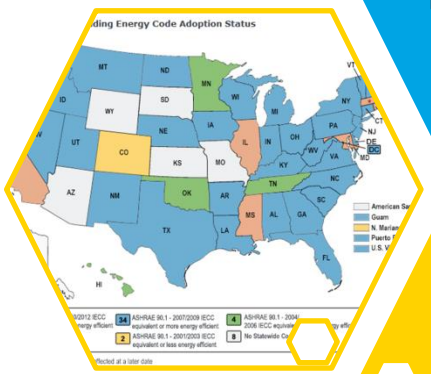
PNNL Energy Codes Portfolio

2015 Building Technologies Office Peer Review

DEVELOP



COMPLY

ADOPT

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Bing Liu bing.liu@pnnl.gov
Rosemarie Bartlett rosemarie.bartlett@pnnl.gov
Pacific Northwest National Laboratory

Project Summary

Timeline:

Multi-year program in support of DOE statutory requirements

Key Milestones:

1. DOE's Determinations on 90.1-2013 and 2015 IECC
2. Update DOE's Energy Codes Cost-Effectiveness Methodology
3. Commercial Codes Roadmap
4. 90.1-2013 and 2015 IECC Cost Analyses
5. RES/COM*check* new release with 2015 IECC

Budget:

FY14 (past)	FY15 (current)	FY16 (planned)
$4.0M	$2.8M	$2.66M

Target Market/Audience:

Policymakers, code officials, designers, engineers, industry, builders, home and building owners

Key Partners:

Codes and standards development (e.g., ANSI/ASHRAE/IES, and ICC)
Code implementation stakeholders (e.g., states, national/regional organizations)

Project Goal:

Near-term: Assist states and localities in implementing the model energy codes resulting in higher-performing buildings that maximize cost-effective energy savings.

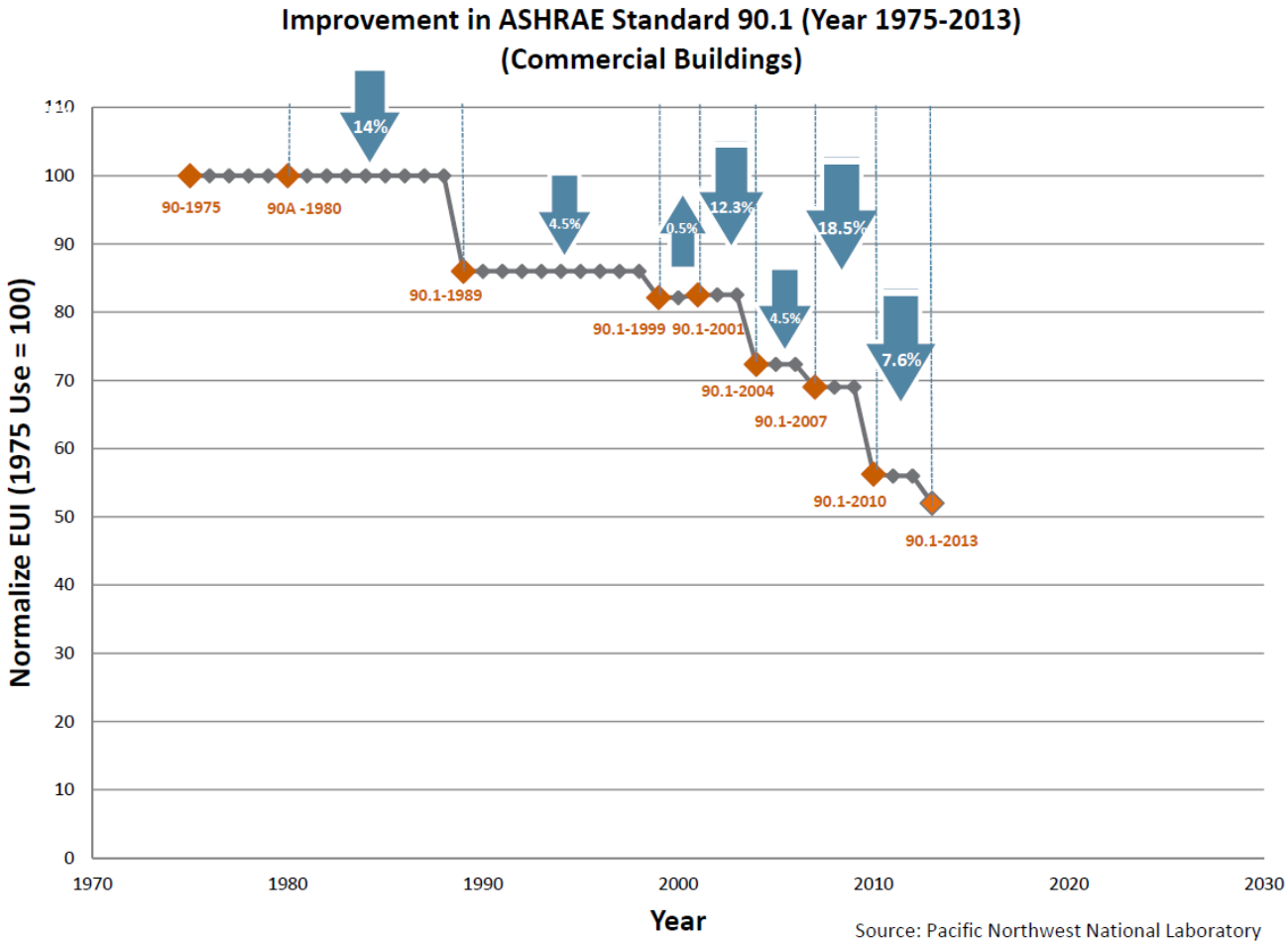
Mid-term: By 2020, achieve energy savings of 1.1 quads annually.

