U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Codes Around the Globe: A Cross-National Comparison of Building Energy Codes

National Energy Codes Conference Seminar Series

Building Technologies Office

Summer 2021

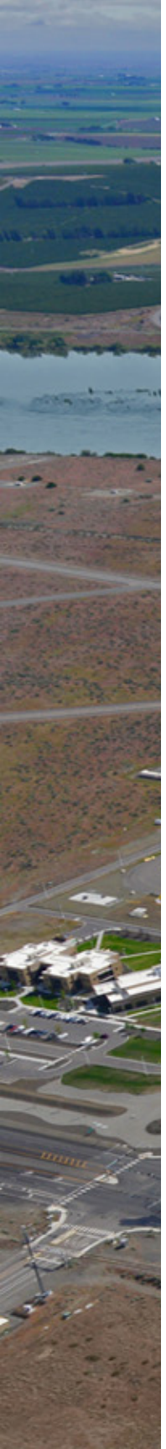
NECC Seminar Series Lineup

Catch the entire lineup of sessions bi-weekly—Thursdays @ 1p ET:

- 8/12: Grid Integration and Electrification in Energy Codes
- 8/26: Approaching Zero, Where Do We Go From Here for Commercial Buildings
- **9/9: Codes Around the Globe: A Cross-National Comparison of Building Energy Codes (AT 2PM ET)**
- 9/23: Evolution of Commercial Building Design and Construction
- 10/7: Equity and Codes: Ensuring Codes and Energy Efficient Buildings Address Affordable Housing Needs
- 10/21: Zoning and Land-Use Regulation: Emerging Tools for Advancing Climate-Friendly Development

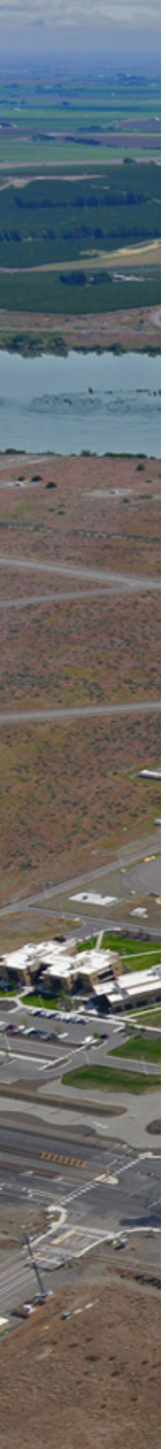
> Learn more: https://www.energycodes.gov/2021-summer-seminar-series

Building Energy Codes
U.S. DEPARTMENT OF ENERGY



IEA/EBC Building Energy Codes Working Group (BECWG) Goals and Activities

- Objectives
  - To enhance understanding of impactful options and practices regarding building energy codes across different countries.
  - To provide methods for cross-national comparison that lead to meaningful information sharing.
  - To foster collaboration on building energy code issues that leads to enhanced building energy code programs by incorporating new issues and practices.
- Activities
  - Exchange on Building Energy Code Practices (quarterly webinars, Annual symposium)
  - Comparative Analysis (Reports on codes for existing buildings, codes compliance, virtual inspections)
  - Dissemination (EBC website, papers, quarterly e-newsletter)
- BECWG member countries
  - Australia, Brazil, Canada, China, India, Ireland, Italy, Japan, New Zealand, Portugal, Singapore, Sweden, Turkey, U.K., U.S.

