ressources naturelles Canada Canada



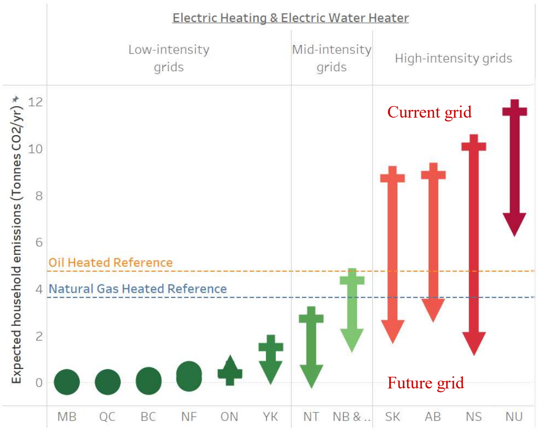



*This is the most relevant period!*

For effective code design, we need to know what the future energy system will look like.

Robust forecasts for 2030 and beyond are essential.

Natural Resources Canada Ressources naturelles Canada Canada

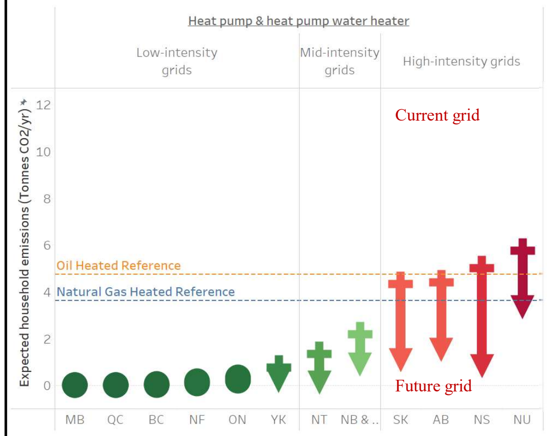



The reliability of grid emission forecasts is potentially a major issue for low carbon code design.

Electrically heated buildings will produce more emissions if the grid does not make progress towards decarbonization targets.








Energy efficiency can mitigate those risks.

Better envelopes and heat pumps further reduce carbon emissions in all electrically heated homes, and reduce the potential for increased emissions if grids do not decarbonize.





## Conclusions

1. **Lower-carbon energy supply technologies** will affect building the building code, even if they are not connected to the building!
2. **Future-looking forecasts** for are essential for countries and jurisdictions with utilities that are transitioning to lower-carbon energy supply.
3. **Energy efficiency can mitigate the risk** that utilities won't decarbonize as fast as we expect.





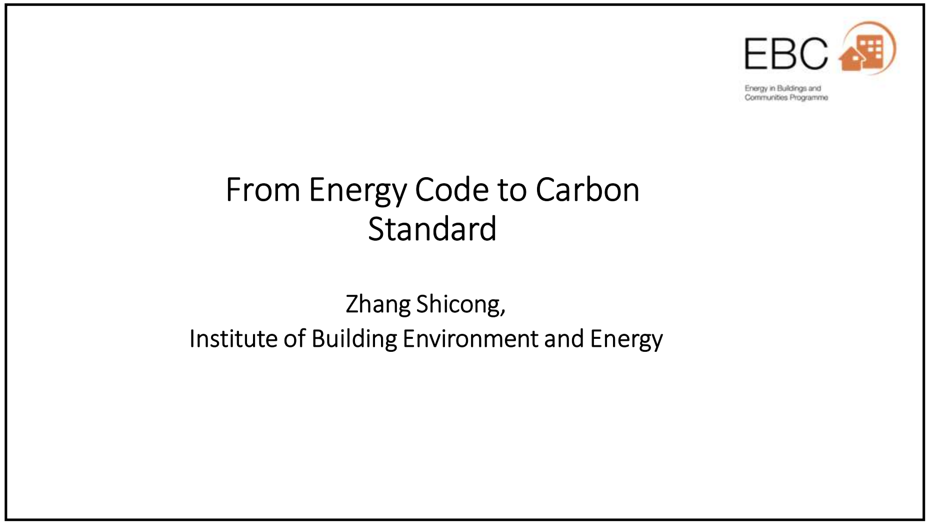
## Thank-you!