Long-term: Through 2030, achieve cumulative energy savings of 14 quads, reduce energy bills by $125 billion and avoid carbon emission by 1 billion metric tons.

Purpose and Objectives

Codes Challenges:

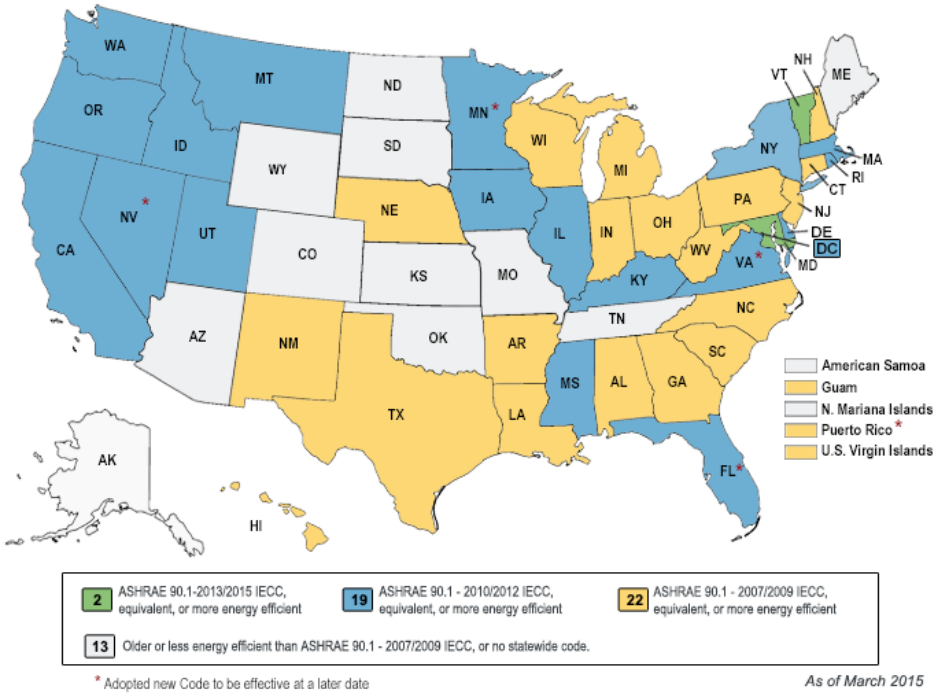
- **Development**: Model codes have advanced significantly in recent cycles—current remaining opportunity for cost-effective energy savings is diminished.

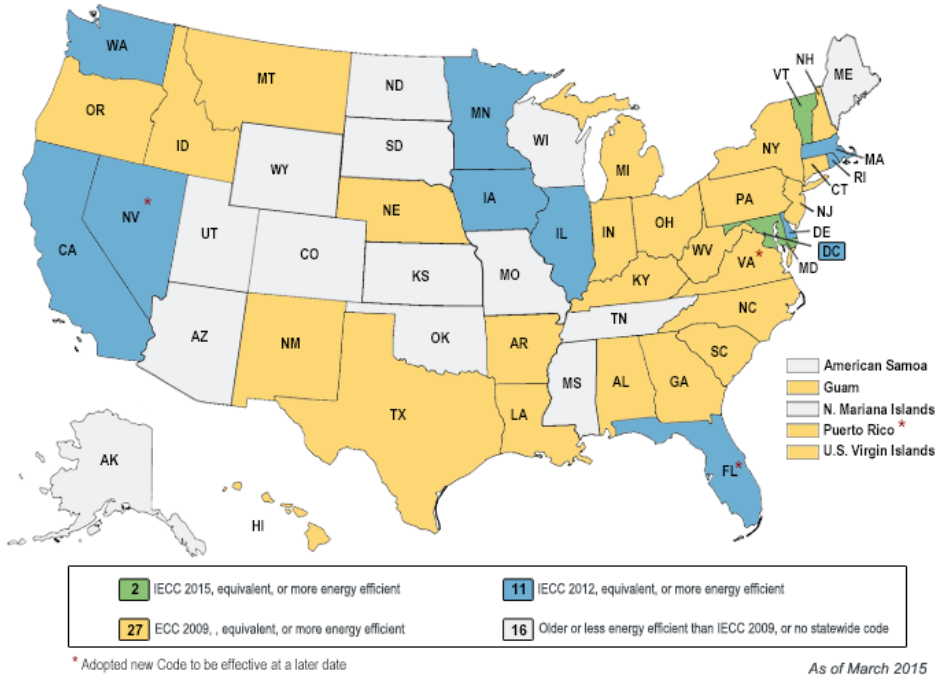


Purpose and Objectives

Codes Challenges:

- **Adoption**: Unique scenarios exist at state and local levels, creating uncertainty around potential energy and cost savings impacts.
- **Compliance**: Lack of resources, knowledge or motivation to ensure full implementation of energy code requirements in the field. Lack of information and data to adequately measure and verify intended energy savings.