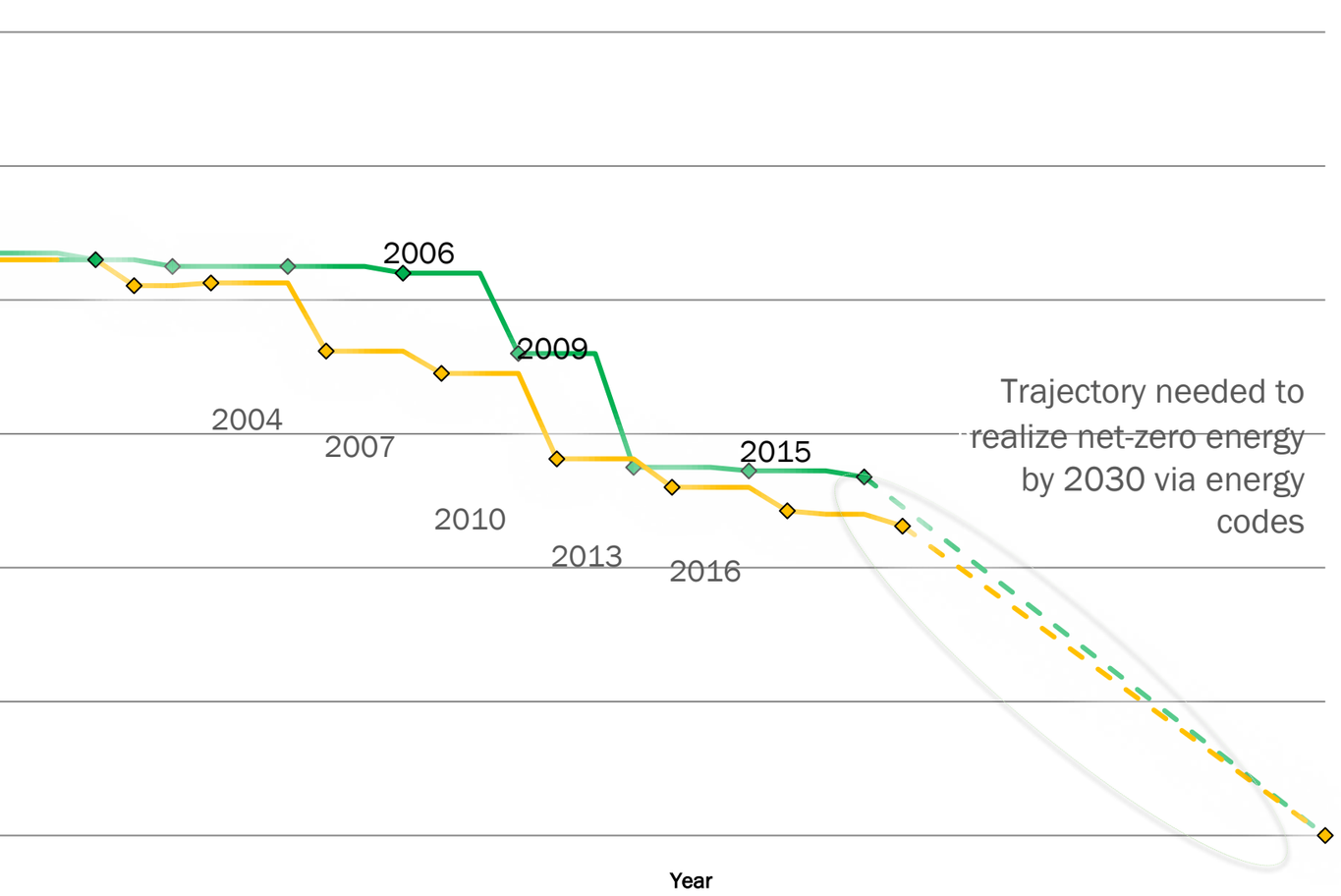


How to participate in the BECWG as an expert

- Contact your EBC national representative www.iea-ebc.org/contacts
  - If your country is not listed, please contact
    - BECWG Chairs and Operating Agent: *David Nemtzow* (Chair), david.nemtzow (at) ee.doe.gov / *Michael Donn* (Co-Chair), michael.donn (at) vuw.ac.nz) / *Meredydd Evans* (Operating Agent), m.evans (at) pnnl.gov, or
    - EBC's Secretariat: *Malcolm Orme*, malcolm.orme (at) aecom.com
- Get on the mailing list for quarterly webinars and e-newsletters (POC: *Alison Delgado*, Alison.Delgado (at) pnnl.gov)

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

Building Energy Codes: Building Better Buildings



Source: Pacific Northwest National Laboratory

- ~ **US$126 billion** energy cost savings
- ~ **840 MMT** of avoided carbon emissions
- ~ **13 quads** of primary energy

These savings equate to the annual emissions of:

- ~ 177 million passenger vehicles
- ~ 89 million homes

Emerging Themes in Building Energy Codes

- **Net zero energy / Net zero carbon** (+Readiness)
  - ICC specified an optional stretch goal of zero energy by 2030; optional zero-ready appendices in the 2021 IECC
- **Electrification** (+Readiness):
  - Pre-wiring for future electric appliances, reserved space for heat pump water heaters
- **Renewable integration** (PV):
  - CA T24, ASHRAE Standard 90.1
- **Grid integration**:
  - Grid-interactive water heaters, smart thermostats, methods for evaluating grid-interactive measures
- **Electric Vehicles**: Pre-wiring or actual charging
- **Performance-based codes**
- **Existing Buildings: Building Performance Standards** (BPS)

> ***Opportunity***: DOE can bolster support for these efforts through increased technical analysis—both for the model codes and by working with states/locals

Model Energy Code Determinations

> Every household in the U.S. should have the opportunity to benefit from the latest building codes and standards.

RECENTLY ANNOUNCED: Model energy code Determinations:

- **Commercial**: 4.7% site energy savings based on Standard 90.1-2019
- **Residential**: 9.4% site energy savings based on the 2021 IECC

Adopting the latest building codes is a critical opportunity to increase energy efficiency in buildings, as well as to ensure modern standards for health, comfort, durability and resilience in their homes, businesses, and communities.

DOE is challenging states, local governments, and the design and construction industry to update their building energy codes based on the latest model codes and standards, and to help ensure all construction meets or exceeds these standards.

New Technical Assistance Supporting Energy Codes

> DOE is ramping-up efforts to support building energy codes and help states and local governments embrace the latest standards.

RECENTLY ANNOUNCED: New technical assistance to support state and local adoption and implementation:

- State, regional and national partnerships to support energy codes
- Innovative topics, from advanced “stretch” codes to PV and EV charging, to building performance standards for existing buildings, to smart homes and more!
- Workforce education and training initiatives that help workers take advantage of new technologies, construction practices, and evolving building standards
- Technical analyses to quantify the impacts on energy savings, cost-benefit, jobs and the economy, and related GHG impacts

New Technical Assistance Supporting Energy Codes

> DOE and PNNL have recently released **177 new technical reports, factsheets and other resources** to support the latest codes.

- National energy savings analysis for the 2021 IECC and Standard 90.1-2019
- National cost-effectiveness analysis for the 2021 IECC and 90.1-2019
- State cost-effectiveness analysis for the 2021 IECC and 90.1-2019
- State and city factsheets highlighting the benefits of the latest codes
- New *stretch code* concepts which can be adopted by states or local governments, or considered for future model codes (e.g., EV charging)
- Updated Impact Report quantifying the energy, cost and carbon impacts associated with the latest codes
- Plus, visit the brand new energycodes.gov

Who are We Working With?

