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Energy in Buildings and Communities Programme

Next Generation Building Energy Codes

Fifth EBC Building Energy Codes Working Group Symposium

14 November 2023, Beijing, China

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Welcome and Introduction

Xudong Yang
Tsinghua University

Meeting goals and overview of BECWG accomplishments and planned activities

Meredydd Evans
Pacific Northwest National Laboratory

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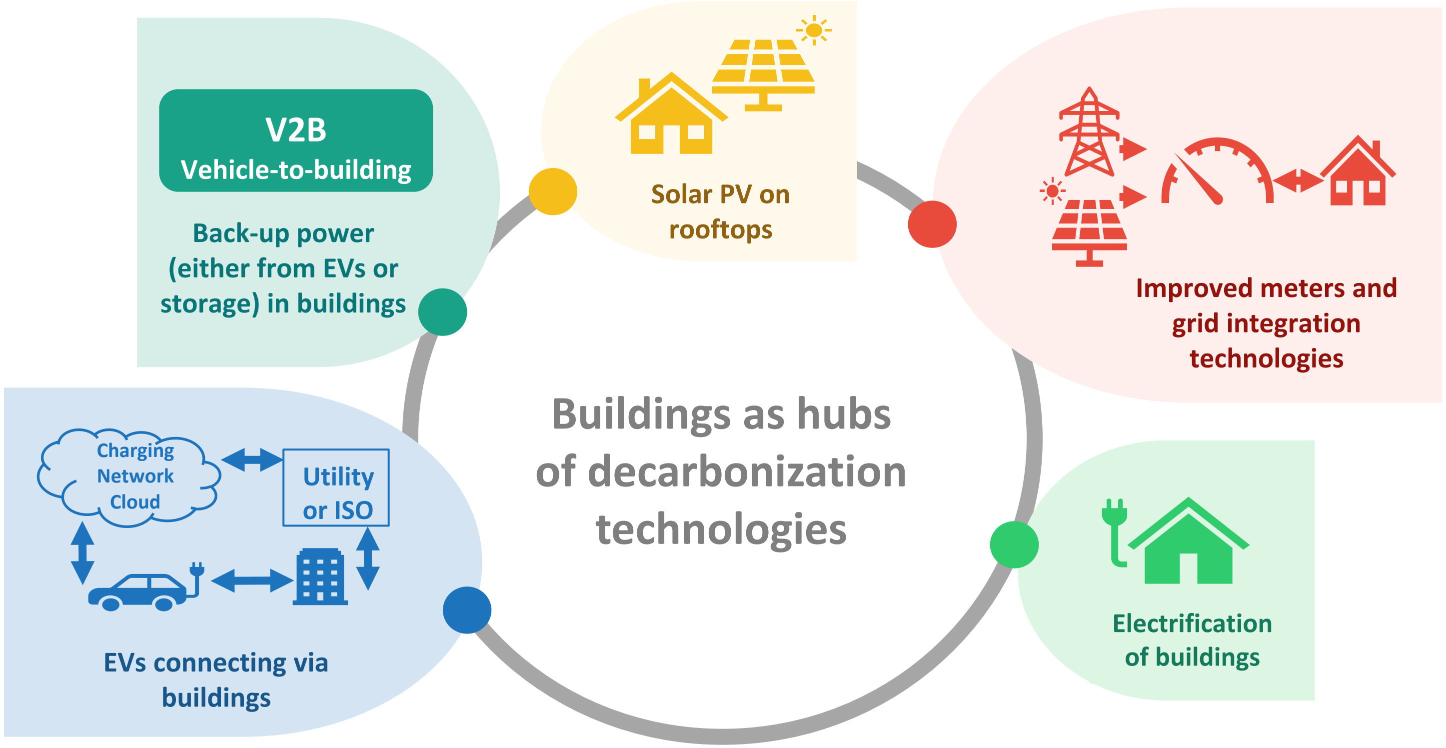
Meeting Objectives

1. Learn from countries' experiences and perspectives on building energy codes, particularly next-generation building energy codes and related issues
2. Develop key research questions and next steps for collaboration on building energy codes



Symposium Agenda

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

Symposium Agenda, contd.

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Session II. Performance Gaps in Building Energy Codes		
Moderator: Meli Stylianou, Natural Resources Canada		
15:45 – 16:55	*Introduction to Performance Gaps in Building Energy Codes*	Meli Stylianou, Natural Resources Canada
	Systems Performance and Gaps in Building Energy Codes	Meredydd Evans, Pacific Northwest National Laboratory
	Closing the building energy performance gap in Australia's commercial building sector	Helen Bell, Green Building Council of Australia
	State-of-the-art of Building Energy Efficiency Codes in China for Operation, Retrofitting, and Design	Qingpeng Wei, Tsinghua University
	Occupants and building codes: Challenges and future directions	Liam O' Brien, Carleton University
16:55 – 17:30	**Discussion**	Moderator: Meli Stylianou, Natural Resources Canada

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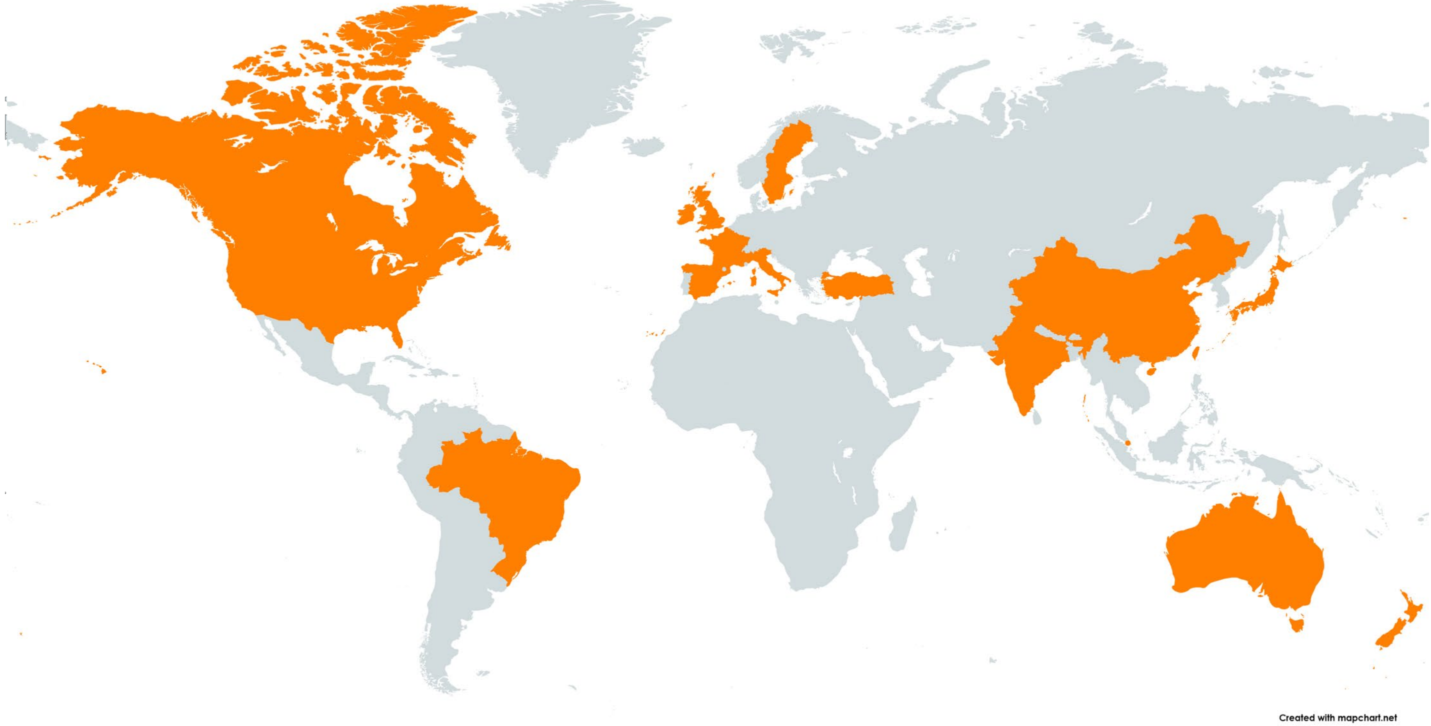
Symposium Agenda, contd.

Closing		
17:30 – 17:55	Key research questions and next steps for collaboration	Meredydd Evans
17:55 – 18:00	Concluding remarks	Meli Stylianou and Xudong Yang

IEA EBC Building Energy Codes Working Group

Types of exchange:

- ✓ Research/analysis on innovative code practices
- ✓ Webinars on latest code developments
- ✓ Quarterly newsletters highlighting BECWG activities and emerging research
- ✓ Outreach/dialog to disseminate findings and encourage improvements and innovation in practices
- ✓ Free and open access



18 member countries. 69 Working Group members/delegates and ~110 regular participants (webinars, newsletters)

https://www.iea-ebc.org/working-group/building-energy-codes

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BECWG Activities: Topical reports this year

The BECWG developed three topical reports in 2023:

1) Scan of code requirements to address GHG emissions - June 2023
2) Climate resilience in building energy codes - August 2023
3) New technology integration in building energy codes - November 2023

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International Energy Agency

EBC Working Group Final Report: Scan of Code Requirements to Address Greenhouse Gas Emissions

Energy in Buildings and Communities Technology Collaboration Programme

June 2023

BUILDING ENERGY CODES WORKING GROUP

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Resilience Issues in Building Energy Codes

August 2023

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International Energy Agency

Survey on New Technology Integration in Building Energy Codes

Energy in Buildings and Communities Technology Collaboration Programme

November 2023

Session 1: New Technology Integration in Building Energy Codes

Moderator:
Takao Sawachi

Michael Tillou
Pacific Northwest National Laboratory

Alex Ferguson
Natural Resources Canada

Zhang Shicong
Institute of Building Environment and Energy

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How "New Technologies" are dealt with in Building Energy Codes: Case Studies from 13 Countries

Takao Sawachi
Building Research Institute Japan

How ‘New Technologies’ are dealt with in Building Energy Codes: Case Studies from 13 Countries

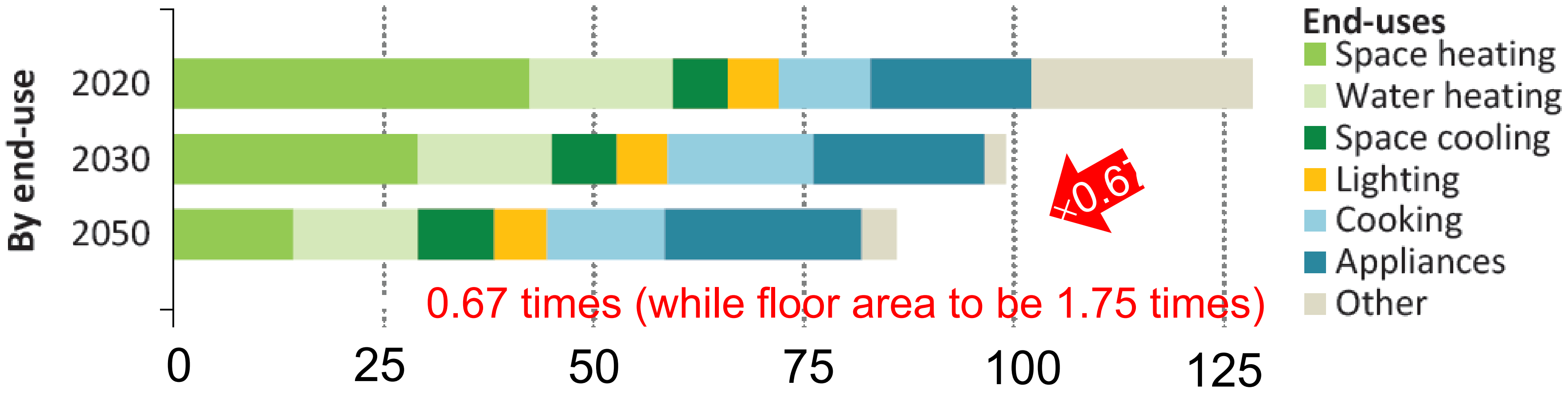
Dr. Takao Sawachi
Building Research Institute, Japan
EBC Executive Committee Member for Japan, Chair

EBC Building Energy Codes Working Group Annual Symposium
14th November 2023 in Beijing, China

Contents

1. About EBC Building Energy Codes Working Group

- Decarbonization to be realized by end-use energy reduction plus renewable energy supply.
- “Tighter building standard and codes” has been the first priority (IEA 2012).
- EBC has launched Building Energy Codes Working Group in 2019.



Source: Net Zero by 2050, IEA, May 2021

2. About 'New Technologies' for Building Energy Codes

- They are defined as technologies new for building energy codes.
- It means that well-known technologies, which cannot be evaluated in building energy codes, are also 'new technologies', here.
- For example, fuel cells for residential bldg. is not a new technology, but natural ventilation and CO_2 control ventilation for non-residential bldg. are new technologies for the Japanese building energy code.

3. Questionnaires asked to respondents of 13 countries

The primary objective of the questionnaire survey is to learn mutually experiences on how to deal with new technologies in building energy codes.

Responses from AU, BR, CA, CN, ES, FR, IN, IT, JP, NZ, PT, SG and US were received.

3. Questionnaires asked to respondents of 13 countries

List of 9 questions:

Question 1. Existence of a process to approve the integration of new technologies in building energy codes

If answer to Q1 is “Yes”,

Question 2. Brief description of the framework dedicated to the approval process of new technologies

Question 3. Links (URL) to documents related to the approval process

Question 4. Any barriers associated with integrating new technologies in building energy codes

3. Questionnaires asked to respondents of 13 countries

Question 5. Necessity of relevant testing standards for a new technology to be incorporated into the building energy codes

Question 6. Availability of building energy simulation software to assess the energy reduction by the new technologies

Question 7. Any procedures in place to validate the energy simulation software for the new technologies in building energy codes

3. Questionnaires asked to respondents of 13 countries

If answer to Q1 is “No”,

Question 8. Any barriers associated with integrating new technologies in building energy codes

Question 9. Any future plans to produce a process to approve the integration of new technologies in building energy codes

4. Key findings

- Existence of any system to integrate new technologies in building energy codes (Q1, Q2, Q3)
  - 11 countries have systems for new technologies, while 2 countries do not have.
  - Even for the countries without the system, codes are revised periodically.
  - Even for the countries with the system, it takes time (i.e., years) and cost to make new technologies integrated in building energy codes.
  - All countries have strict rules and systems to deal with proposed new technologies.

4. Key findings

- Barriers when new technologies to be integrated in building energy codes (Q4)
    - The current codes are not '*technology agnostic*' (not dependent on a particular kind of technology), and new technologies do not get '*level playing field*' (situation where all participants have an equal chance to succeed).
    - Because it is necessary to protect consumers (building owners, tenants, etc.), the process has to be cautious and slow. The model proposed by the developer sometimes cannot reflect the actual operation of the technology.
    - Some code is performance-based and therefore '*technology agnostic*', but it is not always possible to update relevant documents in a timely manner.

4. Key findings

- Needs for testing standards and other standards when evaluating new technologies (Q5)
  - Performance of new technologies is often not well understood. Testing and rating standards are often lacked. It is partly because the cost of standard development cannot be borne by the developers.
  - The schemes to support the demonstration of new technologies require IPMVP reports to validate the performance of the new technologies.

4. Key findings

- Energy simulation programs used in the evaluation of new technologies (Q6, Q7)
  - There are simulation programs used for building energy codes
  - ANSI/ASHRAE Standard 140, CIBSE TM33 and CIBSE AM11 are mentioned by plural countries as a requirement for validating energy simulation programs.
  - However, aspects of buildings and systems, which are dealt with in the above-mentioned documents for validation, are still very much limited. It is not possible to validate algorisms developed for new technologies by using the documents.
  - The validation of the simulation programs for new technologies has to be taken care of in their R&Ds.

4. R&D Activities and Building Energy Codes

- The Working Group of Building Energy Codes has been launched in EBC TCP because building energy codes are the most dependable tool to promote buildings of higher energy efficiency.
- The EBC TCP's Annexes are developing mainly practical guidelines and design tools for targeted technologies. It is strongly recommended that the targeted technologies are to be integrated in building energy codes.
- It is highly recommendable that the research plans of Annexes cover the development of relevant standards and the logic for estimating energy consumption by the technologies, so that the standards and logic can be utilized when the technologies are integrated in building energy codes.

Thank you very much for your attention

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Performance Approaches Paving the Way for Innovative Technologies

Michael Tillou
Pacific Northwest National Laboratory

Pacific Northwest
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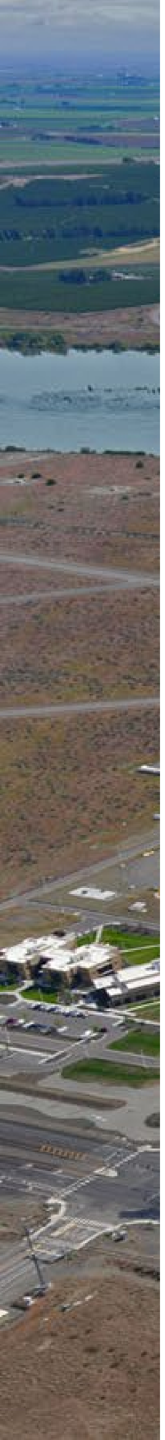
Performance Approaches Paving the Way for Innovative Technologies

EBC BECWG 5th Annual Symposium
November 14, 2023



U.S. DEPARTMENT OF ENERGY BATTELLE

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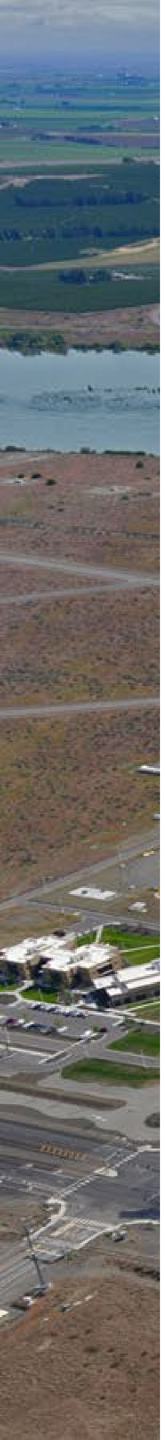
Topics

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

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



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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.

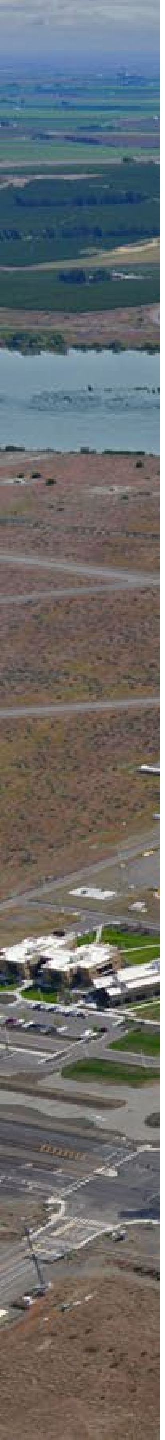
Performance based solutions currently adopted under United States energy codes

- **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.

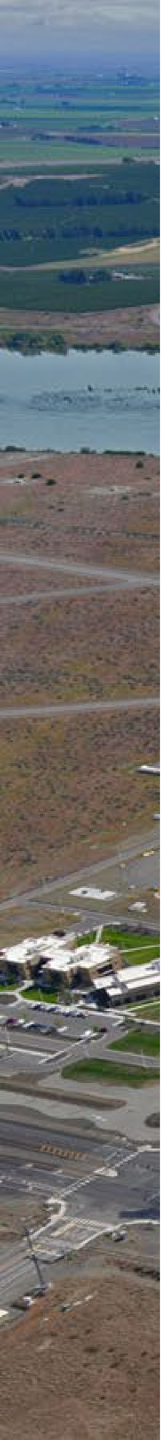
Why PRM?

- 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



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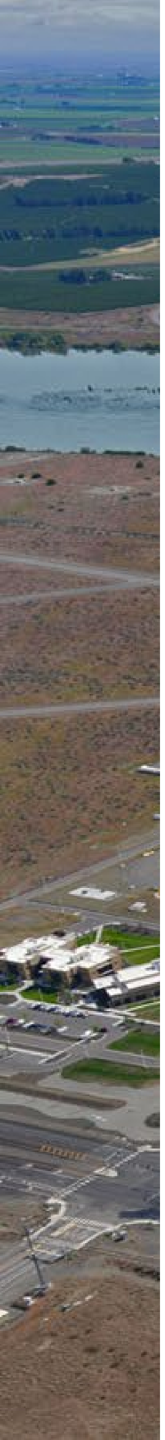
HVAC Total System Performance Ratio (TSPR)

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)

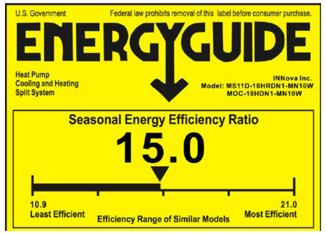
HVAC Performance Metric: Total System Performance Ratio

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

* 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 <u>whole building HVAC system</u>
(more like a seasonal heat pump rating than boiler efficiency)



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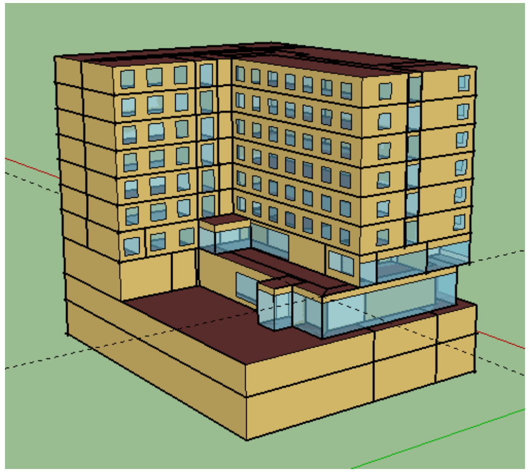
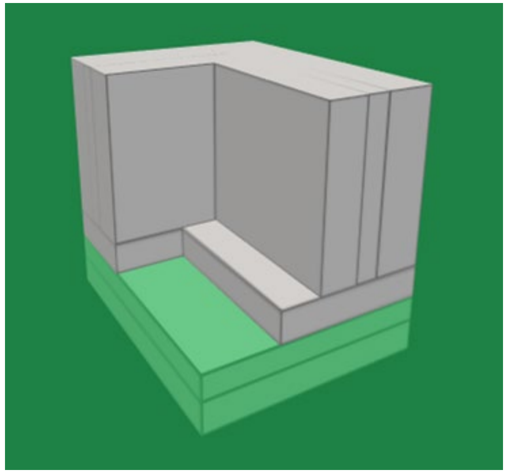
HVAC Total System Performance Ratio (TSPR)

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

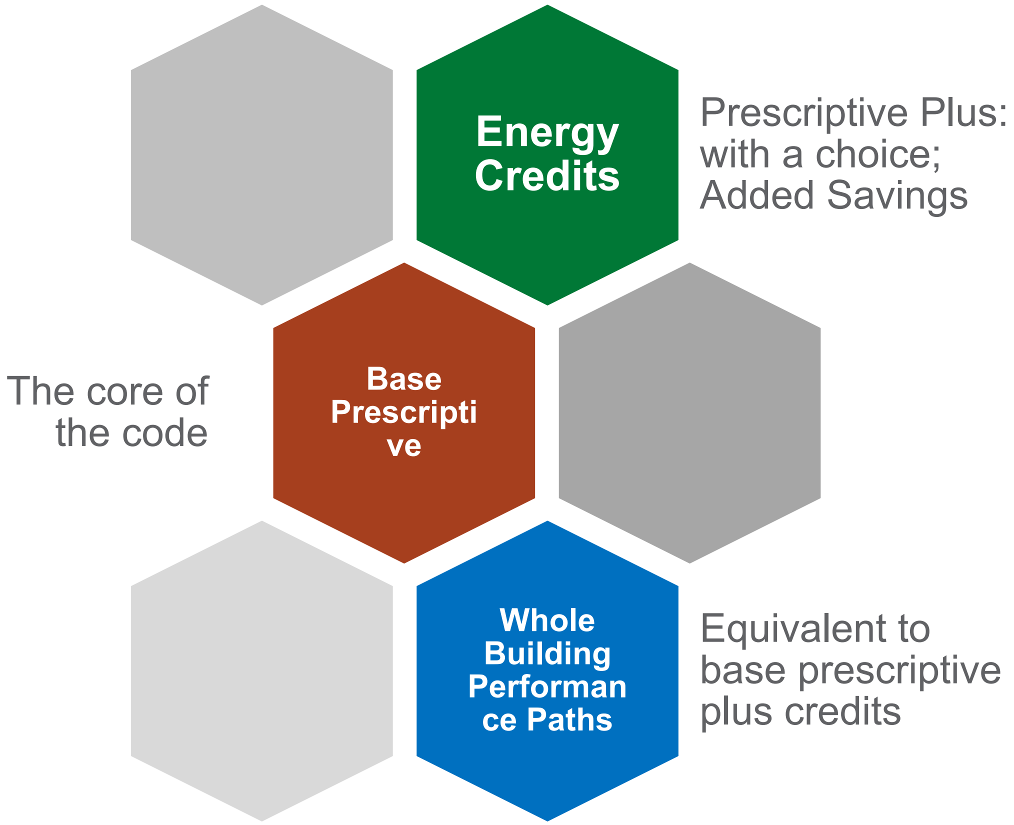


Block Based Simplified Model

Energy Credits

Energy Credits

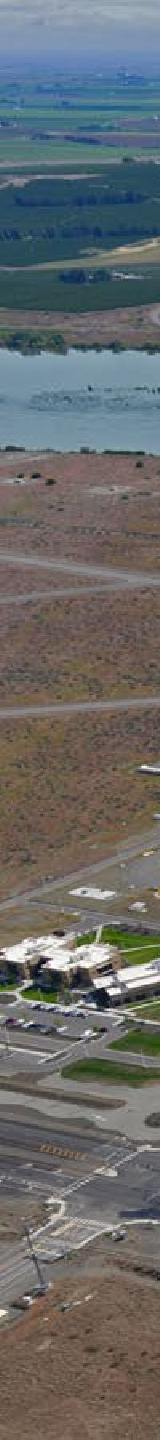
How Do Energy Credits Fit?



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 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

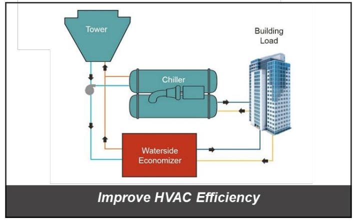
Water Heating Measures

- 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

**Only in IECC;*
***Only in Standard 90.1*

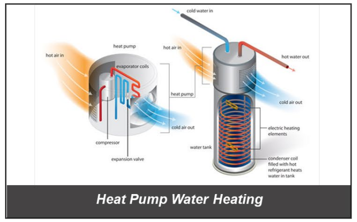
Improve Building Envelope

Improve Lighting



Improve HVAC Efficiency

Renewable Energy



Heat Pump Water Heating

Lighting Measures

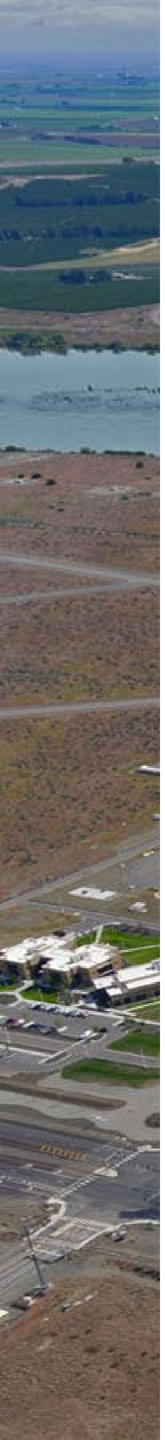
- Lighting dimming & tuning
- More occupancy sensors
- Increase daylight area
- Residential light control
- Light power reduction

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



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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

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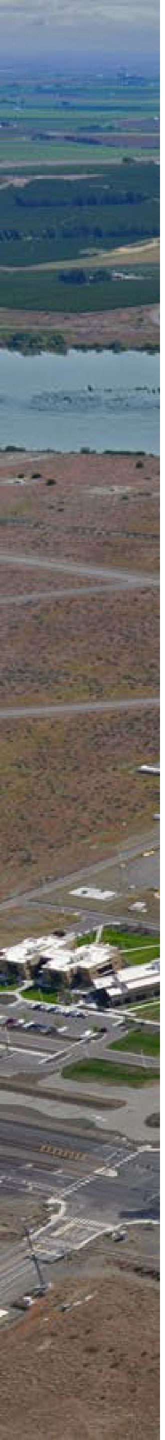
Summary

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

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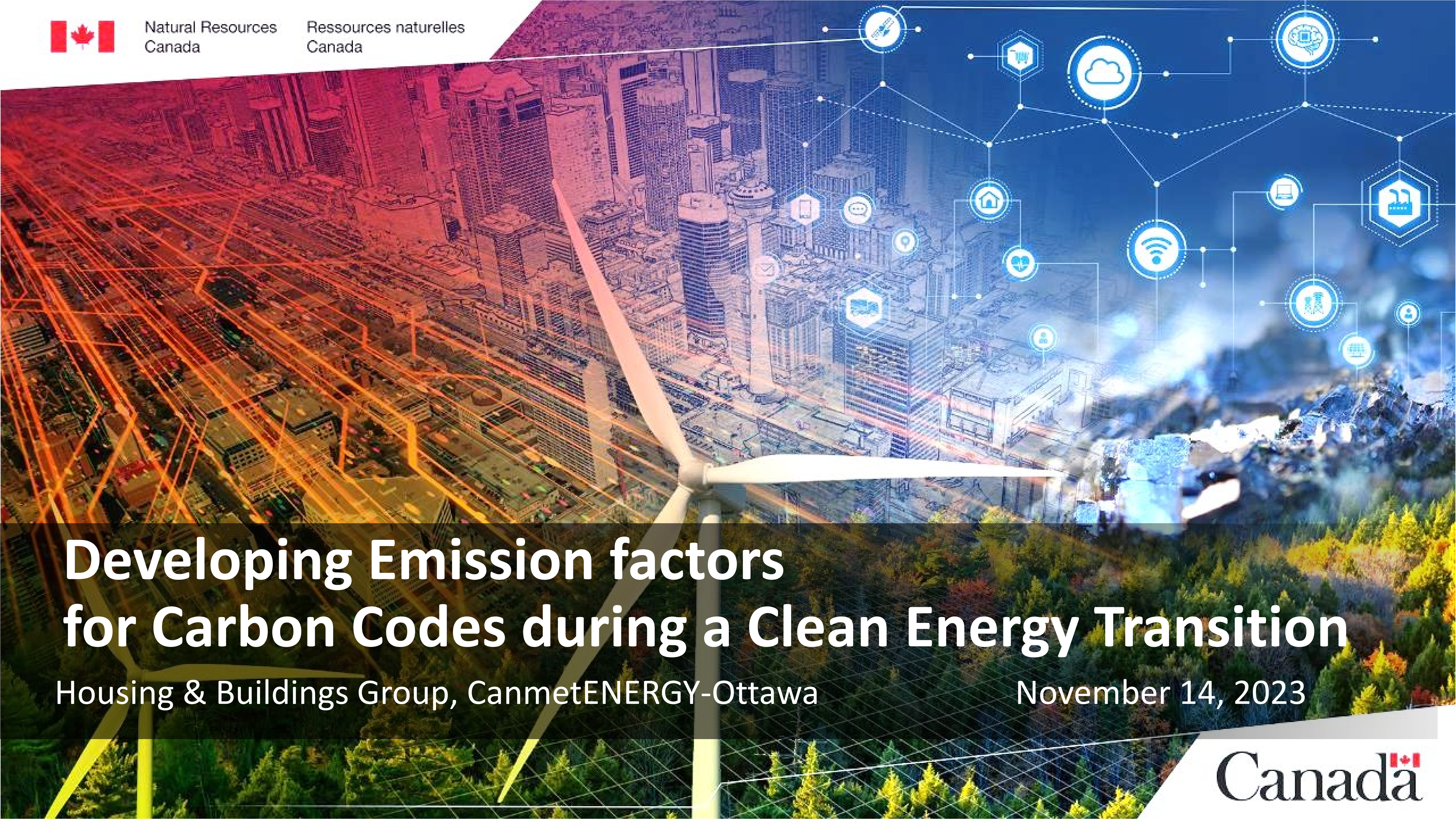
Developing Emission factors for Carbon Codes during a Clean Energy Transition

Alex Ferguson
Natural Resources Canada



Developing Emission factors for Carbon Codes during a Clean Energy Transition

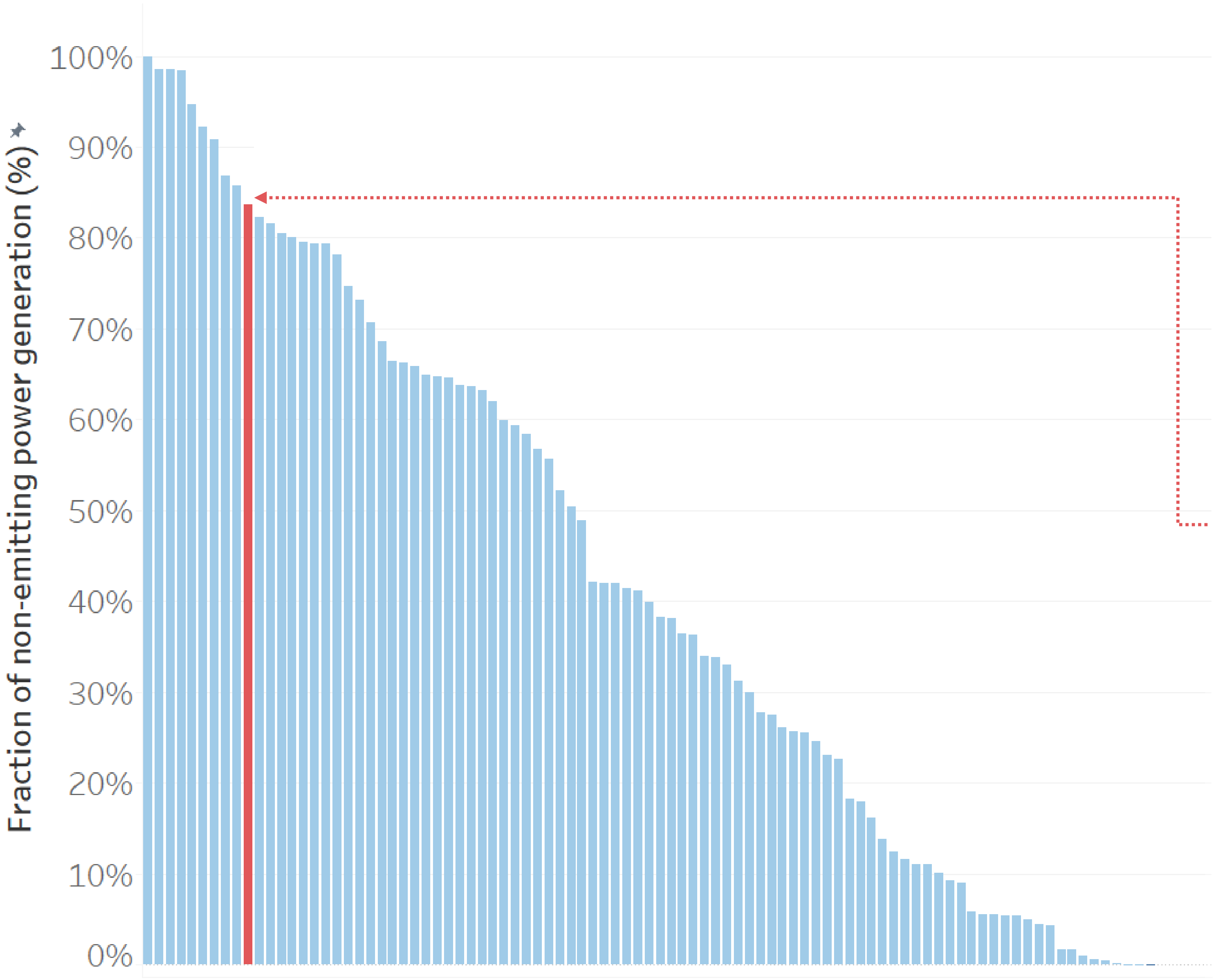
Housing & Buildings Group, CanmetENERGY-Ottawa

November 14, 2023

How will building codes code adapt to changing energy supply?

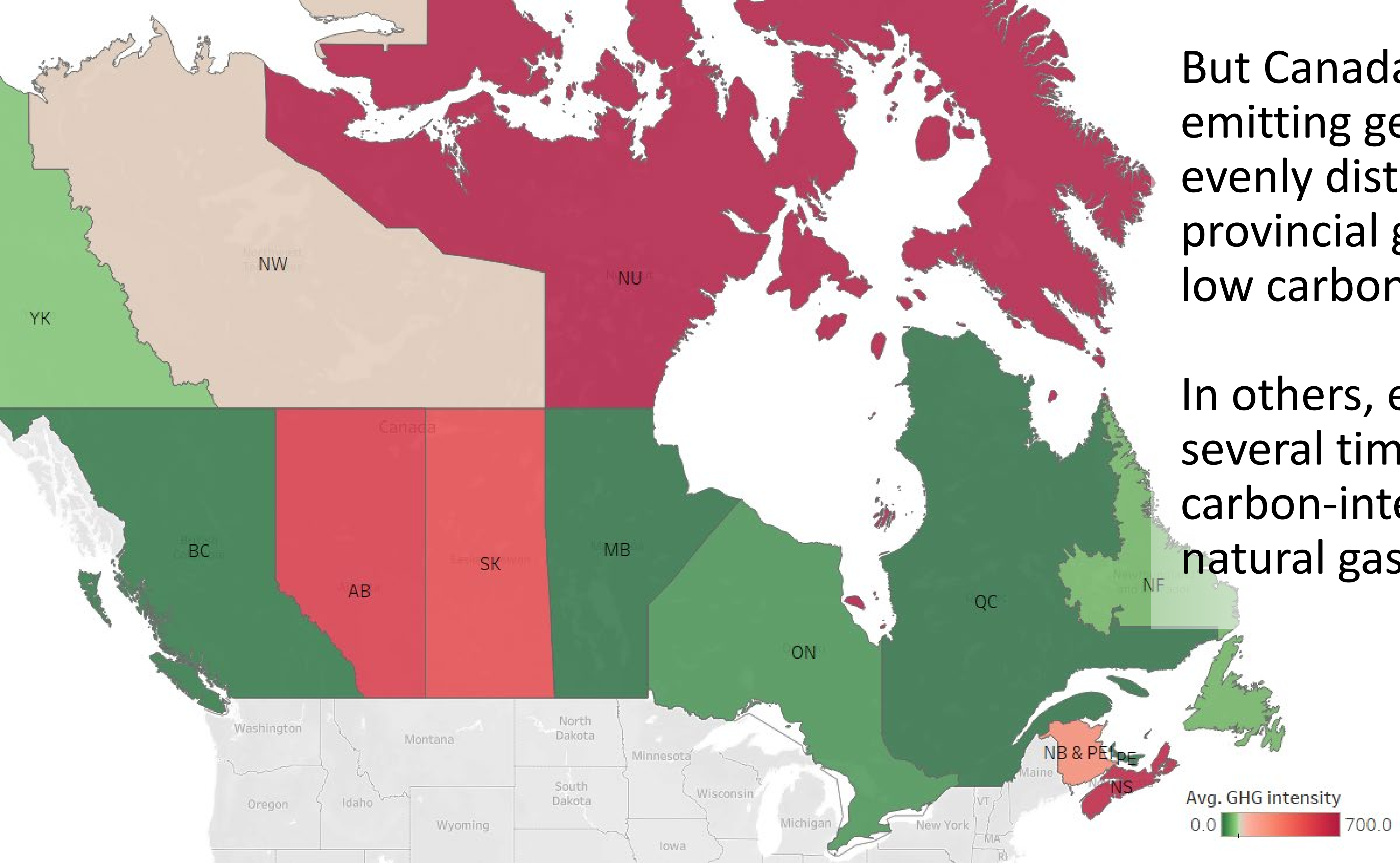
Canada is adapting our building codes to support carbon reduction policies.

