

Presentation 1 (United States of America)



Performance Approaches Paving the Way for Innovative Technologies

Michael Tillou
Pacific Northwest National Laboratory



Topics

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



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

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

* 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



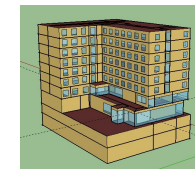
TSPR is the HVAC system performance for the whole building HVAC system (more like a seasonal heat pump rating than boiler efficiency)



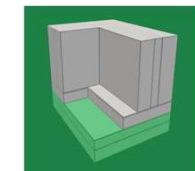
HVAC Total System Performance Ratio (TSPR)

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



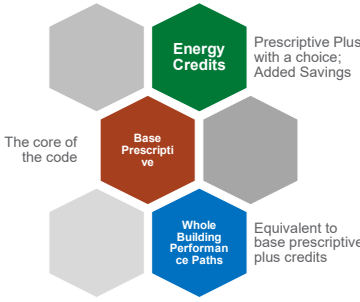
Block Based Simplified Model

Energy Credits



Energy Credits

How Do Energy Credits Fit?




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 its 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 <ul style="list-style-type: none"> • Envelope performance • UA reduction (15%)* • Envelope leak reduction* • Add roof insulation* • Add wall insulation* • Improve fenestration* 	 Lighting Measures <ul style="list-style-type: none"> • Lighting dimming & tuning • More occupancy sensors • Increase daylight area • Residential light control • Light power reduction
HVAC Measures <ul style="list-style-type: none"> • HVAC performance • Heating efficiency • Cooling efficiency • Residential HVAC control • Ground source heat pump* • DOAS/fan control 	 Power & Equipment Measures <ul style="list-style-type: none"> • Energy monitoring • Efficient elevator • Efficient commercial kitchen equipment • Residential kitchen equipment • Fault detection • Guideline 36 controls**
Water Heating Measures <ul style="list-style-type: none"> • 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 	 Renewable & Load Management Measures <ul style="list-style-type: none"> • 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



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

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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

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Thank you

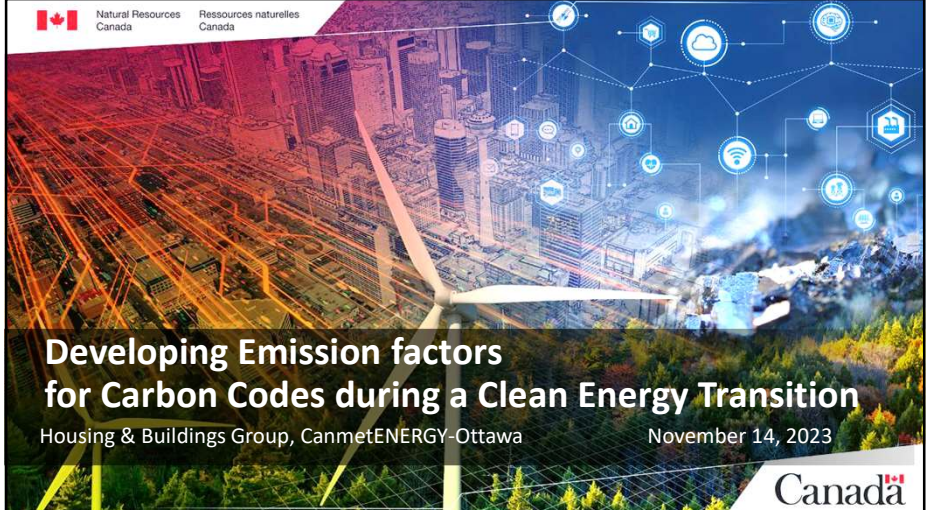
Presentation 2 (Canada)



Developing Emission factors for Carbon Codes during a Clean Energy Transition

Alex Ferguson
Natural Resources Canada


Natural Resources Canada / Ressources naturelles Canada



Developing Emission factors for Carbon Codes during a Clean Energy Transition

Housing & Buildings Group, CanmetENERGY-Ottawa

November 14, 2023



How will building codes adapt to changing energy supply?