Program Partners:

- ✓ DOE national laboratories (PNNL / NREL / LBNL)
- ✓ Model code and standard organizations (ICC, ASHRAE)
- ✓ Federal government agencies (EPA, HUD, FEMA, OMB)
- ✓ State agencies (state energy offices, code and safety agencies)
- ✓ Municipal agencies (e.g., building code and safety departments)
- ✓ Trade and professional organizations, NGOs
- ✓ Research teams

ENERGY.GOV
Office of
ENERGY EFFICIENCY & RENEWABLE ENERGY
Building Technologies Office

Building Energy Codes
U.S. DEPARTMENT OF ENERGY

Key Stakeholders

Designers, builders, contractors, policymakers, building officials, government agencies, energy-efficiency organizations, manufacturers, and more…

And all of *you*!

Pacific Northwest
NATIONAL LABORATORY

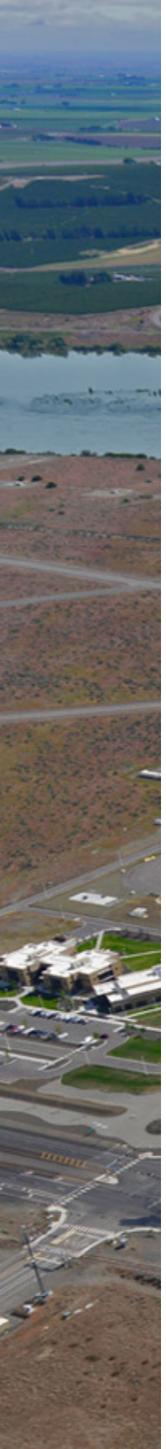
Codes Around the Globe: A Cross-national Comparison of Building Energy Codes

Meredydd Evans
Pacific Northwest National Laboratory

September 9, 2021

2021 National Energy Codes Conference
Summer Seminar Series

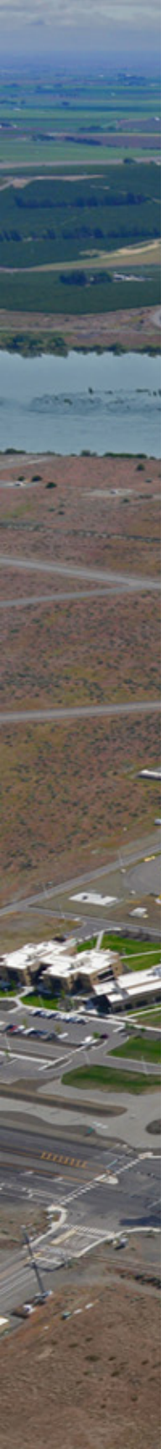
U.S. DEPARTMENT OF ENERGY BATTELLE



Pacific Northwest NATIONAL LABORATORY

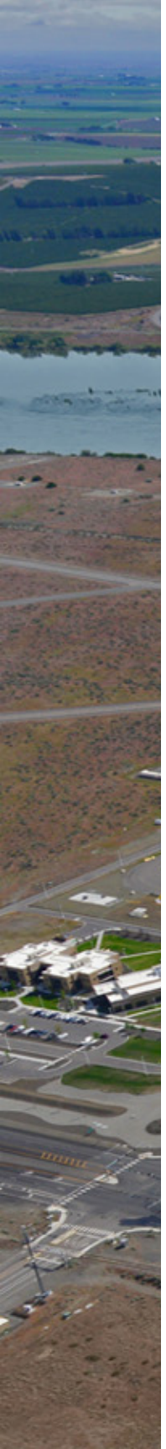
Outline

- Background & Context
- Emerging Areas in the Building Energy Codes Space
  - Net Zero Energy in Codes
  - Compliance Best Practices
  - Codes for Existing Buildings
  - Other Emerging Areas Covered
- Takeaways
- References



Pacific Northwest
NATIONAL LABORATORY

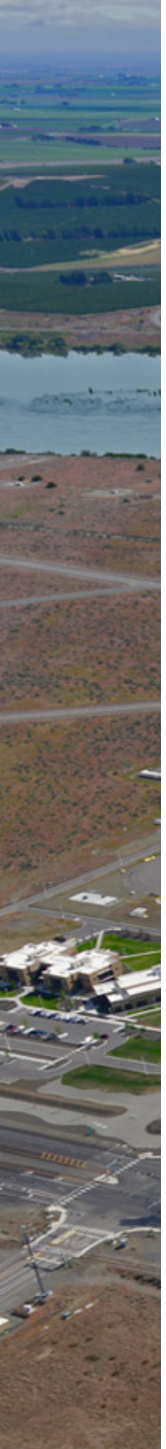
Background & Context



Pacific Northwest NATIONAL LABORATORY

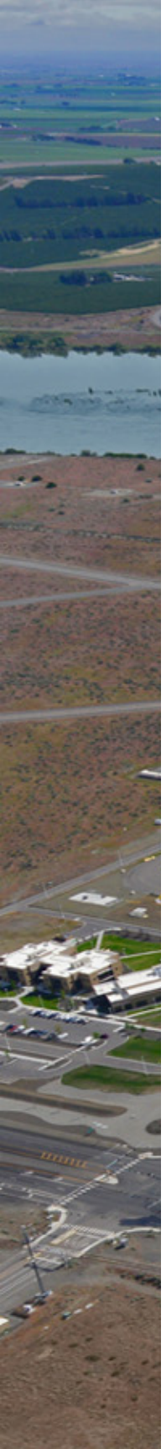
Background and Context

- More and more countries are adopting building energy codes with increasing coverage and stringency
- Why?
  - They are one of the most cost-effective policies for energy savings and greenhouse gas reduction
  - Energy efficiency measures are implemented during the initial construction and provide benefits throughout a building's long lifetime