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



#	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.



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.

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

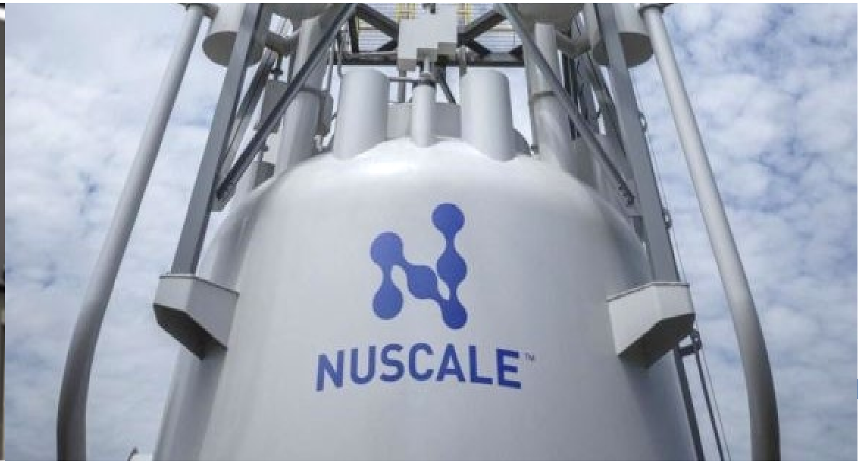
1) More Solar!

2) More Wind!

3) Enhanced Distribution!

4) Carbon Capture ?

5) Bio-energy ?



6) Small-scale nuclear ?

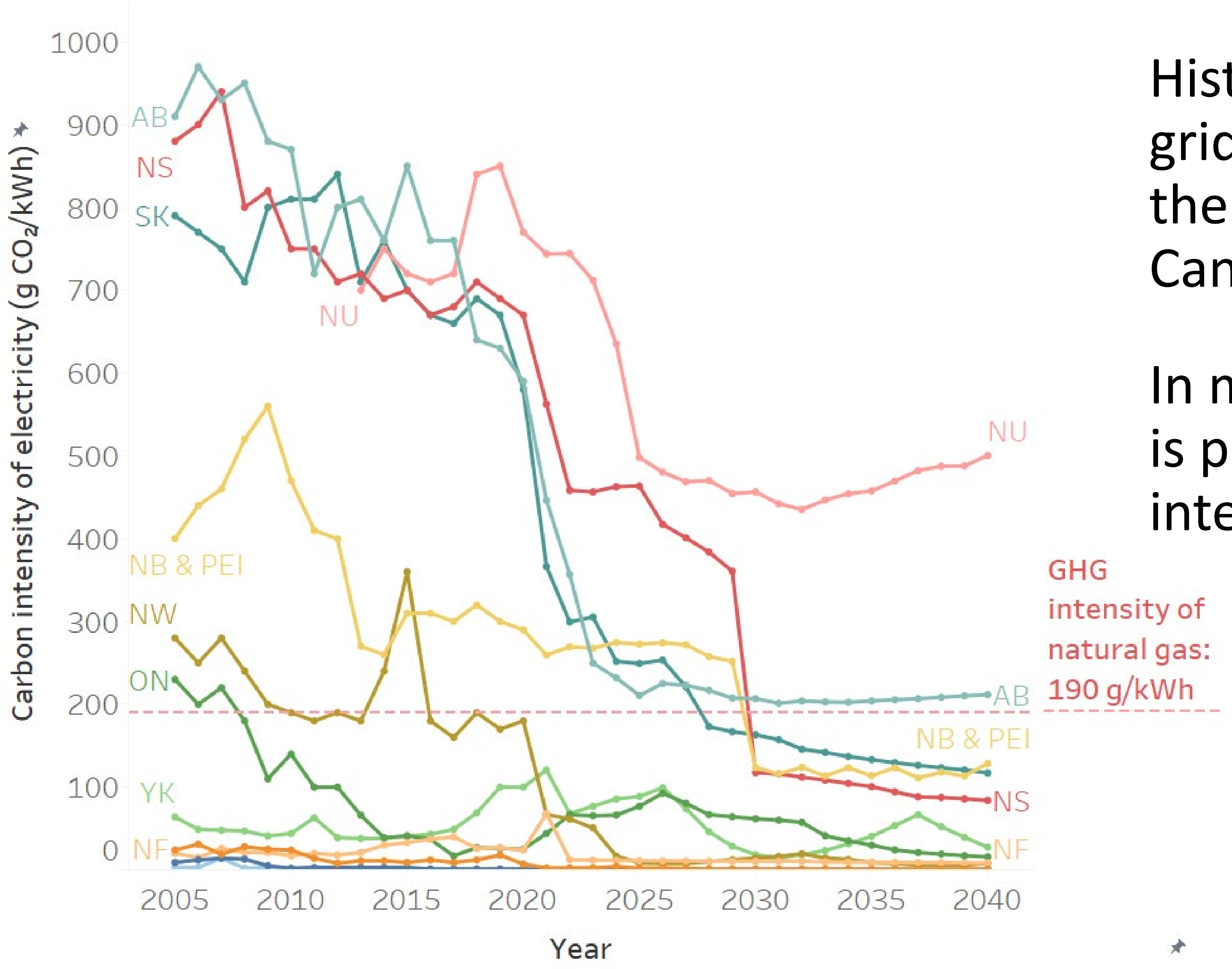
Low-carbon technology is expected disrupt other energy supply infrastructure as well. In Canada, renewable natural gas (sourced from biogenic or waste resources) is already blended into our gas networks. Hydrogen-blending pilots are also operating in some parts of the country.

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.

Timelines for Code Impacts

2030 Onwards: Building Operation

2023 — 2025 — 2030 — 2035

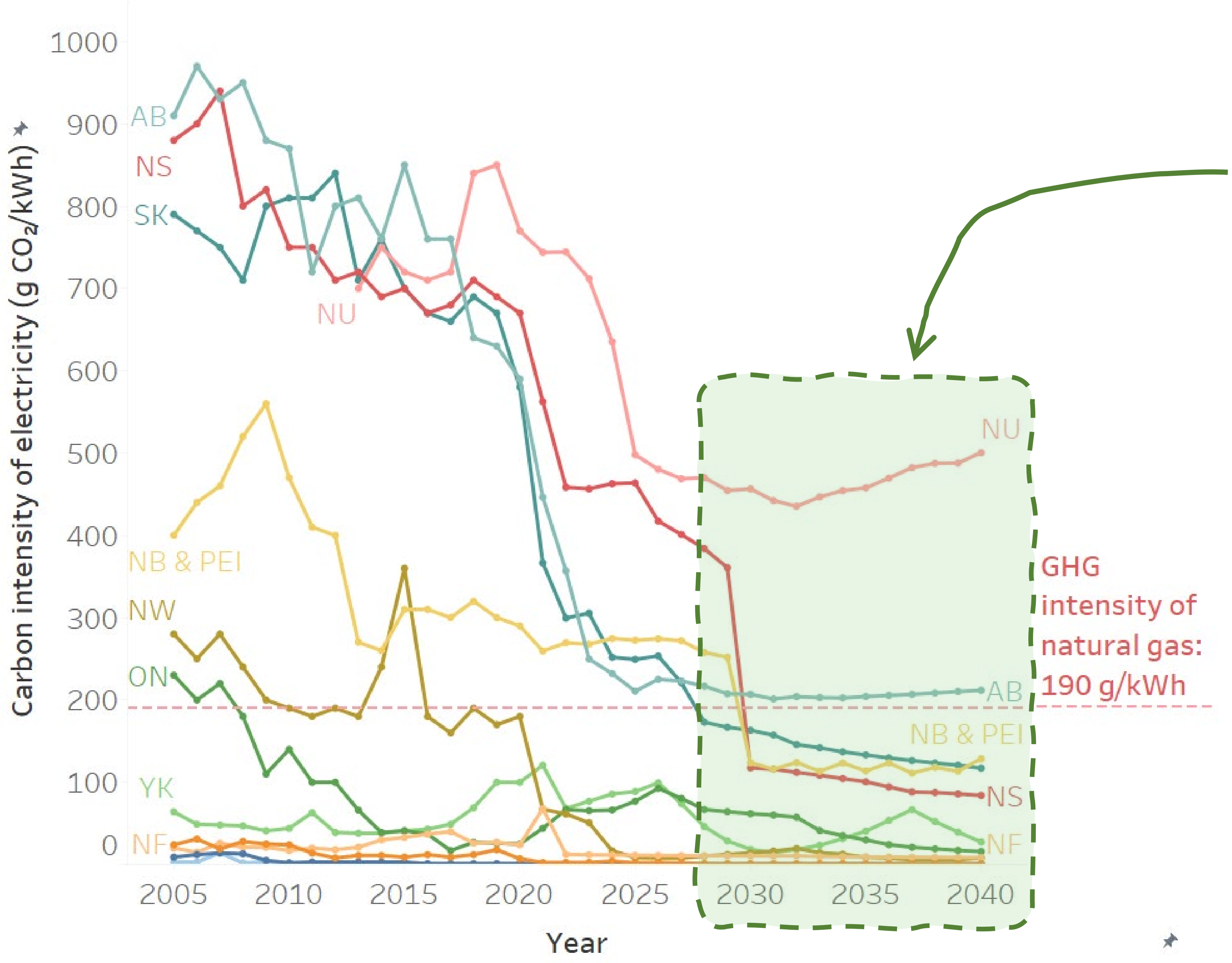
2023: Carbon code requirements designed

2025: Model Code Published

2027: Provinces, Territories begin to adopt the code

2028: First buildings designed to code

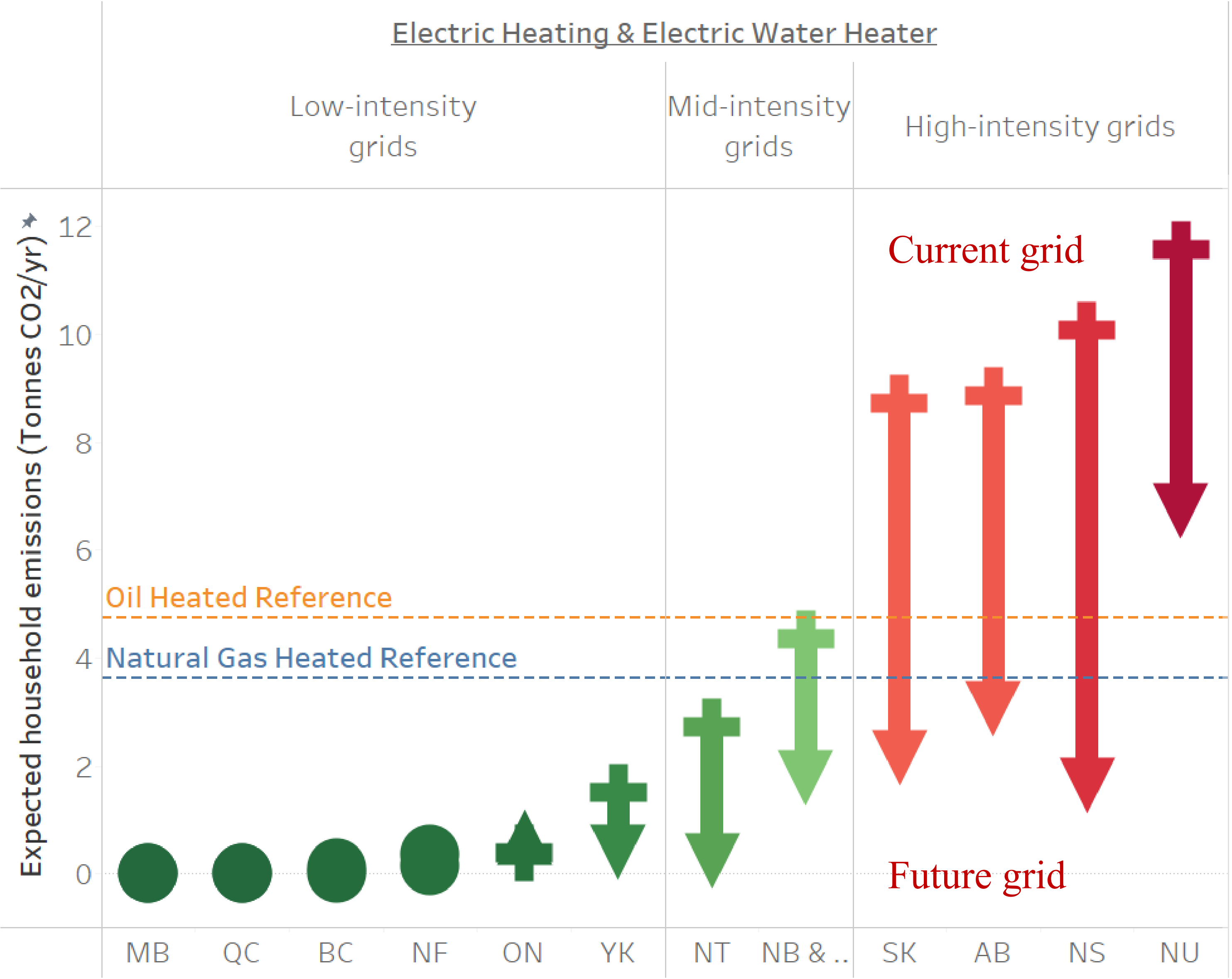
2029: First buildings break ground



This is the most relevant period!

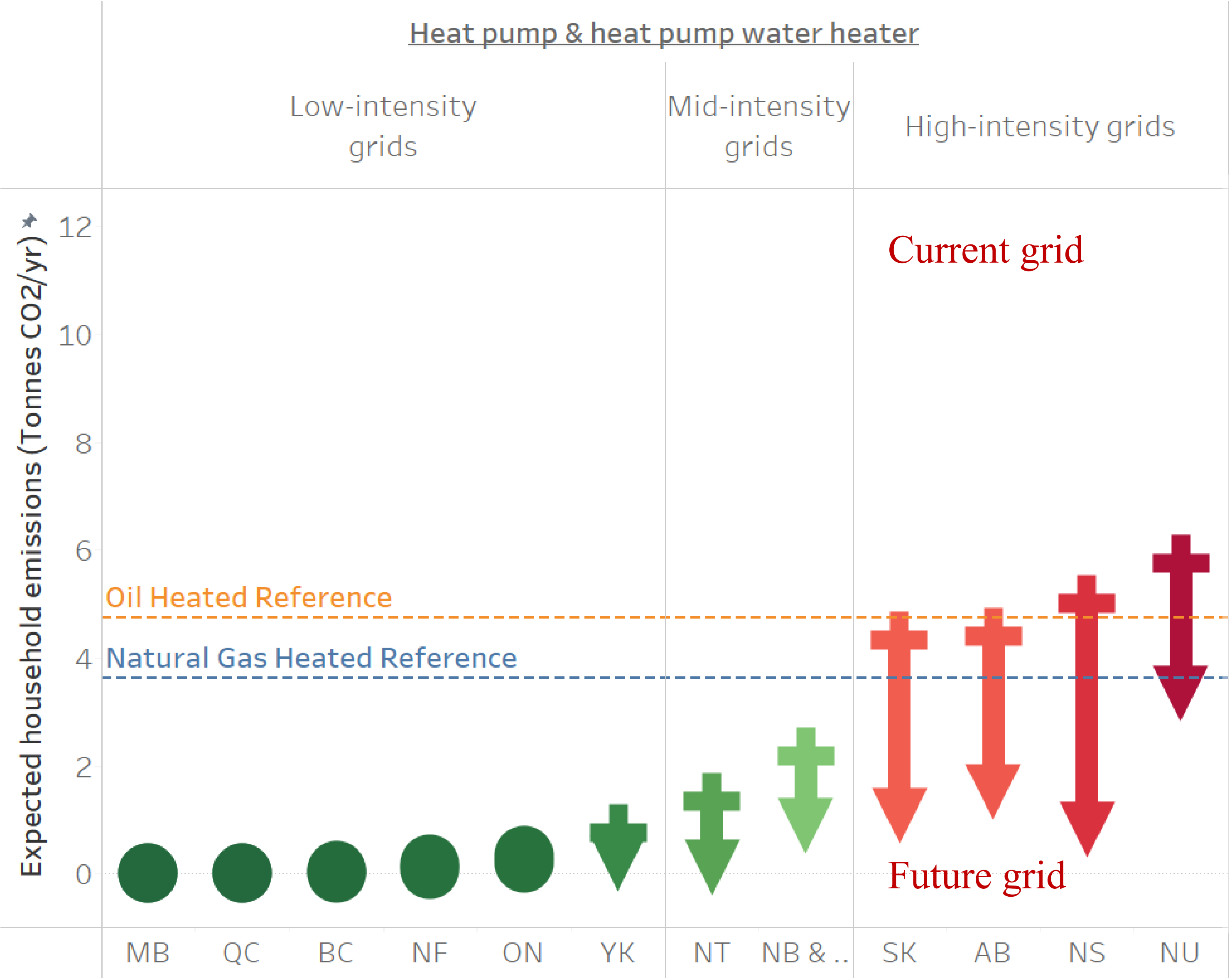
For effective code design, we need to know what the future energy system will look like.

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.

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:

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- Sébastien Brideau
- Sarah Brown
- Mark Carver
- Brock Conley
- Alex Ferguson
- Sara Gilani
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- Chris Kirney
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- Julia Purdy
- Navid Shirzadi
- Ali Syed
- Jessica Webster

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Energy in Buildings and Communities Programme

From Energy Code to Carbon Standard

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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

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China Academy of Building Research
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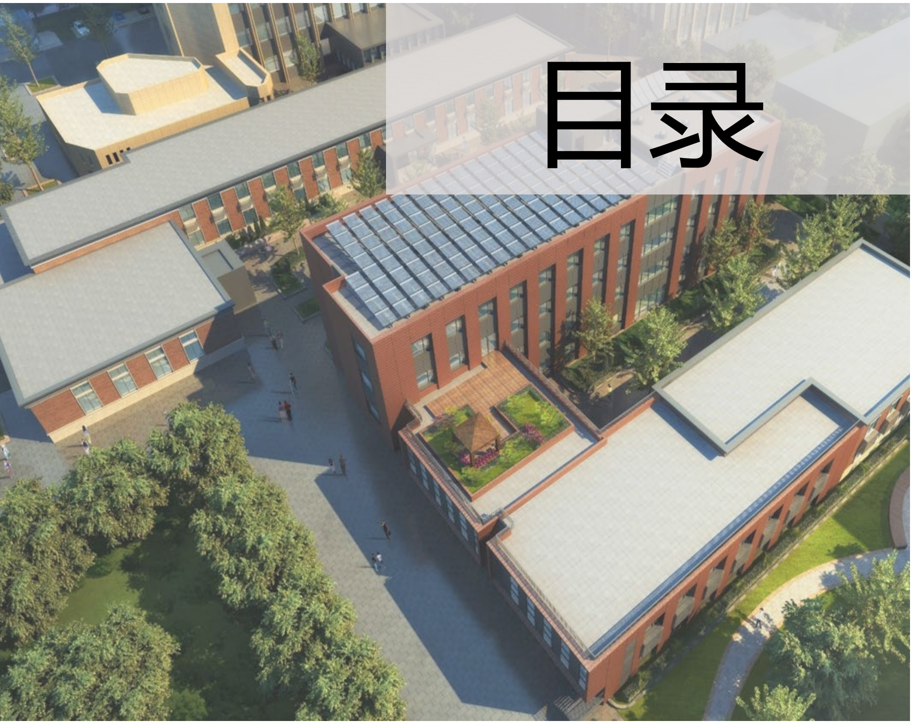
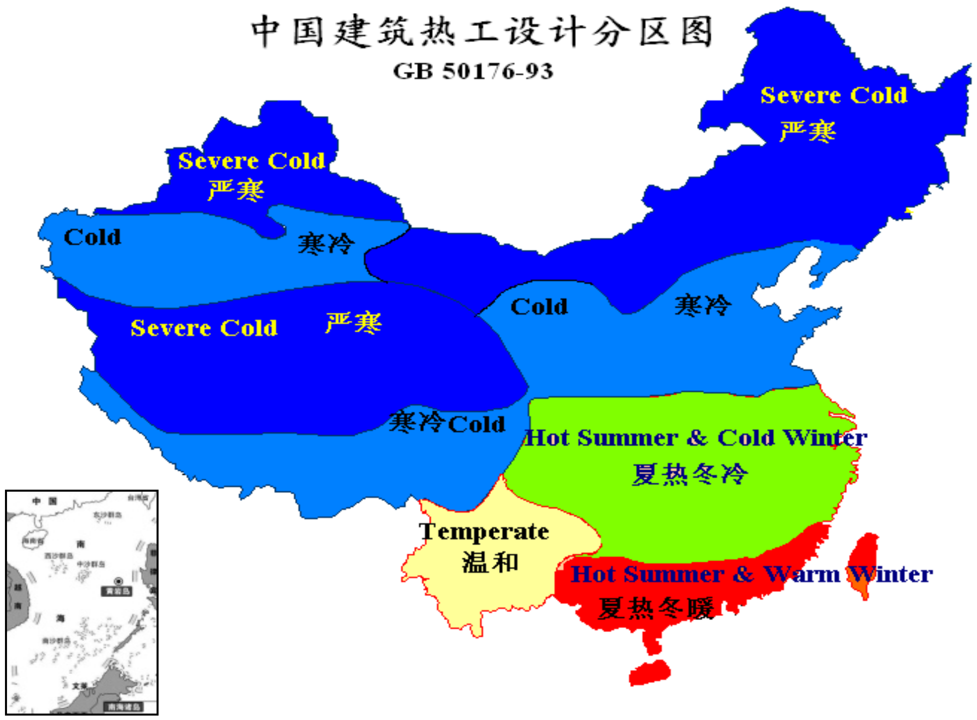


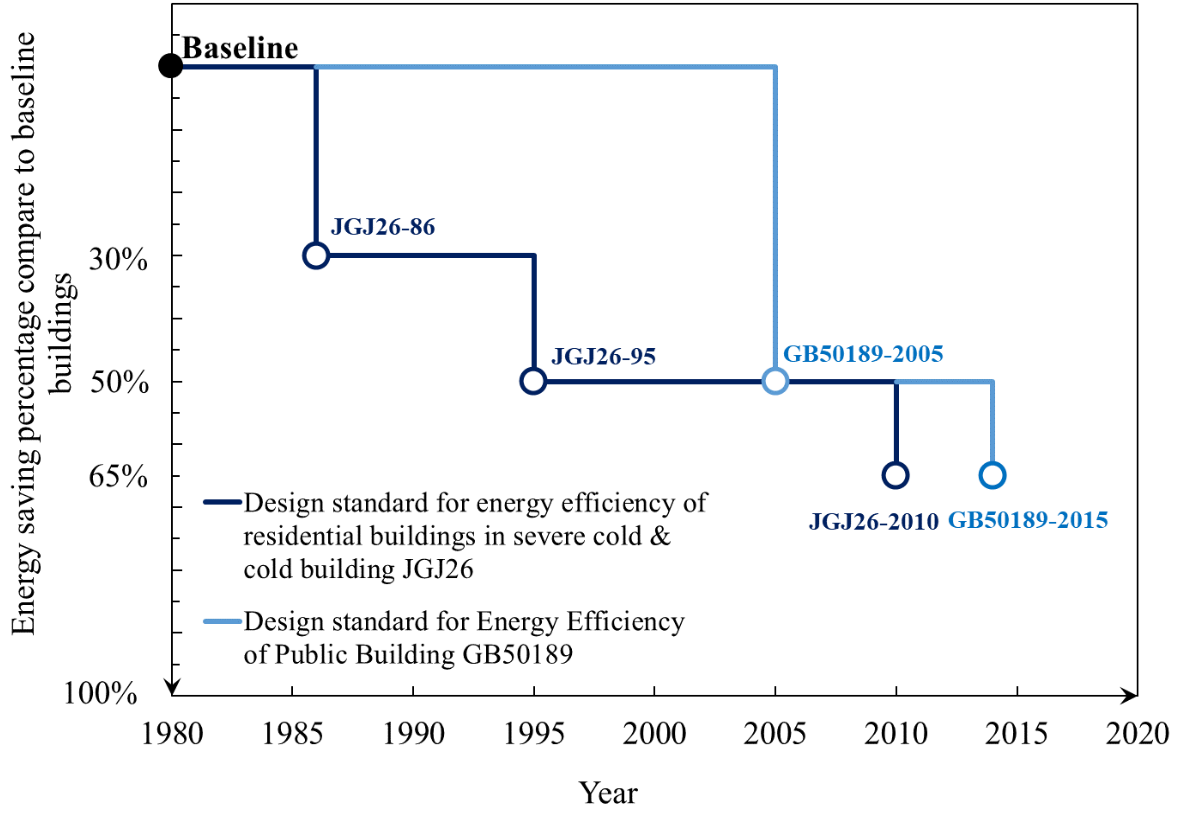
目录

Mandatory standard	Nearly Zero Energy	General code	Zero carbon

- 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%.

China Building Climate Zoning map

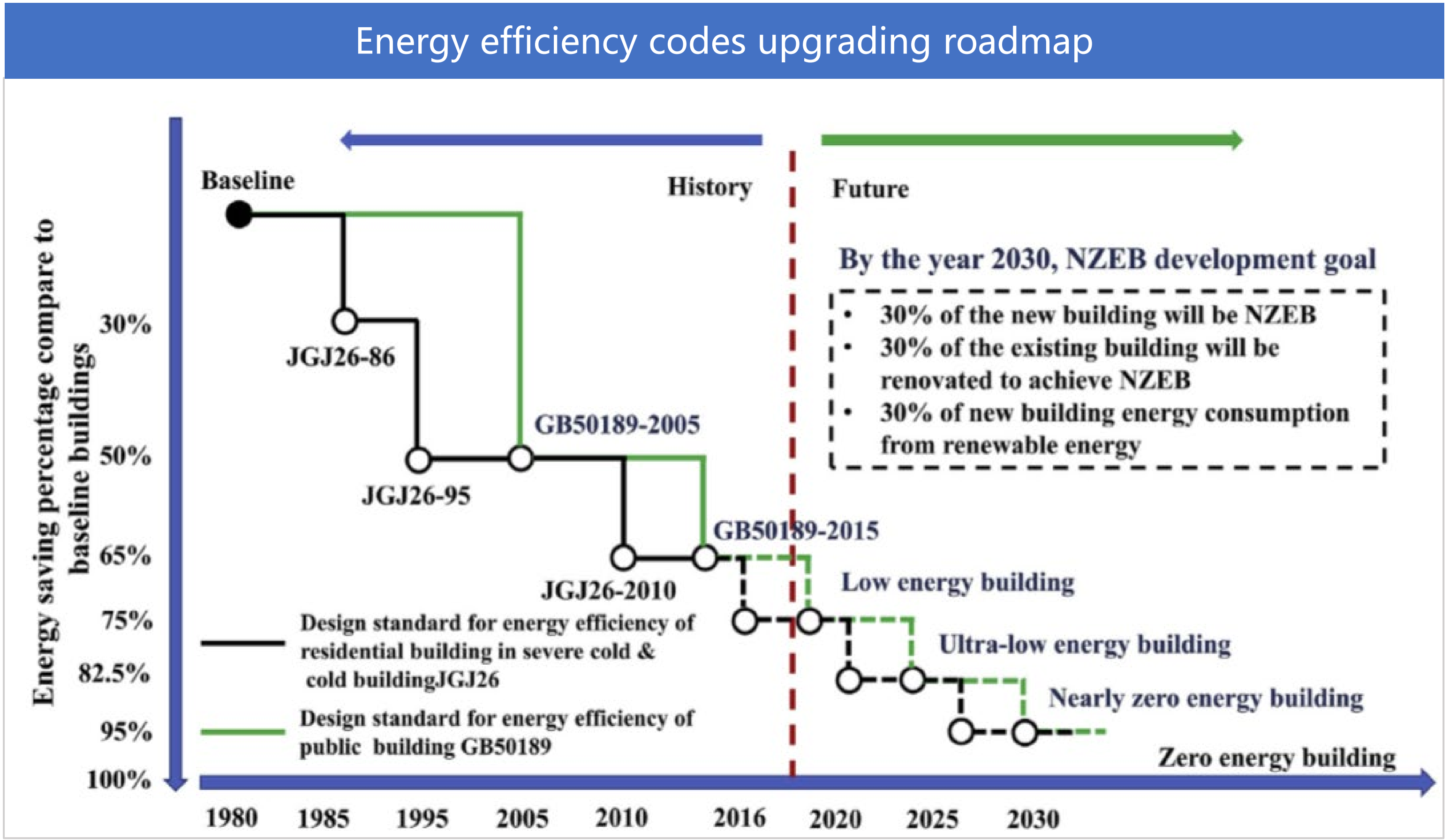




1 Development history of standard development

Mandatory standard	Nearly Zero Energy	General code	Zero carbon

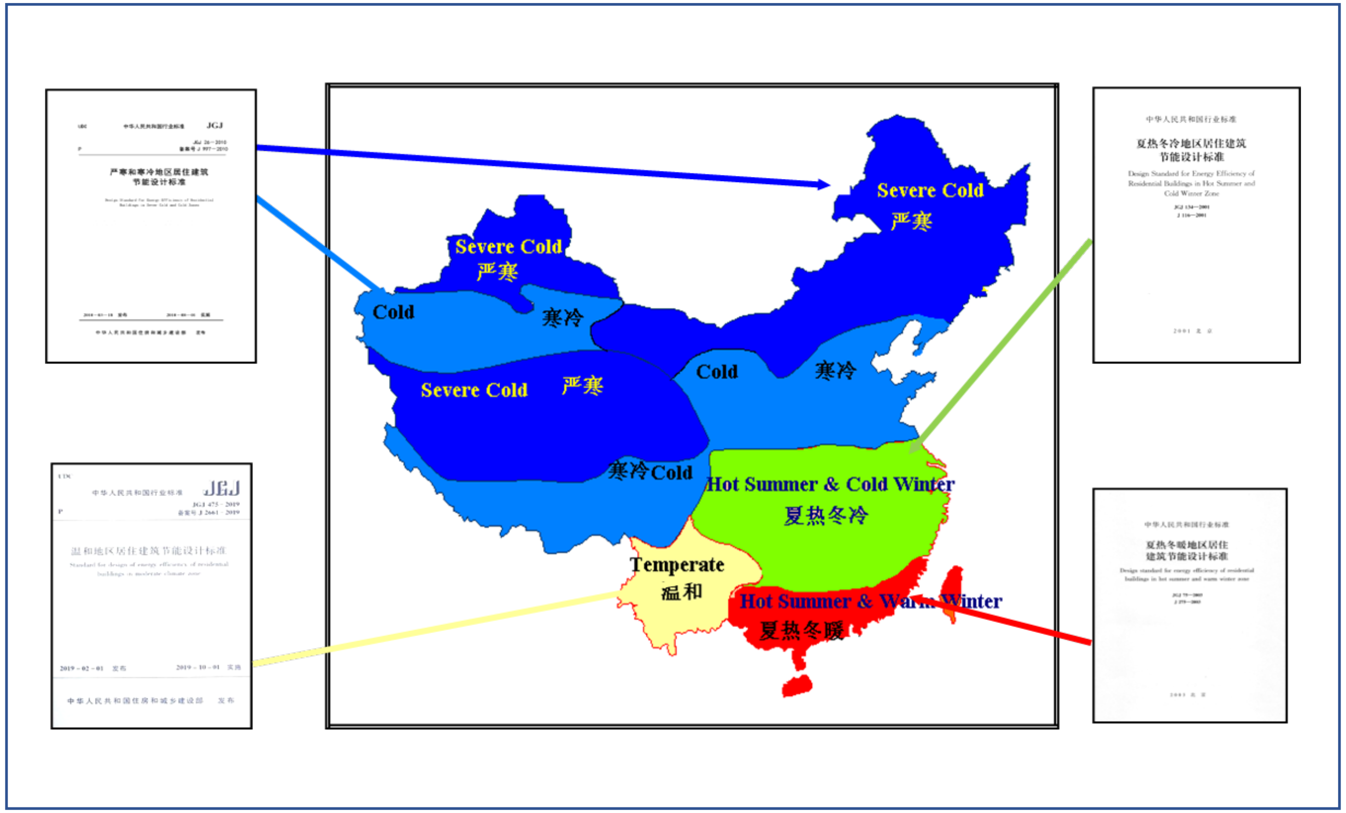
- In 2019, China implemented the first national standard to lead improvements in building energy efficiency. Building Efficiency 2016 as the baseline, the process of achieving a zero-energy building is divided into ultra-low energy(50%), nearly zero energy(60~75%) and zero energy buildings(100%).

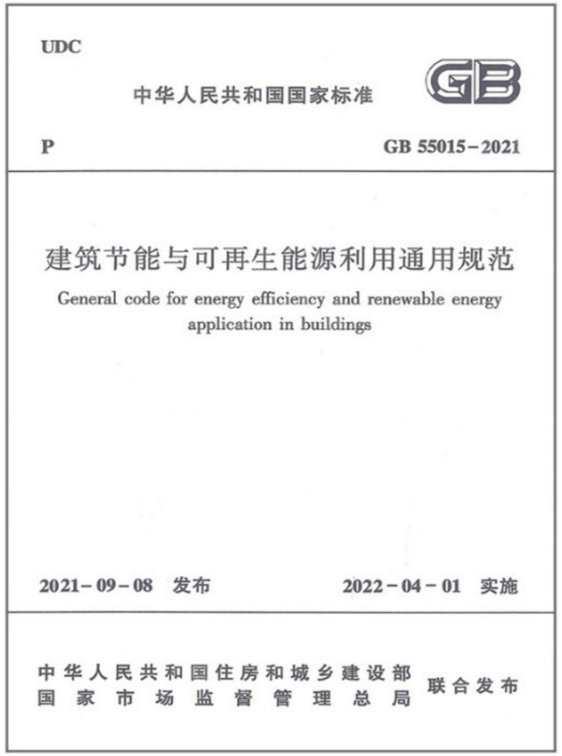


1 Development history of standard development

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

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.