CanmetENERGY-Ottawa's Housing and Buildings team:

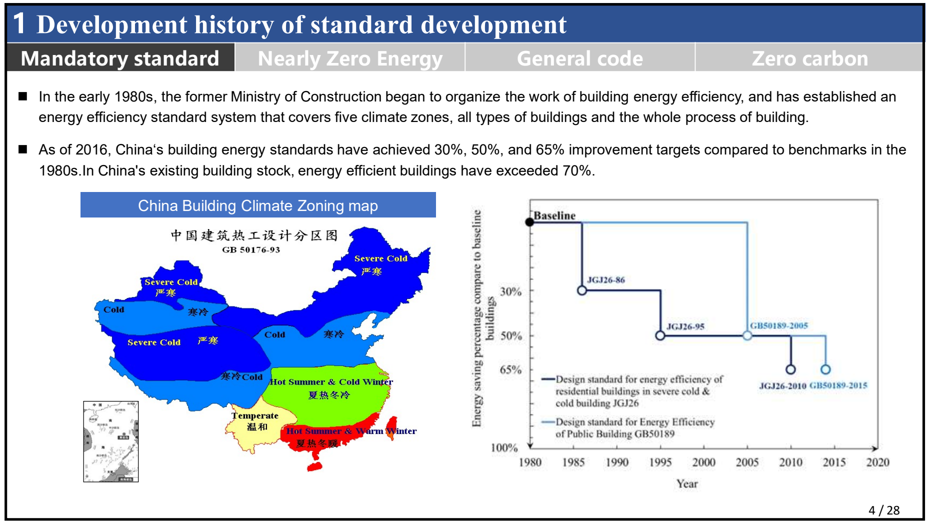
- Sara Azimi
- Martin Boulay
- Sébastien Brideau
- Sarah Brown
- Mark Carver
- Brock Conley
- Alex Ferguson
- Sara Gilani
- Kamel Haddad
- Chris Kirney
- Phylroy Lopez
- Chris McLellan
- Hamish Pope
- Julia Purdy
- Navid Shirzadi
- Ali Syed
- Jessica Webster

General Inquiries: Meli Stylianou (Meli.Stylianou@Canada.ca)

# Presentation 3 (China)





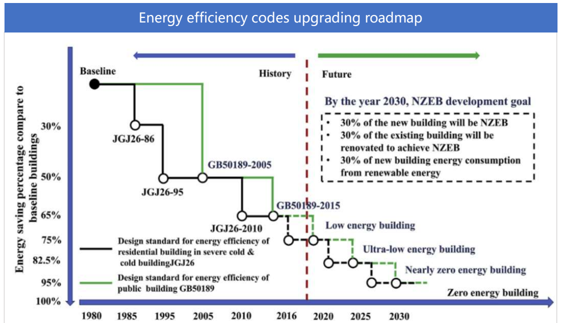



# 1 Development history of standard development

Mandatory standard | **Nearly Zero Energy** | General code | Zero carbon

- In 2019, China implemented the first national standard to lead improvements in building energy efficiency. Building Efficiency 2016 as the baseline, the process of achieving a zero-energy building is divided into ultra-low energy(50%), nearly zero energy(60~75%) and zero energy buildings(100%).


中华人民共和国国家标准 GB
P GB/T 51350-2019
近零能耗建筑技术标准
Technical standard for nearly zero energy buildings
2019-01-24 发布 2019-09-01 实施
中华人民共和国住房和城乡建设部
国家市场监督管理总局 联合发布

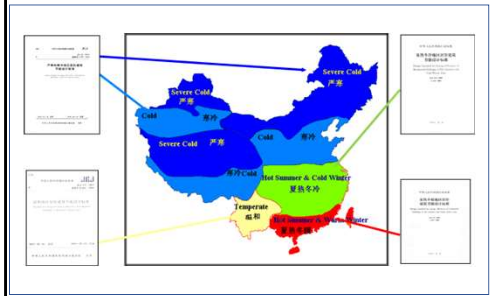


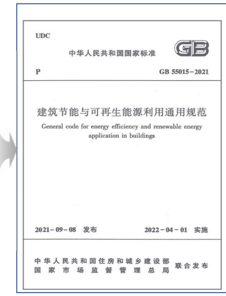



# 1 Development history of standard development

Mandatory standard | Nearly Zero Energy | **General code** | Zero carbon

- The implementation of the "General Code for Building Energy Efficiency and Renewable Energy application in building " in 2022, which increases energy efficiency by 20% compared with 2016, is the first step in the mandatory standards towards ultra low and nearly zero energy building energy efficiency levels.
- The code covers all building types in all climate zones and can better guide the implementation of relevant standards.