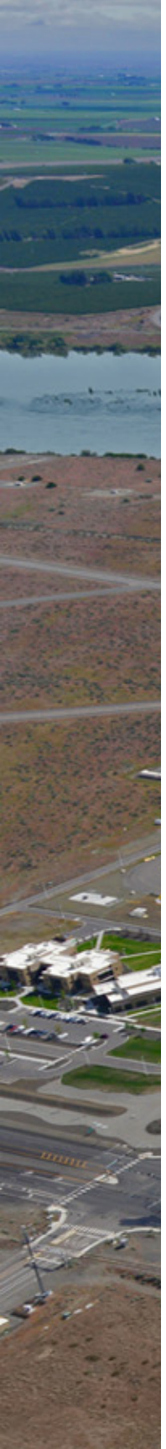
IEA Buildings and Communities Programme (EBC) Building Energy Codes Working Group

- Working Group launched in 2018
- Charge: Share comparative information with EBC's 24 member countries to better understand the codes landscape across the range of nations
- Key issues across countries:
  - Meeting ambitious policy objectives
  - Improving compliance and methods to assess compliance
  - Addressing the challenge of incorporating energy efficiency into major retrofits
  - Adapting/expanding code coverage in places with hot climates
  - Integrating research and technology breakthroughs



Pacific Northwest
NATIONAL LABORATORY

Emerging areas within the building energy codes space



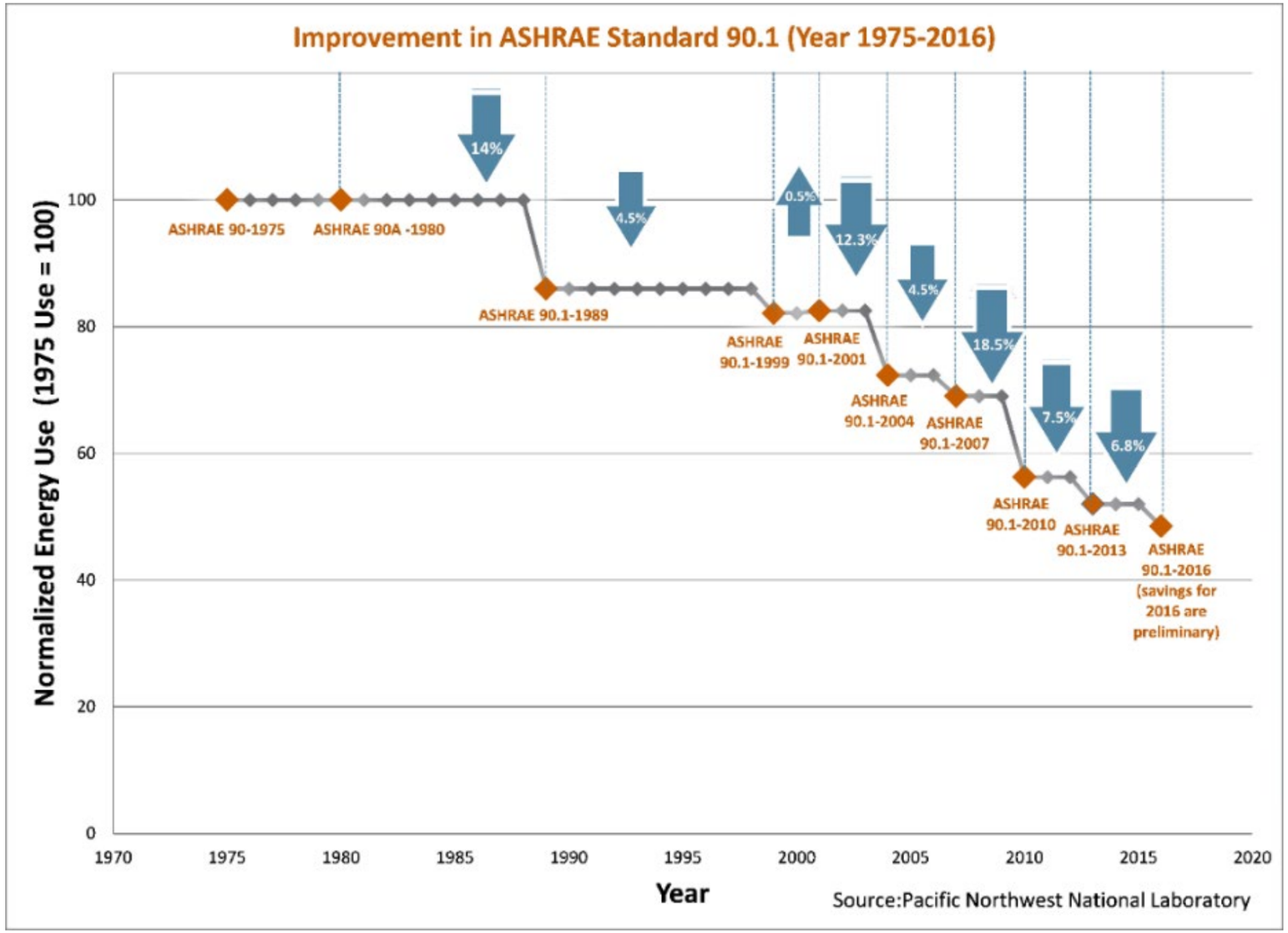
Pacific Northwest NATIONAL LABORATORY

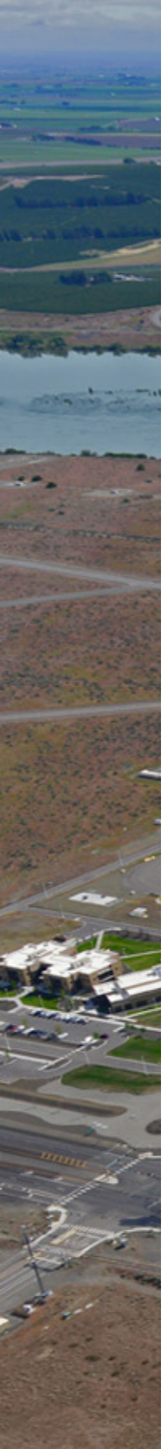
The Path to Net Zero Energy

- Many jurisdictions are making commitments for net or nearly zero energy buildings in their codes