Natural Resources Canada / Ressources naturelles Canada

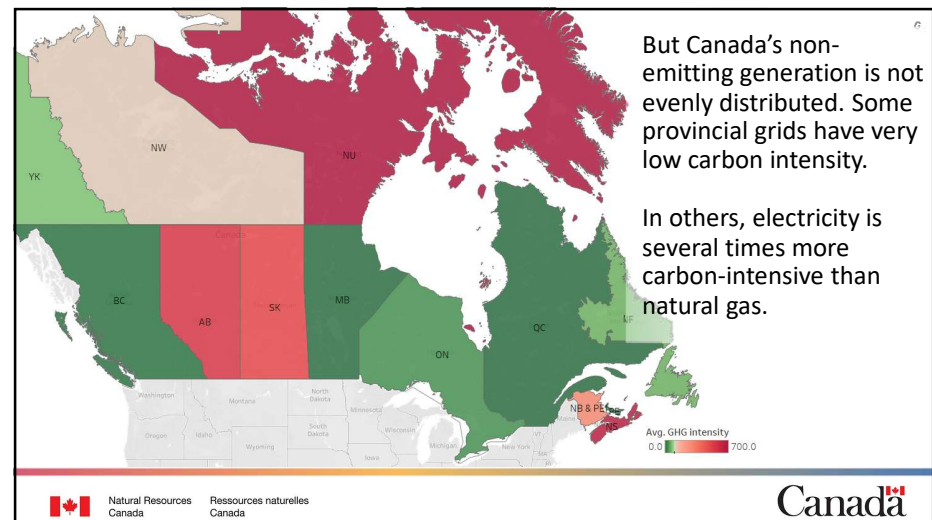
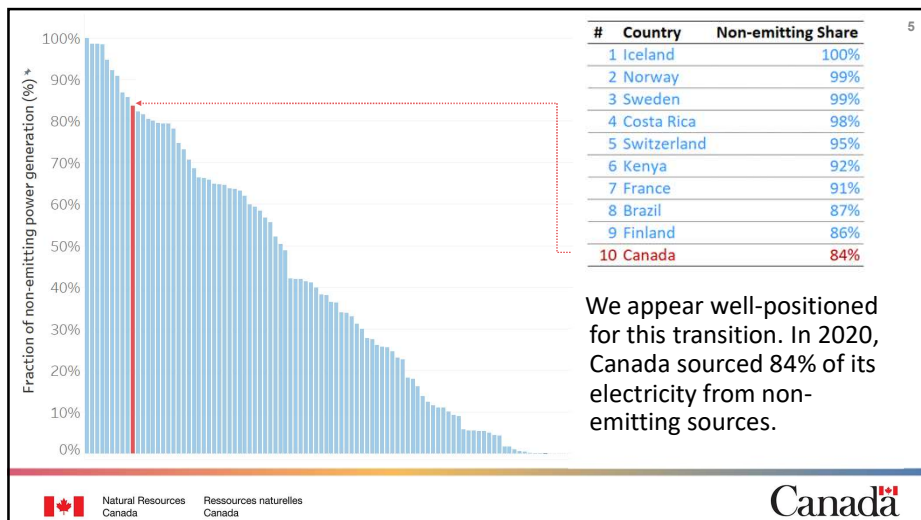


Canada is adapting our building codes to support carbon reduction policies.

Our approach is largely built on phasing out fossil-fuels with lower carbon alternatives.

Natural Resources Canada / Ressources naturelles Canada





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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 ?

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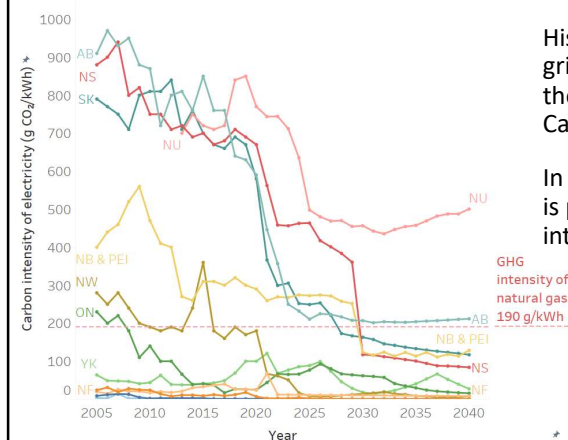
Low-carbon technology is expected disrupt other energy supply infrastructure as well. In Canada, renewable natural gas (sourced from biogenic or waste resources) is already blended into our gas networks. Hydrogen-blending pilots are also operating in some parts of the country.