Purpose and Objectives

Target Market and Audience:

- Newly constructed and renovated buildings
- Policymakers, code officials, designers, engineers, industry, builders, home and building owners

Project Objectives:

- Provide robust and transparent analyses in advancing codes development and implementation
- Provide easy to use and reliable tools, guidance, and resources to facilitate codes adoption and compliance
- Assist DOE on timely publication of DOE's Determination on national model codes within statutory deadlines
- Analyze and evaluate DOE's code program impacts to track its progress

Approach

Impactful Deliverables

- Developing tasks to directly support DOE's statutory requirements
- Delivering impactful products to the market

Technical Leadership

- Understanding the challenges, analyzing various facets, and providing meaningful and relevant solutions to states and stakeholders
- Growing core capabilities to support DOE's needs

Disciplined Product Delivery

- Developing detailed Project Work Plan and planning staff and resources accordingly
- Reviewing and updating Project Work Plan monthly
- Engaging external technical peer reviews to ensure high quality products

Project Portfolio

Development

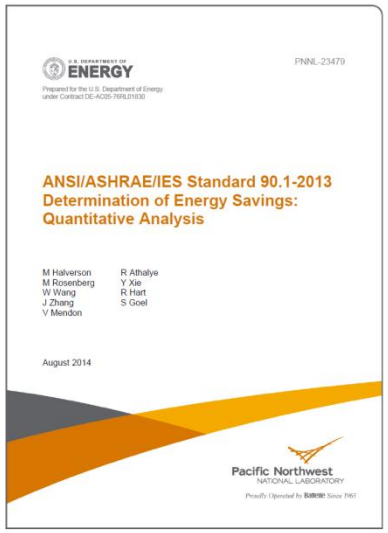
- ASHRAE Standard 90.1
- International Energy Conservation Code (IECC)
- Analysis supporting DOE's Determinations

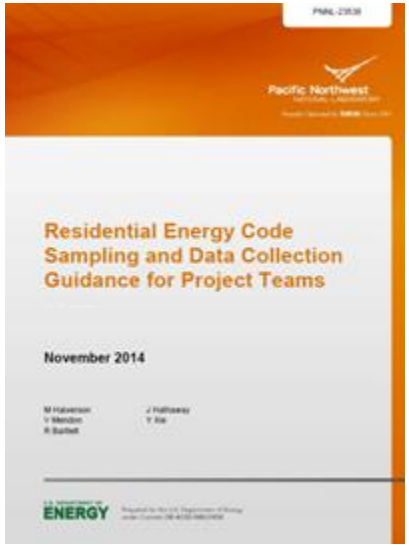
Adoption

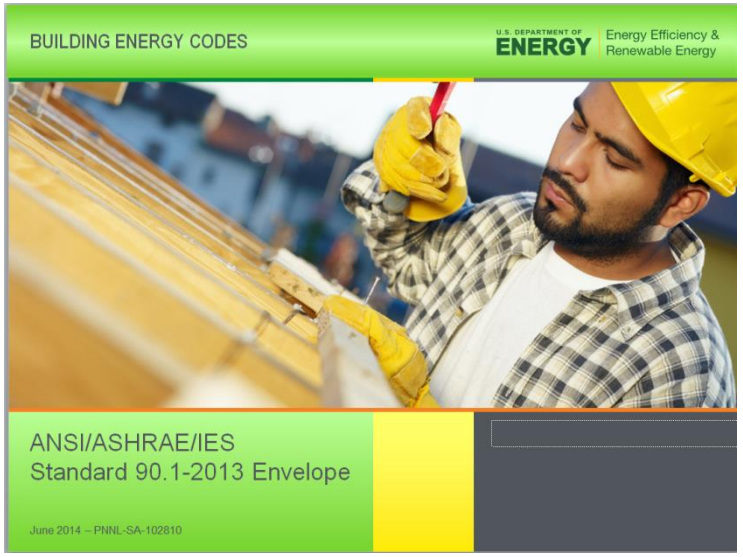
- State-specific energy & cost analyses
- State technical assistance
- State-specific code impacts analysis

Compliance

- Compliance software tools & resources
- User Support
- Trainings
- Field study guideline and methodology







REScheck

COMcheck

Key Issues

Development:

- Future commercial code approach: performance to lead and prescriptive packages to follow

Adoption:

- Fast track publication of DOE's Determinations on national model codes
- Evaluate cost-effectiveness on newly published national model codes to bolster and accelerate code adoption