  - **EU**: All member states must have codes that mandate nearly zero energy buildings by 2021
  - **California**: The energy code requires that all new residential buildings must be net zero energy starting in 2020, and commercial buildings must be net zero by 2030.
  - **Australia**: Set a trajectory towards zero energy (and zero carbon) '*ready*' buildings. Canada is introducing a similar framework
  - **Net Zero Carbon Buildings for All initiative**: Several countries have announced commitments for net zero carbon buildings as part of this initiative (e.g., Kenya, Turkey, the UAE, and the UK)

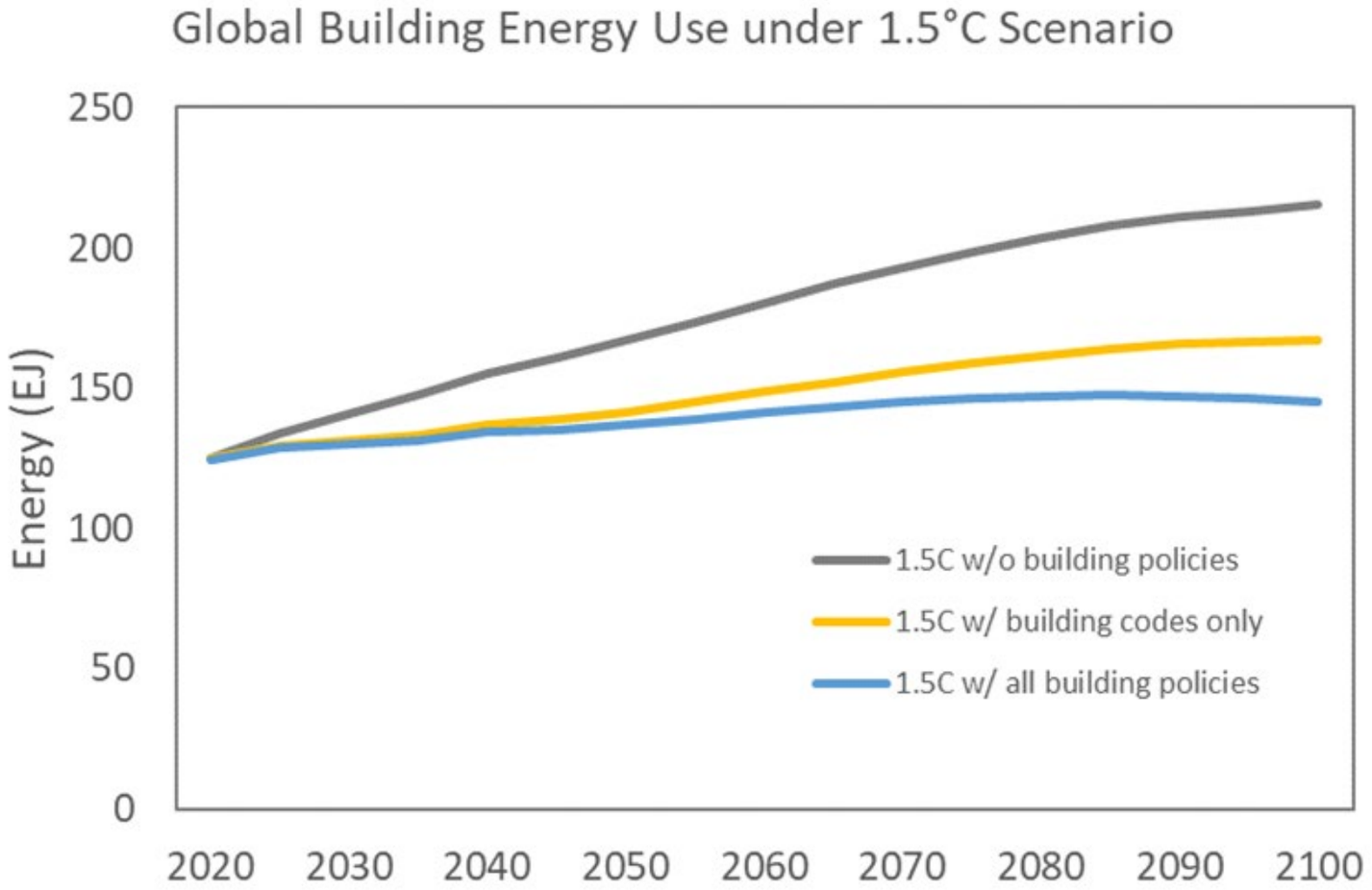
Code Improvements

- Figure: Improvement in ASHRAE Standard 90.1
- In Denmark, buildings built to the 2020 version of the code will consume 20 kwh/m^2 for heating, cooling and hot water versus 120 kwh/m^2 for these services in 1982