UDC
中华人民共和国国家标准 GB
P GB 55015-2021
建筑节能与可再生能源利用通用规范
General code for energy efficiency and renewable energy application in buildings
2021-09-08 发布 2022-04-01 实施
中华人民共和国住房和城乡建设部
国家市场监督管理总局 联合发布

- Full-text mandatory code
- New and existing
- Residential and buildings
- energy efficiency and renewable energy
- 5 major climate zones and 11 subdivisions



# 1 Development history of standard development

Mandatory standard | Nearly Zero Energy | **General code** | Zero carbon

- In order to achieve the overall goal of energy conservation, the contribution of various energy-saving measures is decomposed reasonably, and the improved technical measures are given.

| | Improvement ratio | Envelope Improvement | Energy efficiency of equipment | Lighting power density value | Coverage area |
|---|---|---|---|---|---|
| GB 50189-2015 | 20% | 10%~20% | 10%~45% | 9%~12% | Add the design index of typical building energy |
| JGJ26-2018 | 1%~2% | Same level | Same level | 9%~12% | Same level |
| JGJ134-2010 | 30% | 12%~20% Improved shading requirements | more than 30% | 9%~12% | Add water supply and drainage, electrical indicators |
| JGJ75-2012 | 30% | 10%~12% Improved shading requirements | more than 30% | 9%~12% | |
| JGJ475-2019 | 30% | 5%~20% | more than 30% | 9%~12% | |
| GB1245-2017 | 15% | Same level | 10%~45% | 9%~12% | Same level |

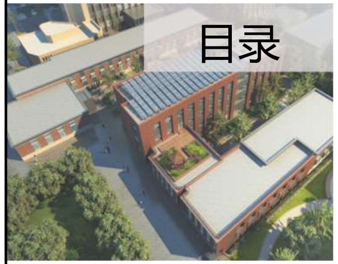


# 1 Development history of standard development

Mandatory standard | Nearly Zero Energy | General code | **Zero carbon**

**Ministry of Housing and Urban-Rural: Construction carbon peak implementation plan**

- Explore zero carbon community construction
- Promote large-scale development of low carbon buildings and encourage zero carbon buildings and nearly-zero energy buildings。
- Guide ultra-low energy buildings in cold areas to no longer use municipal central heating
- Encourage the construction of zero carbon agricultural housing by 2030.
- Develop and improve standards for zero carbon buildings.








## 2 Major technical measures

Building envelope | Energy equipment | Heat pump | Building photovoltaic

- Vacuum insulation board, aerogel board and other new insulation materials gradually applied; The new insulation system (insulation structure integration) is becoming mature.
- In recent years, the performance of the mainstream exterior window has decreased from 3.0W/ (m·K) to 2.0W/ (m·K). The heat transfer coefficient of the high-performance external window reaches 0.8~1.2W/ (m·K), and the cost is reduced by more than 50%.
- External window sunshade technology and products have made remarkable progress, and their applications are becoming more and more extensive. Air tightness, no thermal bridge, energy saving frame and other envelope construction and external window installation technology gradually popularized.

| | |
|---|---|
| EPS薄抹灰 | JG 149-2003 |
| 胶粉EPS颗粒保温浆料 | JGJ 144-2004 |
| EPS板现浇混凝土 | JG 158-2004 |
| EPS钢丝网架板现浇混凝土 | GB/T 20473-2006 |
| 机械固定EPS钢丝网架板 | GB 50404-2007 |
| 建筑保温砂浆 | |
| 喷涂PUR | |
| PUR板 | |

| | |
|---|---|
| 岩棉 | GB/T 25975-2010 |
| 水泥基泡沫保温板 | JC/T 2200-2013 |
| 真空绝热板 | JG/T 438-2014 |
| 酚醛板 | JC/T 2265-2014 |
| 泡沫玻璃 | JC/T 647-2014 |
| 泡沫陶瓷 | GB/T 33500-2017 |
| 热固EPS | JG/T 536-2017 |
| 保温装饰板 | JG/T 287-2013 |
| 保温防火复合板 | JGJ/T 350-2015 |

1995 | 2009 | 2014




## 2 Major technical measures

Building envelope | Energy equipment | Heat pump | Building photovoltaic

- On the basis of the substantial reduction in the energy load of the building body, efficient air conditioning equipment, energy recovery elevator, efficient lighting and other measures are adopted, combined with intelligent operation and maintenance, to reduce building energy consumption and carbon emissions.