中华人民共和国住房和城乡建设部
Ministry of Housing and Urban-Rural Development of the People's Republic of China
www.mohurd.gov.cn
首页 机构 新闻 公开 服务 互动 专题
首页 > 公开 > 法定主动公开内容 > 部发文件

索 引 号：000013338/2022-00328
主题信息：标准定额
发文单位：住房和城乡建设部　国家发展改革委
发文日期：2022-06-30
文件名称：住房和城乡建设部　国家发展改革委关于印发城乡建设领域碳达峰实施方案的通知
有 效 期：
文　　号：建标〔2022〕53号
主 题 词：

住房和城乡建设部　国家发展改革委关于
印发城乡建设领域碳达峰实施方案的通知

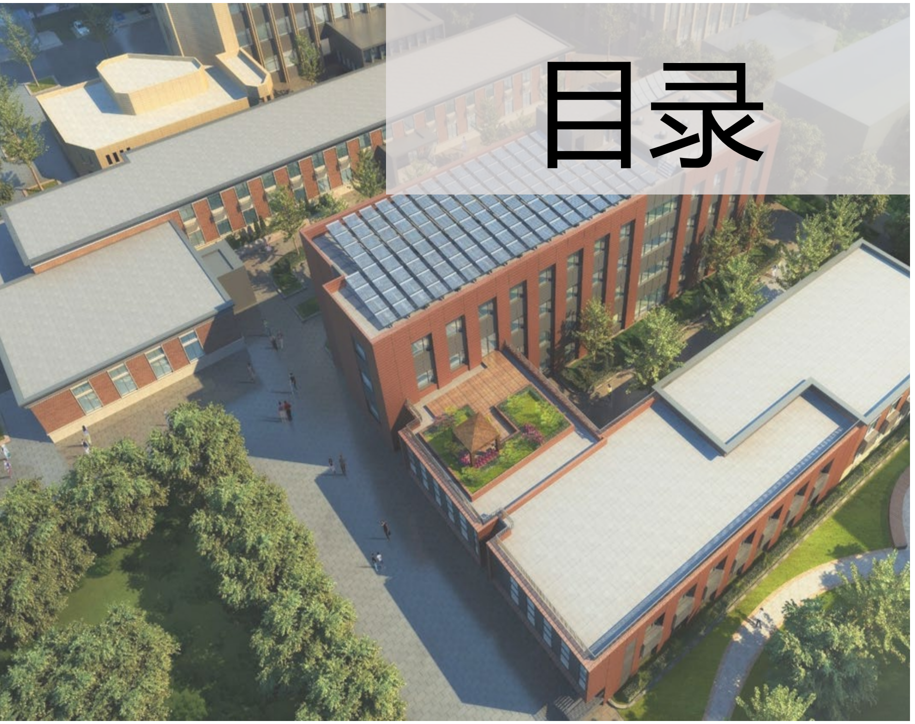
（此件公开发布）

城乡建设领域碳达峰实施方案

城乡建设是碳排放的主要领域之一。随着城镇化快速推进和产业结构深度调整，城乡建设领域碳排放量及其占全社会碳排放总量比例均将进一步提高。为深入贯彻落实党中央、国务院关于碳达峰碳中和决策部署，控制城乡建设领域碳排放量增长，切实做好城乡建设领域碳达峰工作，根据《中共中央 国务院关于完整准确全面贯彻新发展理念做好碳达峰碳中和工作的意见》、《2030年前碳达峰行动方案》，制定本实施方案。

一、总体要求

（一）指导思想。以习近平新时代中国特色社会主义思想为指导，全面贯彻党的十九大和十九届历次全会精神，深入贯彻习近平生态文明思想，按照党中央、国务院决策部署，坚持稳中求进工作总基调，立足新发展阶段，完整、准确、全面贯彻新发展理念，构建新发展格局，坚持生态优先、节约优先、保护优先，坚持人与自然和谐共生，坚持系统观念，统筹发展和安全，以绿色低碳发展为引领，推进城市更新行动和乡村建设行动，加快转



目录

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

CL体系

SD体系

EPS体系

RQB体系

- 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

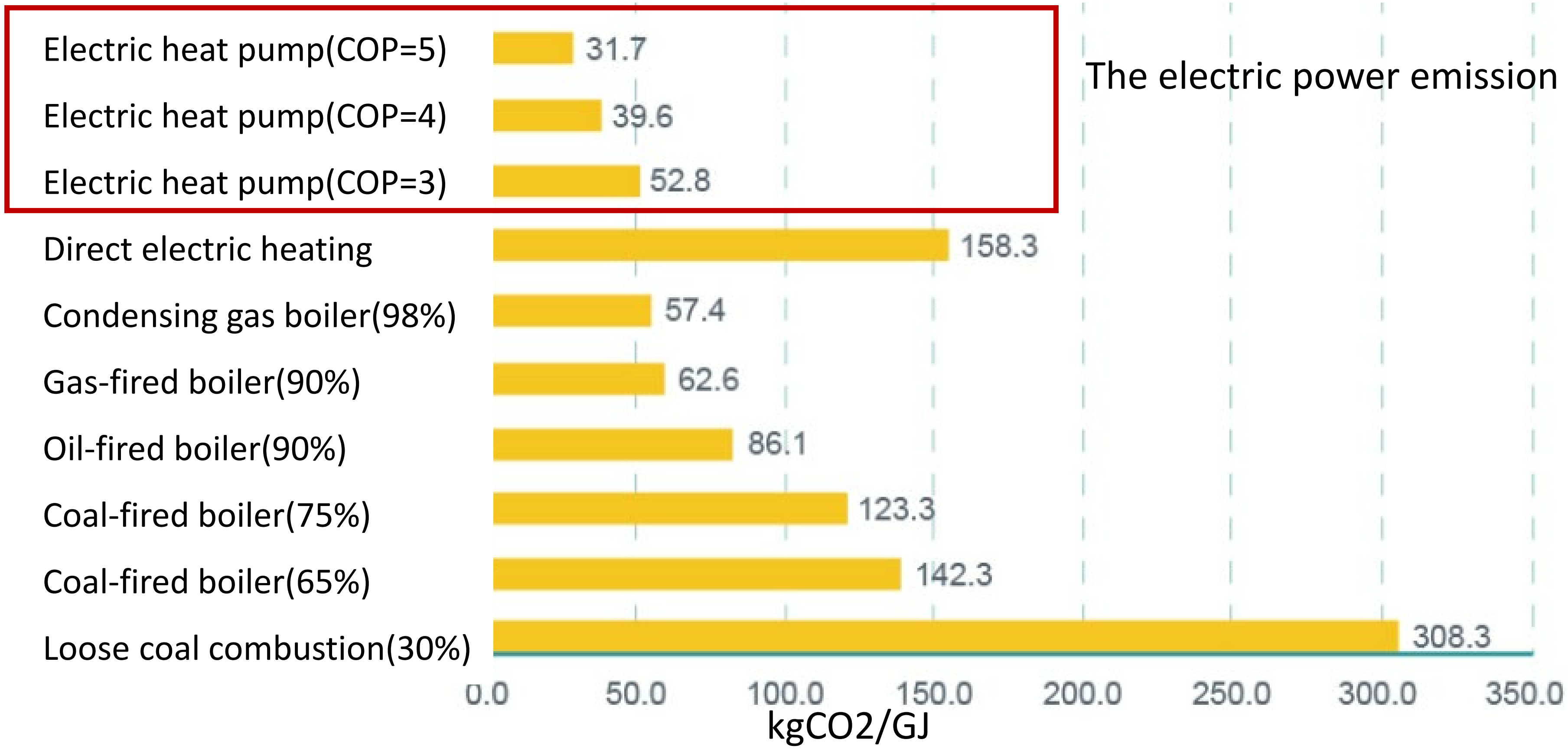
High efficiency lighting system

- 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

- 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..



The electric power emission factor is 0.5703kgCO_2/kWh

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

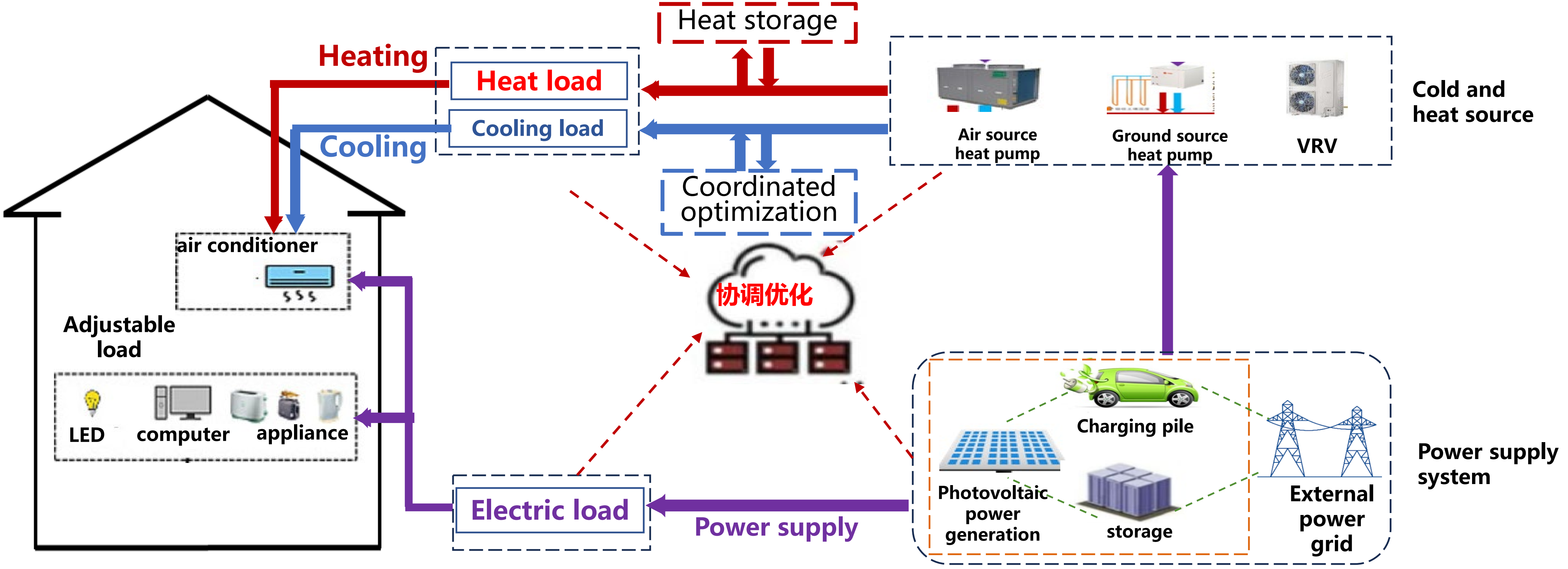
【Product type】 The common types of thin film batteries mainly include copper indium gallium selenium thin film batteries (CIGS), cadmium telluride thin film batteries (CdTe) and amorphous silicon thin film batteries, of which cadmium telluride thin film is the most commonly used.

【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%**.

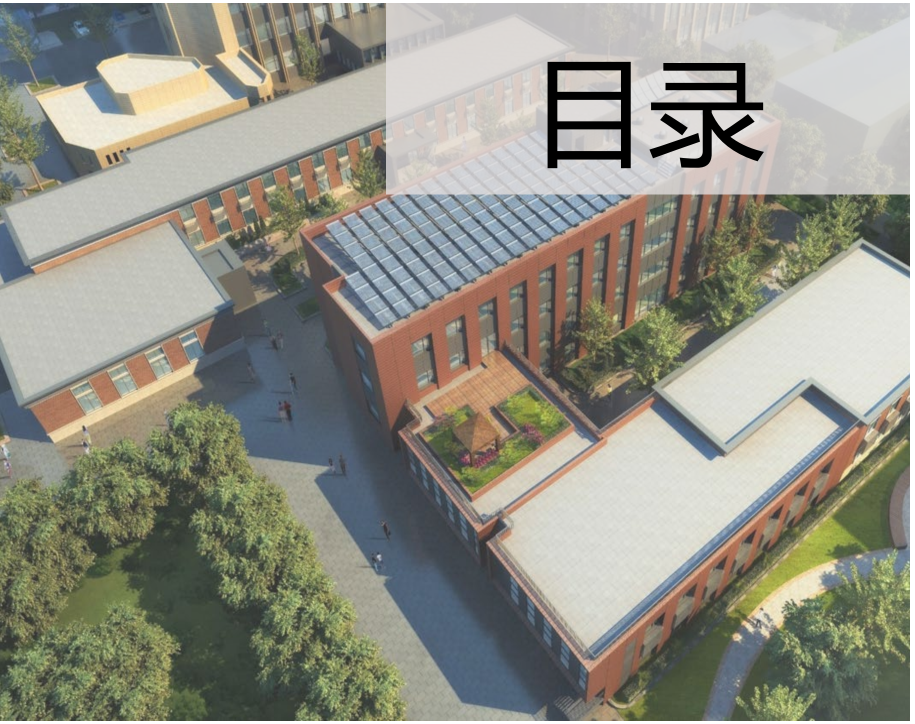
2 Major technical measures

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.



目录



Two cases of science and technology research and development support standards

中华人民共和国国家标准 GB

P GB/T 51350–2019

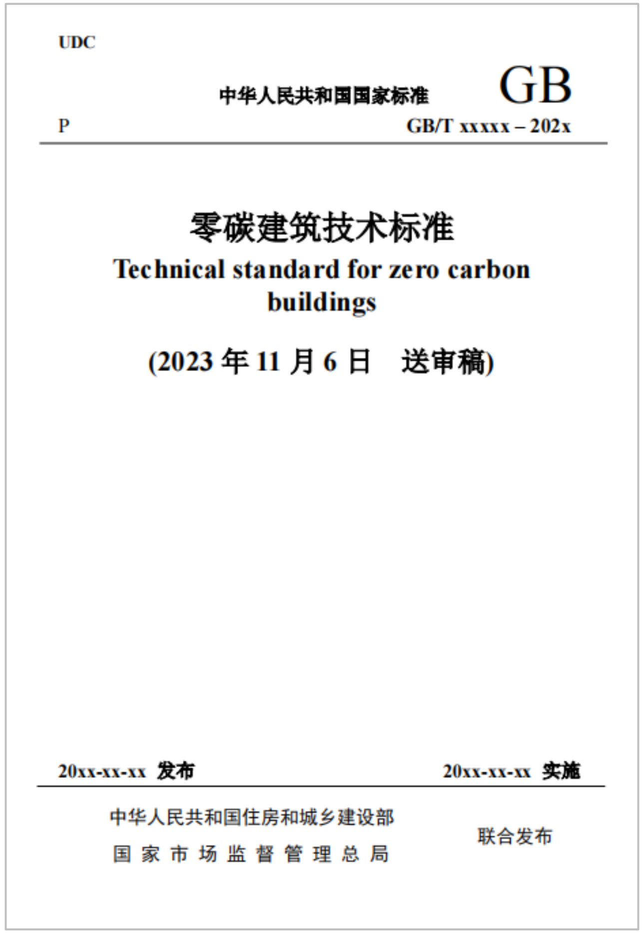
近零能耗建筑技术标准

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

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



UDC

中华人民共和国国家标准 GB

P GB/T xxxxx – 202x

零碳建筑技术标准

Technical standard for zero carbon buildings

(2023 年 11 月 6 日 送审稿)

20xx-xx-xx 发布 20xx-xx-xx 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

- **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

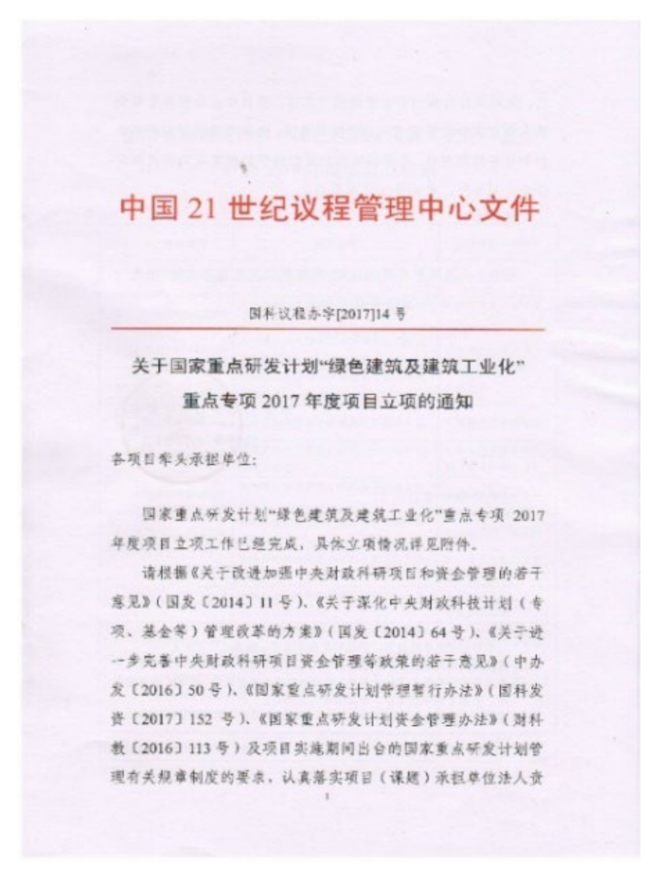
Participants unit： 29 agencies 参与单位：29家

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:

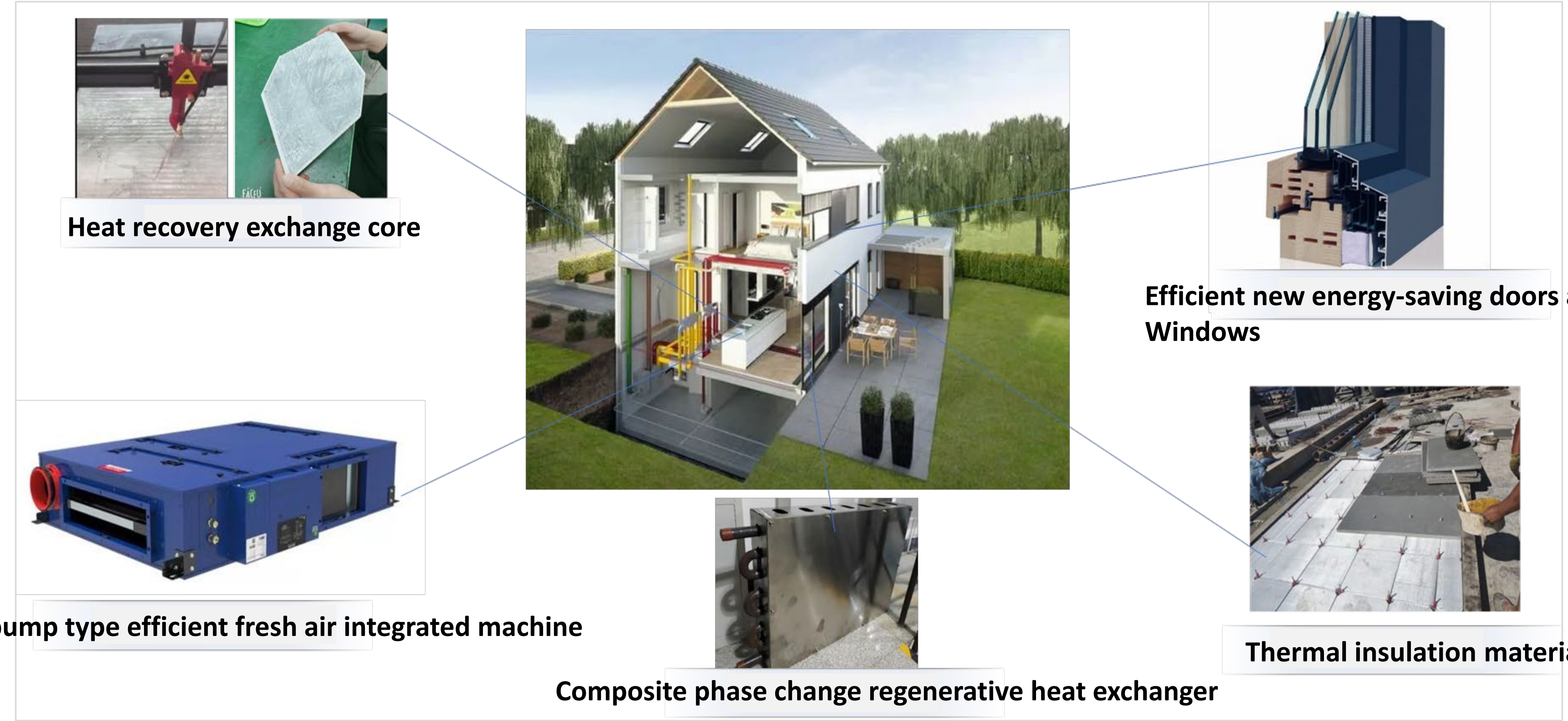
国家重点研发计划"绿色建筑及建筑工业化"重点专项 2017 年度项目立项工作已经完成，具体立项情况详见附件。

请根据《关于改进加强中央财政科研项目和资金管理的若干意见》（国发〔2014〕11 号）、《关于深化中央财政科技计划（专项、基金等）管理改革的方案》（国发〔2014〕64 号）、《关于进一步完善中央财政科研项目资金管理等政策的若干意见》（中办发〔2016〕50 号）、《国家重点研发计划管理暂行办法》（国科发资〔2017〕152 号）、《国家重点研发计划资金管理办法》（财科教〔2016〕113 号）及项目实施期间出台的国家重点研发计划管理有关规章制度的要求，认真落实项目（课题）承担单位法人责

1

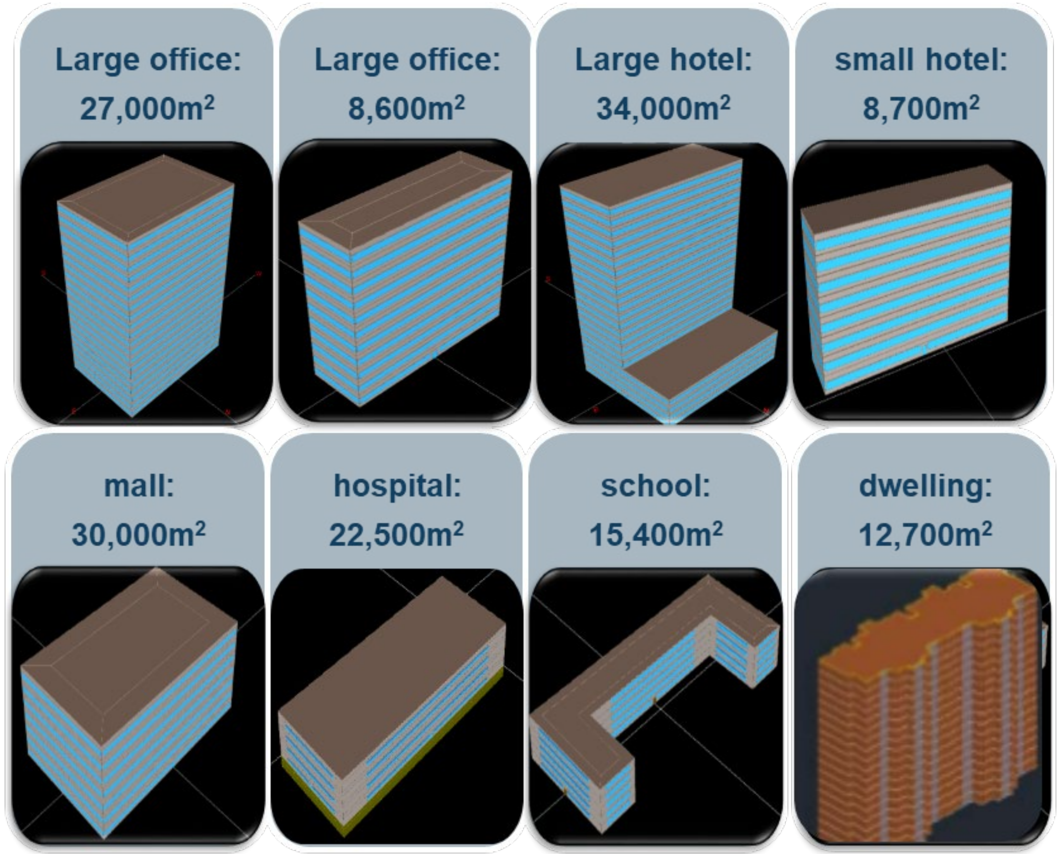
Case 1: Technical standards for nearly zero energy buildings

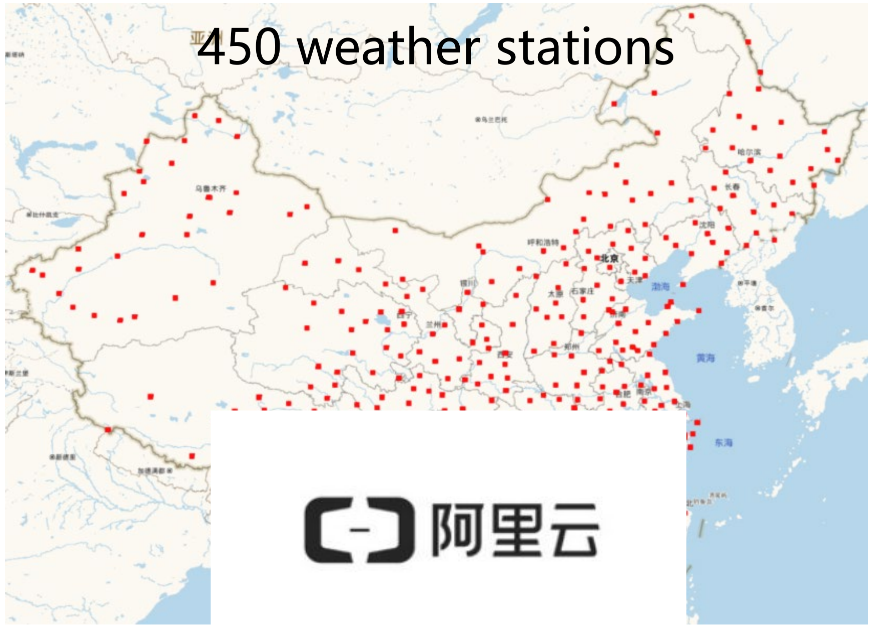
- The project completed a series of high performance key product parts 21 items. Research and development of thermal conductivity ≤0.0035W/m·K vacuum insulation external wall materials, overall thermal insulation coefficient K≤0.8W/(m^2·K) doors and Windows, fresh air integrated machine and other core products, the performance indicators reached the international advanced level and 100% localization.



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

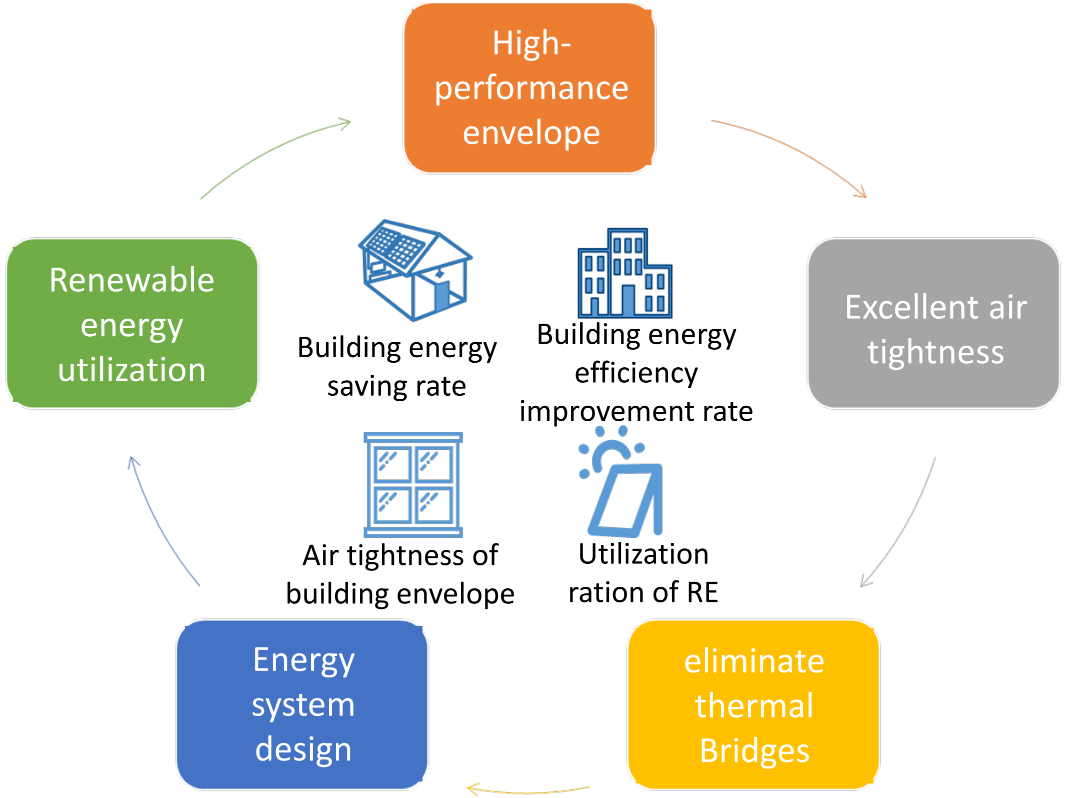
- Different from the prescriptive indicators of traditional energy efficiency standards, the indoor environment parameters and building energy efficiency indexes of near-zero energy consumption buildings are taken as the core discriminating conditions.
- The nearly zero energy building adopts the performance-based 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/ (m^2·a))或≤6.8 (kgce/ (m^2•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/ (m^2·a))	≤18	≤15	≤8		≤5
	供冷年耗冷量(kWh/ (m^2·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%				

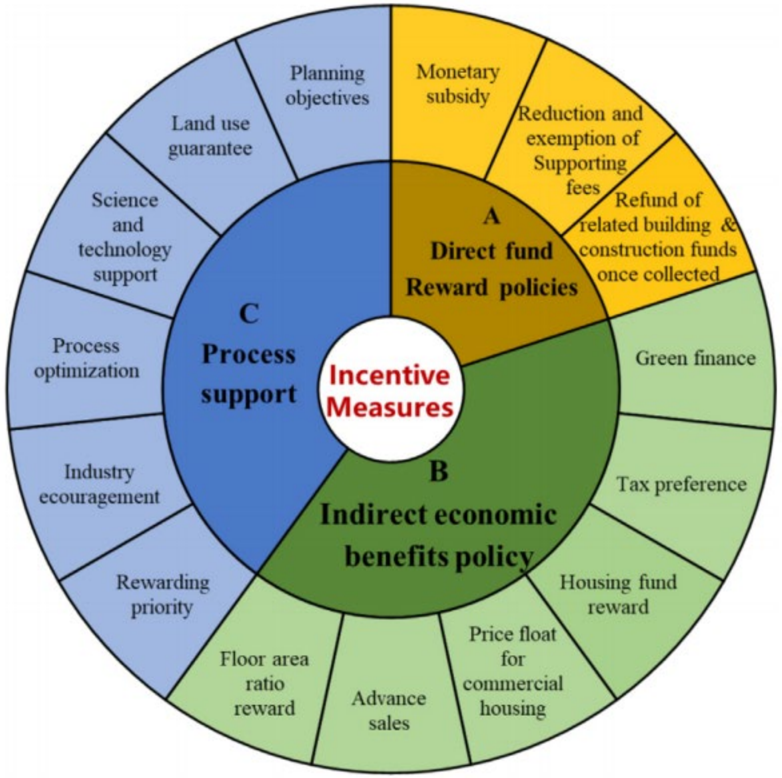
Public building energy and air tightness index

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%				



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.

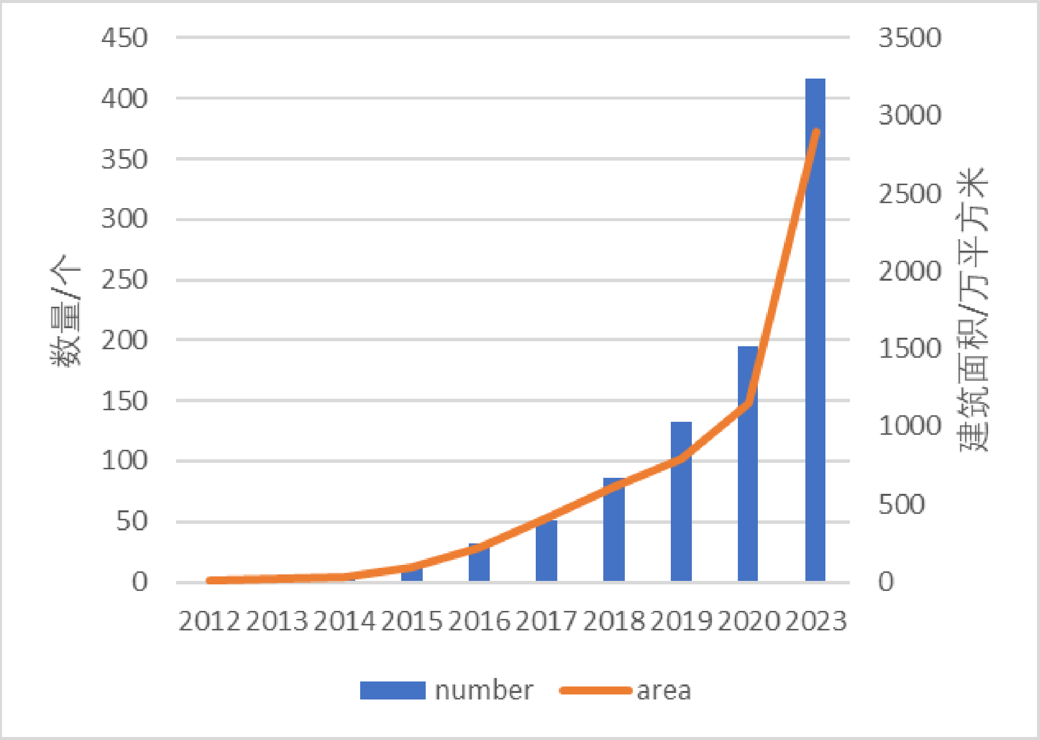


	Policies / Provinces	He bei	He nan	Shan dong	Jiang su	Bei jing	Ning Xia	Urum qi	Tian jin	Hu bei	Hu nan	Shan xi	Guang dong	Shang hai	Number	Grade
1	Planning objectives														30	A
2	Monetary subsidy														25	C
3	Floor area ratio reward														14	B
4	Industry ecouragement														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

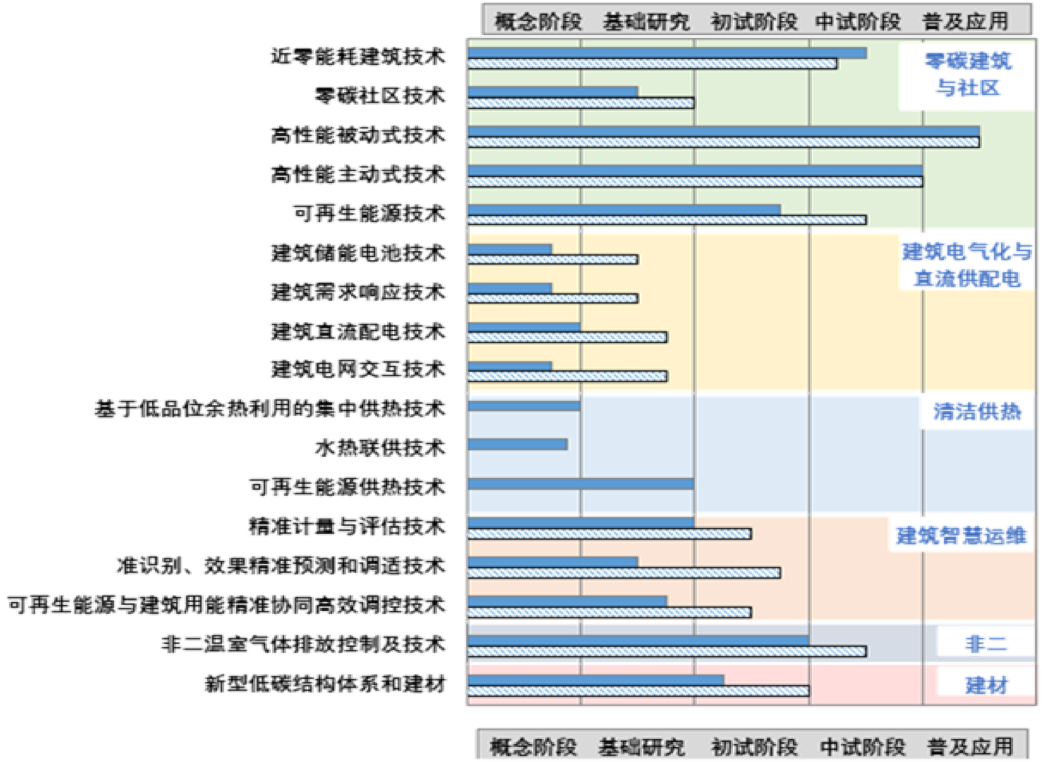
Senior title: 44， Middle title: 28 PhD: 24， Master: 53

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.