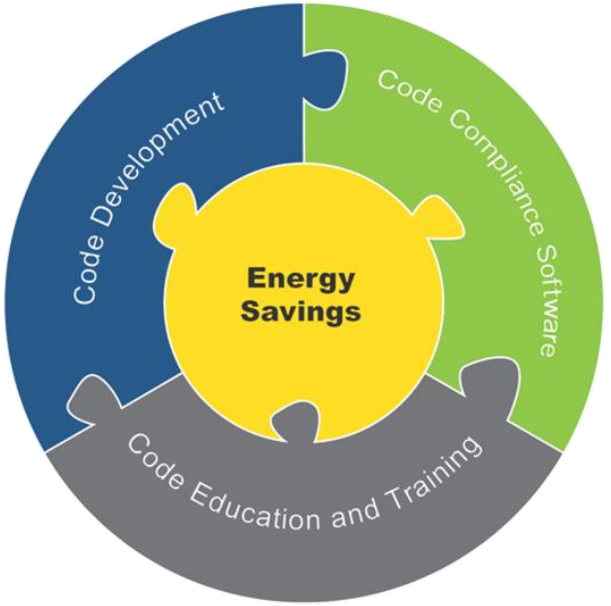
Compliance:

- Energy savings associated with the energy codes are only realized with actual compliance with the requirements
- As the codes become more complex, compliance challenges increase

Distinctive Characteristics

PNNL Codes Ecosystem:

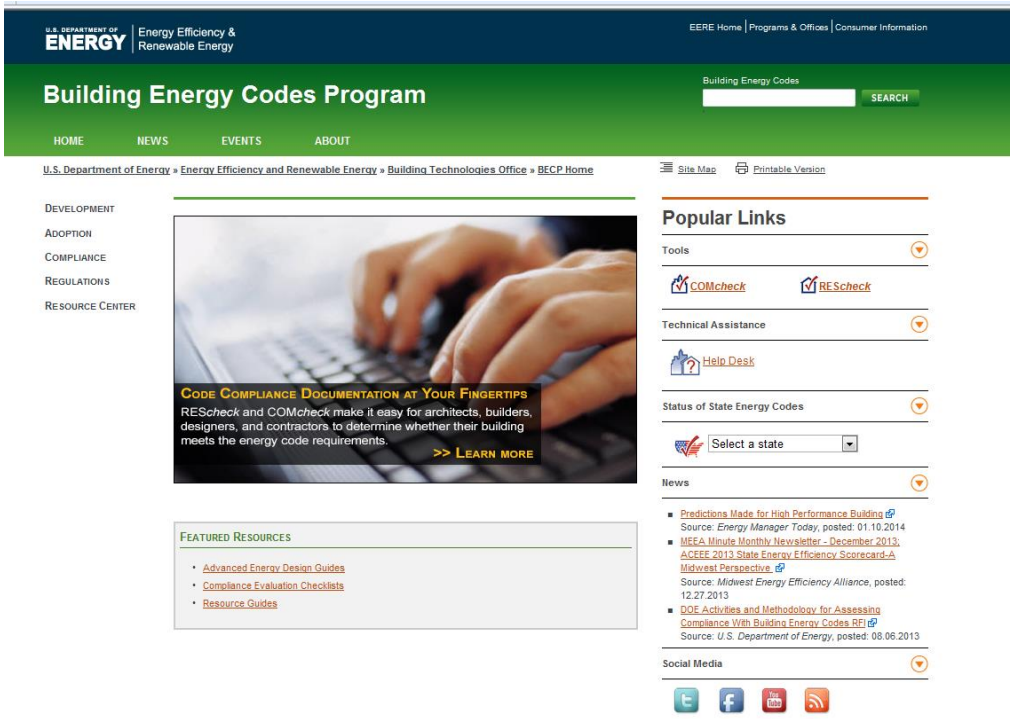
- Domain knowledge in codes carries to compliance software development, resulting in more user-friendly software.
  - Code knowledge assists in developing effective communications tools that help users implement and enforce complicated code requirements and understand their intent.
- Codes development team is informed by user feedback gathered through technical support team on the tools and trainings.



Distinctive Characteristics

Supporting Trusted DOE Brands:

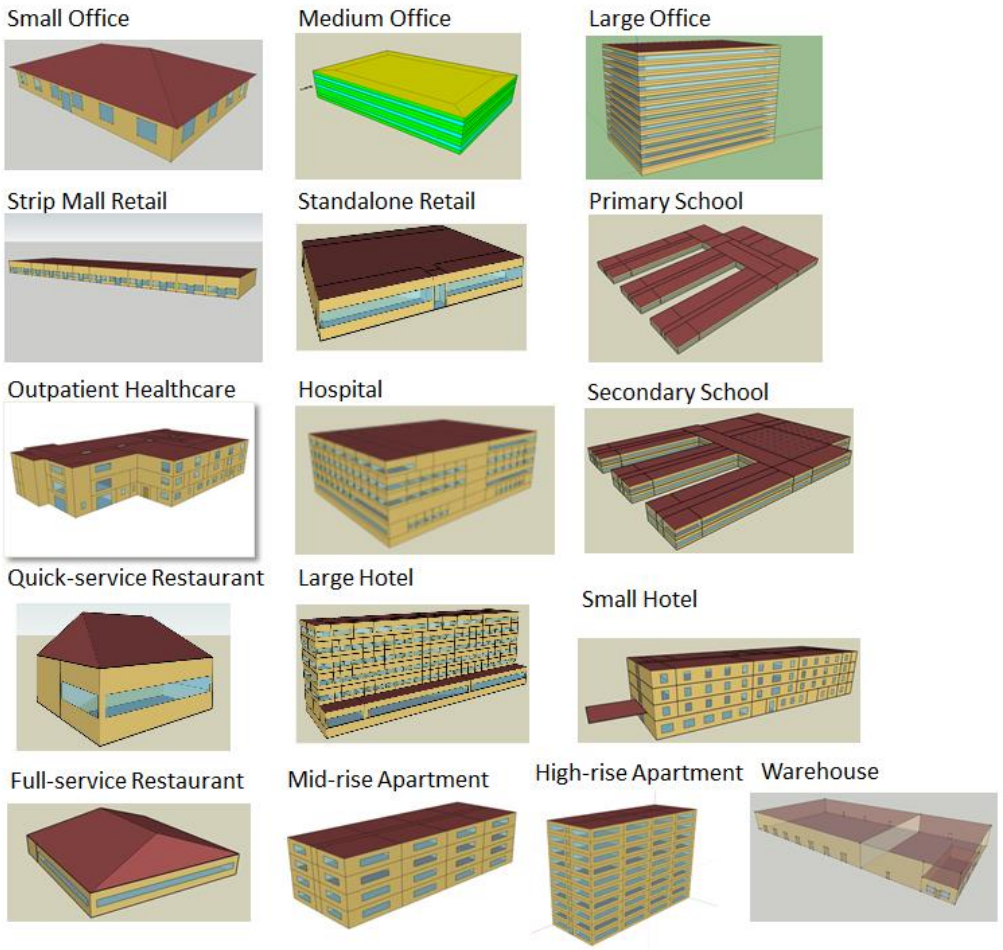
- Availability of free software is a key adoption and compliance driver.
- Several states have accelerated code adoption because of state-customized versions of COM*check* and RES*check*.
- Compliance is a legal process that requires assurance of consistency/quality.
- Software used as ‘de facto’ code in many jurisdictions.



Distinctive Characteristics

Robust and Transparent Analyses:

- *ASHRAE 90.1 Progress Indicator* consists of a suite of over 1,000 code-compliant building models based on 16 prototype commercial buildings in all U.S. climate zones, representing 80% of the U.S. commercial building stock.
- Models were peer reviewed by industry, documented in a technical report, and published online for easy public access, demonstrating analysis that is robust, transparent, and reproducible.
- Approach has been adopted by other researchers to evaluate the energy savings potential of emerging technologies and to develop code proposals at the state or local level.



http://www.energycodes.gov/development/commercial/90.1_models

http://www.energycodes.gov/development/residential/iecc_models

Progress and Accomplishments

FY14 Progress:

Completed and delivered all products on time and within budget (20 major deliverables)

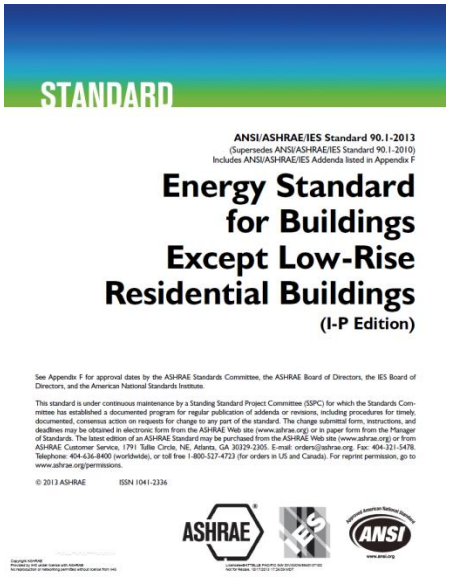
Highlight FY14 Accomplishments:

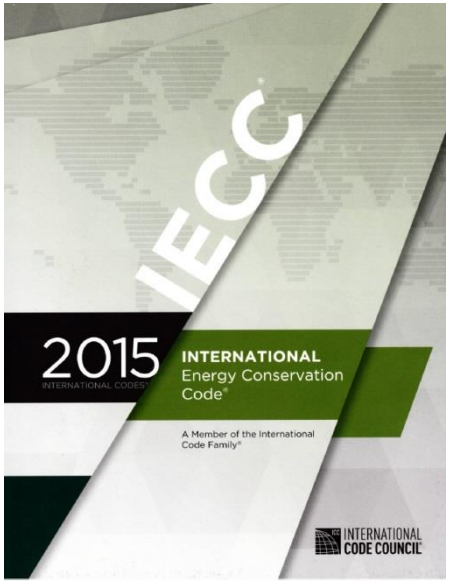
- Understand and shape national priorities
- Maintain technical leadership
- Provide easy-to-use and reliable tools to advance code implementation