**High energy efficiency equipment**

- First class energy efficiency cold source heat unit
- High efficiency heat recovery fresh air
- EC fan, High energy efficiency pump
- Energy feedback elevator

**High efficiency lighting system**

- Lighting power density value standard specified value below 70%
- intelligent lighting control, lighting energy saving more than 30%

**Intelligent operation and maintenance**

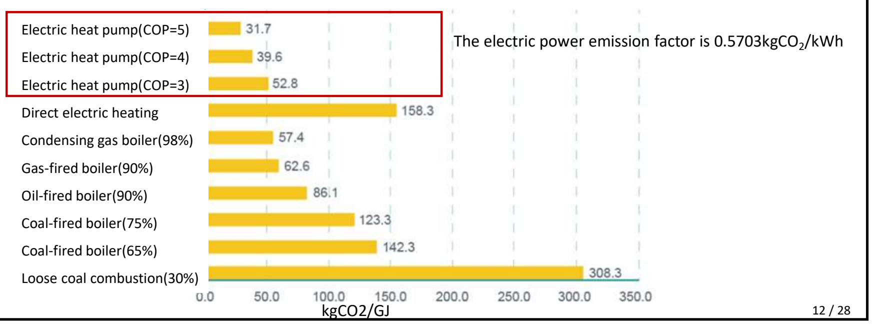
- Through the digital intelligent energy platform, we can better control the energy waste in the building operation process and reduce carbon emissions



## 2 Major technical measures

Building envelope | Energy equipment | Heat pump | Building photovoltaic

- Heat pumps are the best technical path to achieve zero carbon in the thermal field. According to the calculation of China's current power emission factor, when the efficiency of the heat pump reaches 5.0, the carbon emission is only 50% of that of the gas boiler, and the emission reduction potential will continue to increase with the continuous improvement of the cleanliness of the power grid..



## 2 Major technical measures

Building envelope | Energy equipment | Heat pump | **Building photovoltaic**

- The efficiency of photovoltaic modules continues to improve, the average photoelectric conversion efficiency of crystalline silicon reaches more than 20%, the film cell reaches about 13%, and the cost of photovoltaic modules continues to decline.

Single crystal silicon   Polycrystalline silicon

**【Product type】**Crystalline silicon includes monocrystalline silicon and polysilicon, which are solar cells made of high-purity monocrystalline silicon rods and are **mostly used for building roofing.**

**【efficiency】**In the crystalline silicon photovoltaic modules developed in the laboratory, the efficiency of monocrystalline silicon cells is the highest **25.0%**, and the efficiency of polycrystalline silicon cells is the highest **20.4%**.

Film module

**【Product type】**The common types of thin film batteries mainly include copper indium gallium selenium thin film batteries (CIGS), cadmium telluride thin film batteries (CdTe) and amorphous silicon thin film batteries, of which cadmium telluride thin film is the most commonly used.

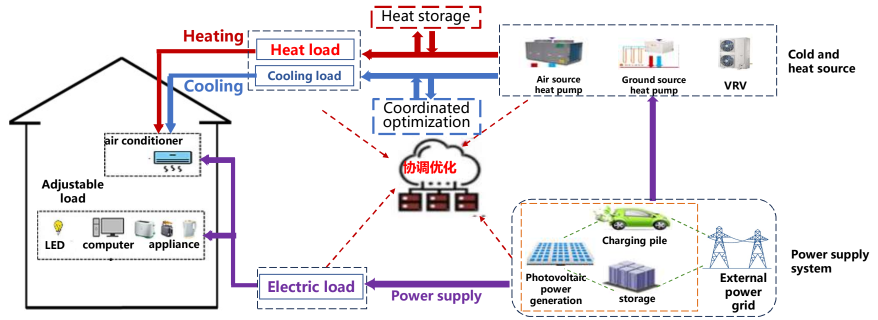
**【efficiency】**The efficiency of copper indium gallium selenium thin film (CIGS) cells is **19.6%**, cadmium telluride (CdTe) thin film cells is **16.7%**, and amorphous silicon (amorphous silicon) thin film cells are **10.1%**.