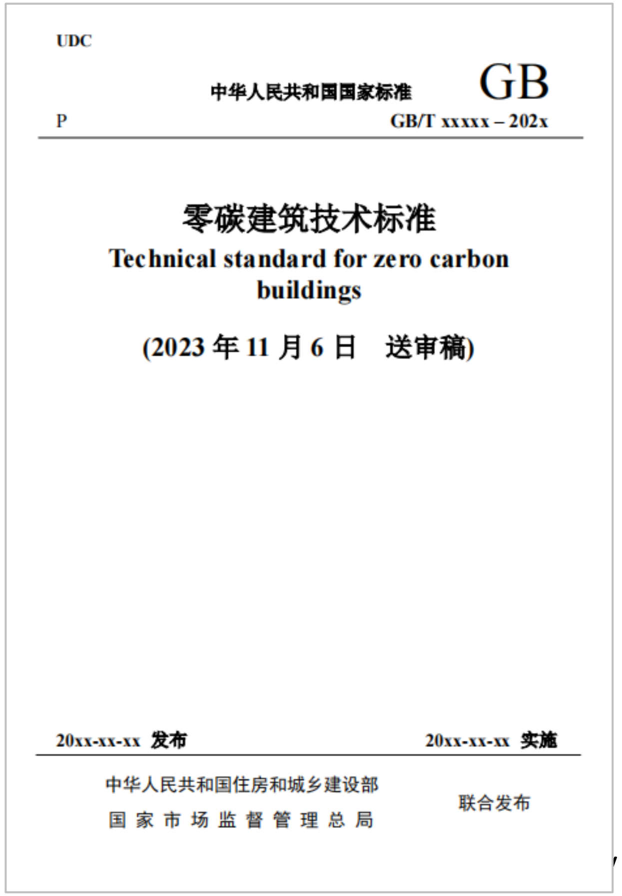
1. Coordinated development of energy conservation and carbon reduction standards
2. Energy saving and carbon reduction technology maturity assessment
3. Energy structure transformation development trend
4. low carbon building and regional key technologies and future development
5. Research on key factors 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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中华人民共和国国家标准 GB

GB/T xxxxx – 202x

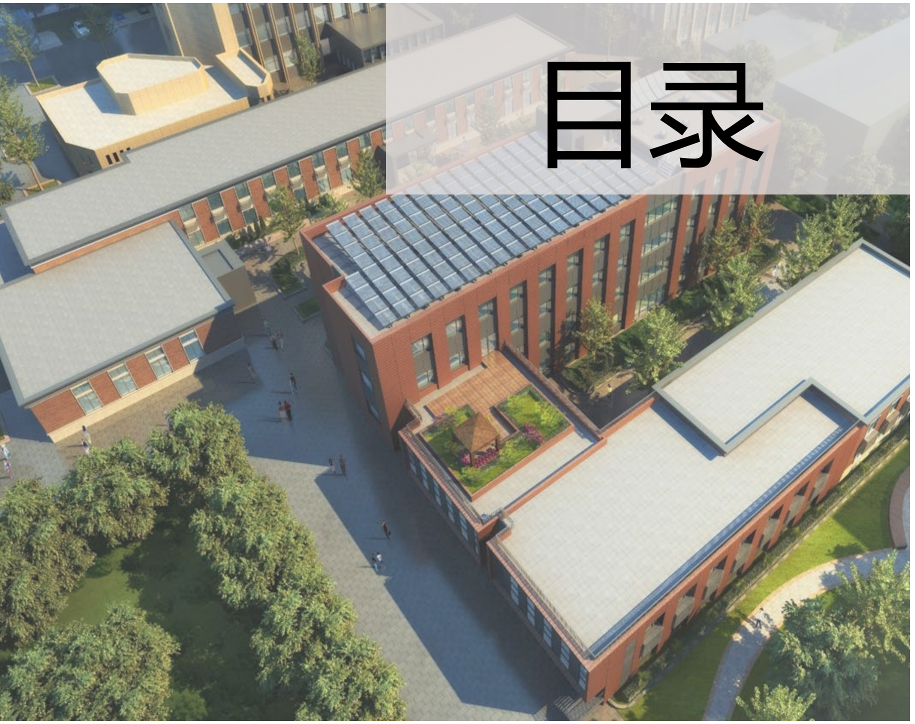
零碳建筑技术标准

Technical standard for zero carbon buildings

(2023 年 11 月 6 日　送审稿)

20xx-xx-xx 发布　　　20xx-xx-xx 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



目录

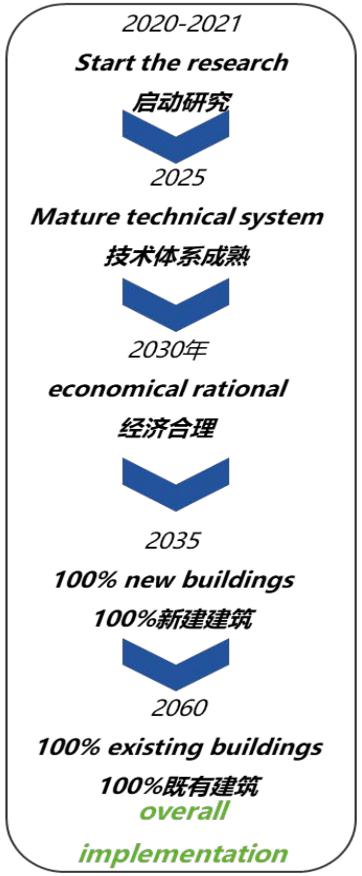
4 Promote and support policies

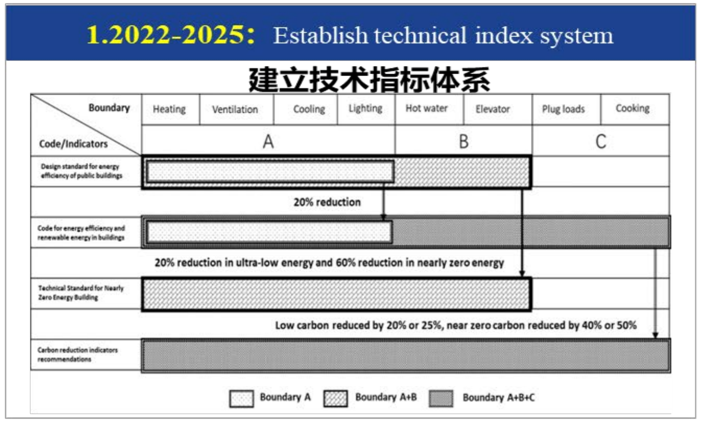
- A large number of monitoring data prove that nearly zero energy buildings and zero carbon buildings have remarkable energy-saving and carbon reduction effects.
- Promoting the large scale development of nearly zero energy buildings and zero carbon buildings has been included in a number of central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

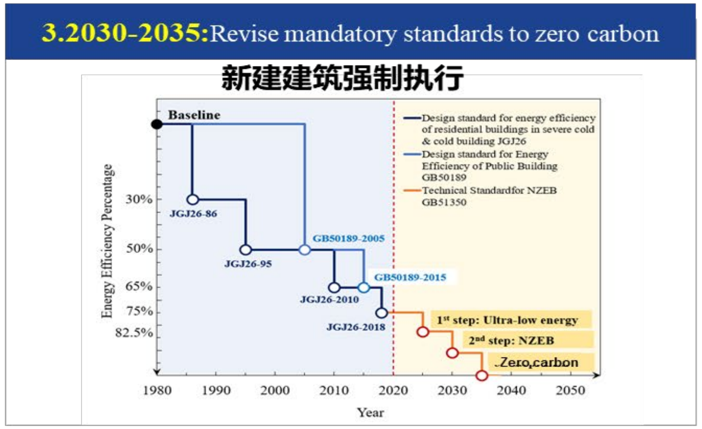
No.	Issued department	Policy	Date	Main content
1	CPC Central Committee The State Council	Opinions on Fully, Accurately and Comprehensively Implementing the New Development Concept and Doing a Good Job in Carbon Peaking and carbon Neutrality	2021.09	Accelerate the large-scale promotion of **ultra low, 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/(㎡·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

Panel Discussion 1: New Technology Integration in Building Energy Codes

Moderator:
Takao Sawachi

Michael Tillou
Pacific Northwest National Laboratory

Alex Ferguson
Natural Resources Canada

Zhang Shicong
Institute of Building Environment and Energy

Session 2:
Performance Gaps in Building Energy Codes

Moderator:
Meli Stylianou

Meredydd Evans
Pacific Northwest National Laboratory

Helen Bell
Green Building Council of Australia

Qingpeng Wei
Tsinghua University

Liam O’ Brien
Carleton University

Introducing Performance Gaps in Building Energy Codes

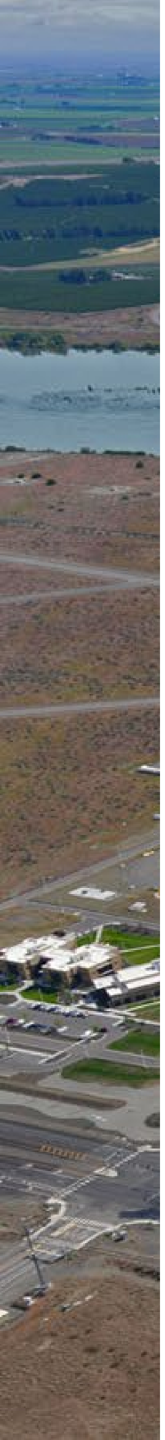
Meli Stylianou
Natural Resources Canada

EBC
Energy in Buildings and Communities Programme

Systems Performance and Gaps in Building Energy Codes

Meredydd Evans
Pacific Northwest National Laboratory

Energy in Buildings and Communities Programme



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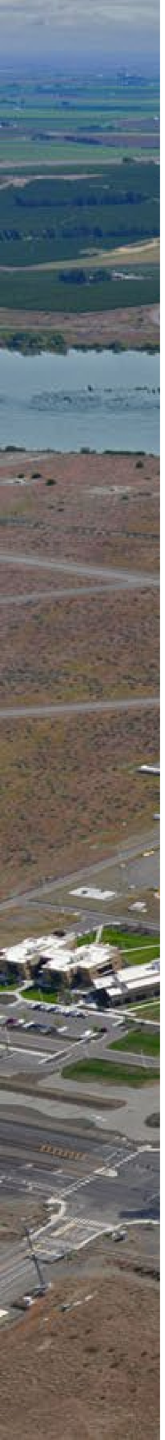
NATIONAL LABORATORY

Systems Performance and Gaps in Building Energy Codes

EBC BECWG 5th Annual Symposium
November 14, 2023

U.S. DEPARTMENT OF ENERGY BATTELLE

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



Contents

- Key challenges with performance gap issues
- Typical paths for code compliance
  - Prescriptive vs. performance-based codes
  - Problems with reliance on prescriptive
  - Transition to performance-based codes
- Performance gap issues in performance-based codes
- US code program activities to support transition to performance-based codes

Systems Performance and Gaps in Building Energy Codes

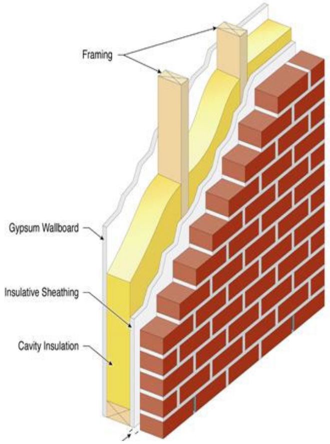
- Performance gap issues in building energy codes present significant challenges for range of reasons

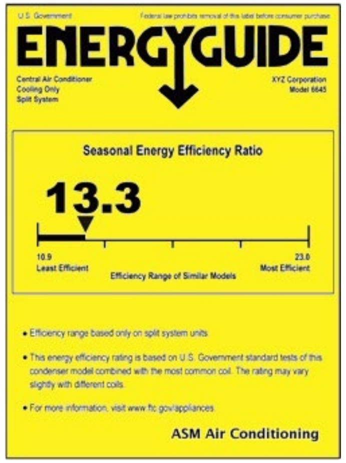
1. Misalignment between design and operation
2. Lack of accountability and Enforcement Challenges
3. Compliance vs. Performance

- Reducing performance gaps in codes benefits both the environment and building occupants by improving energy efficiency and reducing costs

Typical Paths for Code Compliance

Prescriptive




U.S. Government

ENERGYGUIDE

Central Air Conditioner
Cooling Only
Split System

XYZ Corporation
Model 6645

Seasonal Energy Efficiency Ratio

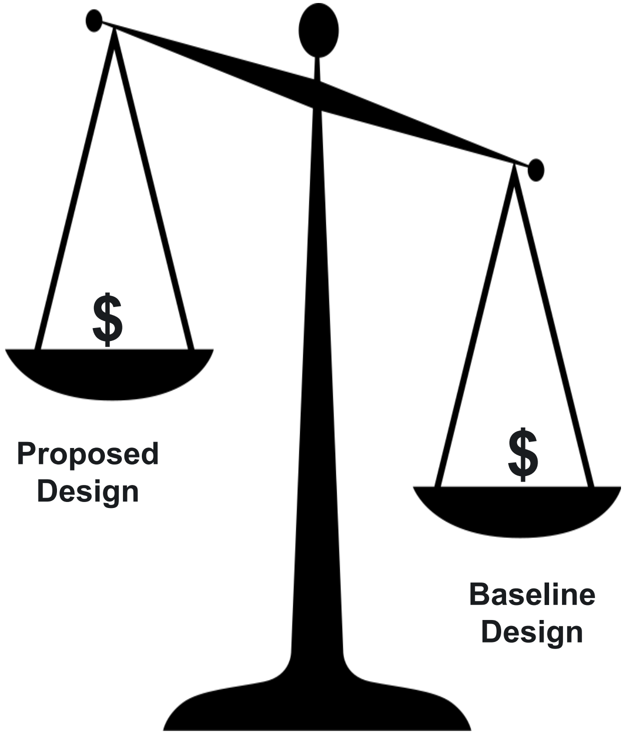
13.3

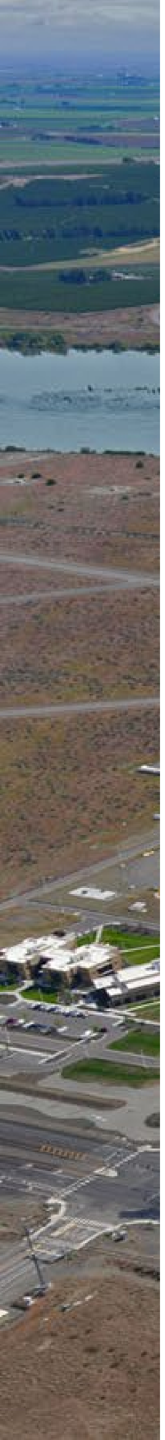
10.9 Least Efficient — Efficiency Range of Similar Models — 23.0 Most Efficient

- Efficiency range based only on split system units
- This energy efficiency rating is based on U.S. Government standard tests of this condenser model combined with the most common coil. The rating may vary slightly with different coils.
- For more information, visit www.ftc.gov/appliances

ASM Air Conditioning

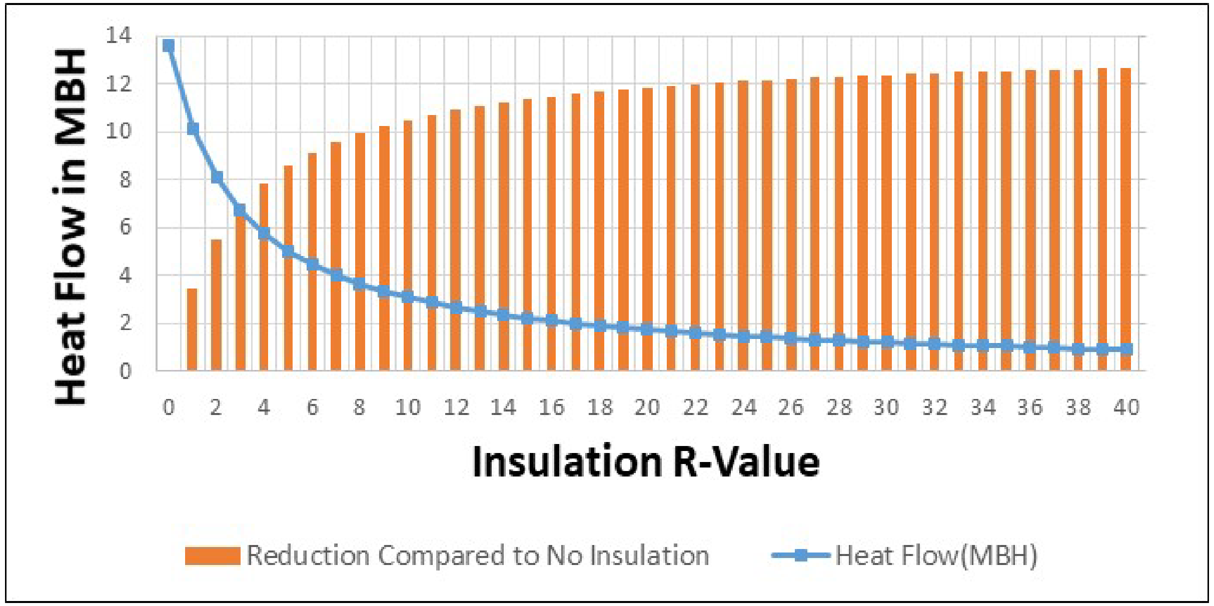
Whole Building Performance

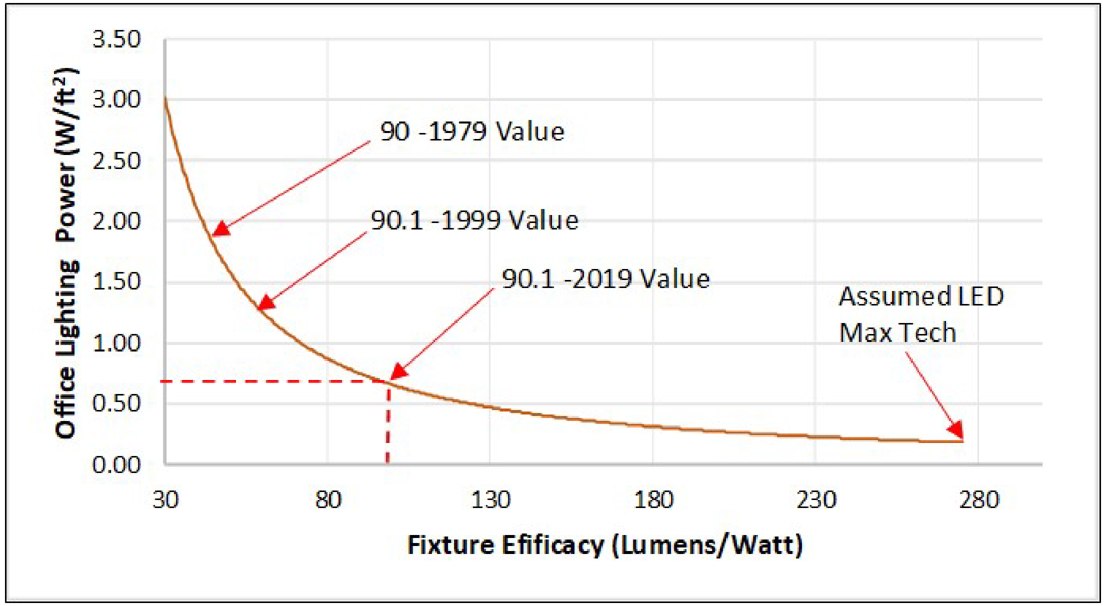




Problems with Reliance on Prescriptive

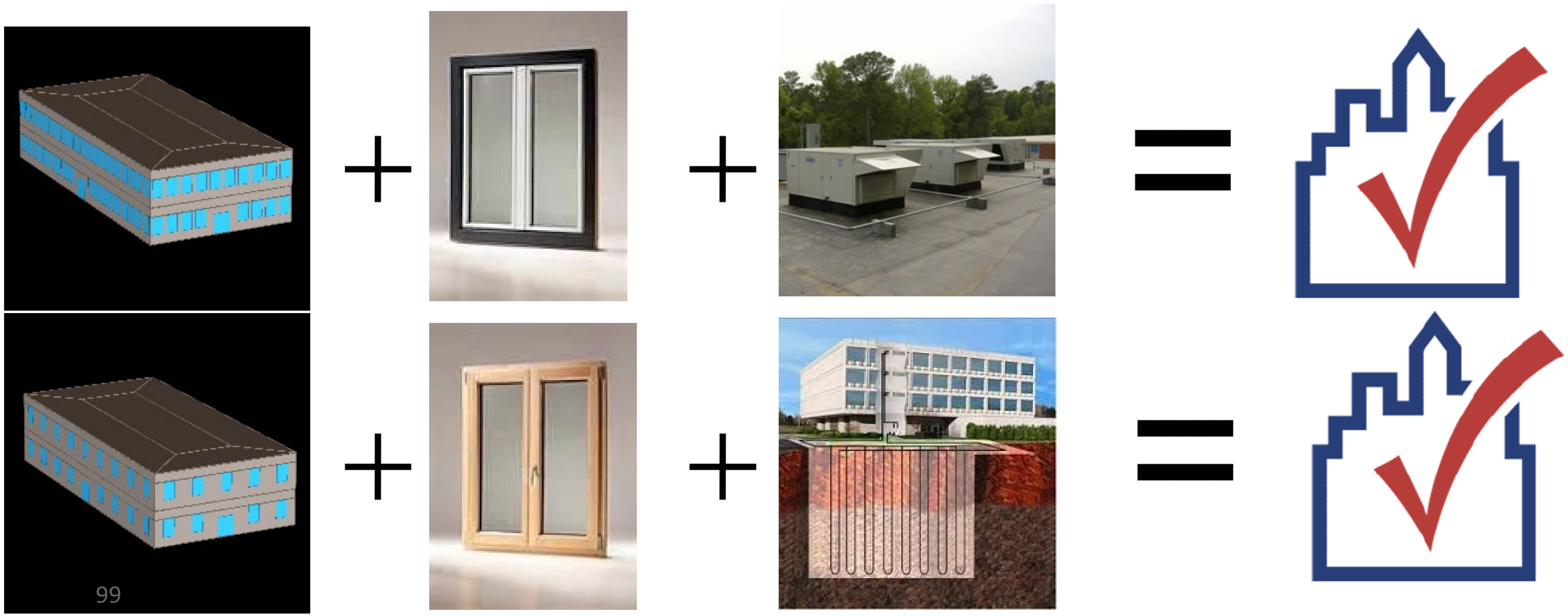
- Prescriptive approach is reaching a point of diminishing returns
  - Uninsulated wall + R-20 reduces heat loss by ~87%
  - Adding an additional R-20 reduces only ~10% more
  - Current LED to theoretical limit could improve efficacy by another 165 lm/W but will only reduce power consumption by a little





Problems with Reliance on Prescriptive

- Prescriptive path does not prescribe energy use or recognize good design choices
  - Multitude of prescriptive options – each judged independently
  - Each combination chosen results in very different energy use

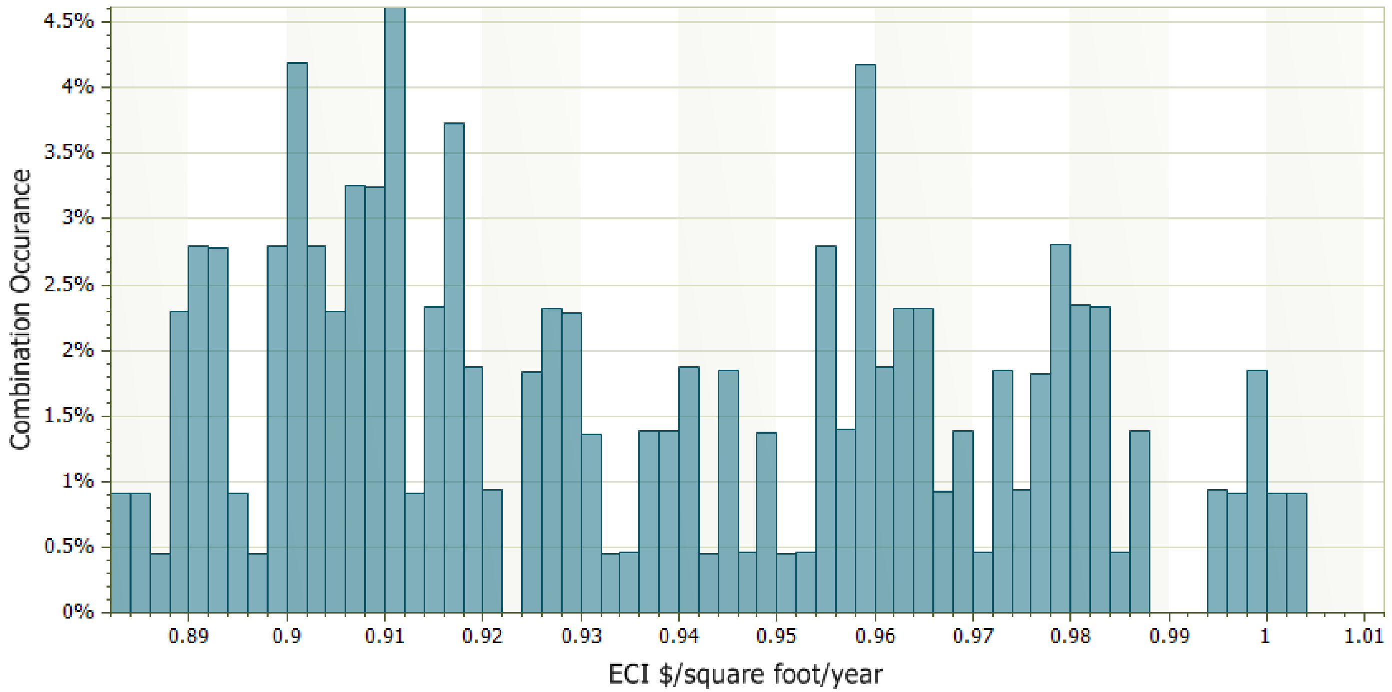


Problems with Reliance on Prescriptive

- Wide variation in energy outcomes with prescriptive compliance

Varying just six parameters for:

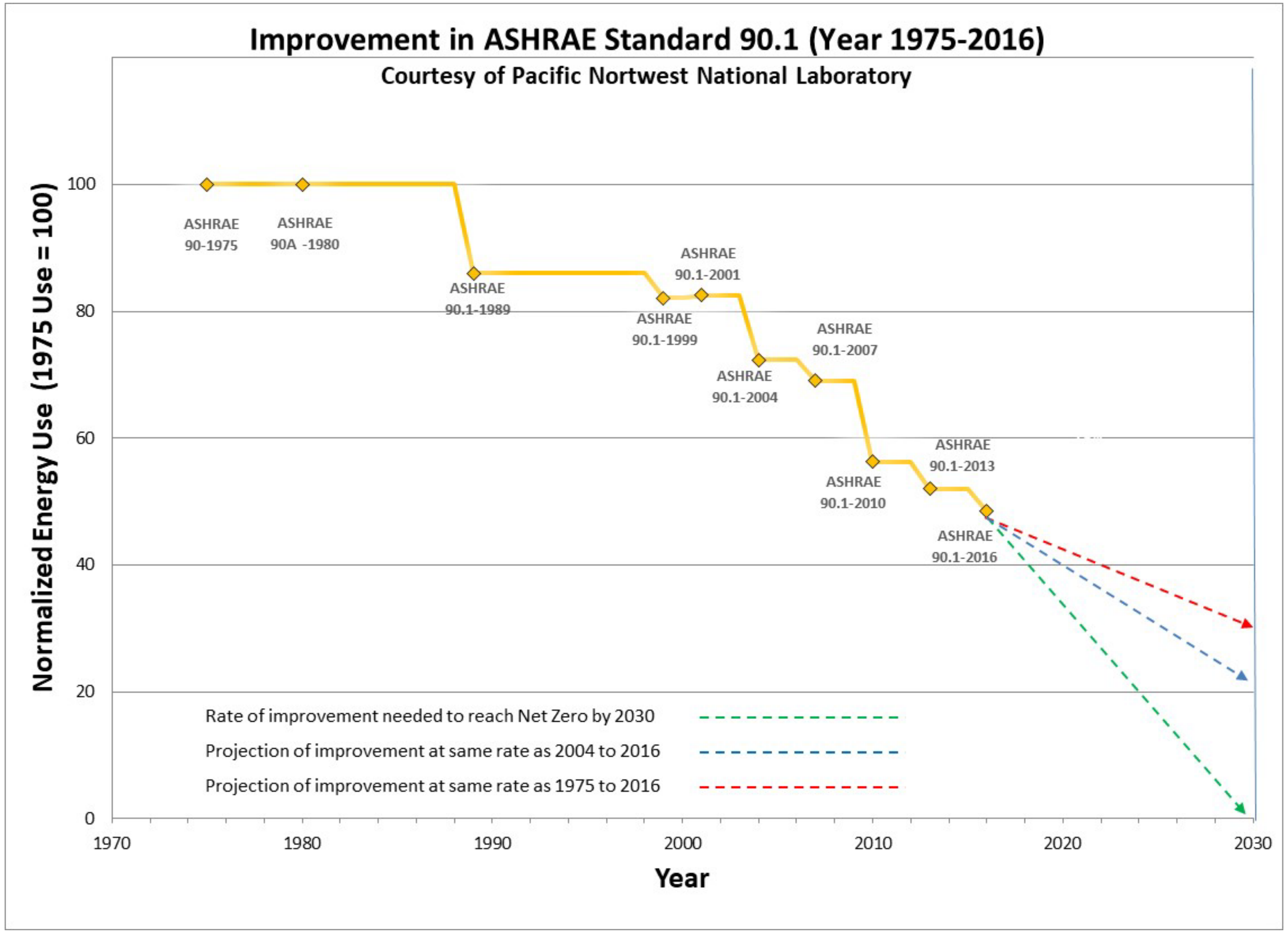
- Medium Office Building
- Climate Zone 5A
- 14% variation in annual energy cost



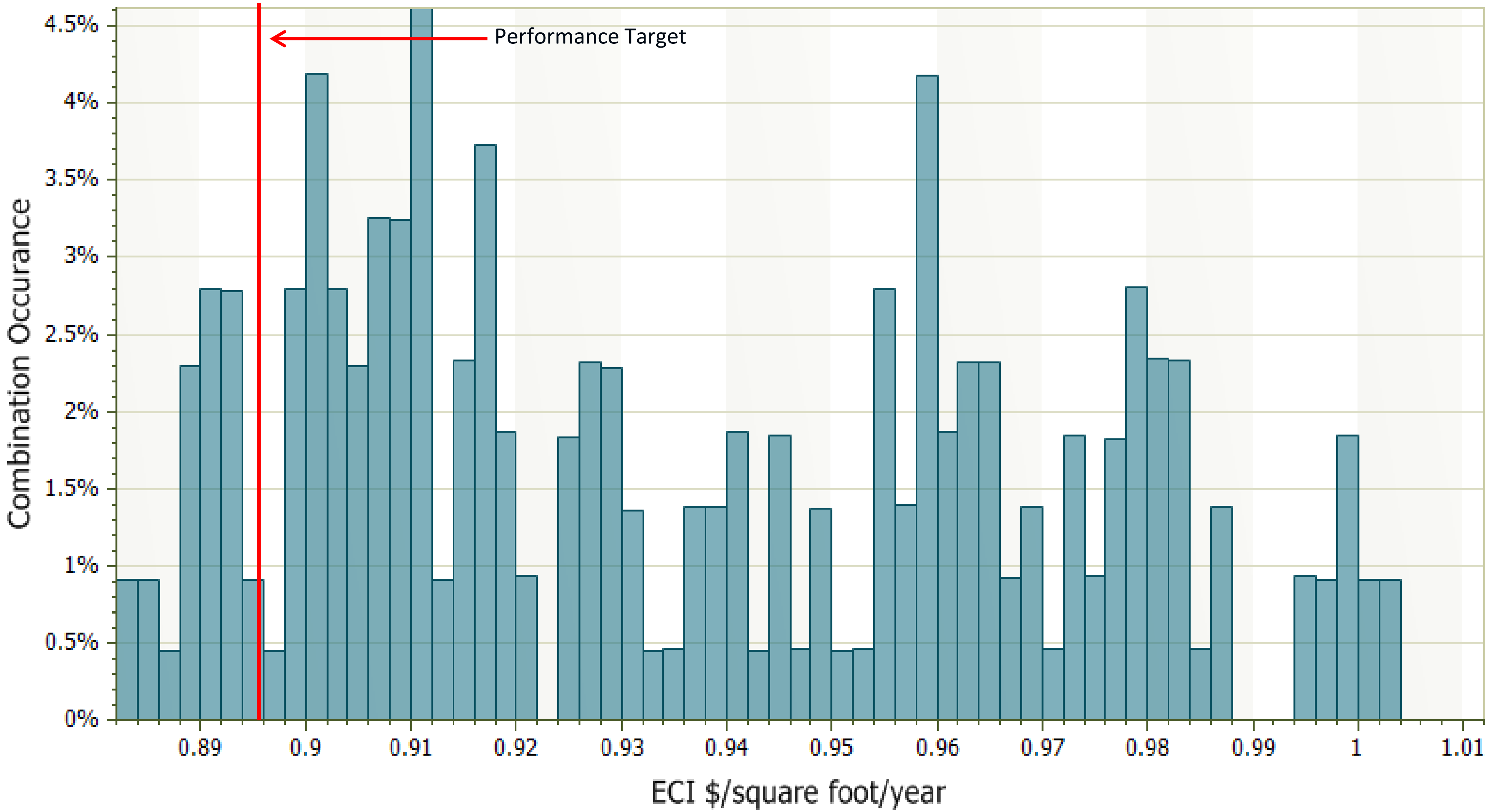
- Window-wall ratio (WWR): 25%→40%
- Window frame: metal→ non-metal
- HVAC size: small → large
- Roof insulation: above deck → below deck
- Wall type: steel frame → mass wall
- Heat source: electric →natural gas

Problems with Reliance on Prescriptive

- Unlikely to meet aggressive savings targets – Net Zero by 2030 (ASHRAE, AIA)

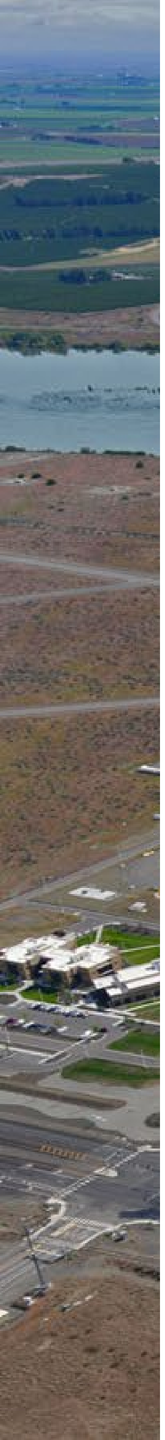


Solution – Transition to Performance Based Code



Challenges Faced in the Transition to Performance Based Code

Usability	Complexity	Time and cost intensive
Usability	Lack of Prescriptive Solutions	Designers like the simplicity of prescriptive requirements
Usability	Difficult to Verify Compliance	Hard to check models and match to design
Stringency	Allows Unequitable Trade-Offs	Trade-off between long-lasting envelope measures and shorter-lived HVAC controls
Policy Goals	Metrics	Standard metric of cost conflicts with many state and jurisdiction goals of electrification and decarbonizaiton



Performance Gap Issues in Performance-based Codes

- **Model Accuracy:** inaccuracies in models can lead to performance gaps
- **Assumption Errors:** accuracy of performance-based codes is contingent on the correctness of assumptions made during modeling (e.g., occupancy patterns, weather data, and equipment efficiency)
- **Behavioral Assumptions:** The assumed occupant behavior might not align with real-world usage
- **Monitoring and verification:** typically resource intensive and costly to implement
- **Data availability:** adequate data on building performance and energy consumption might not always be readily available

PNNL code program activities to support a smooth transition to performance-based codes are highlighted in the next few slides

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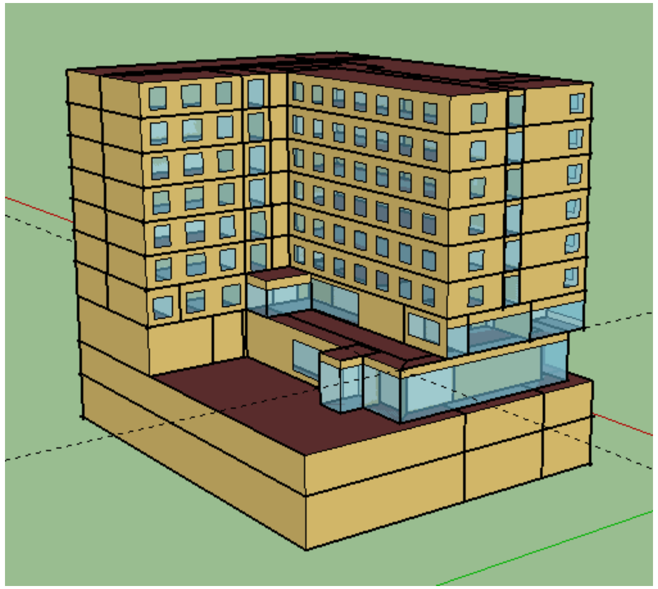
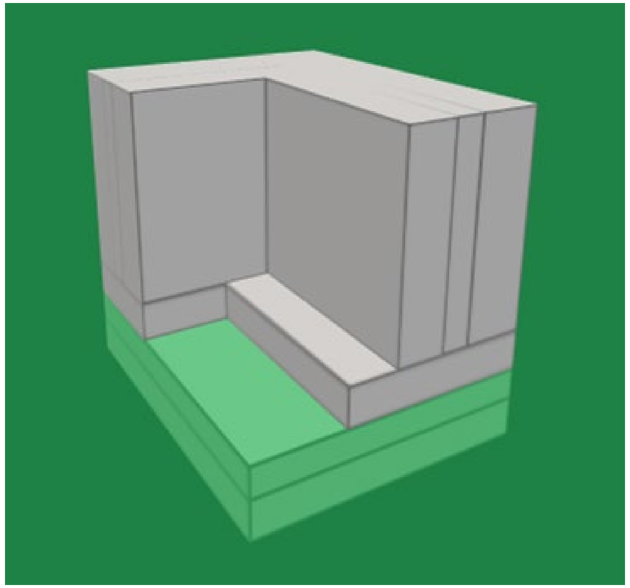
Simplified Approaches – Reduce Complexity

- Simplified Energy Modeling Ruleset (SEM) – New Project 2019-2022
  - Appropriate for small, simple buildings – 50% of non-res buildings <5,000 ft2
  - Reduces modeling time and cost
    - Standard Appendix G model for 50,000 ft^2 project can require 75-100 hours
    - Simplified Energy Model using Asset Score Tool may be 5 hours

Typical App G Energy Model



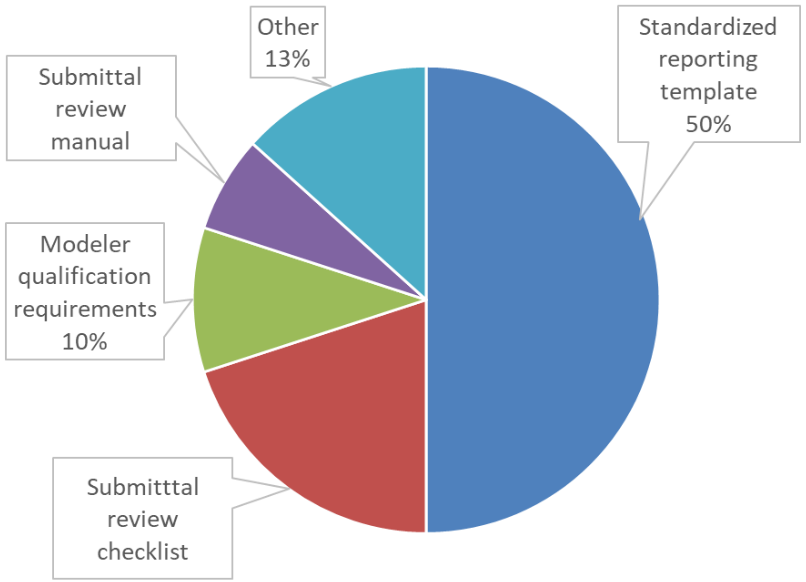
Asset Score Simplified Model



Verify Compliance - Ensure Accurate Performance Model Submittals

Stakeholder Survey

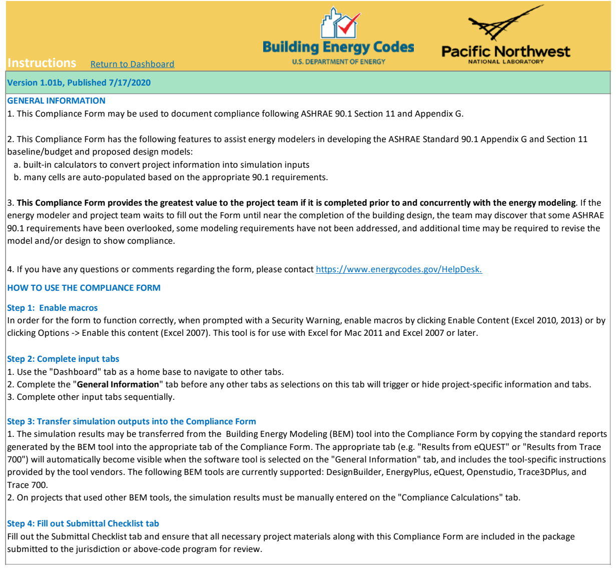
Q: **Near term tools and resources** to facilitate performance-based compliance?



Source: Karpman, Maria, 'High Priority Tools to Facilitate Compliance with ASHRAE Standard 90.1 2016 Section 11 and Appendix G'

Solution

1. Developing **standardized compliance documentation** to help jurisdictions verify the accuracy of performance-based compliance
   - Reporting template and checklists
   - Submittal review manual



Instructions Return to Dashboard

Building Energy Codes
U.S. DEPARTMENT OF ENERGY

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Version 1.01b, Published 7/17/2020

GENERAL INFORMATION

1. This Compliance Form may be used to document compliance following ASHRAE 90.1 Section 11 and Appendix G.

2. This Compliance Form has the following features to assist energy modelers in developing the ASHRAE Standard 90.1 Appendix G and Section 11 baseline/budget and proposed design models:
   a. built-in calculators to convert project information into simulation inputs
   b. many cells are auto-populated based on the appropriate 90.1 requirements.

3. **This Compliance Form provides the greatest value to the project team if it is completed prior to and concurrently with the energy modeling**. If the energy modeler and project team waits to fill out the Form until near the completion of the building design, the team may discover that some ASHRAE 90.1 requirements have been overlooked, some modeling requirements have not been addressed, and additional time may be required to revise the model and/or design to show compliance.

4. If you have any questions or comments regarding the form, please contact https://www.energycodes.gov/HelpDesk.

HOW TO USE THE COMPLIANCE FORM

Step 1: Enable macros

In order for the form to function correctly, when prompted with a Security Warning, enable macros by clicking Enable Content (Excel 2010, 2013) or by clicking Options -> Enable this content (Excel 2007). This tool is for use with Excel for Mac 2011 and Excel 2007 or later.

Step 2: Complete input tabs

1. Use the "Dashboard" tab as a home base to navigate to other tabs.
2. Complete the "**General Information**" tab before any other tabs as selections on this tab will trigger or hide project-specific information and tabs.
3. Complete other input tabs sequentially.