Why Net Zero Energy Matters

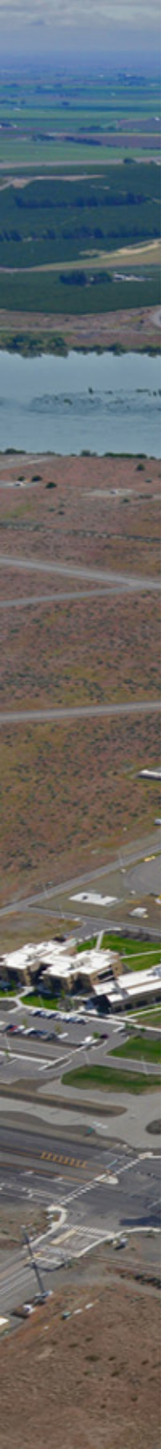


Source: Yu, S., M. Evans, and M. Charles. 2019. Net-Zero Carbon Buildings Make 1.5°C Future Cheaper and Easier to Achieve (PNNL-ACT-SA-10449). Richland, WA: Pacific Northwest National Laboratory..

Compliance Best Practices

- Achieving the potential of codes requires effective implementation systems
- Effective compliance checking requires adequate resources, technical knowledge, capacity, and strong institutions
- Institutional set up for code enforcement varies across jurisdictions
  - Self-certification vs. national, regional/local, or private/third party enforcing institutions
  - Generally, the national government develops the code, while implementation is done at the local level

Building research engineers develop and demonstrate advanced technologies and methods for evaluating building performance. Source: Pacific Northwest National Laboratory, 2017.

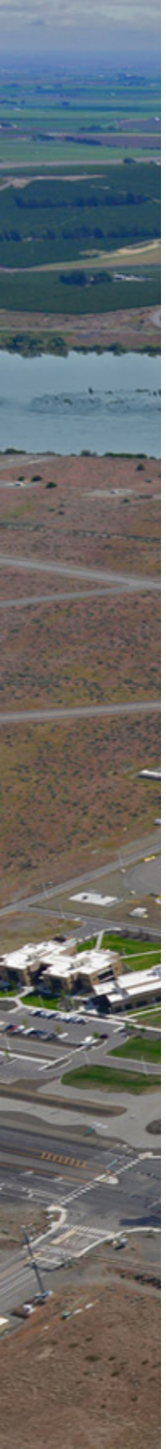


Compliance Best Practices: Training and Capacity Building

- Targeted training and capacity building ensure that different stakeholders can comply with the code

Training and tools	Examples
Training programs for local governments on requirements and compliance	China, Canada, Japan, New Zealand, Singapore, Spain, United States
Software and software training	Australia, Canada, France, New Zealand, Singapore, Spain, United States
Code compliance resource kits	Australia, Canada, China, France, Germany, Italy, New Zealand, Mexico, Singapore, United States
Training and certificate programs for building inspectors	China, Italy, Germany, New Zealand, Spain, Singapore, United States
Sponsored university degree programs on building energy efficiency	China, Denmark, United States, Singapore

Source: GBPN, PNNL, and IPEEC 2015; Evans, Roshchanka, and Graham 2017.



Pacific Northwest NATIONAL LABORATORY

Compliance Best Practices: Code Evaluation

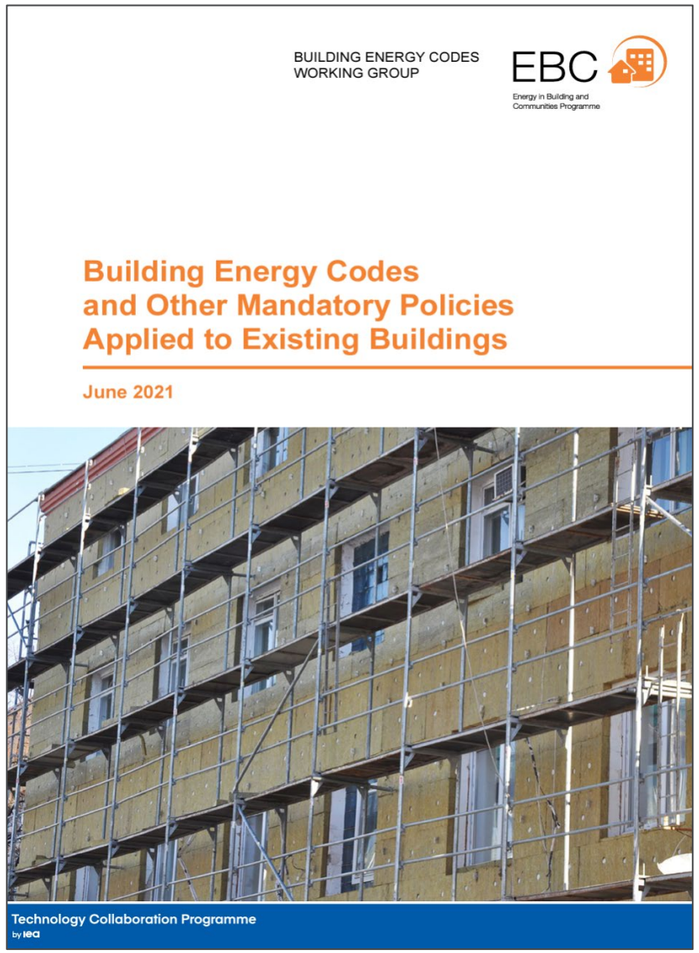
- Evaluating compliance programs can improve enforcement and allow policymakers to make improvements to the code based on hard data
- Evaluation methodologies vary significantly across jurisdictions