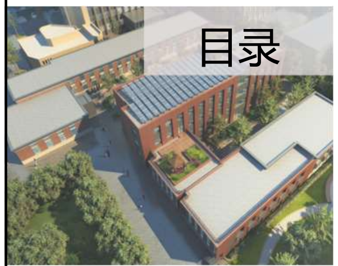
## 2 Major technical measures

Building envelope | Energy equipment | Heat pump | **Building photovoltaic**

- With the application of distributed energy system is gradually increasing, and the development of renewable energy application, energy storage technology and interaction technology with the power grid will accelerate.





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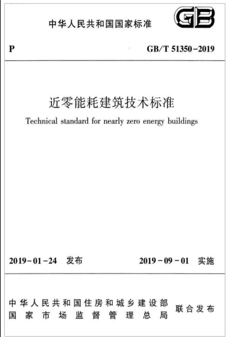
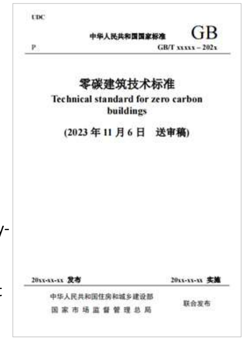
## 3 Science and technology research and development

**Two cases of science and technology research and development support standards**




- **Standard name:** Technical atandard for nearly zero energy buildings
- **Supporting project:** Nearly-ZEB key strategies and technologies development
- **Time period:** 2016-2019




- **Standard name:** Technical atandard for zero carbon buildings
- **Supporting project:** zero carbon building control indicators and key technologies.
- **Time period:** 2022-2025

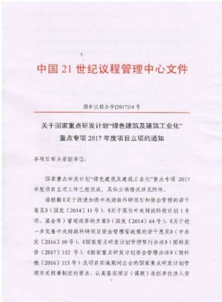
## 3 Science and technology research and development

### Case 1: Technical standards for nearly zero energy buildings

- The only voluntary standard supporting building energy efficiency to a higher level in the 13th Five-Year Plan green building and Building industrialization project: Nearly-ZEB key strategies and technologies development .
- The project focuses on the further improvement potential of major technical measures, the development of products with higher technical performance, and the study of energy-saving effects under different technology combinations.

**The 13th Five-Year National Key R&D Plan Project**

Program undertakers：China Academy of Building Research
承担单位：中国建筑科学研究院有限公司
Program period：2017/07~2020/12
项目执行周期：2017年7月至2020年12月
Research Fund: 120 Million RMB, Government Funds 33.73 Million RMB
项目经费总经费11973万元，其中专项经费3373万元
Participants unit：29 agencies 参与单位：29家
Projects：10 课题划分：10
Participants：143 researchers
项目参加人数：143人
Senior title: 75，Middle title: 54 PhD: 52，Master: 56


中国 21 世纪议程管理中心文件

国科议程办字[2017]14 号

关于国家重点研发计划"绿色建筑及建筑工业化"重点专项 2017 年度项目立项的通知

各项目牵头承担单位：

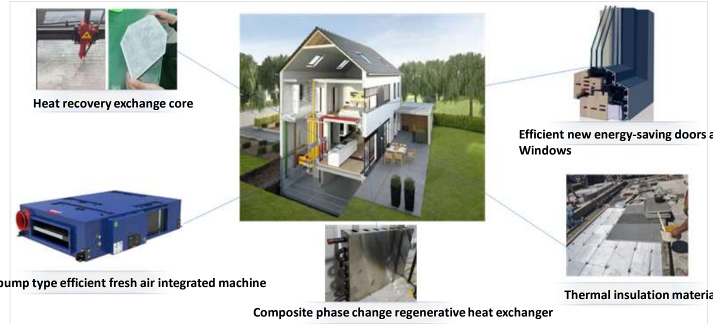
国家重点研发计划"绿色建筑及建筑工业化"重点专项 2017 年度项目立项工作已经完成，具体立项情况详见附件。



## 3 Science and technology research and development

### Case 1: Technical standards for nearly zero energy buildings

- The project completed a series of high performance key product parts 21 items. Research and development of thermal conductivity ≤0.0035W/m·K vacuum insulation external wall materials, overall thermal insulation coefficient K≤0.8W/(m²·K) doors and Windows, fresh air integrated machine and other core products, the performance indicators reached the international advanced level and 100% localization.