Step 3: Transfer simulation outputs into the Compliance Form

1. The simulation results may be transferred from the Building Energy Modeling (BEM) tool into the Compliance Form by copying the standard reports generated by the BEM tool into the appropriate tab of the Compliance Form. The appropriate tab (e.g. "Results from eQUEST" or "Results from Trace 700") will automatically become visible when the software tool is selected on the "General Information" tab, and includes the tool-specific instructions provided by the tool vendors. The following BEM tools are currently supported: DesignBuilder, EnergyPlus, eQuest, Openstudio, Trace3DPlus, and Trace 700.
2. On projects that used other BEM tools, the simulation results must be manually entered on the "Compliance Calculations" tab.

Step 4: Fill out Submittal Checklist tab

Fill out the Submittal Checklist tab and ensure that all necessary project materials along with this Compliance Form are included in the package submitted to the jurisdiction or above-code program for review.

Available at:
https://www.energycodes.gov/performance_based_compliance#tools

Maintaining Prescriptive Options – Reduces Complexity, Eases Verification

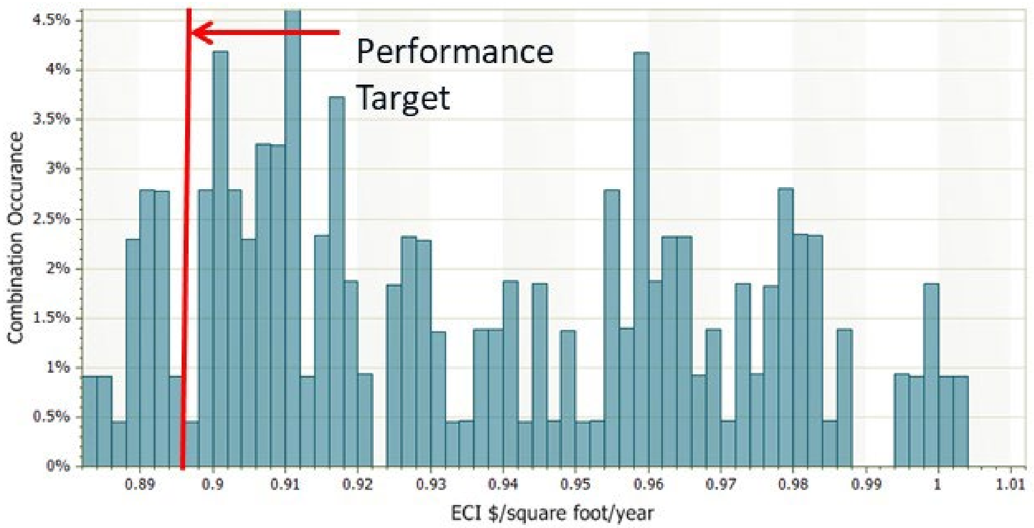
- Stakeholders have expressed the desire to maintain simple, prescriptive solutions
  - Precalculated Prescriptive Packages
  - Able to target performance Levels
  - Includes precalculated trade-offs

Precalculated Packages for Office Buildings 5,000 to 150,000 ft² (450 to 14,000 m²) in Climate Zone 5A

Compliance with the Precalculated Package Path method requires that all parameters for one package in the table below be met in addition to the following:

1. All mandatory requirements of Standard 90.1-2013 must be met.
2. All prescriptive requirements not covered below must comply with Sections 5 to 10 of Standard 90.1-2013.
3. HVAC systems shall be VAV reheat and include economizers in compliance with Section 6.5.1 and energy recovery as required by Section 6.5.6.
4. Cooling source shall be direct expansion.

Package[1]	HVAC System[2]	Minimum Heating Source Efficiency[3]	Minimum Cooling Source Efficiency[4]	Maximum Window Wall Ratio (WWR)	Opaque Construction & Fenestration U-factor[5]	Maximum Fan Brake HP (input kW) for Each System[6]	Percent of Interior LPD (W/ft²) allowance[7]	Minimum Daylight Floor Area[8]	Minimum Occupancy Sensor Coverage Area
1	HyRH	100%	100%	33%	100%	100%	100%	21%	53%
2	HyRH	100%	100%	**50%**	100%	100%	100%	41%	53%
3	HyRH	120%	115%	**50%**	**125%**	100%	100%	21%	53%
4	HyRH	100%	100%	**40%**	**108%**	100%	**122%**	21%	91%
5	HyRH	110%	110%	33%	100%	**135%**	100%	21%	53%
6	**ELRH**	100%	120%	**40%**	**108%**	100%	80%	21%	91%
7	**ELRH**	100%	100%	**40%**	83%	100%	100%	41%	91%
8	**ELRH**	100%	115%	25%	67%	80%	**122%**	21%	91%
9	**ELRH**	100%	115%	33%	100%	**135%**	100%	41%	91%
10	**ELRH**	100%	100%	25%	**108%**	100%	100%	41%	91%



Reduce Complexity / Limit Unequitable Trade-offs Between Long and Short Life Components – System Efficiency

Prescriptive

SEER, AFUE, LED, LPD, Economizer, ERV, Motor Efficiency, Etc.

- Applies mostly to small and simple buildings
- Limited Options
- Doesn't achieve deep savings
- Options limited with increased code stringency

Simple & inexpensive to implement

"THE GAP"

Whole Building Performance

Energy Modeling, Whole Building Integrated Design, LEED Certification,

- Applicable to large/ complex buildings
- Achieves deeper savings
- Unlimited options
- Flexible

Complex & expensive to implement

System Performance

Compare energy to system delivery

- Applicable to a range of buildings
- Includes system effect

Simple to implement

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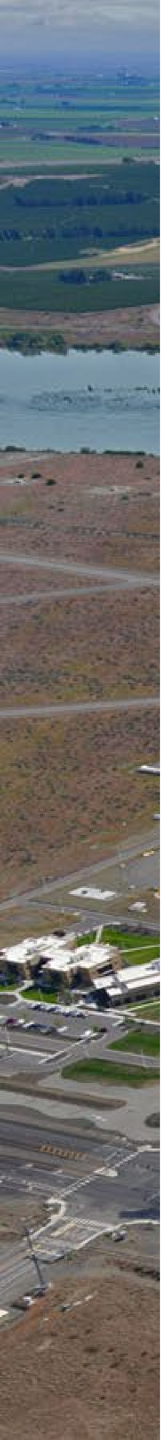


Thank you

EBC

Energy in Buildings and
Communities Programme

Closing the building energy performance gap in Australia's commercial building sector

Helen Bell

Green Building Council of Australia

Green Building Council Australia

greenstar

Closing the building energy performance gap in Australia's commercial building sector

EGBC Energy Codes Working Group Annual Symposium

14 November 2023

Building a sustainable future

Burwood Brickworks, Vic. Frasers Property Australia & Australand Holdings.
6 Star Green Star – Communities v1

Who is the Green Building Council of Australia?

Barangaroo South, NSW.
6 Star Green Star –
Communities Pilot v0.2

GBCA is a world-renowned organisation dedicated to transforming the built environment.

Since 2002, we have driven real change by creating market-based solutions that empower industry to embrace sustainable practices.

> We lead an industry that is building for people today, tomorrow and for future generations.
>
> DAVINA ROONEY | Chief Executive at Green Building Council of Australia

What does the Green Building Council of Australia do?

We lead the sustainable transformation of the built environment.

We rate

We advocate

We educate

We collaborate

Curtin University, School of Design and Built Environment. Targeting a 6 Star Green Star – Design & As Built v1.2

greenstar

We set the standard for Australia

Green Star drives the creation of healthy, resilient, and positive places for people and nature, across all commercial buildings as well as apartments. There is also a rating system for individual homes.

We work closely with NABERS

National Australian Built Environment Rating System

Rates the operational energy use

National program administered by the NSW state government Department of Environment

NABERS Commitment Agreements

Contractual commitment to deliver building that performs as promised

+

Energy only

+

For new buildings, refurbishments and additions

+

Multiple stages of independent verification usually missing at design stage

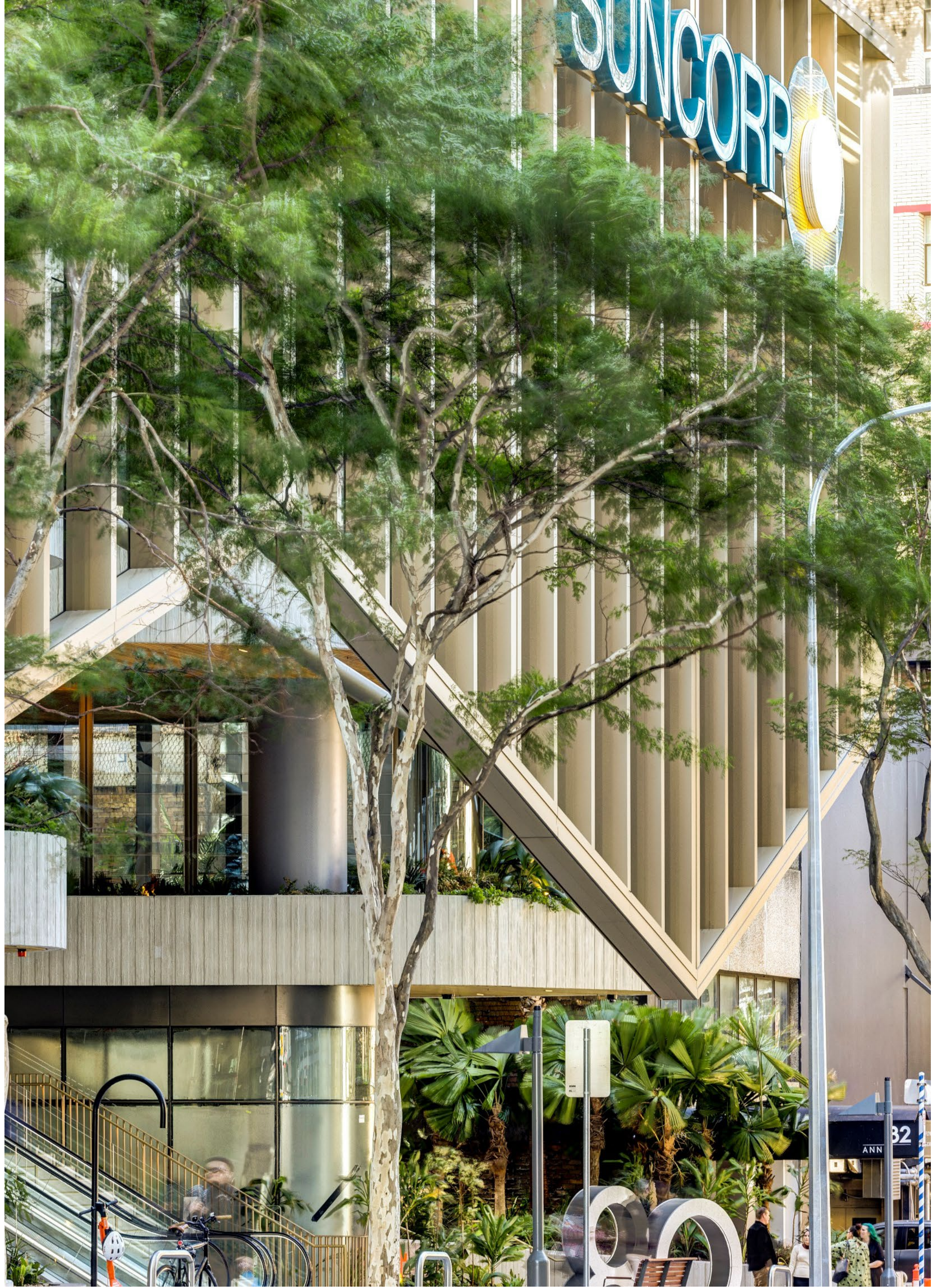
Energy performance in Green Star buildings

Closing the performance gap in Australia's commercial office sector

https://gbca-web.s3.amazonaws.com/media/documents/closing-the-performance-gap-in-australias-commercial-office-sector.pdf

Sample

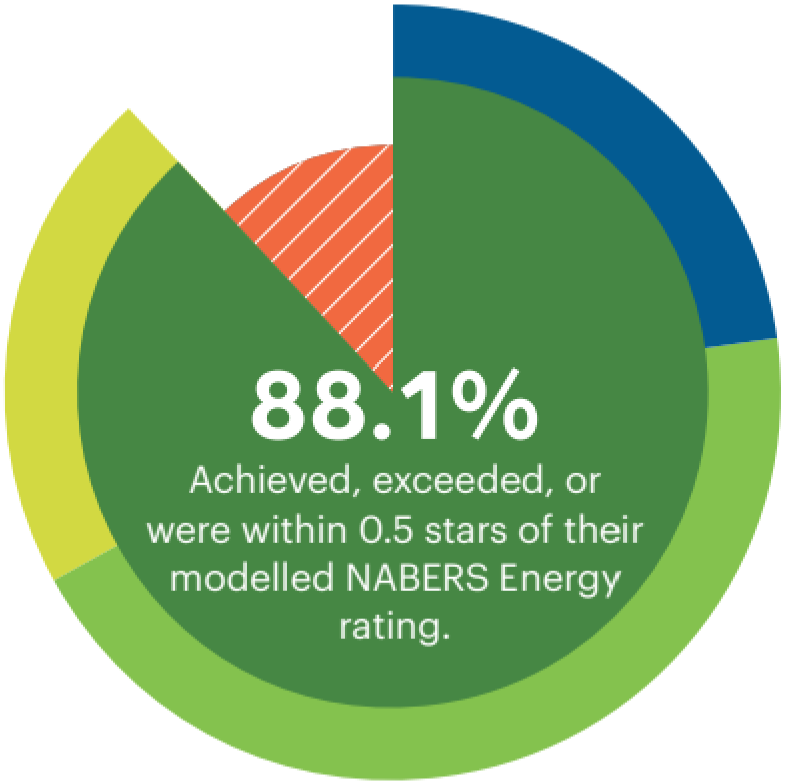
176 office buildings:
+
100% had Green Star ratings
+
36% had NABERS Commitment Agreements



Performance predicted, exceeded or well within reach

11.9%
were more than 0.5 stars off from their modelled NABERS Energy rating

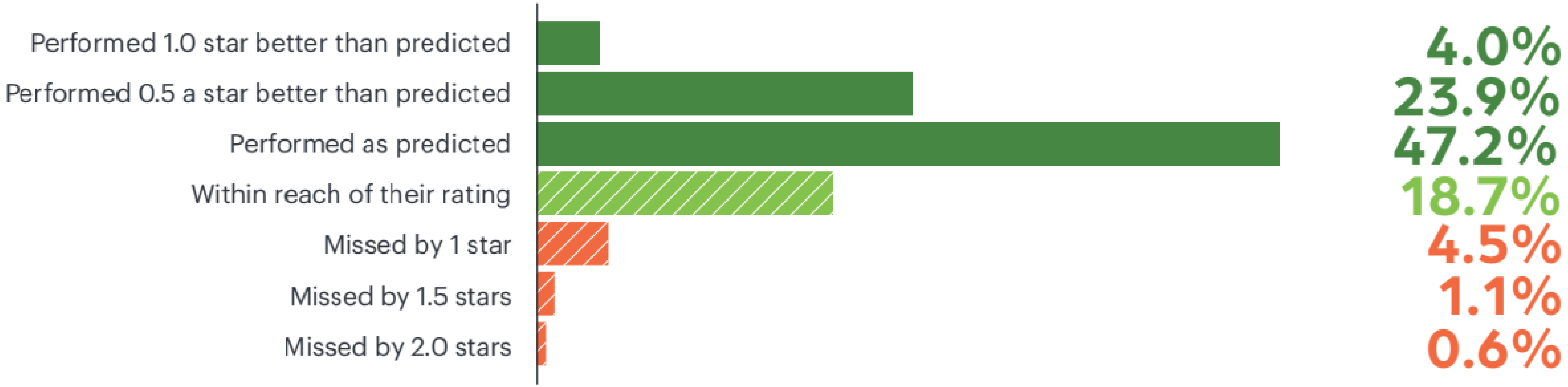
21.0%
were within reach of their modelled NABERS Energy rating – between 0.1 to 0.5 stars



23%
improved on their modelled NABERS Energy rating

44.1%
achieved their modelled NABERS Energy rating

Modelling versus peak performance



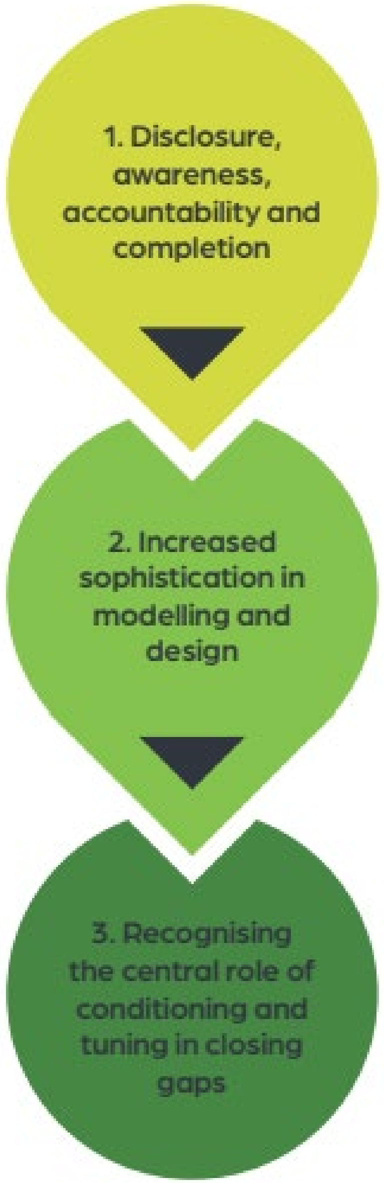
75% of Green Star rated buildings achieved their modelled NABERS rating when operating at peak performance

93% of Green Star rated buildings with NABERS Commitment Agreements met or exceeded their NABERS Energy target at peak performance

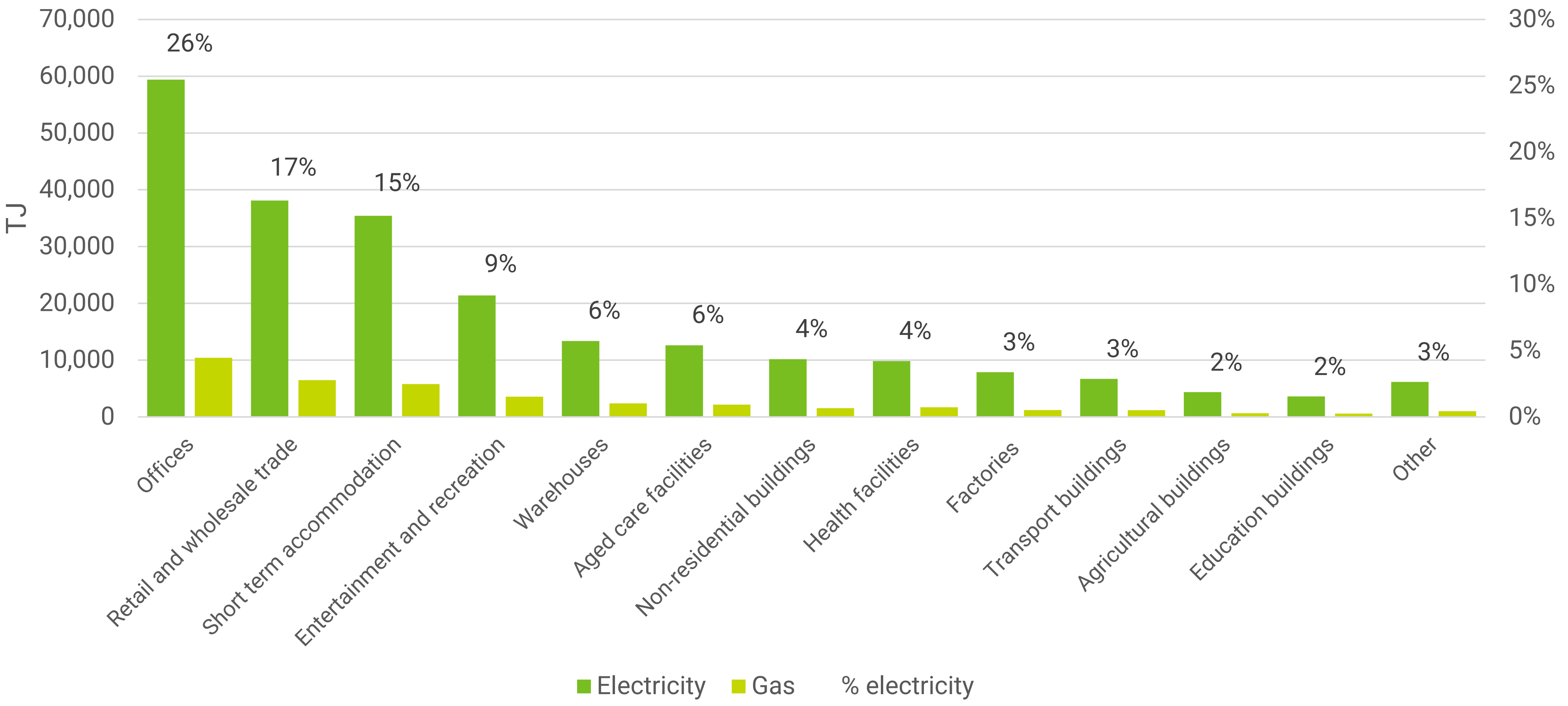
Key findings

- Gap closes when targeted
- Commit to NABERS
- Monitor and manage
- Broaden scope

> 'This investigation into Australia's high performance office buildings represents just 14 per cent of the market. To achieve net zero building at scale, we must transfer the lessons learnt in this segment of the market to mid tier offices and other sectors.'
>
> GBCA Executive Summary



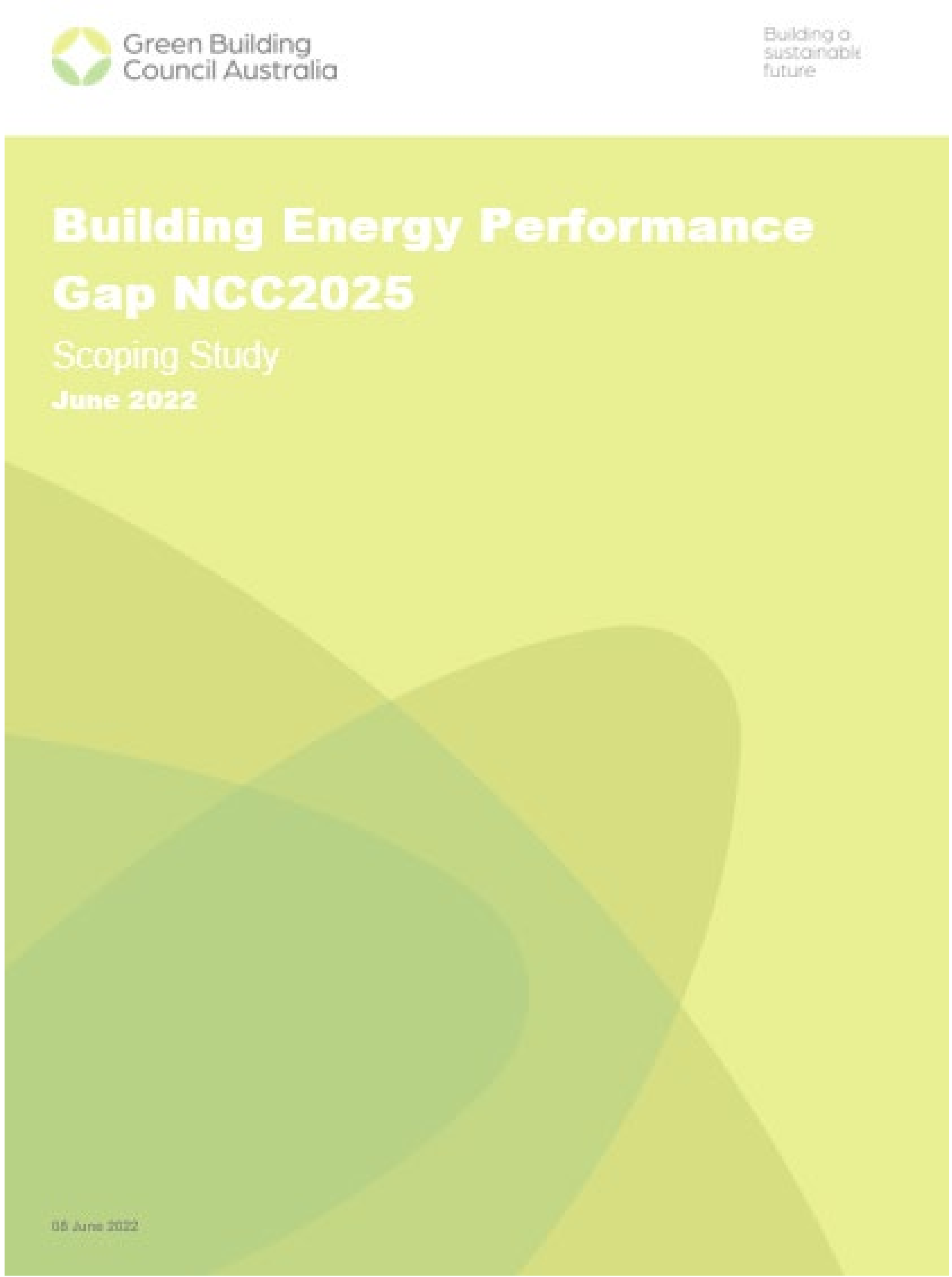
Office buildings only make up part of the market



Source: 2022 Commercial Building Baseline Study, prepared for the Australian Government Department of Industry, Science, Energy & Resources by Strategy Policy Research Pty Ltd.

Scoping Study

Improving the evidence base outside office



Green Building Council Australia

Building a sustainable future

Building Energy Performance Gap NCC2025

Scoping Study

June 2022

08 June 2022

Building types

Green Star Buildings rates most building types that are new buildings or major refurbishments. In principle:

+ Most building types are eligible to be rated, included mixed use developments
+ All National Construction Code (NCC) space uses definitions are eligible for certification, apart from:
    + standalone carparks (NCC Class 7a) and,
    + uninhabited structures (Class 10).

Buildings

Performance

Interiors

Retirement

Warehouse and Cold Stores

Apartment Buildings

Hospitals

Shopping Centres

Data centres

Hotels/Motels

Office Buildings

Retail and Supermarket coming soon

Quantifying the Building Energy Performance Gap NCC2025

Phase 1: Scoping Study: GBCA and Team Catalyst

1. Identification of “Sectors of hope”
2. Interviews with potential data owners
3. Access to 1-2 projects in each sector
4. Analysis of this initial data to assess potential
5. Reference Group Workshop to discuss findings
6. Recommendations to inform a large-scale study on the performance gap

Phase 1: Scoping study

Potential sectors

- **Class 3** - Community centres, hotels, motels, public schools, goals)
- **Class 5** – Non premium office buildings
- **Class 6** – Shopping centres, supermarkets
- **Class 7** – Warehouses, car parks
- **Class 8** – Laboratories, manufacturing
- **Class 9a** – Hospitals, day surgeries
- Data centres, Childcare, Schools, Community centres

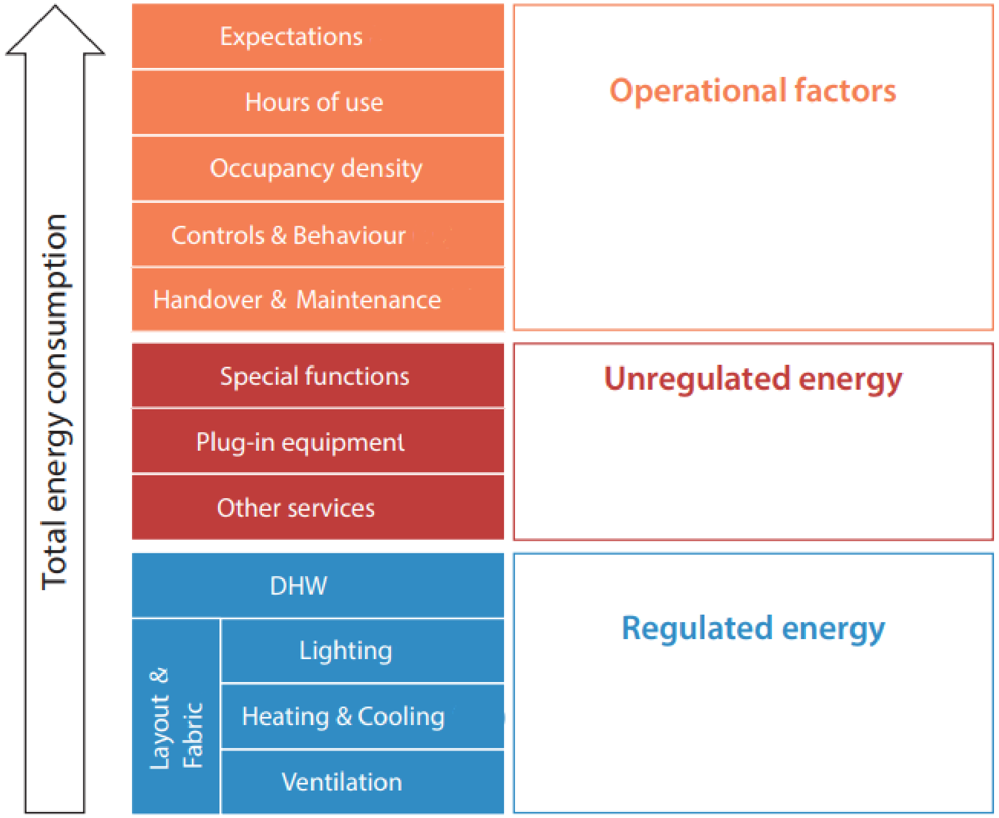
Potential sources of data & stakeholders

1. NABERS data sets e.g. healthcare, retail, hotels
2. GBCA Green Star – (exc. offices)
3. Local Councils
4. Consultants (confidential building energy modelling)
5. Owners/Facility managers (confidential operational data)
6. ABCA, International Building Performance Simulation Association (IBPSA), CIE

JV3 modelling + potential source/s of operational data

The National Construction Code is not an energy budget

Typical energy consumption components – regulated, unregulated and operating



> "During the design stage, two energy models should really be used – one to calculate the regulated energy (building regulations) and one to estimate the actual energy consumption (i.e. the total annual energy bills). The latter should include a sensitivity analysis of assumptions."
>
> David Clark

Source: What Colour Is Your Building? Measuring and reducing the energy and carbon footprint of buildings. David Clark, 2013

Findings

Limited usefulness of NCC energy modelling (JV3) for BEPG analysis

- Data is hard to come by
- Final systems not confirmed when NCC compliance is undertaken
- JV3 is used to compare designs, not to create an energy budget
- Industry workshop suggested a systems level approach building up to an estimated performance gap would be a more useful measure than a total building energy use approach
- NABERS and Green Star remain the only accessible quantitative data sources

> “JV3 isn’t a reliable predicter of the actual energy performance. We use JV3 to validate the performance of the fabric itself. Our buildings have a lot of unknowns, who is going to move in, how will they use it. There are too many unknown. JV3 is used as a thermal comfort assessment. We try to bridge the gap manually with actual data. [We then] use that data to predict the energy use for new customers.”
>
> Building owner

Building an estimated BEPG using a systems level approach

	Energy split*	Component error	Total Error
HVAC	43%	10%	4.30%
Lighting	20%	0.1%	0.02%
Equipment	13%	15%	1.95%
Pool Heating	9%	5%	0.45%
Other	9%	20%	1.80%
Water Heating	5%	1%	0.05%
Kitchen/Catering	1%	30%	0.30%
Laundry	1%	30%	0.30%
		Estimated gap	9.17%

**The energy split in this illustrative example is taken from Climateworks' "Low Carbon High Performance" report. The component errors are simply illustrative at this stage.*

""The key issue is not whether energy efficiency modelling accurately predicts the level of energy consumption; rather, it is the extent to which energy savings from more energy efficient design and technology choices are accurately estimated that matters."

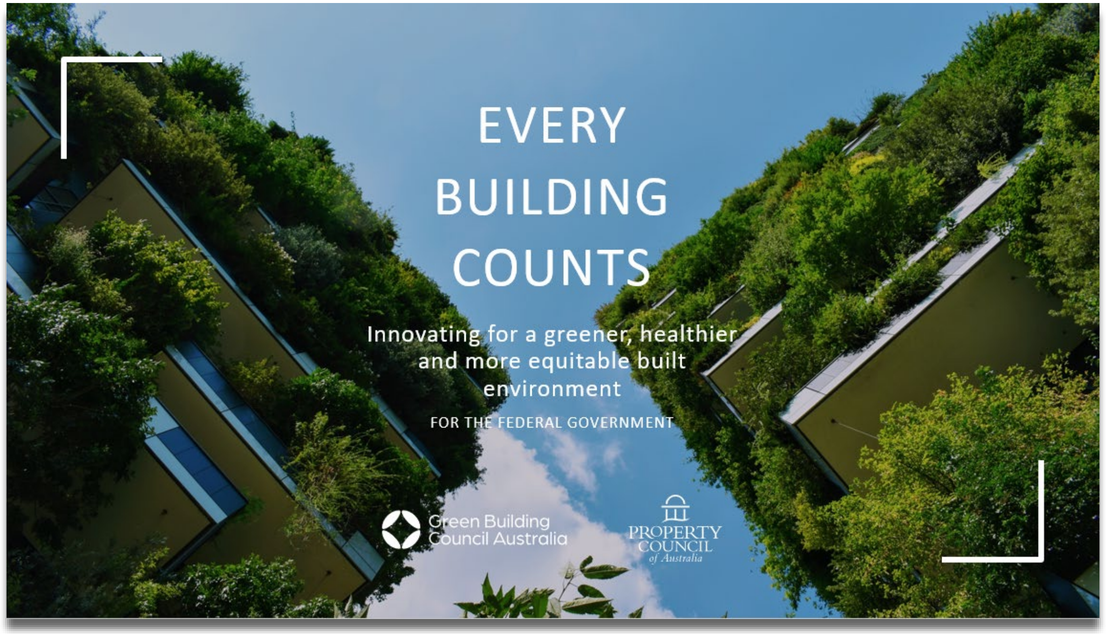
CIE NCC2019 report

Where to from here?

Advocacy & education

80 Ann Street, QLD. Mirvac.
6 Star Green Star – Buildings v1

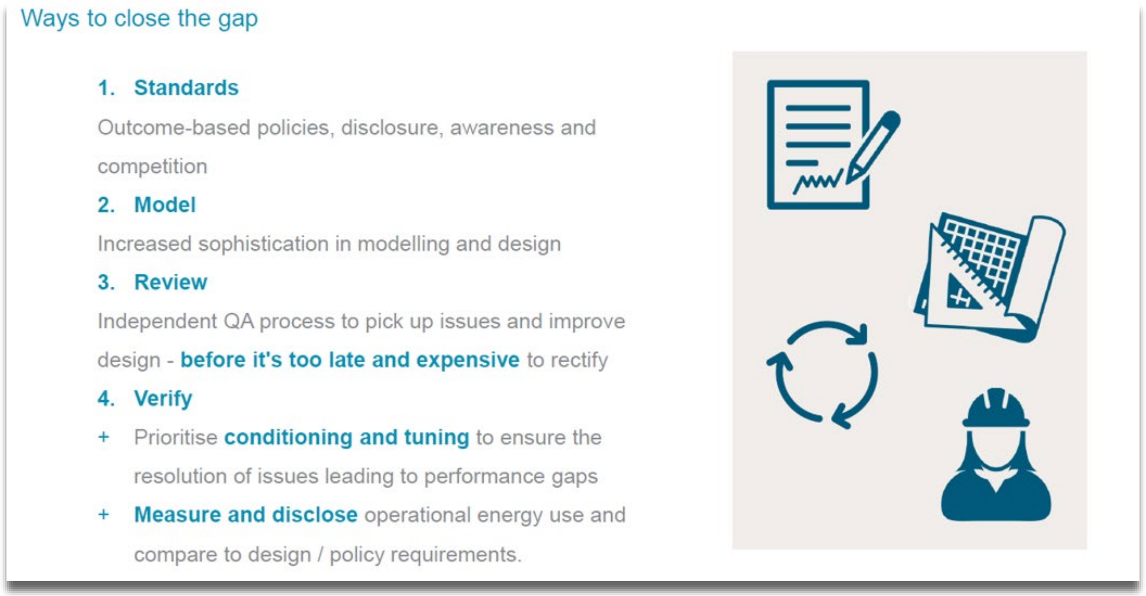
Promoting the uptake and expansion of NABERS



Key Recommendations:

7.1 Expand the coverage of NABERS to all building types and extend the Commercial Building Disclosure Program.

Education



https://www.nabers.gov.au/news/new-webinar-series-nabers-helps-governments-close-performance-gap

Case study – NSW Sustainable Building SEPP

The NSW Sustainable Buildings SEPP is a new policy targeting large commercial buildings to:

- Link design and performance
  - In the design stage
  - Via the planning system
  - Using NABERS
- Require disclose of operational efficiency
- Build in compliance mechanisms
- Minimise energy use and emissions
- Lead the market to collect data

Case study – City of Sydney LEP

Sydney Local Environmental Plan 2012, 7.2.5A -**Sustainable development in Central Sydney tower cluster areas, where:**

(3)Development consent must not be granted to development for the purposes of office premises unless the consent authority is satisfied that appropriate measures will be taken to ensure the development is capable of achieving **best practice energy performance** in the common areas of the part of the building to be used as office premises.

(4)In this clause— ***best practice energy performance*** means any of the following performance standards—

(a)a maximum of 45.0 kWh per year for every square metre of gross floor area,

(b)a **5.5 star + 25% NABERS** energy rating, through a **NABERS energy commitment agreement** between the applicant and the NABERS National Administrator,

(c)a **Green Star building rating** with a **“credit achievement”** in Credit 22: Energy Use,

(d)a standard the consent authority is satisfied is equivalent to a standard referred to in paragraphs (a)–(c).

The need for additional research

- Metering and monitoring
- Complete the learning circle – design, construct, commission, tune – use the same energy modelling team and learn from results
- Encourage the expansion of NABERS beyond office and the continued uptake of Green Star
- Repeat the predicted versus actual project with other sectors as NABERS expands beyond office

Curtin University, School of Design and Built Environment. Targeting a 6 Star Green Star – Design & As Built v1.2

Green Building Council Australia

greenstar

Thank you for your time.