Natural Resources Canada / Ressources naturelles Canada

GHG Intensity Factor: g CO₂-equivalent / kWh

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

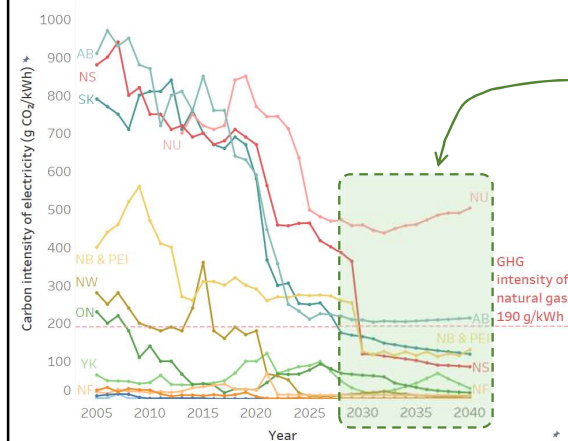
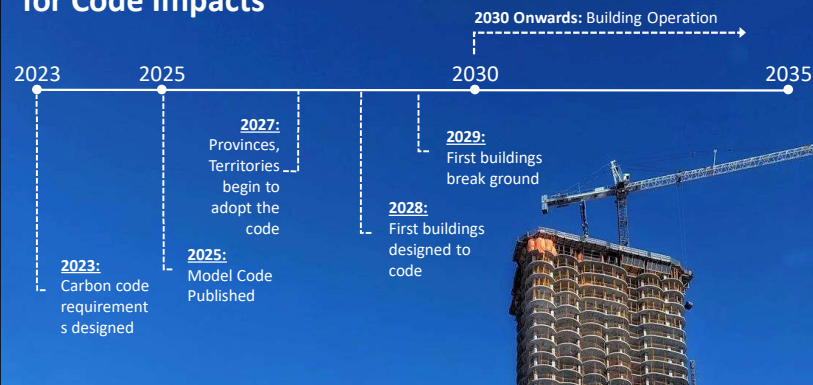
Most jurisdictions abstract utility emissions using a GHG intensity factor. Those factors reflect the mix of electricity supplied from fossil-fired and non-emitting sources.



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.

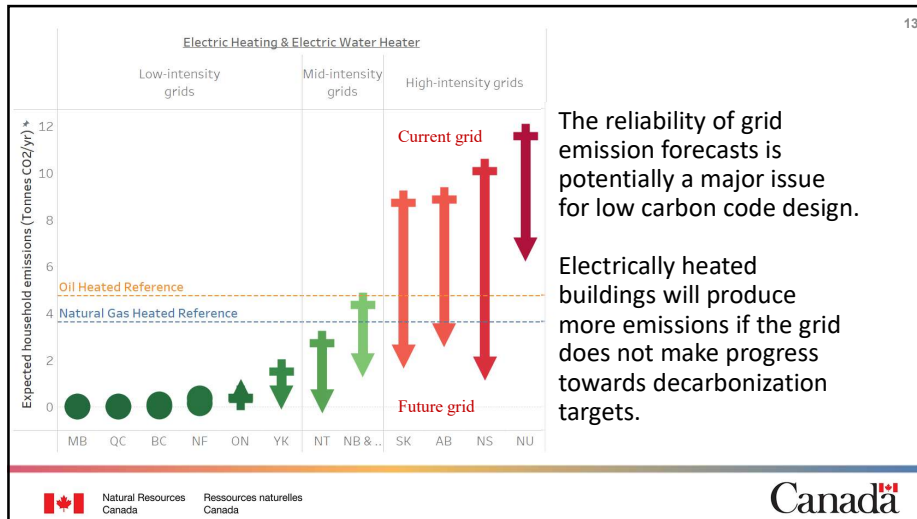
Timelines for Code Impacts



This is the most relevant period!