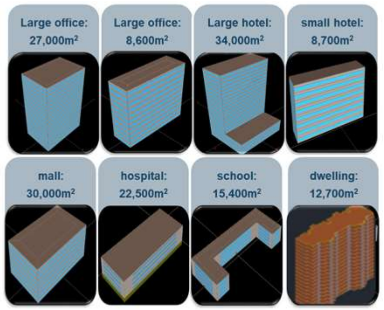


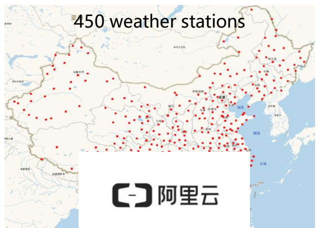



## 3 Science and technology research and development

### Case 1: Technical standards for nearly zero energy buildings

- The researchers conducted a comprehensive analysis of the technologies developed by the project team and industry-related energy-saving technologies, and sorted out the list of new technologies currently available in the industry.
- Eight typical building models are established, parameter indicators of new technologies are input into the calculation model, the energy-saving effects and economy of different technical measures on different buildings in different cities are calculated, and whether they are suitable for inclusion in the standard and the limit requirements for their performance parameters after inclusion in the standard are determined.




3 servers,
a total of 4300 hours,
450 cities to solve the technical and economic optimal solution



## 3 Science and technology research and development

### Case 1: Technical standards for nearly zero energy buildings

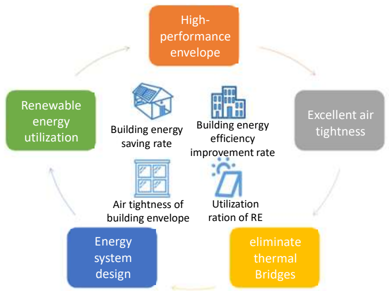
- Different from the prescriptive indicators of traditional energy efficiency standards, the indoor environment parameters and building energy efficiency indexes of near-zero energy consumption buildings are taken as the core discriminating conditions.
- The nearly zero energy building adopts the performance-based design method, and achieves the final energy efficiency goal through the way of "passive priority, active optimization, and renewable energy replacement".

**Residential building energy and air tightness index**

| | | | | | | |
|---|---|---|---|---|---|---|
| 建筑能耗综合值 | | ≤55 (kWh/ (m²·a))或≤6.8 (kgce/ (m²•a)) | | | | |
| 建筑本体性能指标 | 气候分区 | 严寒地区 | 寒冷地区 | 夏热冬冷 | 温和地区 | 夏热冬暖 |
| | 供暖年耗热量(kWh/ (m²·a)) | ≤18 | ≤15 | ≤8 | | ≤5 |
| | 供冷年耗冷量(kWh/ (m²·a)) | | | | | |
| | 建筑气密性（换气次数$N_{50}$） | ≤0.6 | | ≤1.0 | | |
| 可再生能源利用率（%） | | ≥10% | | | | |

**Public building energy and air tightness index**

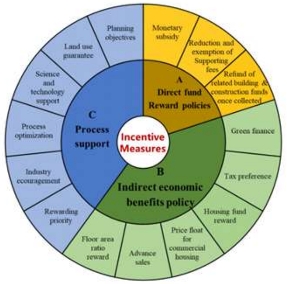
| | | | | | | |
|---|---|---|---|---|---|---|
| 建筑综合节能率（%） | | ≥60% | | | | |
| 建筑本体性能指标 | 气候分区 | 严寒地区 | 寒冷地区 | 夏热冬冷 | 夏热冬暖 | 温和地区 |
| | 建筑本体节能率（%） | ≥30% | | ≥20% | | |
| | 建筑气密性（换气次数$N_{50}$） | ≤1.0 | | —— | | |
| 可再生能源利用率（%） | | ≥10% | | | | |



## 3 Science and technology research and development

### Case 1: Technical standards for nearly zero energy buildings

- However, due to the application and implementation of nearly zero energy buildings need to increase investment in buildings, there are obstacles to their promotion.
- Therefore, in the early stage of promoting high-performance buildings such as near-zero energy buildings and zero-carbon buildings, local governments have provided some financial incentives or other process support to stimulate the enthusiasm of owners to build nearly zero energy buildings.