Helen Bell

Senior Research Manager, GBCA

Email: Helen.Bell@gbca.org.au

Building a sustainable future

EBC

Energy in Buildings and Communities Programme

State-of-the-art of Building Energy Efficiency Codes in China for Operation, Retrofitting, and Design

Qingpeng Wei
Tsinghua University

IEA EBC Building Energy Codes Working Group (BECWG) Symposium

清華大學 Tsinghua University

State-of-the-art of Building Energy Efficiency Codes in China for Operation, Retrofitting and Design

Presented by: Professor Qingpeng WEI

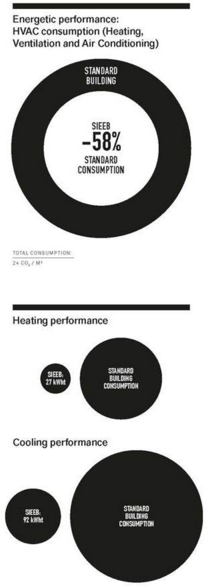
Building Energy Research Center, Tsinghua University

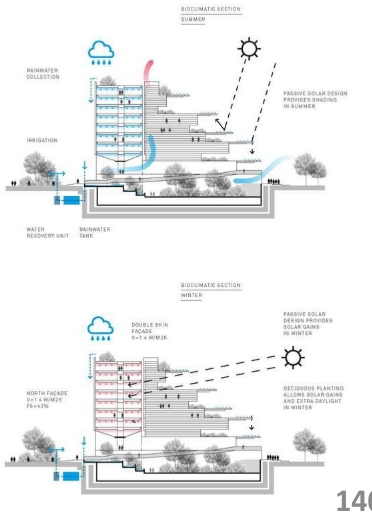
2023/11/14

15 years ago: a China-Italy Low-Energy Demo Building was completed in our campus in Beijing

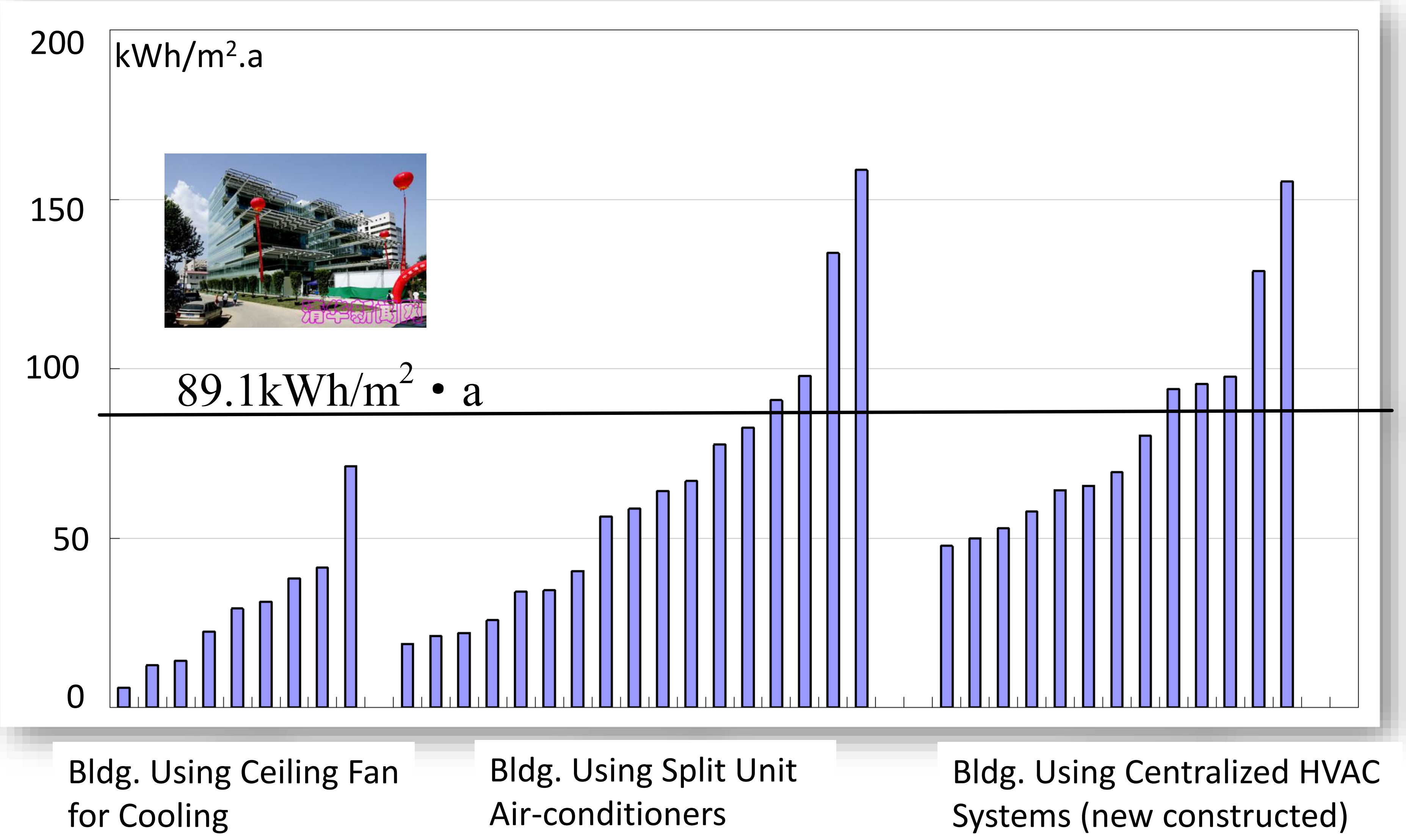
Key Green Technologies Low-carbon target：

- BCCHP, 300m² PV
- High performance windows / façade with passive design
- Cool ceiling + displacement ventilation
- Heat recovery for exhaust air and OA intaking
- Daylighting and LED with dimming system and advanced BAS
-
- 24 kgCO2/m2.a, 58% reduction (compare to common bldg.)

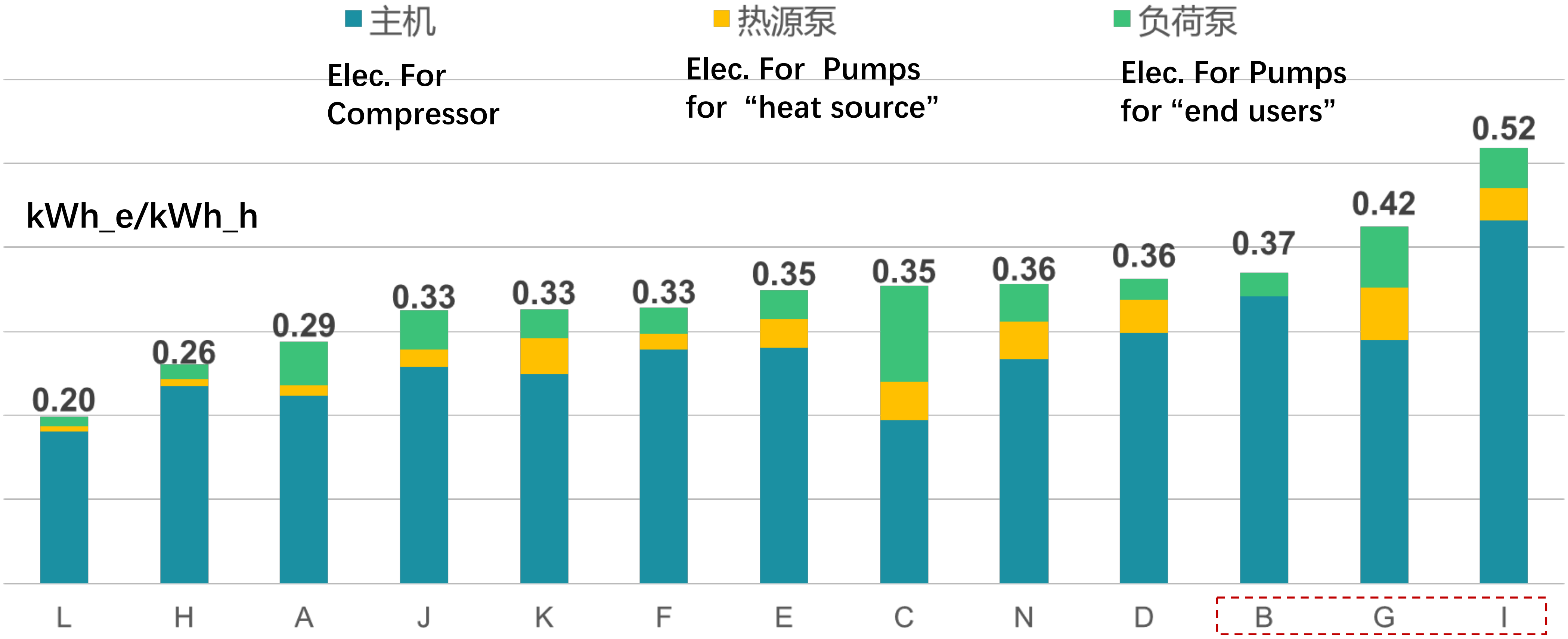




But Comparison of Measured Operating Electricity Use Intensity (EUI) with Bldg.s in the Campus



Case Study: Measured Actual Heat Pump Systems Efficiency for Space Heating

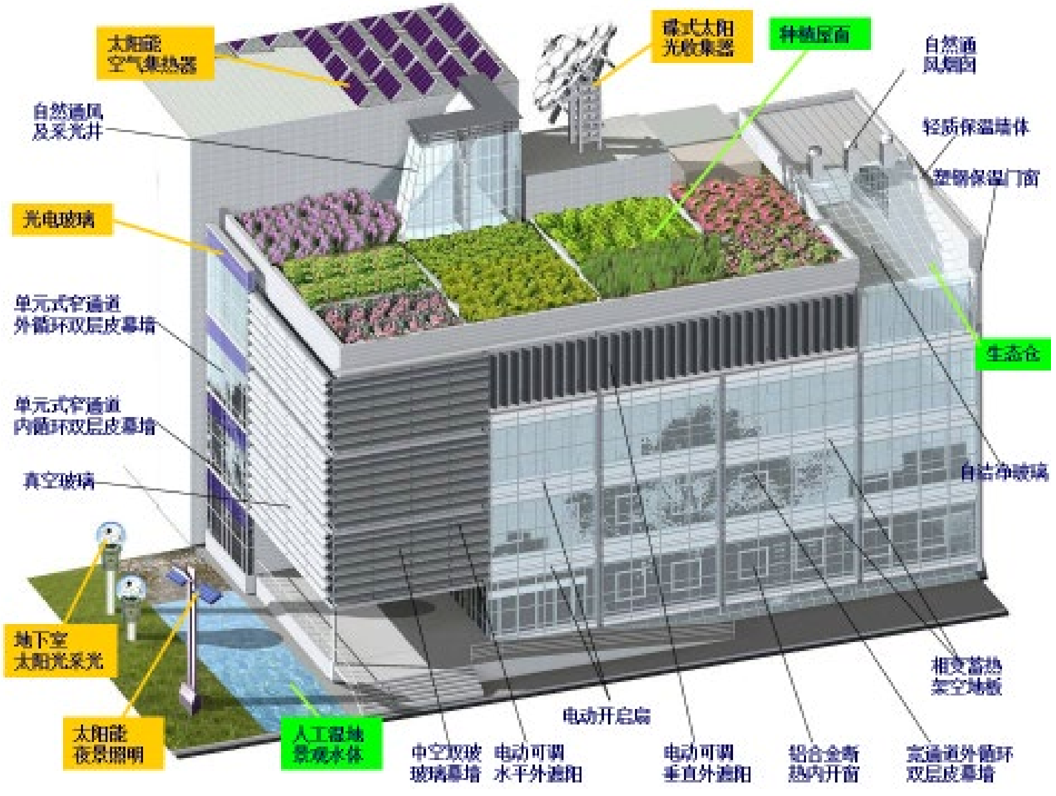


单位制热量系统各环节电耗

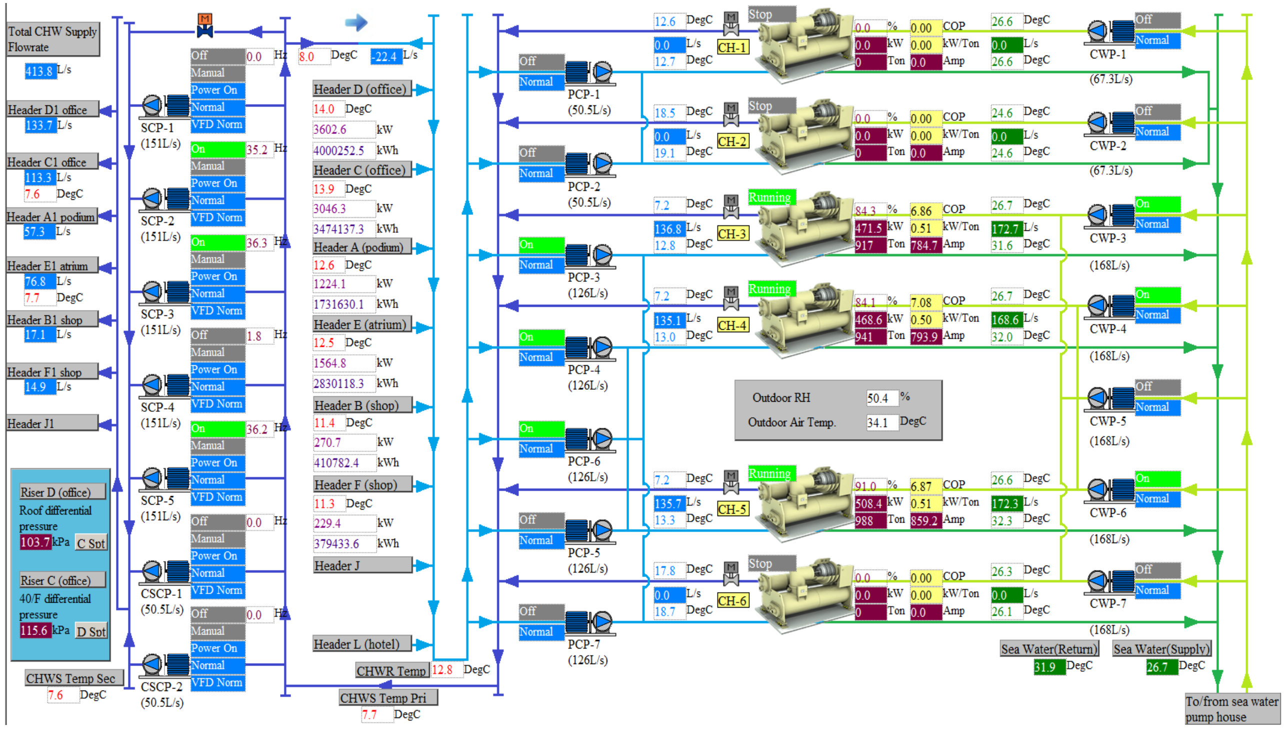
From Primary Energy perspective: Some HP systems were "waste" energy rather than "save" energy; but they obtained subsidies since HP was defined as a "good" technology for energy efficiency and was encouraged for installations.

Challenge for Building Energy Efficiency: Call for New Knowledge based on Data during Operation

From Measure-based EE approach

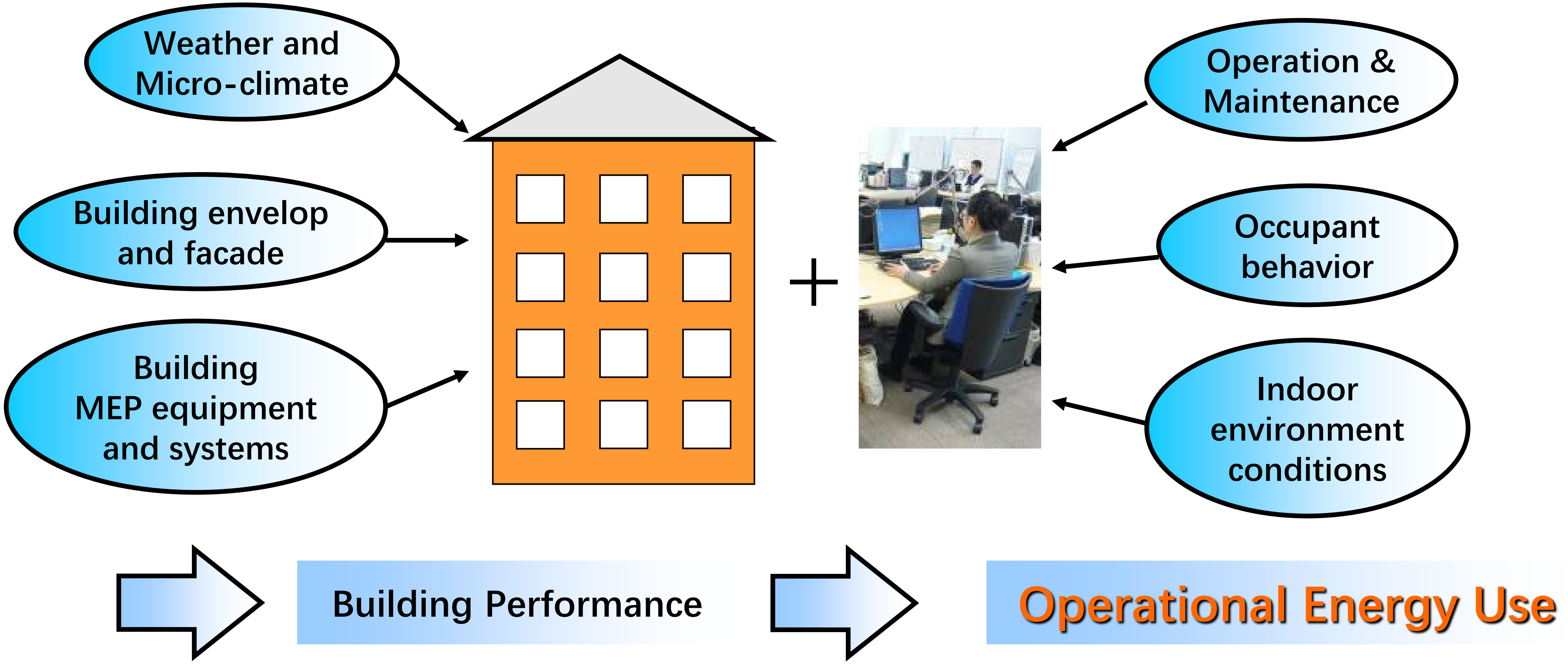


To Data-based approach, therefore, Knowledge-based and AI-aided



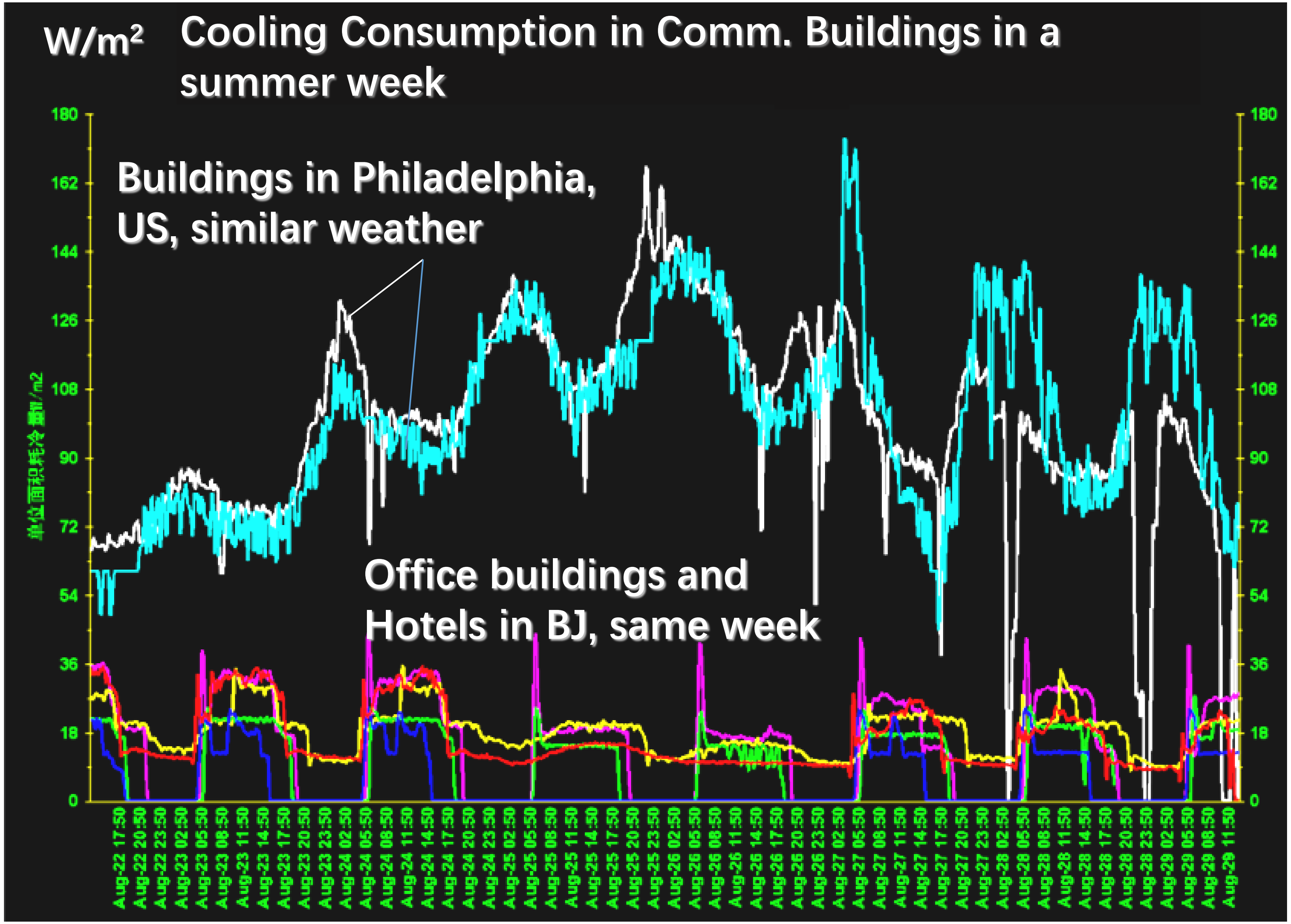
To Bridge the GAP between Codes, Design, and Operational Energy Use

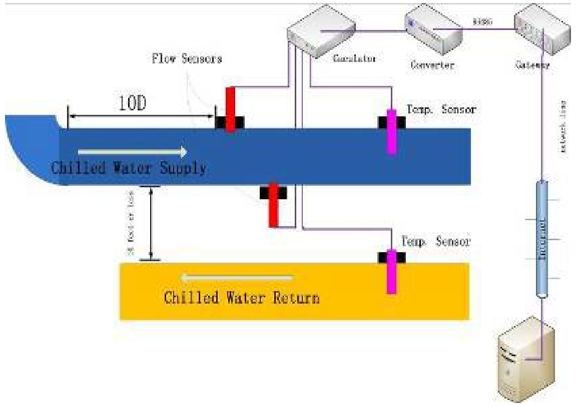
Acknowledgement to IEA EBC Annex 53: Start Point and still Working on our Way



- Codes: theory and principle-based model, need for measured data in reality
- Operation: data in reality and need for scientific data-driven model to explain
- Therefore: Call for Innovation from Operational Scenes for Building Energy Efficiency

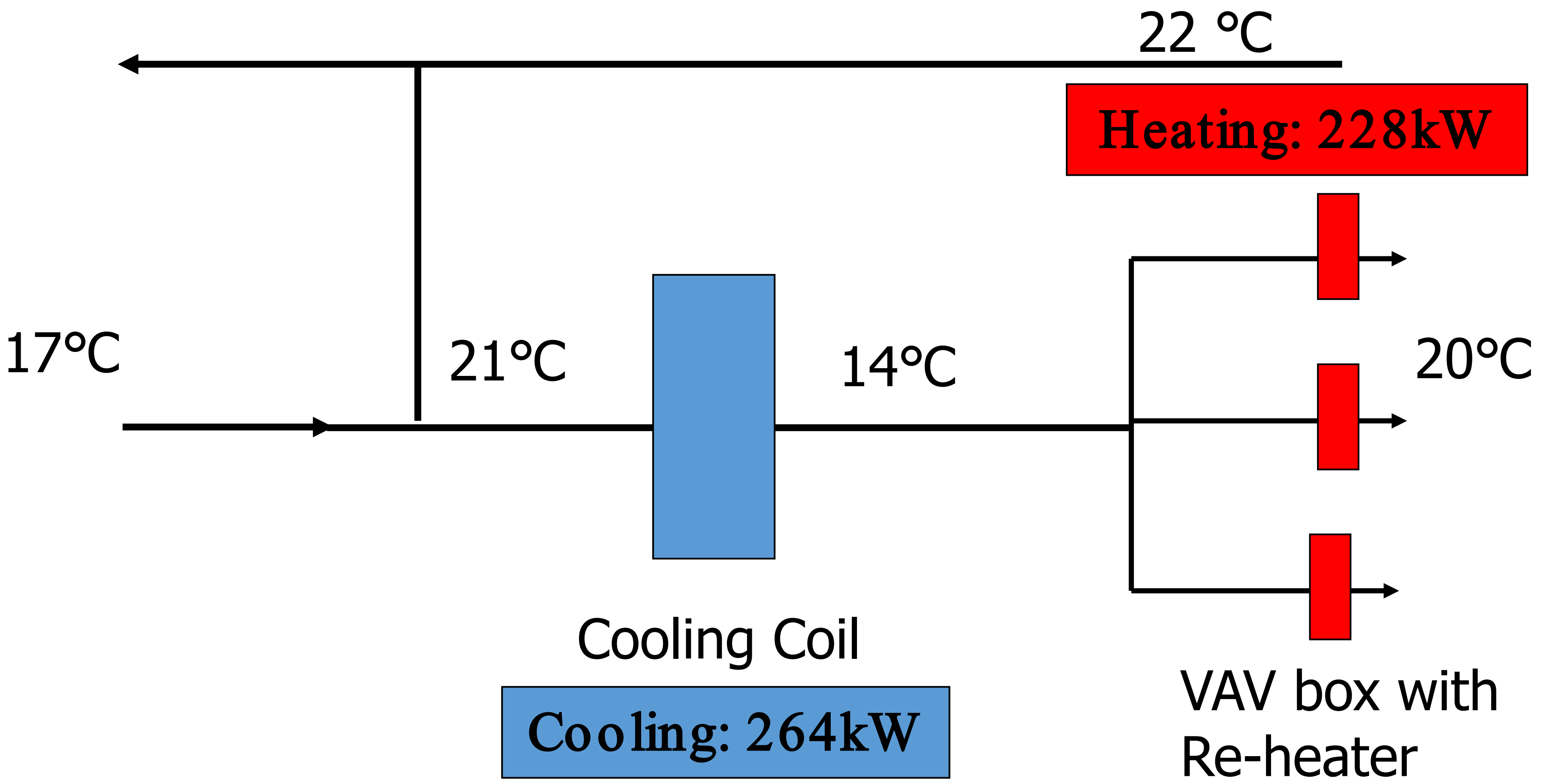
On-line Measured Cooling Consumption of Air-conditions in US and China: Shocked





Details: Cooling with Reheat, and Valve Faults, Sensor Faults - Need for Retro-Cx and Retrofitting

- Typical operation regime of VAV system in US: Cooling + Reheat



More Case Studies for Retro-Cx: Based on Actual EUI, startup with overall EUI and go further details

Tsinghua School
4650m^2, 34kWh/m^2·a

Tsinghua Art School
64k m^2, 65.7kWh/m^2·a

Government office A
16k m^2, 70.1kWh/m^2·a

Government office B
37k m^2, 113kWh/m^2·a

Tower in Shanghai
287k m^2, 215kWh/m^2·a

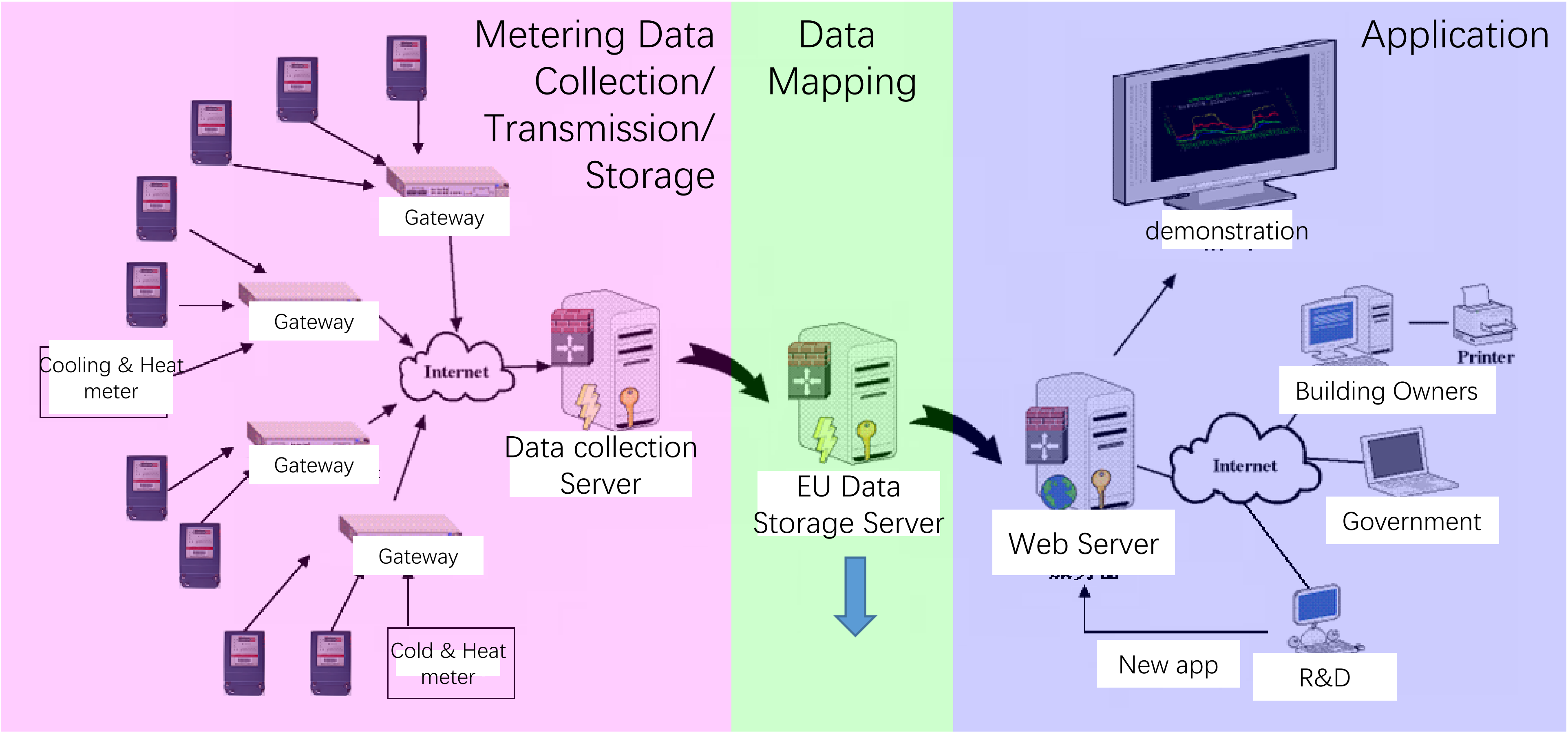
Office building A, USA
6425m^2, 364kWh/m^2·a

Office building B, USA
30k m^2, 356kWh/m^2·a

Office building, Lyon
17k m^2, 165kWh/m^2·a

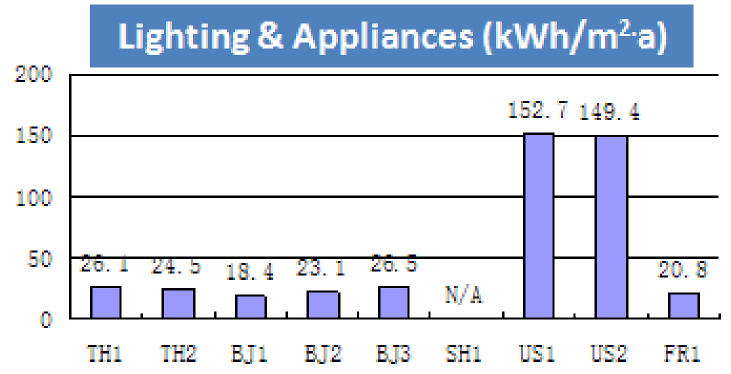
Note: Excluding energy for space heating

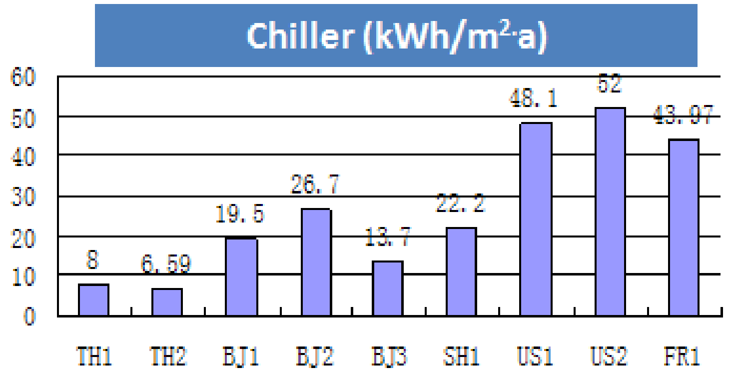
Benchmarking with BMS: Energy Use Sub-metering using ICT (Now it is very cheap, but more “walls” to consider)

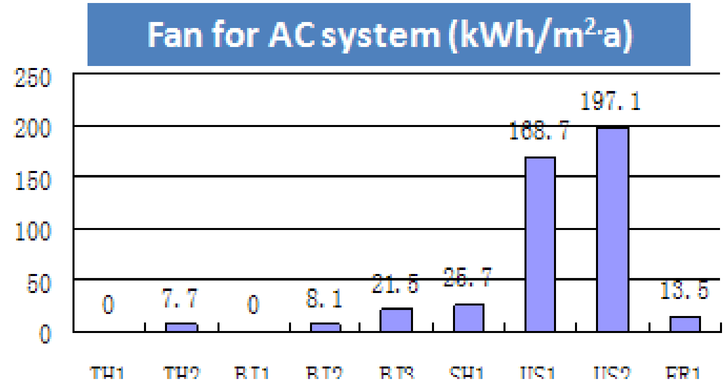


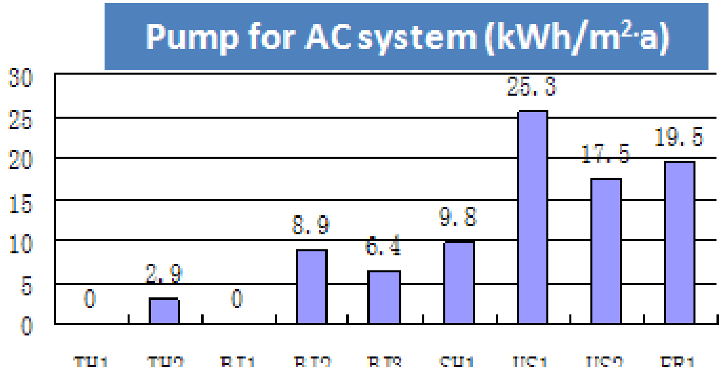
Normalized Energy Use Model for Benchmarking on End Users

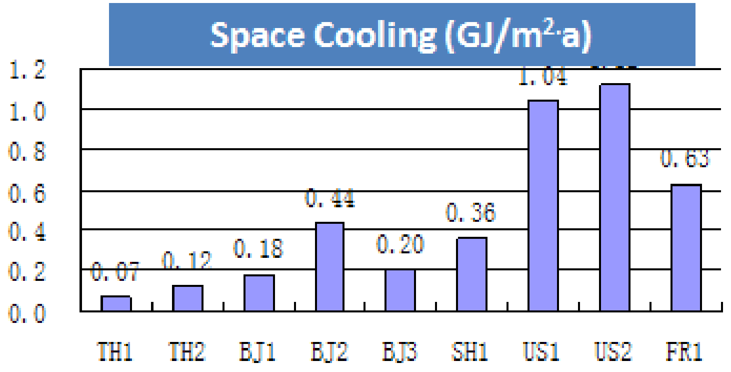
Benchmarking with measured EUI for Energy End-Users in Buildings to Understand WHY

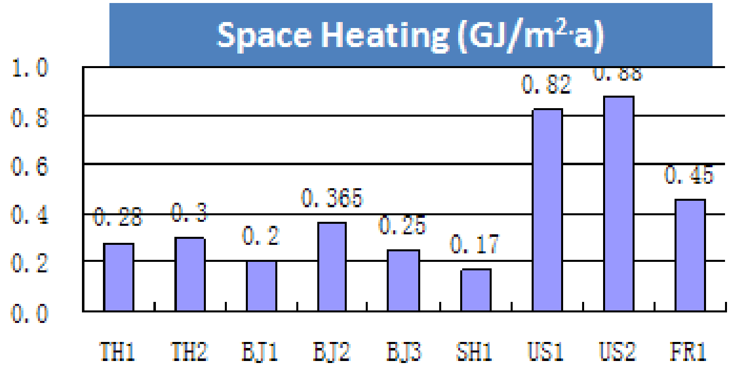












China National Approach: Total Energy Use Intensity (EUI) CAP Control Code


P GB/T 51161-2016

民用建筑能耗标准

Standard for energy consumption of building

2016-04-15 发布 2016-12-01 实施

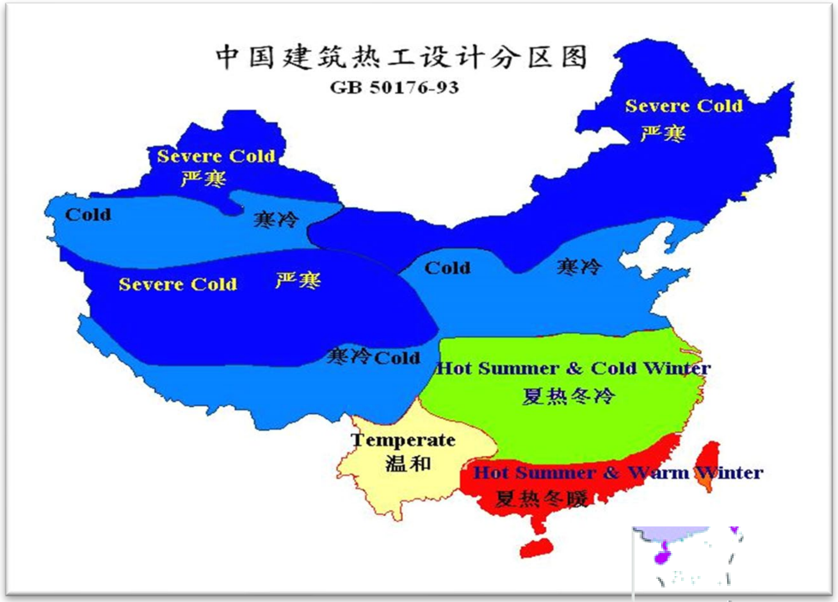
中华人民共和国住房和城乡建设部
中华人民共和国国家质量监督检验检疫总局 联合发布

- **Energy Use Intensity (EUI) CAP Control:**
  - **Similar to EPBD, in terms of annual energy use per sq. meter;**
  - **The first standard dedicated on building energy use data**
  - **Values for various types of buildings in different climate zones**

Office Building, Obliged Value (OV) and Recommended Value (RV)

表 5.2.1 办公建筑能耗指标的约束值和引导值 单位：kWh/(m^2.a)

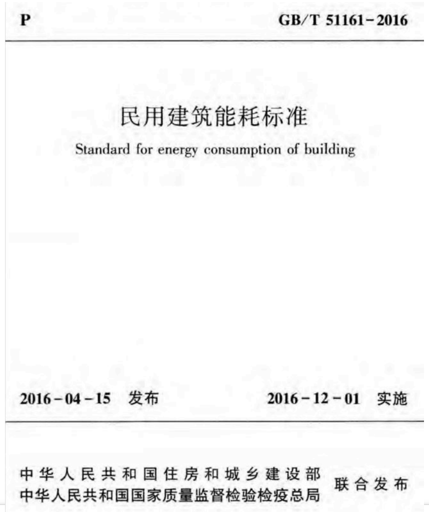
建筑分类		严寒和寒冷地区		夏热冬冷地区		夏热冬暖地区		温和地区	
		约束值	引导值	约束值	引导值	约束值	引导值	约束值	引导值
A类	党政机关办公建筑	55	45	70	55	65	50	50	40
	商业办公建筑	65	55	85	70	80	65	65	50
B类	党政机关办公建筑	70	50	90	65	80	60	60	45
	商业办公建筑	80	60	110	80	100	75	70	55
		(OV)	(RV)	(OV)	(RV)	(OV)	(RV)	(OV)	(RV)



PART ONE

BACKGROUND

Detailed in this Code: EUI of hotels, i.e.