FY14 Accomplishments

Understand and shape national priorities

- Key contributor to the **President's Climate Action Plan**
- In-depth knowledge in **buildings science and code development process** that leads to success in advancing code development
- Enabled DOE to meet several **statutory requirements**
  - Released the **Determination for ASHRAE 90.1-2013**, less than one year after publication of the standard, meeting DOE's statutory requirement
  - Released the **draft Determination on the 2015 IECC**, three months after the publication of the IECC





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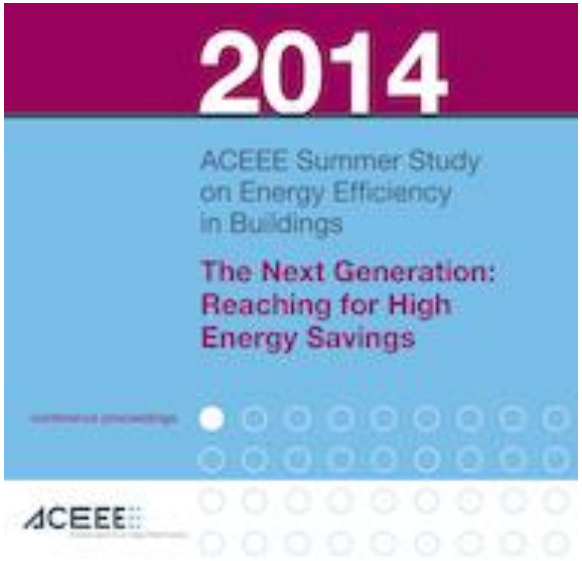
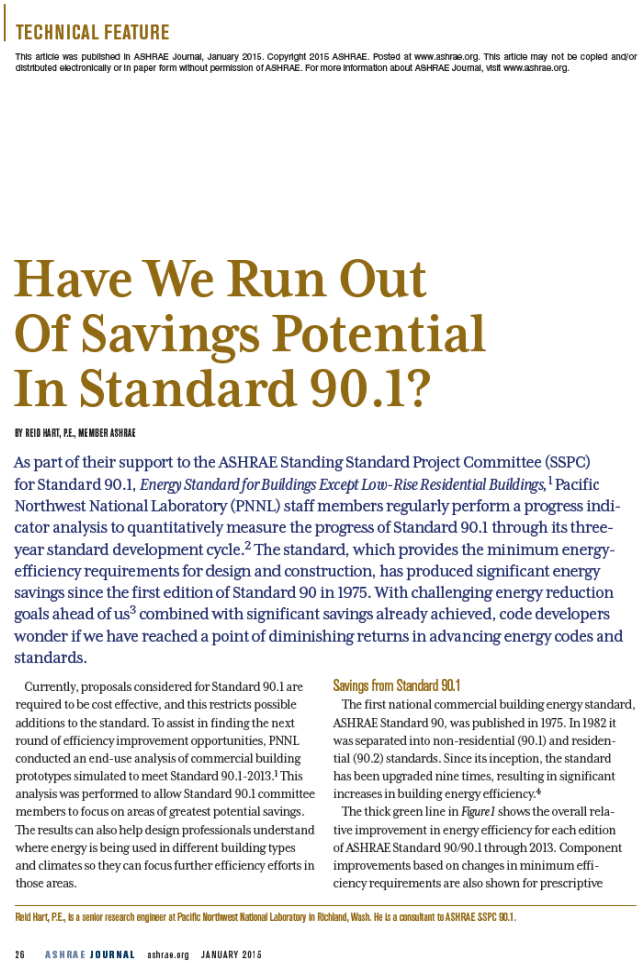
Accomplishments (cont'd)

Maintain technical leadership

- Published 8 **papers** and 33 **technical reports**
- Presented at regional and national technical conferences
- Developed **guidance** and **tools** to support DOE's residential codes field study





TECHNICAL FEATURE

Have We Run Out Of Savings Potential In Standard 90.1?

BY REID HART, P.E., MEMBER ASHRAE

As part of their support to the ASHRAE Standing Standard Project Committee (SSPC) for Standard 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings*,[1] Pacific Northwest National Laboratory (PNNL) staff members regularly perform a progress indicator analysis to quantitatively measure the progress of Standard 90.1 through its three-year standard development cycle.[2] The standard, which provides the minimum energy-efficiency requirements for design and construction, has produced significant energy savings since the first edition of Standard 90 in 1975. With challenging energy reduction goals ahead of us[3] combined with significant savings already achieved, code developers wonder if we have reached a point of diminishing returns in advancing energy codes and standards.