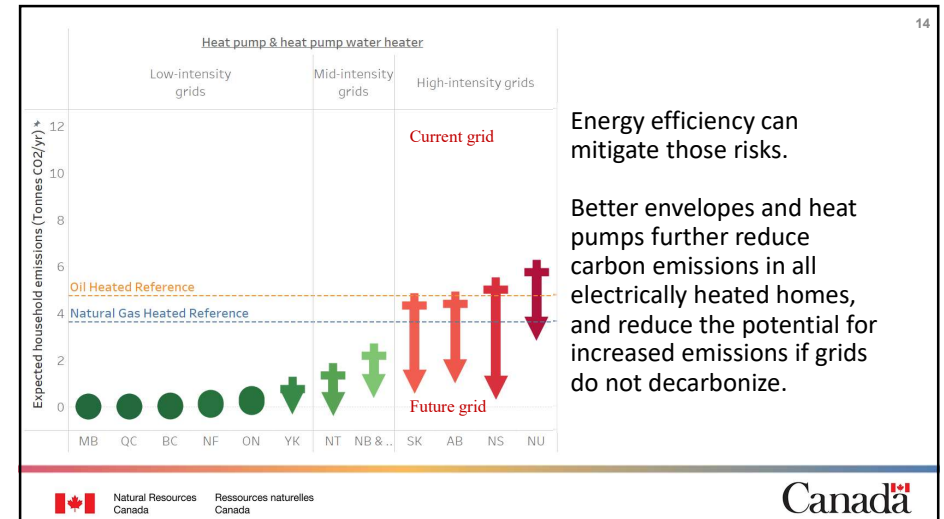
For effective code design, we need to know what the future energy system will look like.

Robust forecasts for 2030 and beyond are essential.



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.

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Conclusions

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

Canada

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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)

Canada

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Canada

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Presentation 3 (China)



From Energy Code to Carbon Standard

Zhang Shicong,
Institute of Building Environment and Energy



中国建筑科学研究院
China Academy of Building Research

China building energy efficiency and carbon reduction code & standard system

Prof ZHANG Shicong
China Academy of Building Research
E-mail: zhangshicong01@126.com



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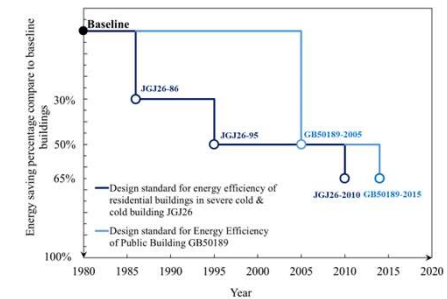
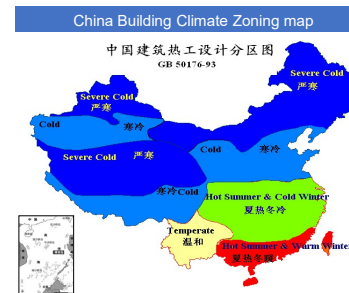
03 Science and technology support standard compilation

04 Promote and support policies

1 Development history of standard development

Mandatory standard	Nearly Zero Energy	General code	Zero carbon
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- In the early 1980s, the former Ministry of Construction began to organize the work of building energy efficiency, and has established an energy efficiency standard system that covers five climate zones, all types of buildings and the whole process of building.
- As of 2016, China's building energy standards have achieved 30%, 50%, and 65% improvement targets compared to benchmarks in the 1980s. In China's existing building stock, energy efficient buildings have exceeded 70%.



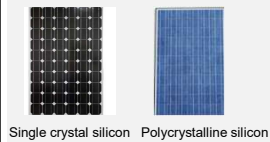


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2 Major technical measures

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.