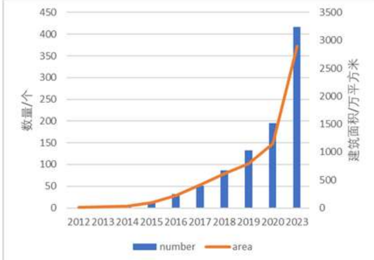

| | Policies / Provinces | He bei | He nan | Shan dong | Jiang su | Bei jing | Ning Xia | Urum qi | Tian jin | Hu bei | Hu nan | Shan xi | Guang dong | Shang hai | Number | Grade |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Planning objectives | | | | | | | | | | | | | | 30 | A |
| 2 | Monetary subsidy | | | | | | | | | | | | | | 25 | C |
| 3 | Floor area ratio reward | | | | | | | | | | | | | | 14 | B |
| 4 | Industry ecouragement | | | | | | | | | | | | | | 8 | A |
| 5 | Land use guarantee | | | | | | | | | | | | | | 8 | A |
| 6 | Advance sales | | | | | | | | | | | | | | 7 | B |
| 7 | Science and technology support | | | | | | | | | | | | | | 6 | A |
| 8 | Green finance | | | | | | | | | | | | | | 5 | B |
| 9 | Process optimization | | | | | | | | | | | | | | 4 | A |
| 10 | Price float for commercial housing | | | | | | | | | | | | | | 4 | B |
| 11 | Housing fund reward | | | | | | | | | | | | | | 4 | B |
| 12 | Reduction and exemption of supporting fees | | | | | | | | | | | | | | 3 | C |
| 13 | Rewarding priority | | | | | | | | | | | | | | 2 | A |
| 14 | Tax preference | | | | | | | | | | | | | | 2 | B |
| 15 | Refund of related building & construction funds once collected | | | | | | | | | | | | | | 1 | C |



## 3 Science and technology research and development

### Case 1: Technical standards for nearly zero energy buildings

- With the support of the policy, the scale of the near-zero energy building industry has gradually increased, and the incremental cost has gradually decreased.
- By the end of 2022, 30 million square meters will be promoted nationwide.




## 3 Science and technology research and development

### Case 2: Technical standards for zero carbon buildings

- During the "14th Five-Year Plan" period, in order to support the establishment of zero carbon building technology system and standard system, and promote the healthy development of zero-carbon buildings, the Ministry of Science and Technology has set up a national key research and development Plan project in 2022: Research and application of zero carbon building control indicators and key technologies.

**The 14th Five-Year National Key R&D Plan Project**

Program undertakers：China Academy of Building Research
承担单位：中国建筑科学研究院有限公司
Program period：2022/11~2025/10
项目执行周期：2022年11月至2025年10月
Research Fund: 23.96Million RMB, Government Funds 11.96 Million RMB
项目经费总经费2396万元，其中专项经费1196万元
Participants unit：10 agencies 参与单位：10家
Projects：5 课题划分：5
Participants：90 researchers
项目参加人数：90人
Senior title: 44，Middle title: 28 PhD: 24，Master: 53

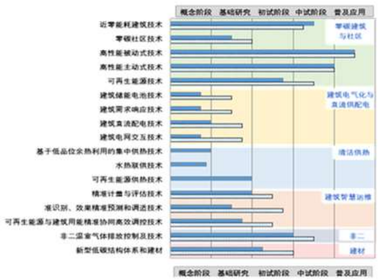



## 3 Science and technology research and development

### Case 2: Technical standards for zero carbon buildings

- Building energy efficiency and carbon reduction technologies continue to develop, but the demand for building use time and comfort gradually increases.
- The "14th Five-Year Plan" project will carry out research and development of a new generation of low-carbon technologies under the background of continuous improvement of power grid cleanliness, continuous improvement of heating heat source cleanliness, continuous enhancement of renewable energy utilization in buildings, and gradual improvement of building comfort.