Currently, proposals considered for Standard 90.1 are required to be cost effective, and this restricts possible additions to the standard. To assist in finding the next round of efficiency improvement opportunities, PNNL conducted an end-use analysis of commercial building prototypes simulated to meet Standard 90.1-2013.[1] This analysis was performed to allow Standard 90.1 committee members to focus on areas of greatest potential savings. The results can also help design professionals understand where energy is being used in different building types and climates so they can focus further efficiency efforts in those areas.

Savings from Standard 90.1

The first national commercial building energy standard, ASHRAE Standard 90, was published in 1975. In 1982 it was separated into non-residential (90.1) and residential (90.2) standards. Since its inception, the standard has been upgraded nine times, resulting in significant increases in building energy efficiency.[4]

The thick green line in *Figure1* shows the overall relative improvement in energy efficiency for each edition of ASHRAE Standard 90/90.1 through 2013. Component improvements based on changes in minimum efficiency requirements are also shown for prescriptive

Reid Hart, P.E., is a senior research engineer at Pacific Northwest National Laboratory in Richland, Wash. He is a consultant to ASHRAE SSPC 90.1.

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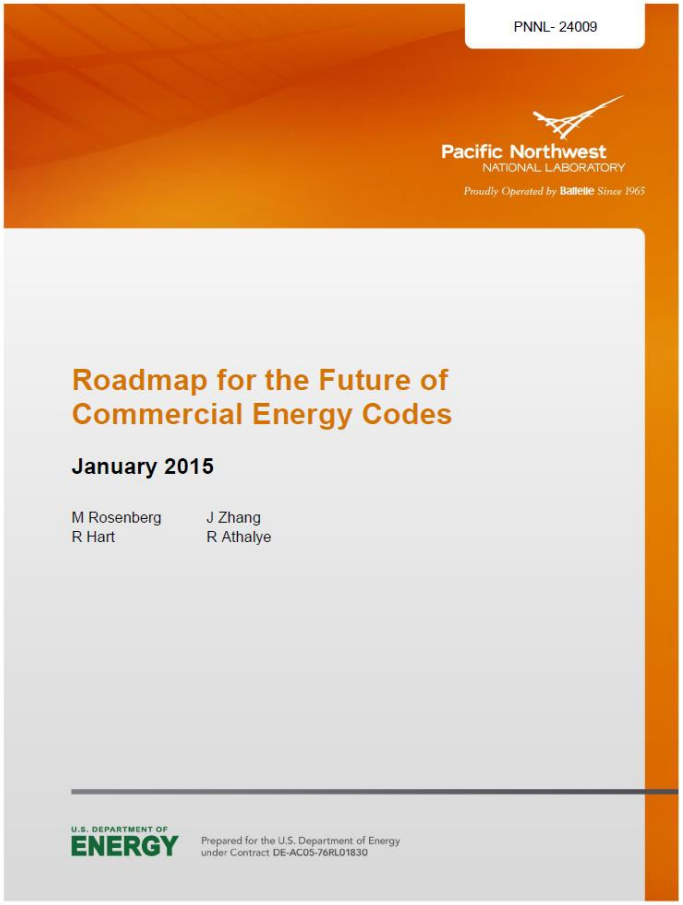
Accomplishments (cont'd)

Maintain technical leadership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Roadmap for the Future of Commercial Energy Codes

January 2015

M Rosenberg
R Hart
J Zhang
R Athalye

U.S. DEPARTMENT OF ENERGY
Prepared for the U.S. Department of Energy under Contract DE-AC05-76RL01830


TECHNICAL FEATURE

A Stable Whole Building Performance Method For Standard 90.1

By Michael Rosenberg, Member ASHRAE, and Charles Eley, P.E., FAIA, Member ASHRAE

Wouldn't it be great if a single energy model could be used to demonstrate minimum code compliance, green code compliance, establish a LEED rating, and determine eligibility for federal tax and utility incentives? Even better, what if the basic rules for creating those models did not change every few years?

A recently proposed addendum to ANSI/ASHRAE/IES Standard 90.1-2010 aims to meet those goals. Addendum *bm* establishes the Performance Rating Method found in Appendix G of Standard 90.1 as a new method of compliance while maintaining its traditional use in gauging the efficiency of "beyond code" buildings. Furthermore, the addendum sets a common baseline building that would stay the same for 2013 and future versions of Standard 90.1, while only the improvement target will change with each new edition.

Background

Standard 90.1-2010 has two whole building performance approaches: the Energy Cost Budget (ECB) method used for code compliance and the Performance Rating Method (PRM) used for LEED calculations and other beyond-code programs. The performance methods are similar in that the design or proposed building is compared to a baseline building that is in compliance with the prescriptive standards. The differences are in the details of how the baseline is defined and the scope of design elements that can be credited.

The ECB method is intended to be used for code compliance, and as result, the baseline building tracks the proposed design in many respects. For example, if the proposed building design has wood-framed walls, a 20% window-to-wall ratio, all windows facing south, and is served by a water-source heat pump system, the comparison is to a baseline building with wood-framed walls, a 20% window-to-wall ratio, all windows facing south, served by a water-source heat pump system, with all components just meeting prescriptive requirements. If the same building had mass walls, a 40% window-to-wall ratio, all windows facing west, and an air-source heat pump system, the comparison would be to a baseline building with mass walls, a 40% window-to-wall ratio, all windows facing west, and an air source heat pump system, with all components just meeting prescriptive requirements.