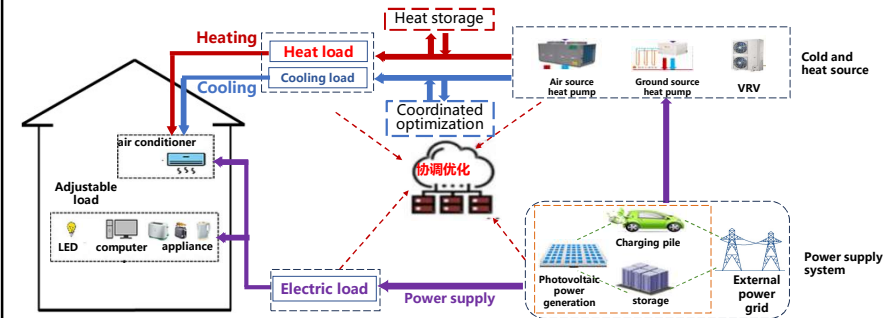
【efficiency】 The efficiency of copper indium gallium selenium thin film (CIGS) cells is **19.6%**, cadmium telluride (CdTe) thin film cells is **16.7%**, and amorphous silicon (amorphous silicon) thin film cells are **10.1%**.

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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.



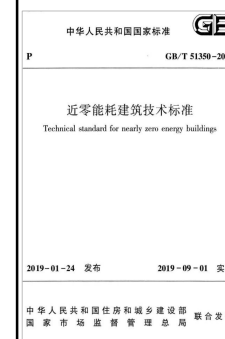
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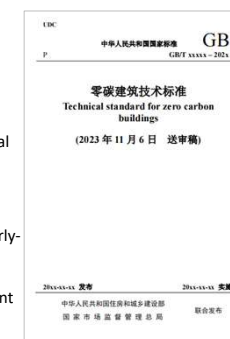
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3 Science and technology research and development

Two cases of science and technology research and development support standards



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



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

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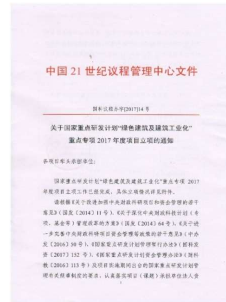
3 Science and technology research and development

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

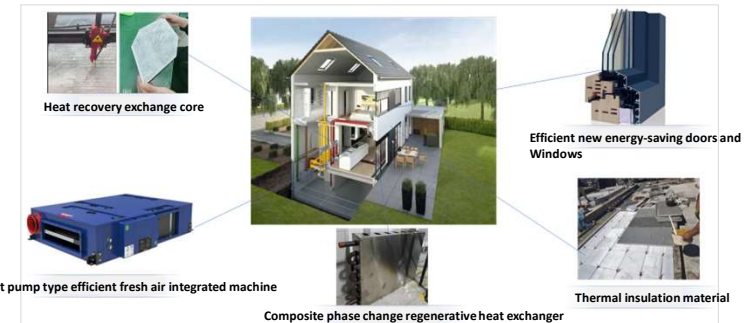


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3 Science and technology research and development

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 $\leq 0.0035\text{W/m}\cdot\text{K}$ vacuum insulation external wall materials, overall thermal insulation coefficient $K \leq 0.8\text{W}/(\text{m}^2\cdot\text{K})$ doors and Windows, fresh air integrated machine and other core products, the performance indicators reached the international advanced level and 100% localization.

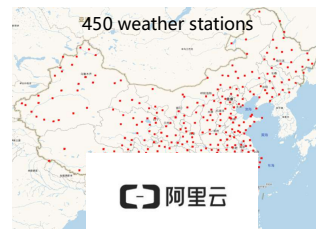
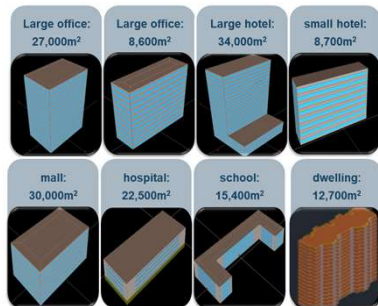


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3 Science and technology research and development