1. Coordinated development of energy conservation and carbon reduction standards
2. Energy saving and carbon reduction technology maturity assessment
3. Energy structure transformation development trend
4. low carbon building and regional key technologies and future development
5. Research on key factors influencing building/regional carbon emissions
6. Building/district carbon emission control indicators

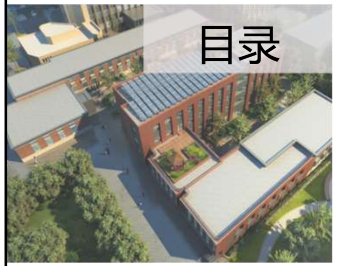


## 3 Science and technology research and development

### Case 2: Technical standards for zero carbon buildings

- The project team collected 16 buildings from across the country, covering all climate zones in China. Each building needs to demonstrate the application of a new technology, and provide long-term operation monitoring data to judge the implementation effect of the new technology.
- Technical measures with significant carbon reduction effects and high economic benefits will be included in the standard.



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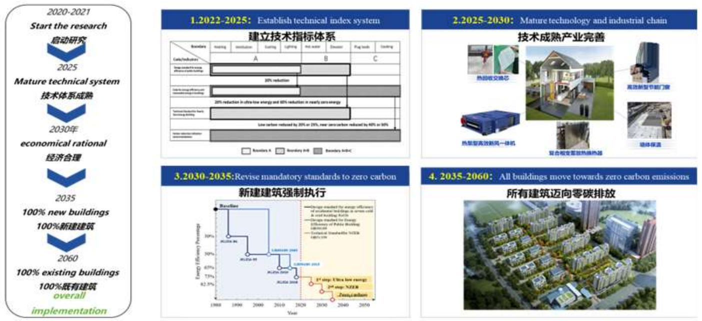
## 4 Promote and support policies

- A large number of monitoring data prove that nearly zero energy buildings and zero carbon buildings have remarkable energy-saving and carbon reduction effects.
- Promoting the large scale development of nearly zero energy buildings and zero carbon buildings has been included in a number of central government documents.

| No. | Issued department | Policy | Date | Main content |
|---|---|---|---|---|
| 1 | CPC Central Committee The State Council | Opinions on Fully, Accurately and Comprehensively Implementing the New Development Concept and Doing a Good Job in Carbon Peaking and carbon Neutrality | 2021.09 | Accelerate the large-scale promotion of **ultra low, nearly zero and low carbon buildings** |
| 2 | The State Council | Action Plan for Carbon Peak by 2030 | 2021.10 | Accelerate efforts to improve the energy efficiency of buildings and promote the large-scale development **of ultra-low-energy and low carbon buildings** |
| 3 | CPC Central Committee The State Council | Opinions on Promoting Green Development of Urban and Rural Construction | 2021.10 | Promote **ultra-low and nearly-zero energy buildings** and develop zero carbon buildings |
| 4 | 7 departments | Implementation Plan for Synergistic Efficiency in Pollution Reduction and Carbon Reduction | 2022.06 | Take multiple measures to increase the proportion of green buildings and promote the large-scale development of ultra-low-energy buildings and **nearly-zero carbon building** |
| 5 | Ministry of Housing and Urban-Rural Development National Development and Reform Commission | Action Plan for Carbon Peak in Urban and Rural Development | 2022.07 | promote the large-scale development of low carbon buildings and encourage the construction of **zero carbon buildings** and **nearly-zero energy buildings** |
| 6 | Ministry of Housing and Urban-Rural Development | 14th Five-Year Building Energy Efficiency and Green Building Development Plan | 2022.03 | Operation energy consumption was controlled at 1.15 billion tons of standard coal; Promote ultra-low energy buildings and zero carbon buildings, and comprehensively improve the development level of building energy efficiency and green buildings. |
| 7 | Ministry of Housing and Urban-Rural Development | General Code for Energy efficiency and Renewable Energy Use in buildings | 2022.04 | Carbon intensity of new residential and public buildings was respectively reduced by an average of 40% based on the energy saving standards implemented in 2016, and the carbon intensity was reduced by 7kgCO2/(m²·a) |

## 4 Promote and support policies

- During the 14th five-year Plan period, a zero carbon building technology standard system will be established to guide buildings to save energy and reduce carbon.
- Nearly zero energy buildings have moved from pilot demonstration to large-scale promotion, and the government should increase policy support to further promote industrial development, so as to gradually incorporate relevant technical measures to achieve nearly zero energy and zero carbon buildings into mandatory standards.
- By 2030 to 2060, all new and existing buildings will have zero carbon emissions, and the construction sector will be carbon neutral.




Thank you for your attention!
Prof ZHANG Shicong
China Academy of Building Research
E-mail: zhangshicong01@126.com
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