Examples of building energy code evaluation programs

Example	Building energy code evaluation
Australia	Sampling of a statistically significant number of buildings under construction within a state to assess compliance
China	Study of discrepancies between building design and construction, points of non-compliance with the code, and variations across jurisdictions
Japan	Annual inspection of selected buildings across the country by a national agency (non-compliant buildings are fixed during the study, so reported compliance rates may not be indicative)
United States	Assess code compliance during construction using a statistical, published methodology

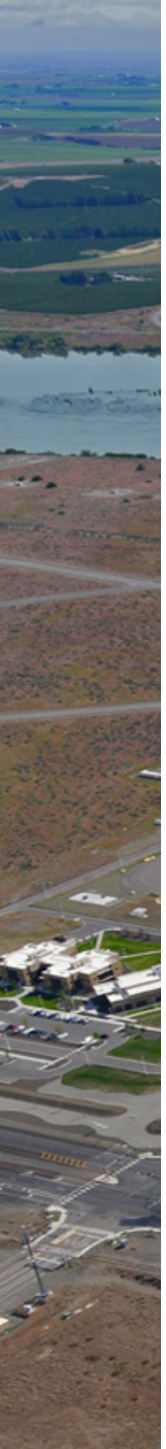
Sources: U.S. DOE, 2016; Pitt and Sherry, 2014; GBPN et al., 2015.

Energy Codes for Existing Buildings



Hinge and Brocklehurst, 2021

- Two main options available for existing buildings:
  - *Codes that apply to renovations*:
    - regulates the efficiency of the building envelope and building systems
  - *Building performance standards:*
    - require building owners to meet a performance benchmark or target (generally an energy performance rating or energy/carbon intensity)
    - often gives building owners multiple years to bring buildings to compliance



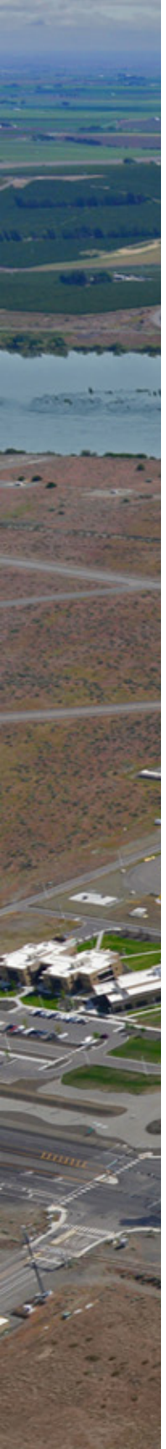
Pacific Northwest NATIONAL LABORATORY

Energy Codes for Existing Buildings

- Significant variation among countries, and within countries, regarding thresholds or triggers when codes applied to existing buildings

Types of thresholds	Examples
Requires meeting the code for the whole building for major renovations	Italy
Requires that all renovated spaces meet the code	United States*, Sweden
Requires meeting other thresholds (e.g., minimum floorspace renovated)	France, Tokyo (Japan)

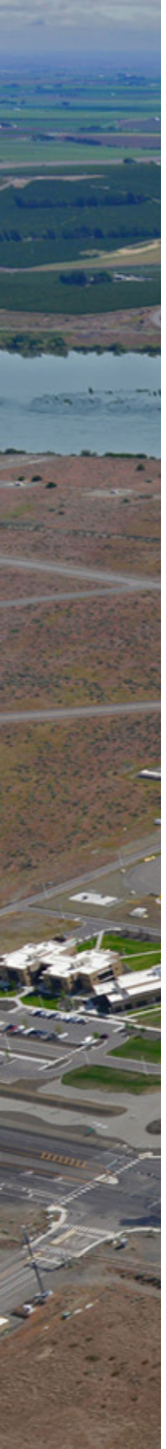
*However, specific requirements vary by jurisdiction.