P GB/T 51161-2016

民用建筑能耗标准

Standard for energy consumption of building

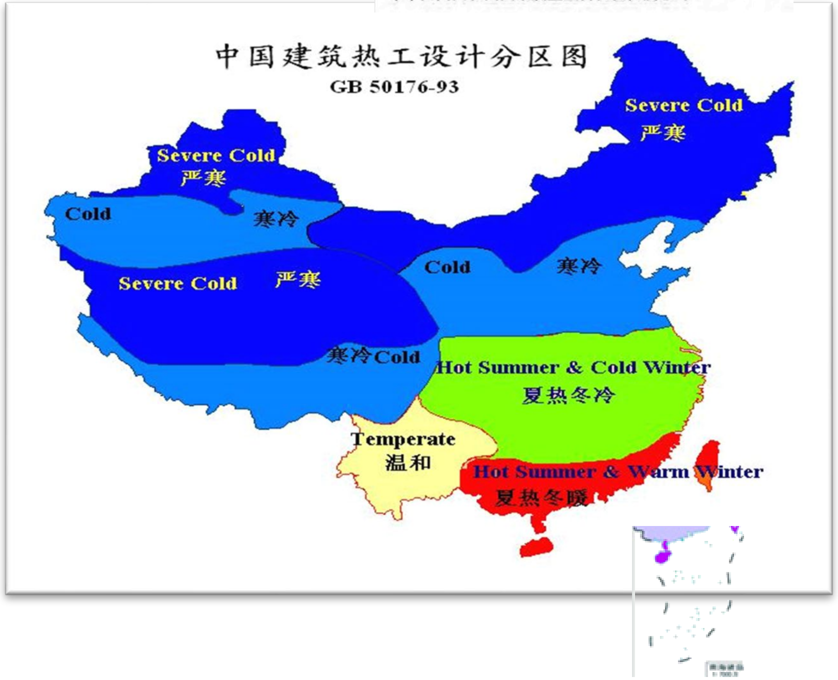
2016-04-15 发布 2016-12-01 实施

中华人民共和国住房和城乡建设部
中华人民共和国国家质量监督检验检疫总局
联合发布

5.2.2 宾馆酒店建筑能耗指标的约束值和引导值应符合表 5.2.2 的规定。

表 5.2.2 宾馆酒店建筑能耗指标的约束值和引导值 单位：kWh/(m^2.a)

建筑分类		严寒和寒冷地区		夏热冬冷地区		夏热冬暖地区		温和地区	
		约束值	引导值	约束值	引导值	约束值	引导值	约束值	引导值
A类	三星级及以下	70	50	110	90	100	80	55	45
	四星级	85	65	135	115	120	100	65	55
	五星级	100	80	160	135	130	110	80	60
B类	三星级及以下	100	70	160	120	150	110	60	50
	四星级	120	85	200	150	190	140	75	60
	五星级	150	110	240	180	220	160	95	75
		(OV)	(RV)	(OV)	(RV)	(OV)	(RV)	(OV)	(RV)



Type A: Nature Ventilated; Type B: Hard to Get Natural Ventilation

ENERGY USE CODES FOR AIRPORTS

• Electricity Use Intensity for Airport Terminals

Annual Electricity Use Intensity Limit Per GFA, kWh/ □ .a

	CLIMATE ZONE 1		CLIMATE ZONE 2	
	OV	RV	OV	RV
CLASS A	140	120	170	140
CLASS B	110	90	120	100

Annual Average Electricity Use Intensity Limit Per PAX, kWh/ PAX

	CLIMATE ZONE 1		CLIMATE ZONE 2	
	OV	RV	OV	RV
CLASS A	1.75	1.35	2.00	1.60
CLASS B	1.10	0.80	1.60	1.30

• Heating and Cooling Use Intensity for Airport Terminals

Space Heating Consumption Per GFA, GJ/ □ .a

	CLIMATE ZONE 1	
	OV	RV
CLASS A	0.36	0.25
CLASS B	0.30	0.20

Space Cooling Consumption Per GFA, GJ/ □ .a

	CLIMATE ZONE 1		CLIMATE ZONE 2	
	OV	RV	OV	RV
CLASS A	0.40	0.30	0.80	0.60
CLASS B	0.20	0.15	0.35	0.25

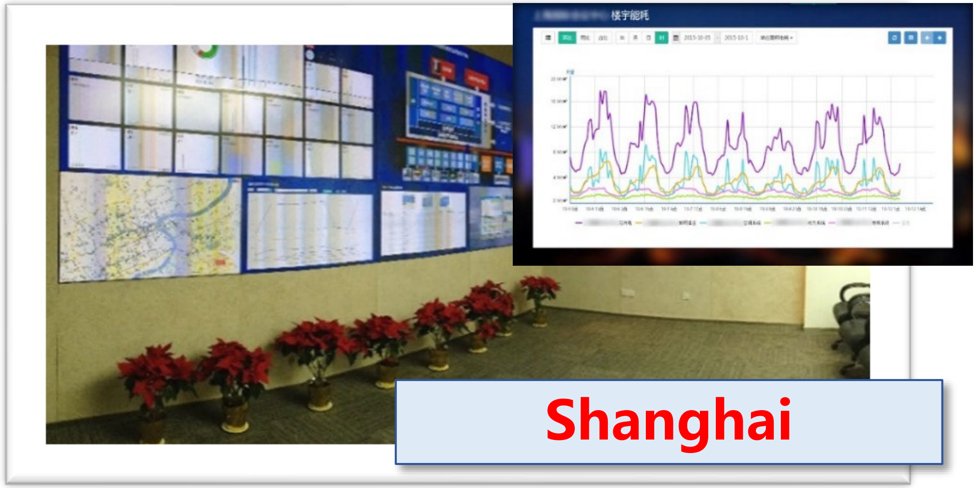
PART TWO
Monitoring Detailed
Operational Energy

Energy Use / Energy Efficiency in Buildings and Systems: On-line Operational DATA

Central Government

Beijing

Jiangxi



Shanghai

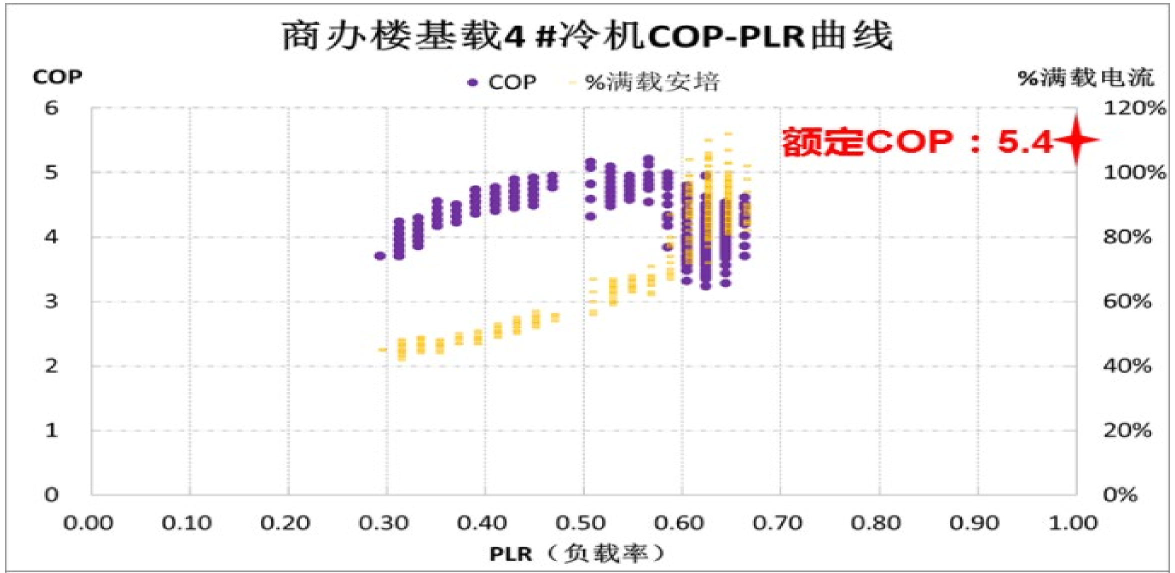
Chongqing

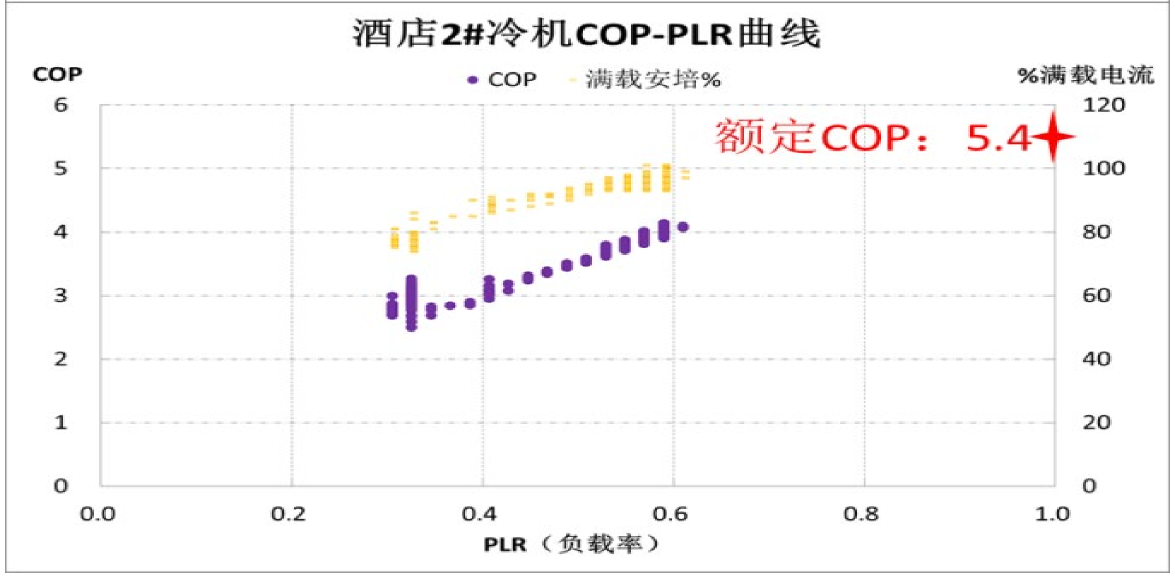
Hunan

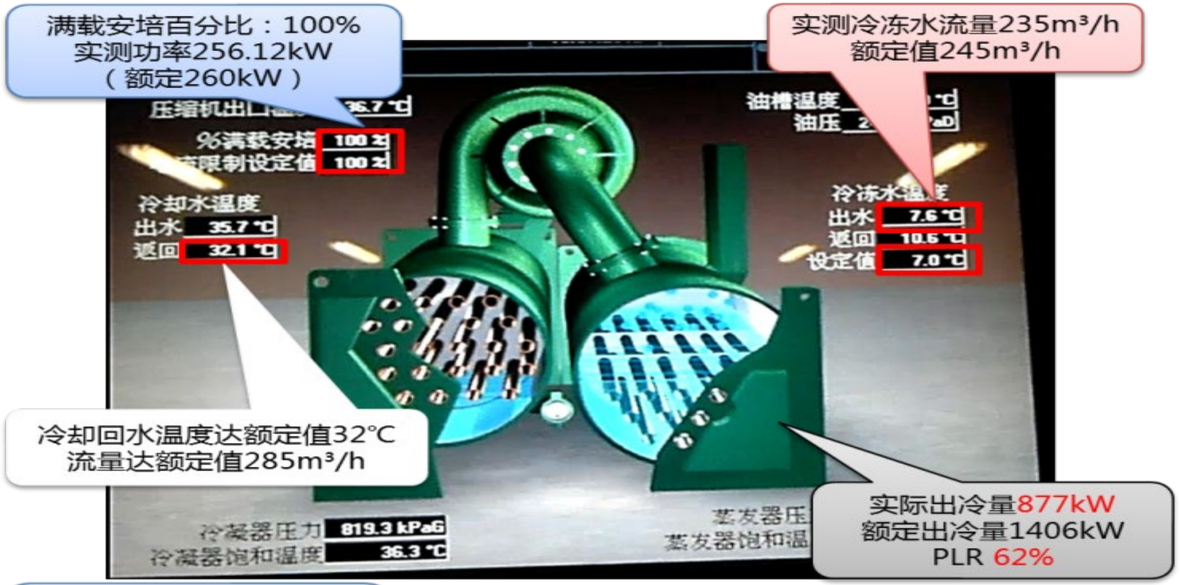
PART TWO

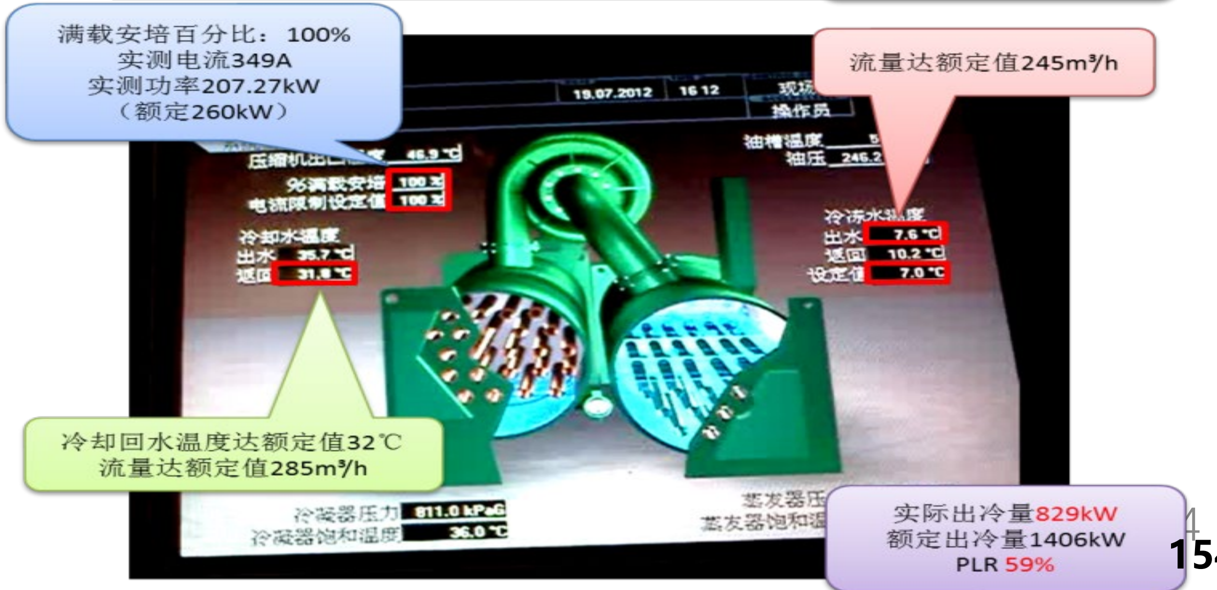
SIMPLE CASE

Check Actual Performance of All the Chillers by Monitored Data and Benchmarking







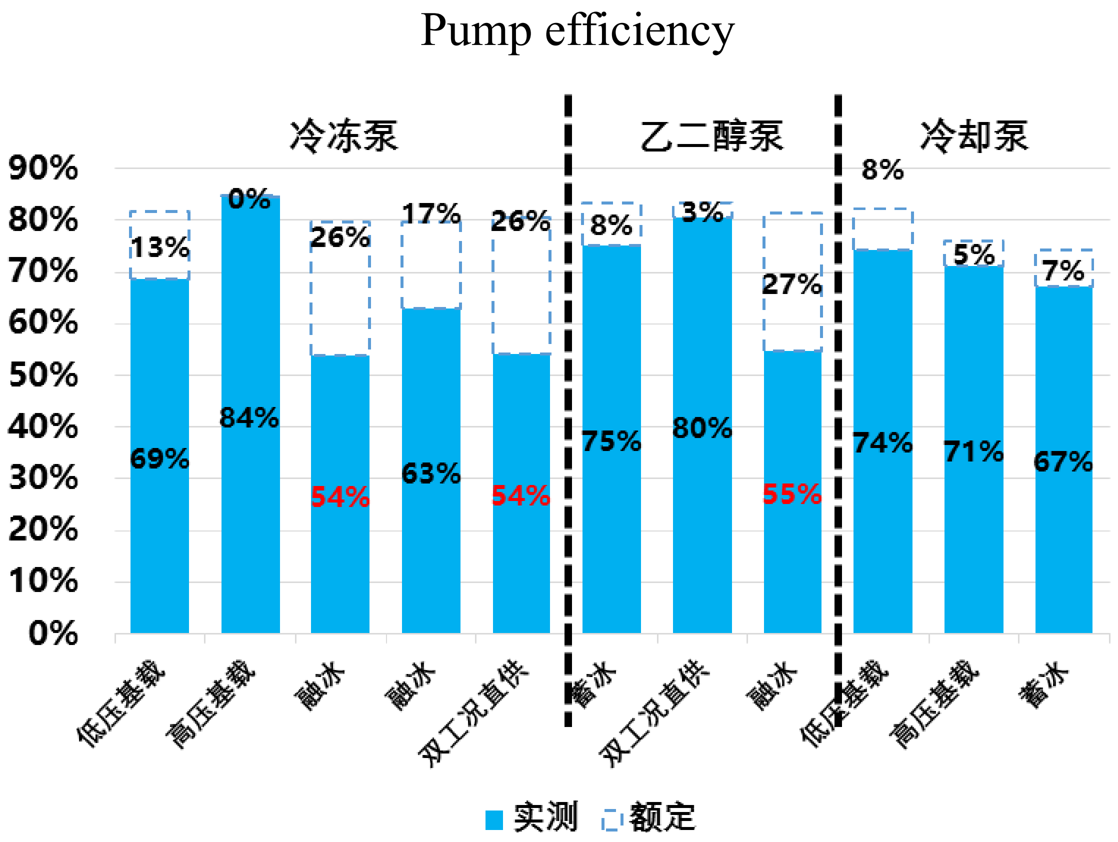


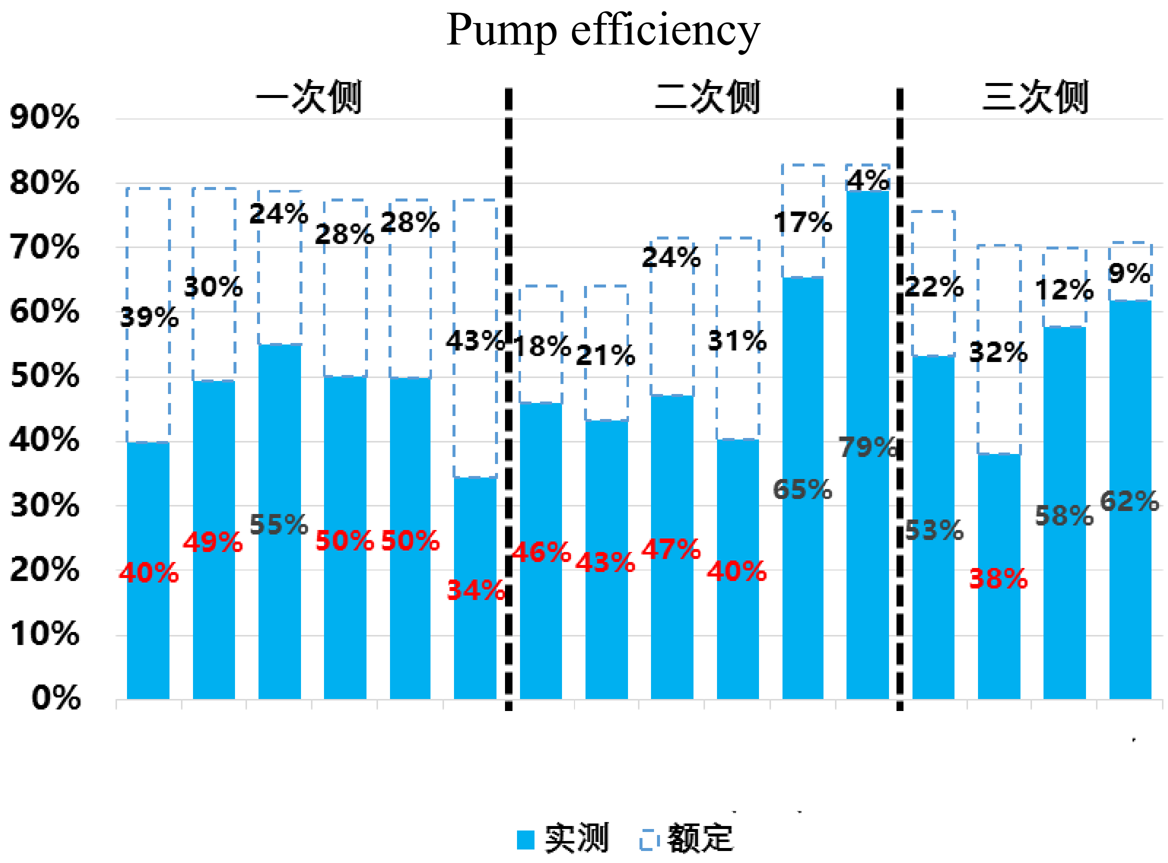
PART TWO

SIMPLE CASE

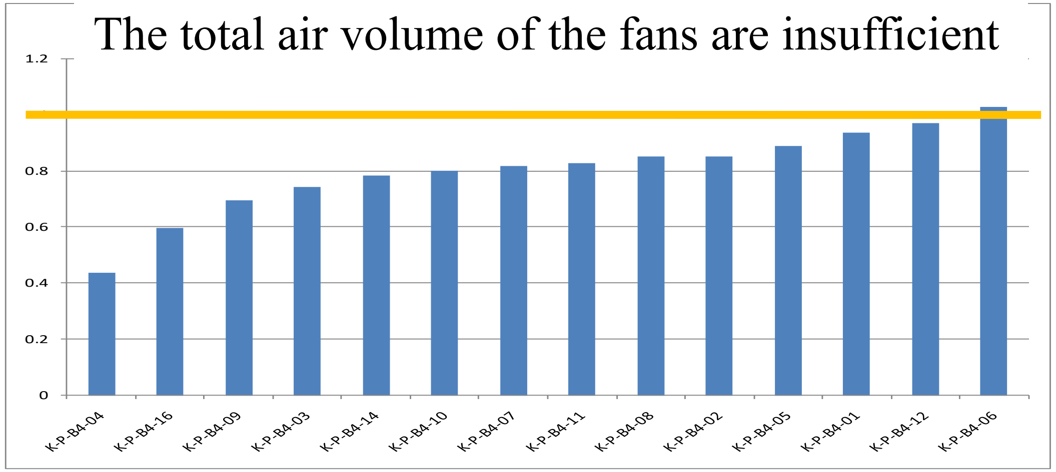
Check Actual Performance of All the Pumps by Monitored Data and Benchmarking

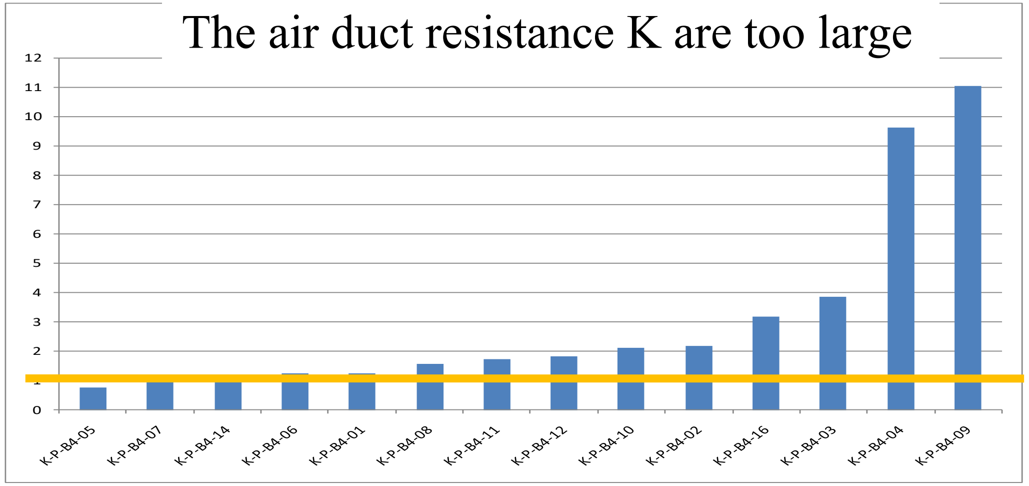
- Case Study: High-rise building with complicated hydraulic systems and many pumps; even calculating S(K) value of pipeline

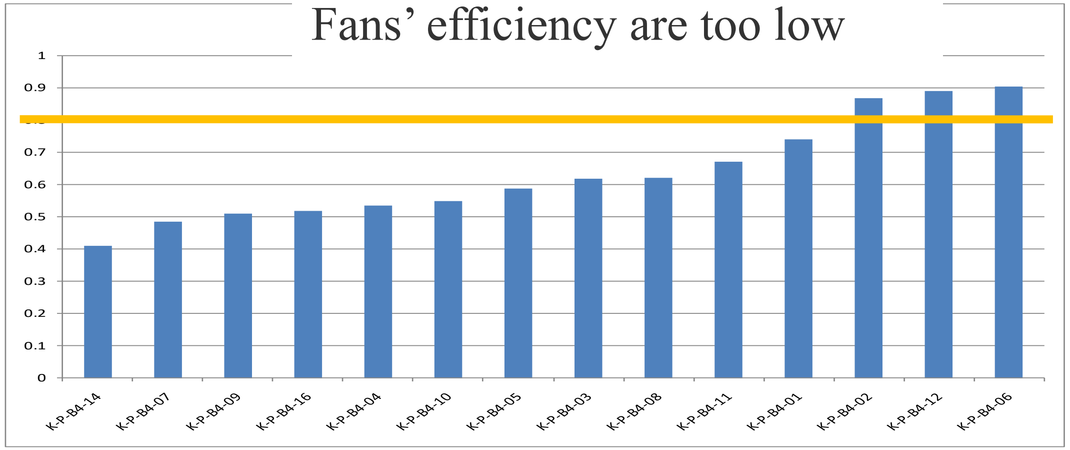


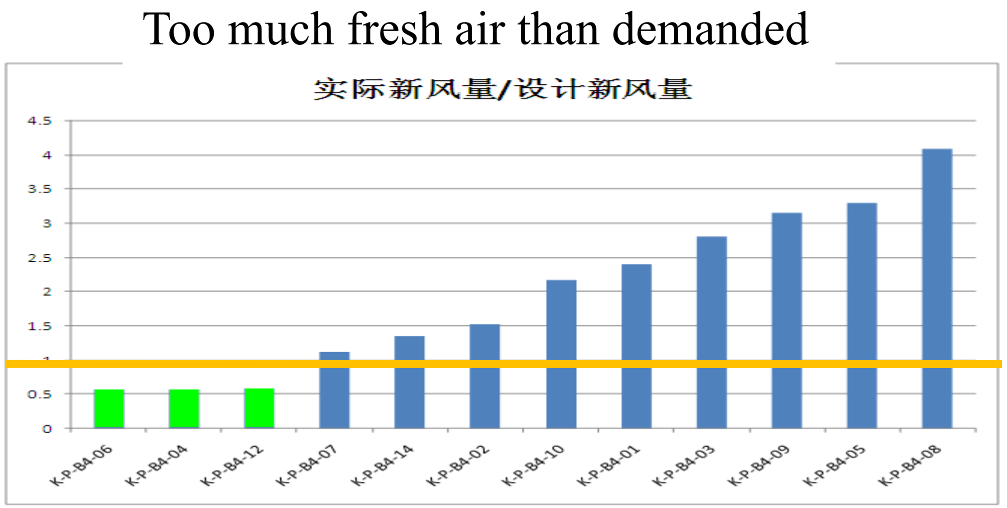


Check Actual Performance of All the AHUs and PAUs by Monitored Data

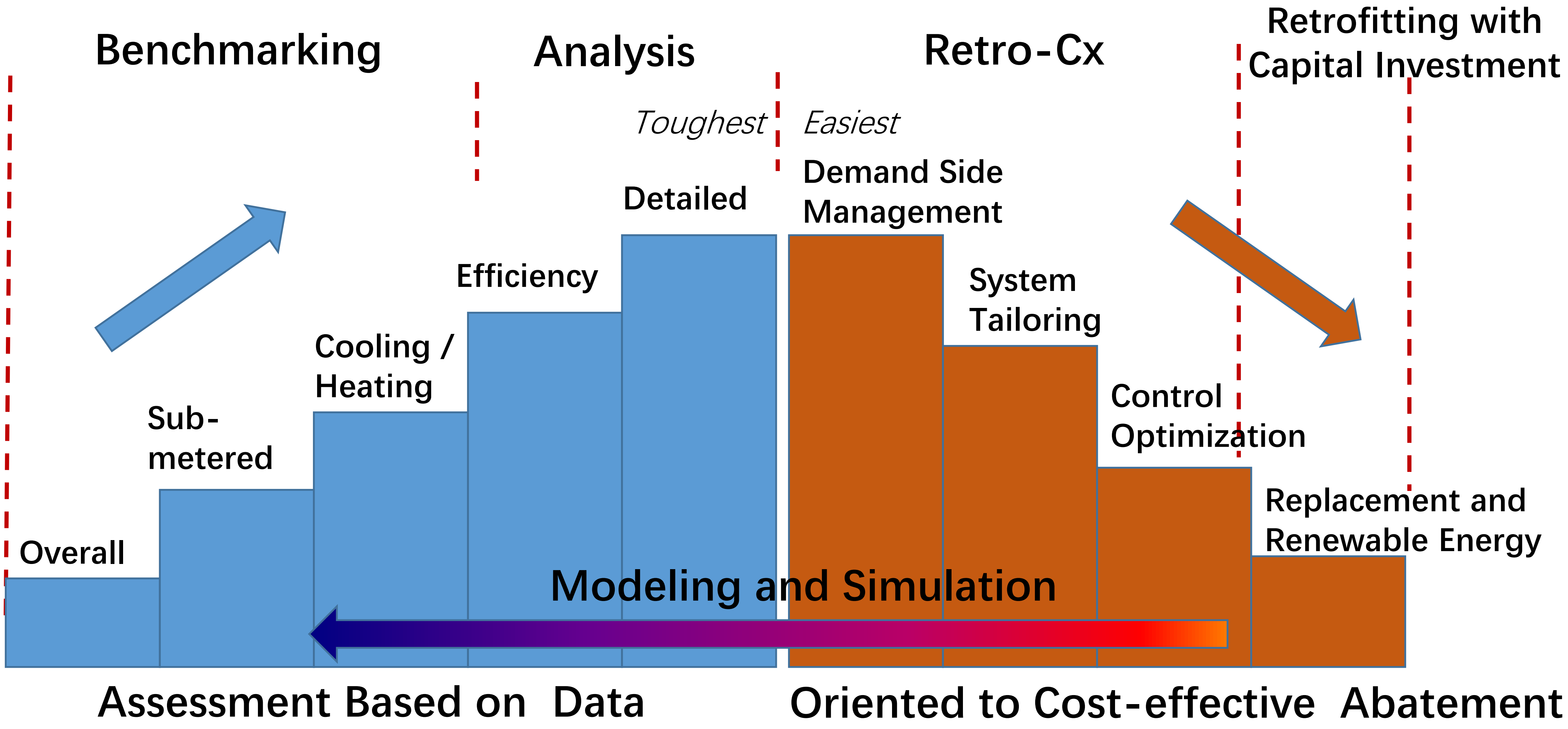






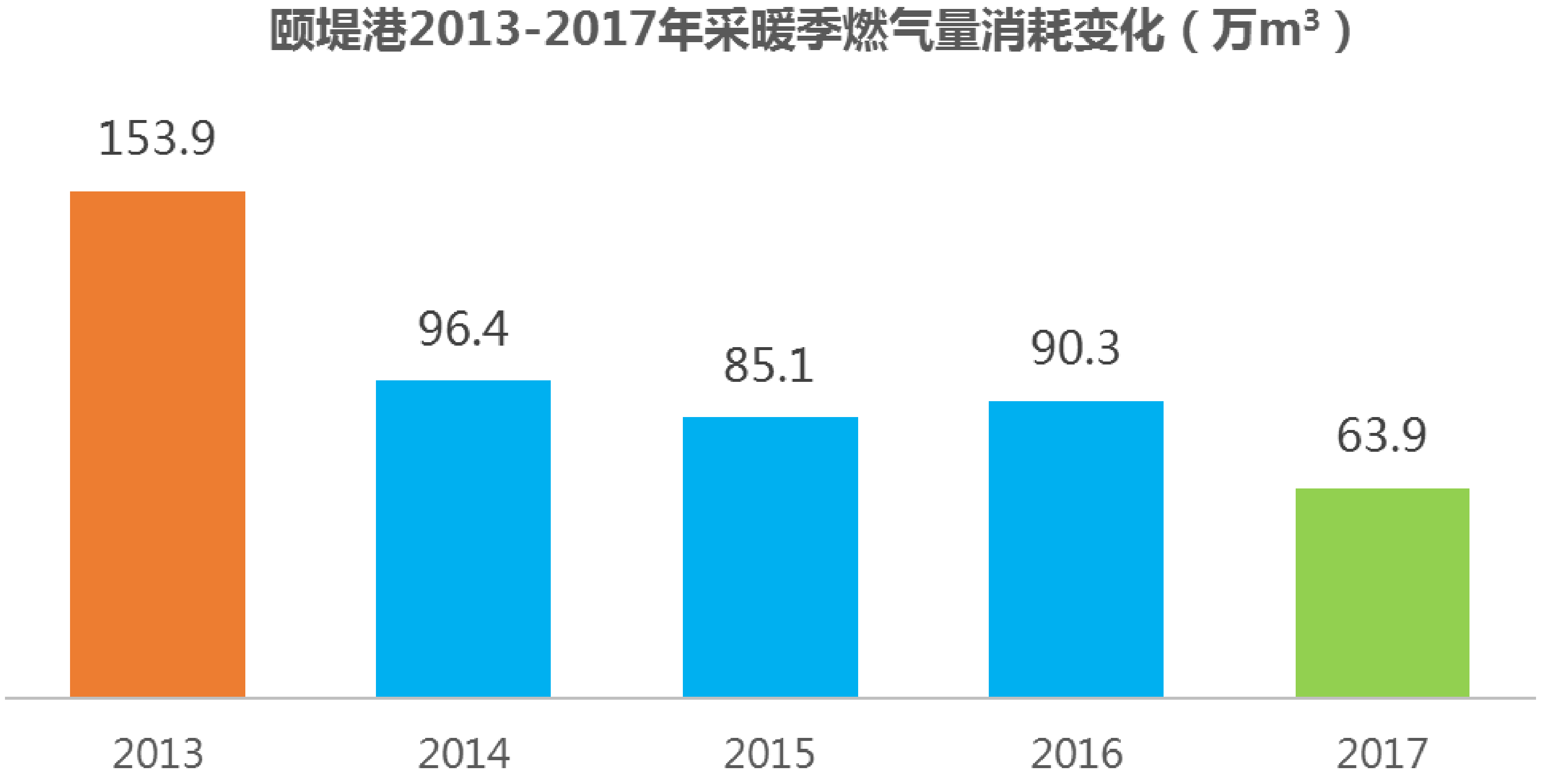


Retro-Cx, Retrofitting, Renewable, and Rethinking: Holistic Approach For Energy Efficiency in Existing Bldg. Based on Monitored Data



Case: Retro-Cx and Retrofitting for Near Zero Heating Energy Building in Beijing

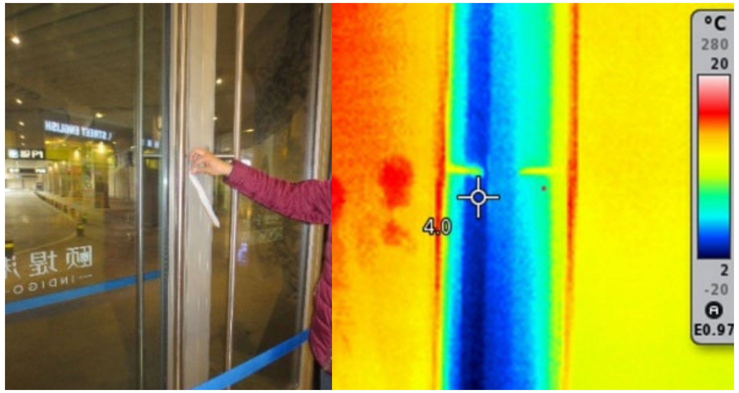
- Green Building: LEED Platinum (office tower) and Gold (Mall) Rated
- In the first winter (Nov. 12 – Mar. 13), Gas consumed for heating: 1.54 mi. Nm^3;
- In the last winter (Nov. 16 – Mar. 17), 640 kilo Nm^3, 60% reduction