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

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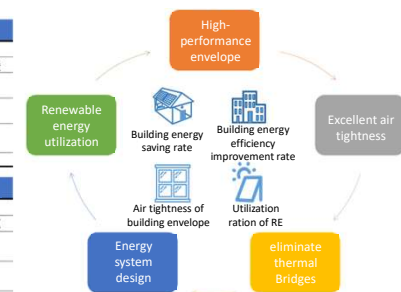
3 Science and technology research and development

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		$\leq 55 (\text{kWh}/(\text{m}^2\cdot\text{a}))$ 或 $\leq 6.8 (\text{kgce}/(\text{m}^2\cdot\text{a}))$			
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 $(\text{kWh}/(\text{m}^2\cdot\text{a}))$	≤ 18	≤ 15	≤ 8	≤ 5
	供冷年耗冷量 $(\text{kWh}/(\text{m}^2\cdot\text{a}))$				
	建筑气密性 (换气次数 N_{50})	≤ 0.6			≤ 1.0
可再生能源利用率 (%)		$\geq 10\%$			

Public building energy and air tightness index				
建筑节能率 (%)		$\geq 60\%$		
建筑本体性能指标	气候分区	严寒地区	寒冷地区	夏热冬冷 温和地区
	建筑节能率 (%)	$\geq 30\%$		$\geq 20\%$
	建筑气密性 (换气次数 N_{50})	≤ 1.0		
	可再生能源利用率 (%)	$\geq 10\%$		

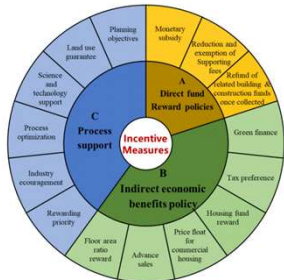


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3 Science and technology research and development

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.



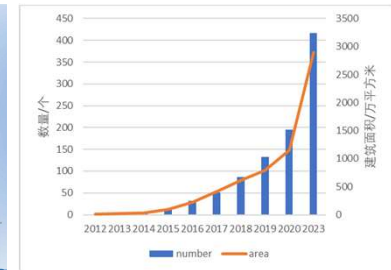
Policies	Heilongjiang	Henan	Shandong	Jiangsu	Beijing	Ningxia	Inner Mongolia	Tianjin	Shanghai	Guangdong	Shenzhen	Number	Grade
1 Planning objectives												30	A
2 Monetary subsidy												25	C
3 Floor area ratio reward												14	B
4 Industry encouragement												8	A
5 Land use guarantee												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 floor for commercial housing												4	B
11 Housing fund reward												4	B
12 Reduction and exemption of supporting fee												3	C
13 Rewarding priority												2	A
14 Tax preferences												2	B
15 Refund of construction funds once collected												1	C

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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.



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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



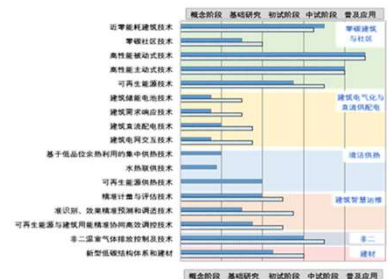
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3 Science and technology research and development

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.

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



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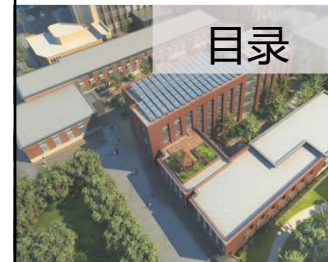
3 Science and technology research and development

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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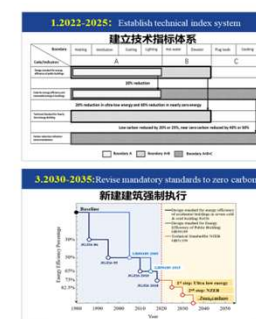
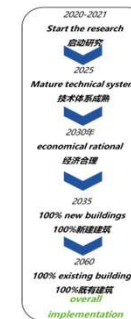
4 Promote and support policies

- 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.



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Thank you for your attention!

Prof ZHANG Shicong
China Academy of Building Research
E-mail: zhangshicong01@126.com