Pacific Northwest NATIONAL LABORATORY

Energy Codes for Existing Buildings: Building Performance Standards

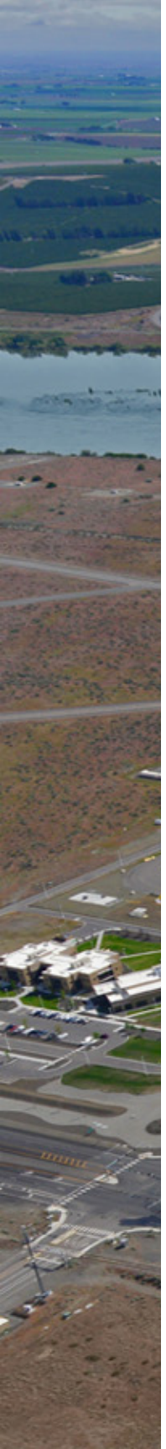
- Implementation issues
  - Has the potential to cover a larger percentage of the building stock than traditional codes
  - New type of regulation so will likely require significant new administrative resources
- Enforcement and compliance issues
  - All properties in the qualifying class are required to meet the standard
    - In principle, should be easier to identify properties that need to comply
    - Many properties are required to meet performance at same time so possible resource issue (for supply chain, e.g., building raters, as well as regulators)
- Enabling and financial issues
  - Requires a mature energy rating system or data for a “fleet standard” that can be the basis for performance measurement
  - Potential financial hardship for some without special financing/incentives in place—or risk that lack of finance means many exemptions



Other Emerging Areas Covered

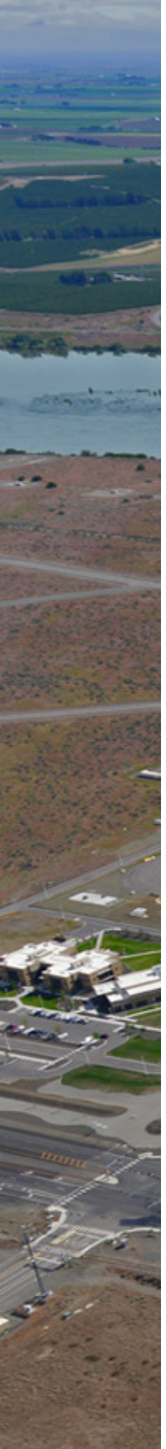
BECWG webinar topics to date

1. *Defining Future Direction and Collaboration for the Working Group* (May 2019)
2. *Cross-national Comparison of Building Codes* (July 2019)
3. *Building Codes Implementation Practices* (September 2019)
4. *Building Energy Issues and the COVID-19 Response* (May 2020)
5. *Towards Net or Nearly Zero Energy Buildings* (May 2020)
6. *Energy Codes for Existing Buildings* (June 2020)
7. *Changing Business-as-Usual: Building Code Virtual Diagnostics & Inspections* (September 2020)
8. *Balancing Costs and Benefits of Building Energy Codes: An Evaluation of Methodologies for Assessing Cost-Effectiveness* (April 2021)
9. *An International Review of Trends in Energy Codes and Mandatory Performance Standards* (June 2021)



Pacific Northwest
NATIONAL LABORATORY

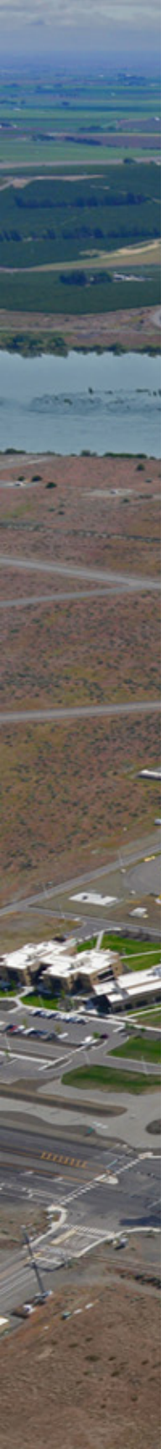
Takeaways



Pacific Northwest NATIONAL LABORATORY

Concluding Thoughts

- Codes have a proven track record of cost-effectively saving energy on a large scale
- Codes work best when complying is the easiest option, which requires strong capacity, tools, and clear enforcement mechanisms
  - A code not implemented is not worth very much
- International collaboration on R&D for building energy codes can play a critical role in speeding the development and adoption of best practices



Pacific Northwest NATIONAL LABORATORY

References

- Hinge, A. and F. Brocklehurst. 2021. Building Energy Codes and Other Mandatory Policies Applied to Existing Buildings. Energy in Building and Communities Programme, Building Energy Codes Working Group.
- Evans, M., A. Delgado, M. Halverson, M. Charles, S. Yu, J. Mayernik, and J. Williams. 2020. Codes Around the Globe: A Cross-national Comparison of Building Energy Codes

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

Pacific Northwest
NATIONAL LABORATORY

Thank you

Thank You!

Building Energy Codes Program
www.energycodes.gov/training

BECP help desk
https://www.energycodes.gov/technical-assistance/help-desk

ICC PREFERRED EDUCATION PROVIDER

CONTINUING EDUCATION AIA®

Building Energy Codes
U.S. DEPARTMENT OF ENERGY

NECC Seminar Series Lineup

Catch the entire lineup of sessions bi-weekly—Thursdays @ 1p ET:

- 8/12: Grid Integration and Electrification in Energy Codes
- 8/26: Approaching Zero, Where Do We Go From Here for Commercial Buildings
- **9/9: Codes Around the Globe: A Cross-National Comparison of Building Energy Codes (AT 2PM ET)**
- 9/23: Evolution of Commercial Building Design and Construction
- 10/7: Equity and Codes: Ensuring Codes and Energy Efficient Buildings Address Affordable Housing Needs
- 10/21: Zoning and Land-Use Regulation: Emerging Tools for Advancing Climate-Friendly Development

> Learn more: https://www.energycodes.gov/2021-summer-seminar-series

Building Energy Codes
U.S. DEPARTMENT OF ENERGY