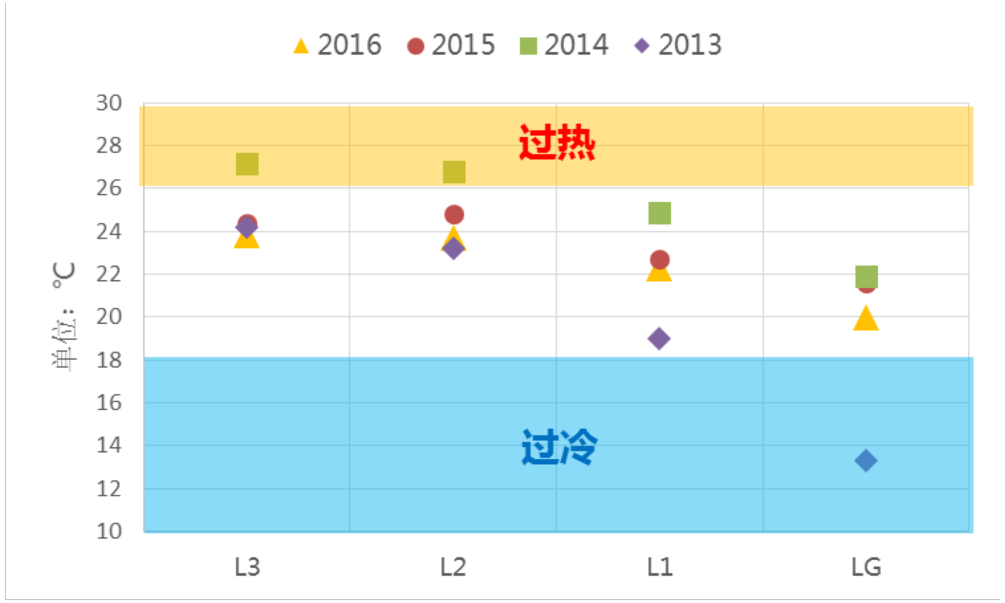


PART THREE
Retro-Cx and Retrofitting

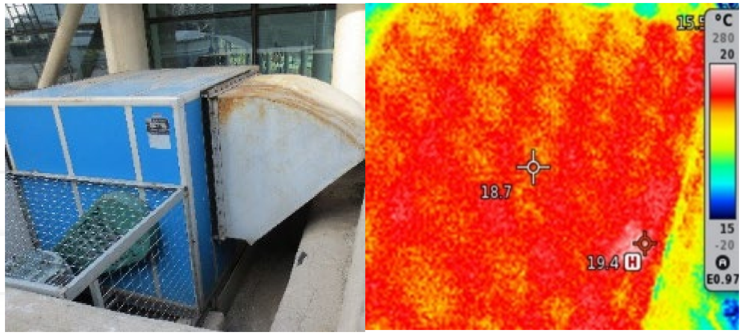
Retro-Cx and Retrofitting: Indoor Environment Quality improved while Gas Consumption declined

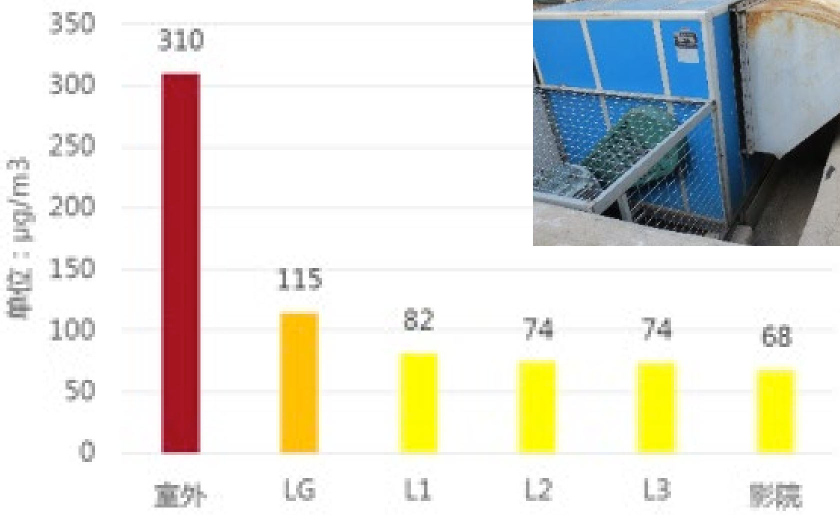
	Indoor Temp, ℃				Delta T of Floors
	L3	L2	L1	LG	
2016	23.8	23.7	22.3	20.0	3.8
2015	24.4	24.8	22.7	21.6	2.8
2014	27.2	26.8	24.9	21.9	5.3
2013	24.2	23.2	19.0	13.3	10.9





Indoor Temp. In different floors





Reduce PM2.5 Concentration

The first REAL operated commercial building reaching Near Zero-Heating Energy in China – Now Try to Use Heat Pump to replace gas boilers

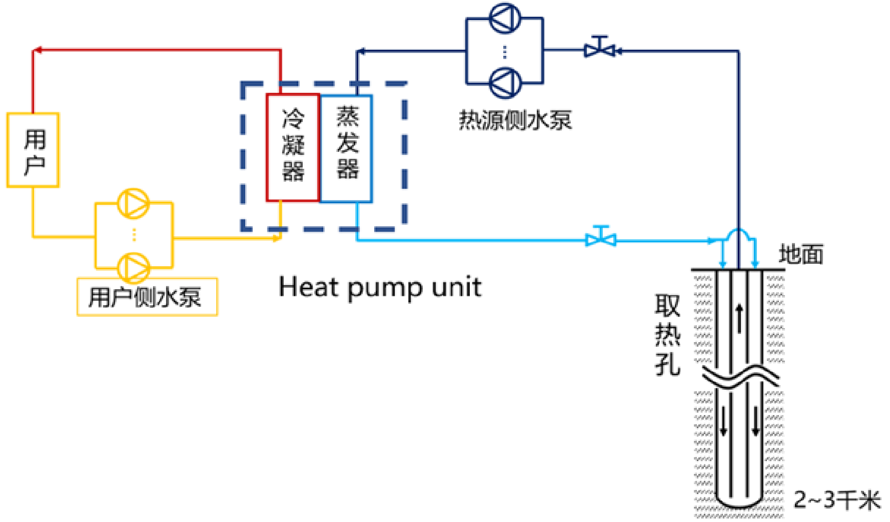
- Energy:
  - Natural Gas：63.9万Nm^3
  - Heating delivered ：21998GJ
  - Electricity for circulating pumps：13.8万 kWhe
- Emission：
  - CO2：1557.2 t
  - NOx：0.31 t

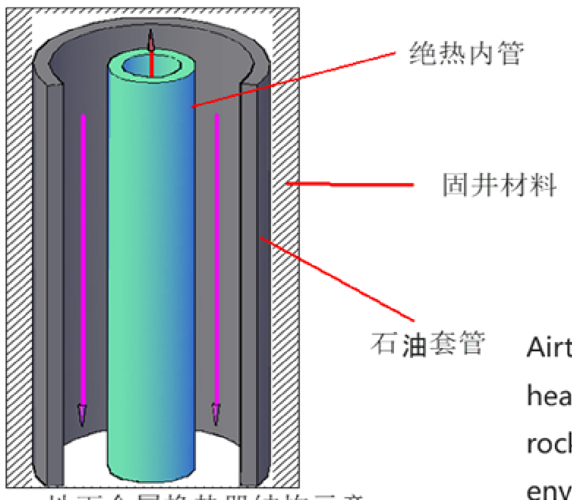
	Unit	Office	Mall	Overall	National Standard	Ref. EU Standard
Heating Consumed	GJ/m^2	0.05	0.23	0.16	0.19[1]	0.11
NG	Nm^3/m^2	1.4	6.6	4.5	6.6[1]	-
Elec. Of Pumps	kWh/m^2	0.8	1.4	1.2	1.0[1]	-
CO2[2]	$kgCO_2/m^2$	3.5	14.5	10.2	14.1	-
NOx [3]	$gNOx/m^2$	0.66	3.17	2.17	6.06[4]	-

[1]：GB/T 51161-2016《民用建筑能耗标准》第六章；
[2]：1m^3天然气碳排放约1.98kgCO_2, 电碳排放按华北电网2010-2012年平均电力排放因子计算，为1.0580kgCO_2/kWh；
[3]：2016年颐堤港锅炉燃烧器低氮改造后，经测试已达到《北京市锅炉大气污染物排放标准》DB11 139-2015所规定NOx排放限值标准30mg/立方米烟气；1m^3天然气燃烧烟气量11.19m^3，其中过量空气系数取1.2；
[4]：根据《北京市锅炉大气污染物排放标准》DB11 139-2015，NOx排放限值按80mg/立方米烟气计算；

Zero-carbon Heating?: Deep ground source heat pump with Enhanced Heat Transfer design (zero water drilling)

Wall-type heat exchange: "only heat" underground + ground heat pump for heating





Airtight heat exchanger, "exchanging heat without touching water" with the rock formation, no interference to the environment

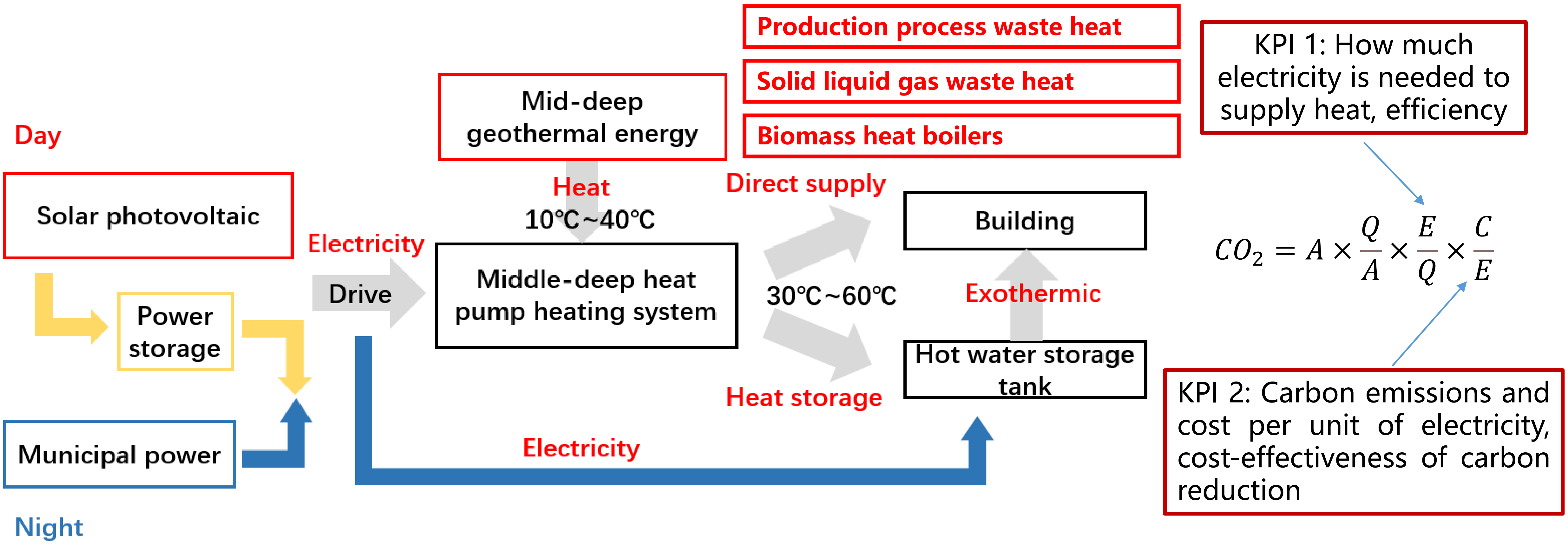
Technology

- Drill holes into the rock formations at a depth of 2 ~ 3km through the drilling rig to cement the well;
- Install a closed-tube structure heat exchanger in the borehole;
- The outer wall of the heat exchanger exchanges heat with the interlayer wall to extract the middle and deep geothermal energy;
- Ground-mounted heat pump heating system: increase the water temperature + lower the return water;

Key features

- It is not restricted and influenced by resource endowments and external environment, and has universal applicability;
- Avoid the environmental problems that may be caused by the direct use of geothermal water;
- Universality, stability, sustainability, and minimal impact on the environment in the deep-seated geothermal energy utilization method;

Flexible and distributed heating for zero-carbon: high-efficiency heat exchanger + low-resistance circulation + high-efficiency heat pump + multi-link thermal storage + using PV/wind and "cheap" electricity



Think of demand in bldg. in the future, say 2050/2060: Still need for different "final energy" with zero carbon emission

100% utilization of renewable electricity

Various functional electrical appliances

+

energy consumption for transportation

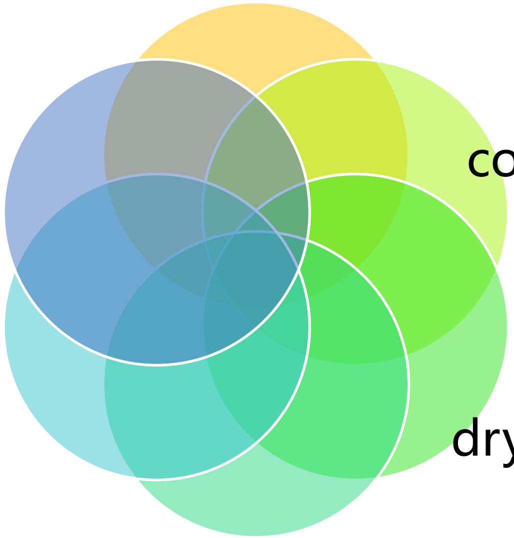
+

Multi-dimensional safe energy storage

Flexible Use of zero-carbon electricity

Zero carbon lighting

Zero carbon space heating/ hot water/ steam



Zero-carbon cooling/air-conditioning/ chilling

Zero carbon drying/humidification/ oxygenation

Zero Carbon Clean Air & Portable Water

$$CO_2 = A \times \frac{E}{A} \times \frac{C}{E}$$

$$CO_2 = \left(A \times \frac{Q_{Cool}}{A} \times \frac{E_{Cool}}{Q_{Cool}} \times \frac{C_{Cool}}{E_{Cool}}\right) + \left(A \times \frac{Q_{Heat}}{A} \times \frac{E_{Heat}}{Q_{Heat}} \times \frac{C_{Heat}}{E_{Heat}}\right) + \left(A \times \frac{E_{ELEC}}{A} \times \frac{C_{ELEC}}{E_{ELEC}}\right) + \ldots$$

PEDF+X: Maximum carbon reduction, in buildings , communities, manufacturing, agricultural parks, etc.

Local Photovoltaic

Energy

Building local photovoltaic
Clean Power from afar

Thermal and Electricity Storage

Link

Cooling, heating and electricity storage; Charing in PV peak output time

Direct Current

Method

Simplify power distribution system
Simplify the control system

Flexibility and Resiliance

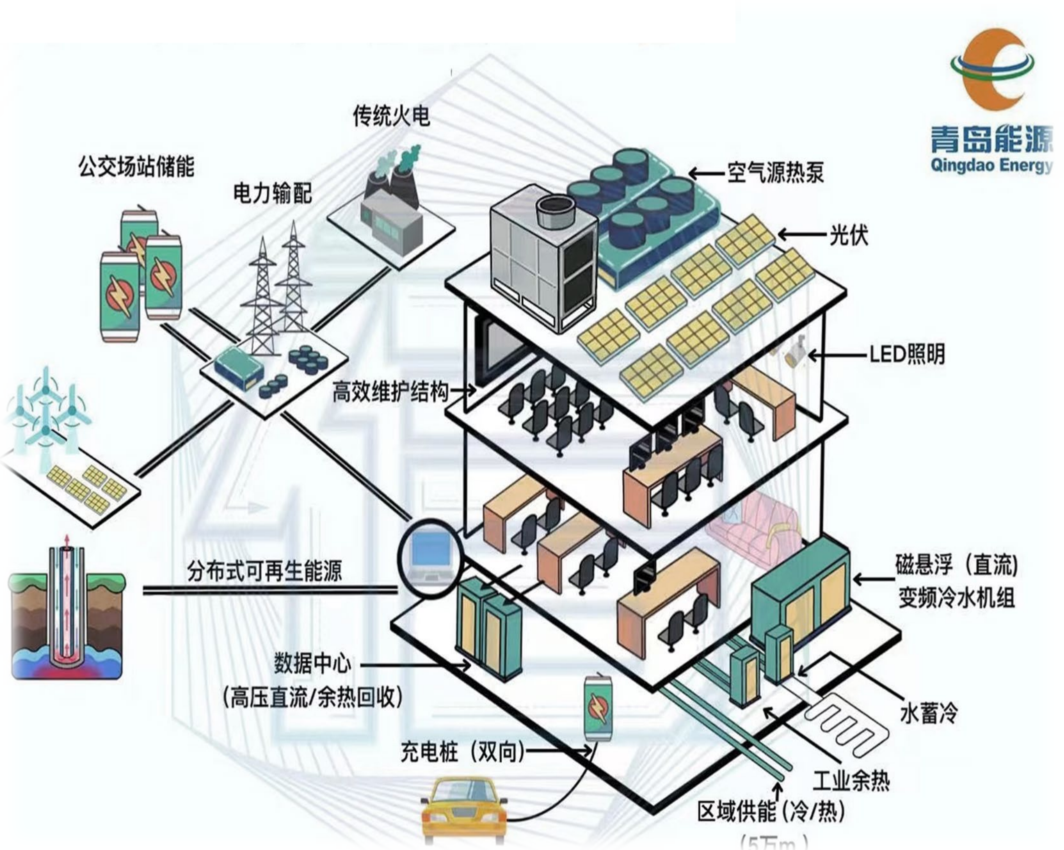
Goal

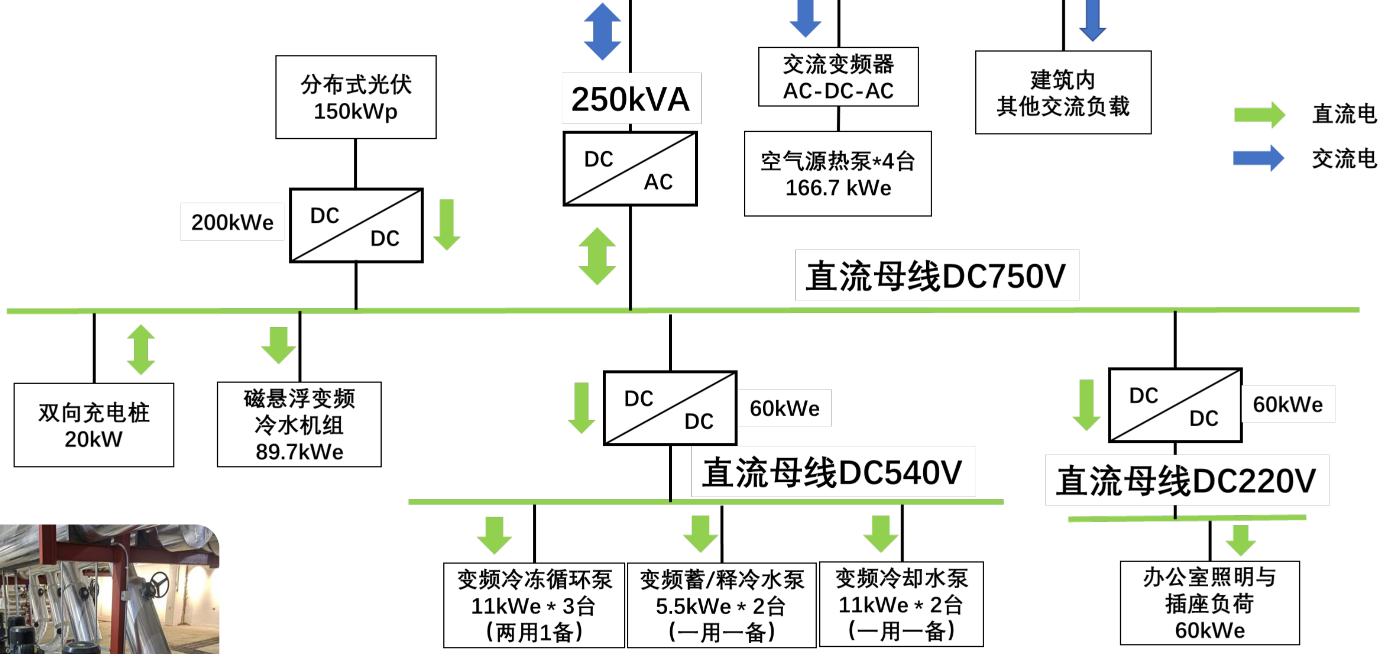
Flexible electrical load
Actively Respond to the Grid

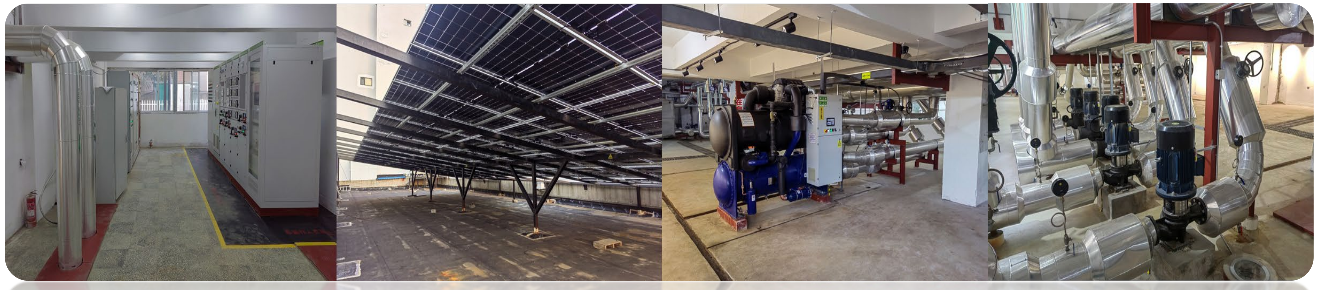
Final Goal

Zero-carbon electricity at the consumer end of the whole society

Perhaps the First Commercial Bldg. with PEDF Retrofitting and Retro-Cx for Centralized AC Systems

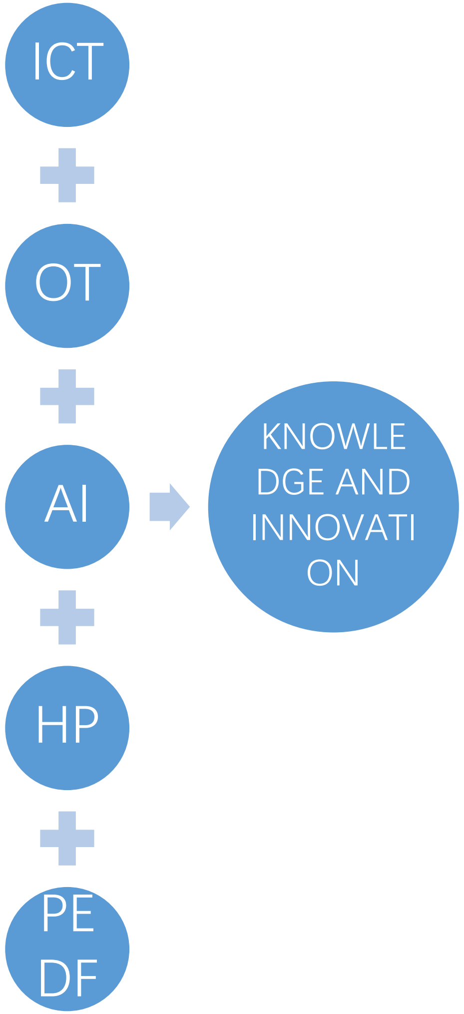


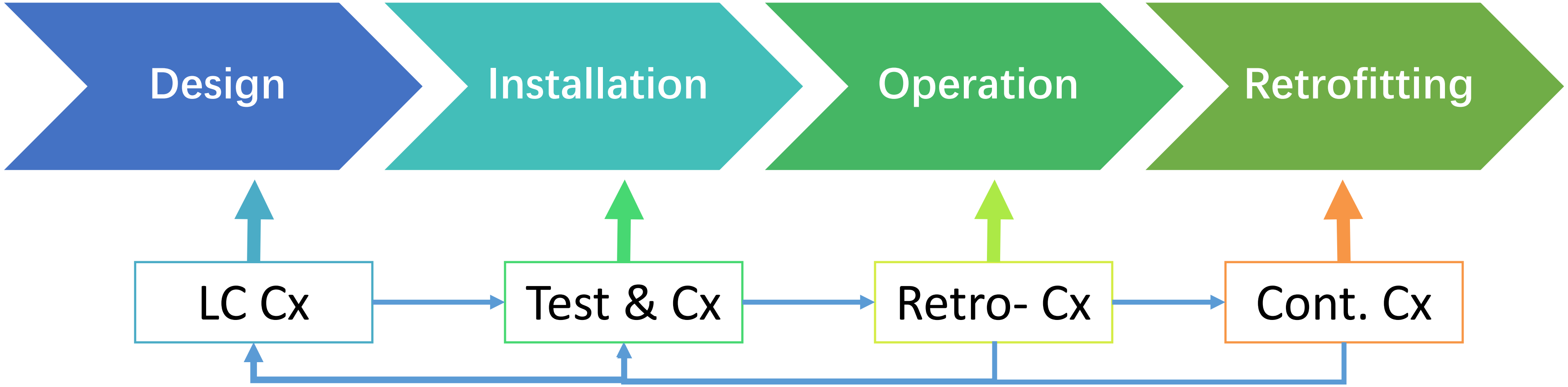




Bridging the GAP: RCx from Experience to Knowledge, Continue with Retrofitting and Renewable

- Problem for Existing Bldg.: Still Lack of Retro-Cx
- Now: Retro-Cx based on Data and Knowledge
- Continue: Retrofitting and Renewable Energy
- Finally: Rethinking and AI-aided Realtime Life-cycle Cx





PART FOUR
SUMMARY

Further Collaboration in GBA on Retro-Cx, Retrofitting and Renewable

- **A Collaboration Leaded Focus on Retro-Cx and Retrofitting in Buildings, covering Great Bay Area and Belt & Road;**
- **IEA EBC in the Future?**

IEA EBC Building Energy Codes Working Group (BECWG) Symposium

清華大學
Tsinghua University

State-of-the-art of Building Energy Efficiency Codes in China for Operation, Retrofitting and Design

Presented by: Professor Qingpeng WEI

Building Energy Research Center, Tsinghua University

2023/11/14

EBC

Energy in Buildings and
Communities Programme

Occupants and Building Codes: Challenges and Future Directions

Liam O’ Brien
Carleton University

Occupants and building codes: Challenges and future directions

Liam O'Brien, Ph.D., P.Eng.
Professor, Civil & Environmental Engineering
Co-Operating Agent, EBC Annex 79
Carleton University

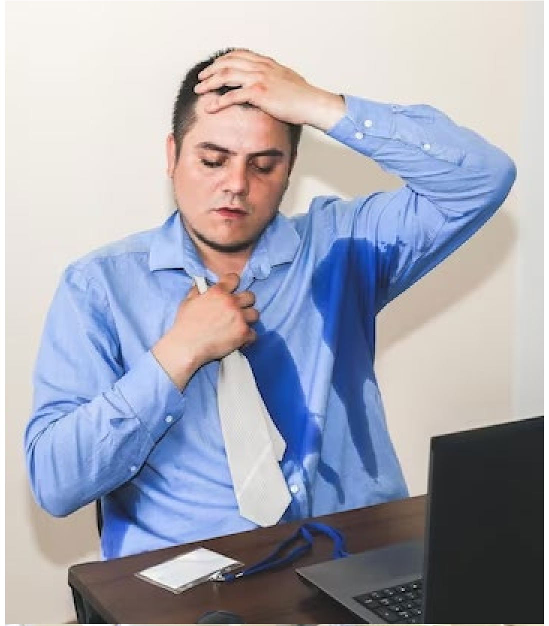
EBC
Energy in Buildings and Communities Programme

Carleton UNIVERSITY

Hbi
Human-Building Interaction Laboratory

Occupant myths

- Occupants are passive recipients of indoor environments
- Occupants cannot be trusted or relied upon to behave "well"
- Occupants are uniformly distributed and follow predictable and repetitive schedules



Occupants as boundary conditions

People are NOT a boundary condition

Implicit messages of codes

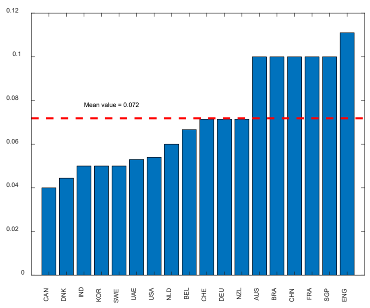
- Building design cannot affect behaviour
- There is no point in implementing occupant-adaptive measures
- Automate everything and take control away from people

Thermostat example

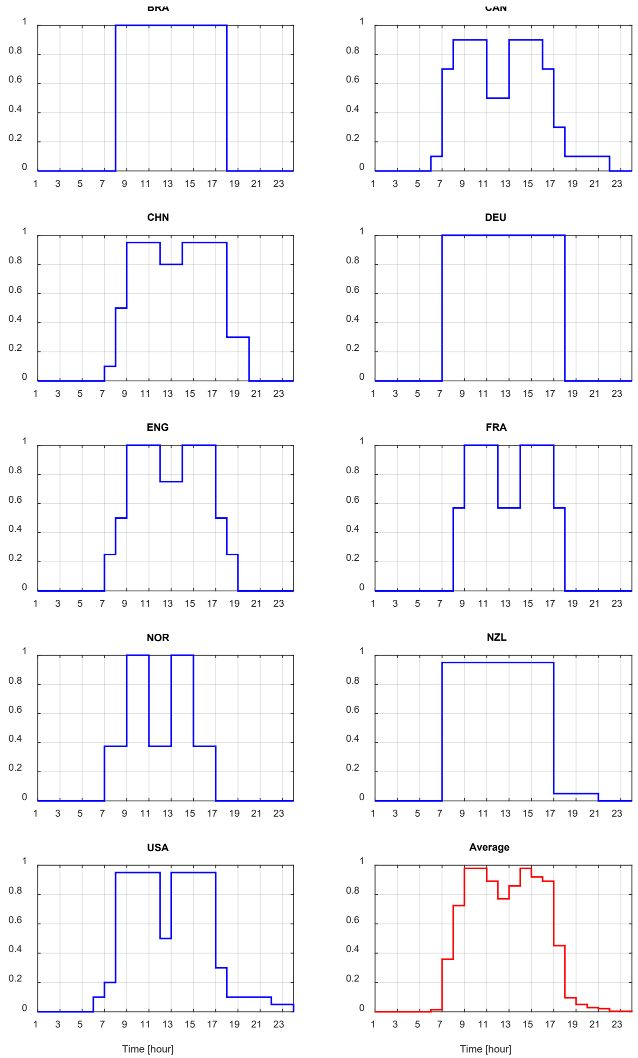
- We learned the hard way about unusable automation systems

Predominant occupant specifications in building codes

- <u>Performance</u>: schedules defining occupants/occupant activities



- <u>Prescriptive</u>: requirements on interfaces and equipment relating to occupants (e.g., lighting controls must be manual-on; vacancy-off)



Human-Building Interaction Laboratory

Building energy code philosophy

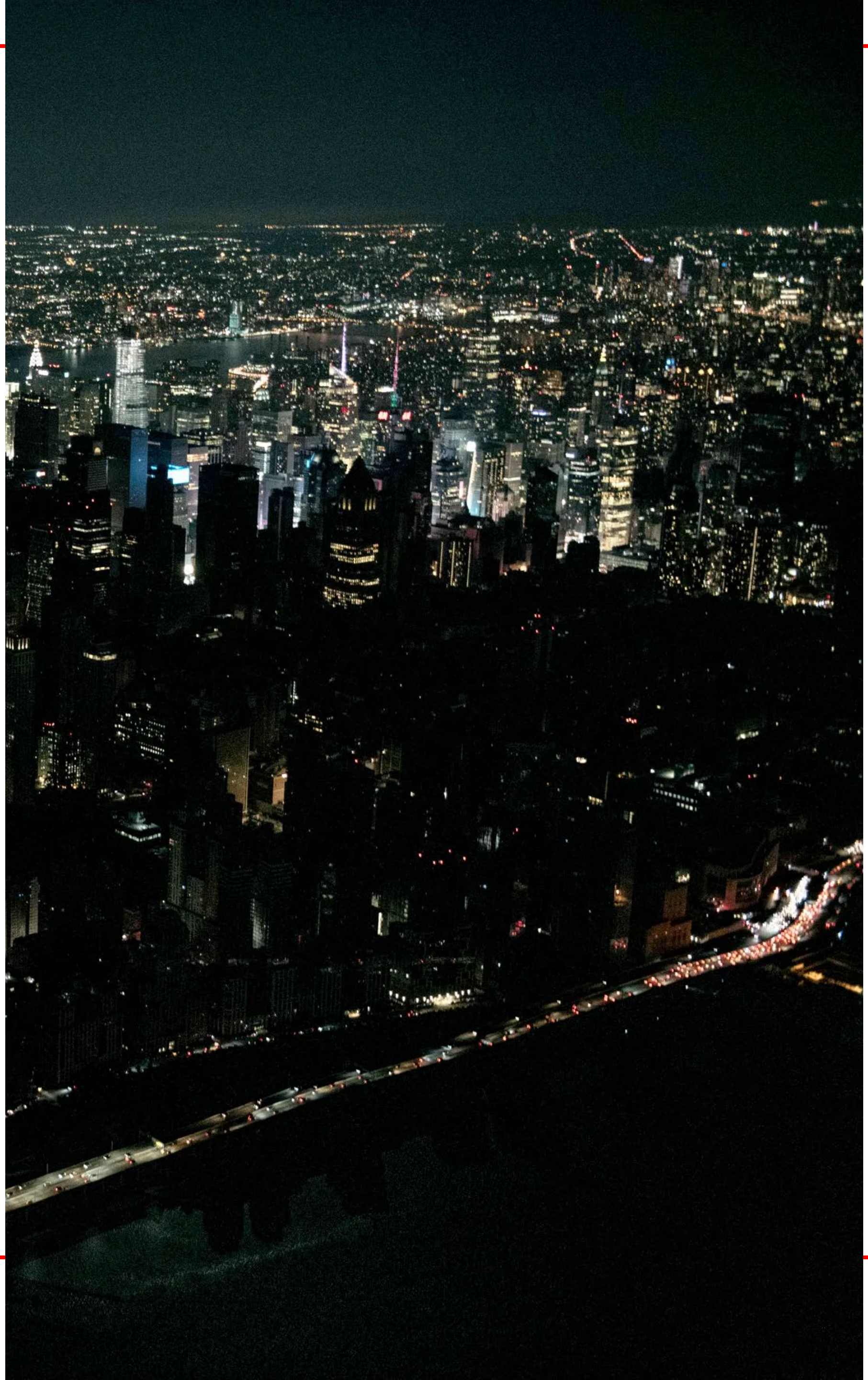
- For many codes, the performance path's goal is not to predict absolute energy use
- If we accept that performance cannot be "accurately" predicted, we should focus on design approaches that, on average, reduce energy use.
- Embrace diversity and uncertainty.

What should building codes encourage?

- Baseline comfort with ample adaptive opportunities (e.g., operable windows)
- Usability – buildings and building systems that are effective, intuitive, and predictable
- Adaptability - real-time learning controls

On resilience

- Over-automation mandated by building codes will have severe consequences during extreme/disruptive events.
- Codes need to have faith in occupants.

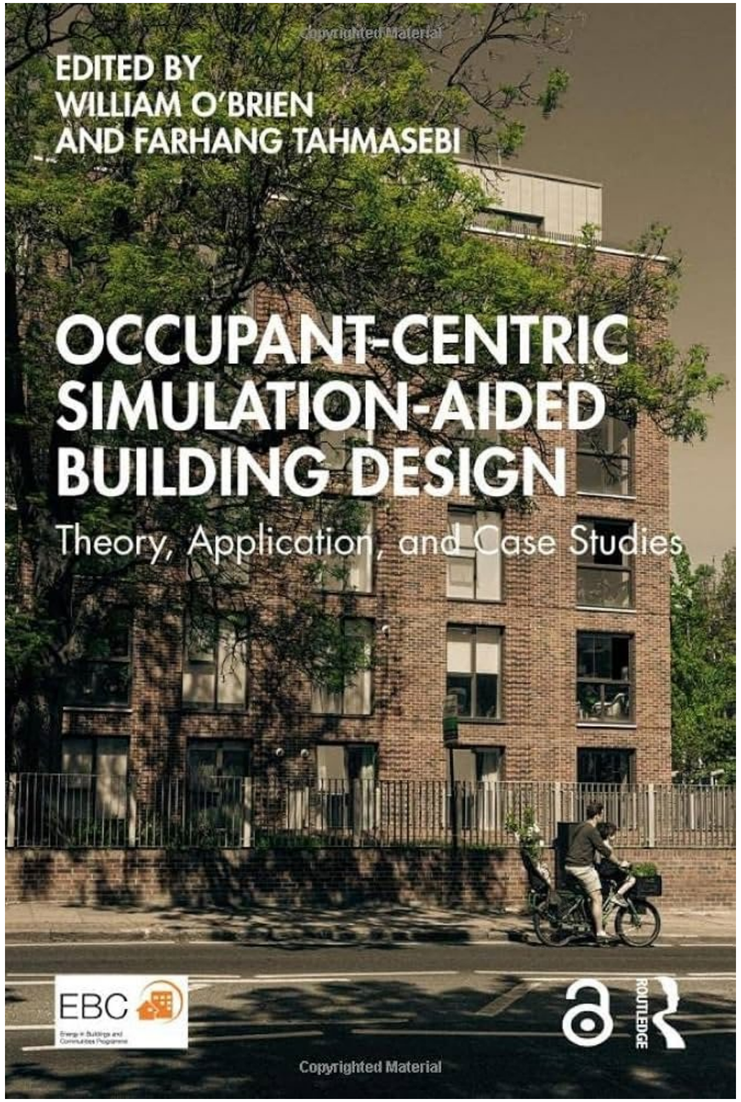


Improving occupant aspects of codes

1. Add new requirements based on literature or other data sources (prescriptive path)
2. Update current schedules/densities/values (performance path)
3. Add additional occupant-related domains (e.g., window shades) (performance path)
4. Require several occupancy scenarios to be analyzed/modelled (prescriptive or performance)
5. Mandate measurement campaign as basis for occupant assumptions in retrofit projects (performance)

Thank you

- IEA EBC Annex 79: Occupant-centric building design and operation (2018-2023)



Panel Discussion 2:
Performance Gaps in Building Energy Codes

Moderator:
Meli Stylianou

Meredydd Evans
Pacific Northwest National Laboratory

Helen Bell
Green Building Council of Australia

Qingpeng Wei
Tsinghua University

Liam O’ Brien
Carleton University

EBC

Energy in Buildings and
Communities Programme

Key research questions and next steps for collaboration

Meredydd Evans
Pacific Northwest National Laboratory

EBC

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Thank you!