About the Authors

Michael Rosenberg is a senior research scientist at Pacific Northwest National Laboratory, Eugene, Ore. He is a member of the SSPC 90.1 Energy Cost Budget Subcommittee and the LEED Energy and Atmosphere Technical Advisory Group. **Charles Eley, P.E., FAIA,** is a consulting architect and mechanical engineer in San Francisco. He is a past member of SSPC 90.1 and is currently a member of SSPC 189.1. He is an ASHRAE certified building energy modeling professional.

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Accomplishments (cont'd)

Provide easy-to-use and reliable tools to advance code implementation

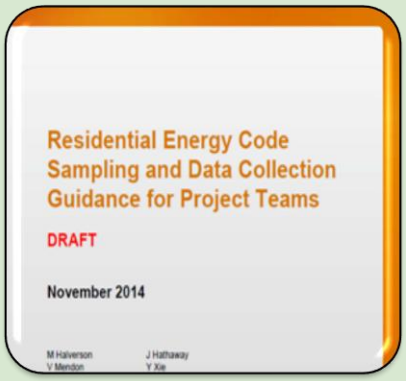
FY14:

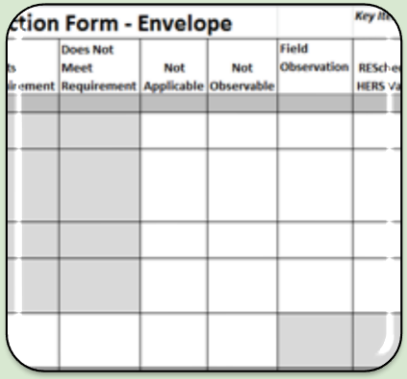
- Released COM*check* V4.0.0: new version supports the latest national model code 90.1-2013, including the new envelope tradeoff compliance option based on whole building energy simulation
- Revised project database to better query project data
- Engaged key stakeholder group to gain feedback on tools

FY15:

- Implement 2015 IECC in RES*check* (residential provisions)
- Implement 2015 IECC in COM*check* (commercial provisions)

Accomplishments (cont'd)
Residential Field Study Methodology





8-step guidance document

State sampling plans

State-specific data collection tools

Online data tool and database

http://www.energycodes.gov/residential-energy-code-field-study

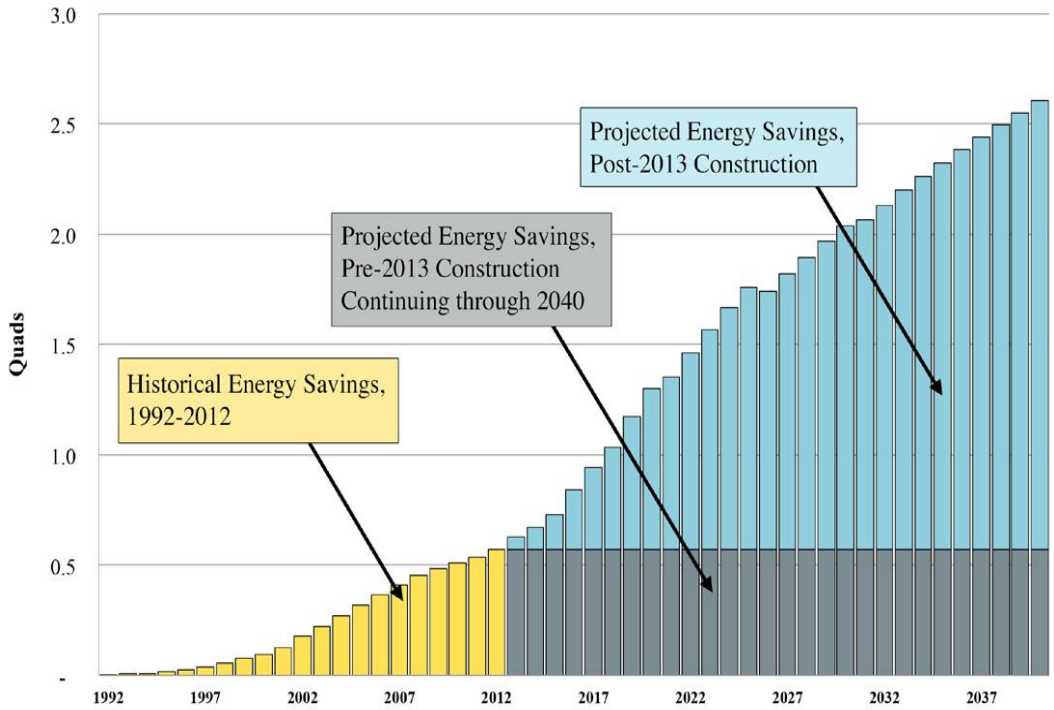
Market Impact

Since 2010:

- **30% savings** in model energy codes
- **42 states** have updated their codes

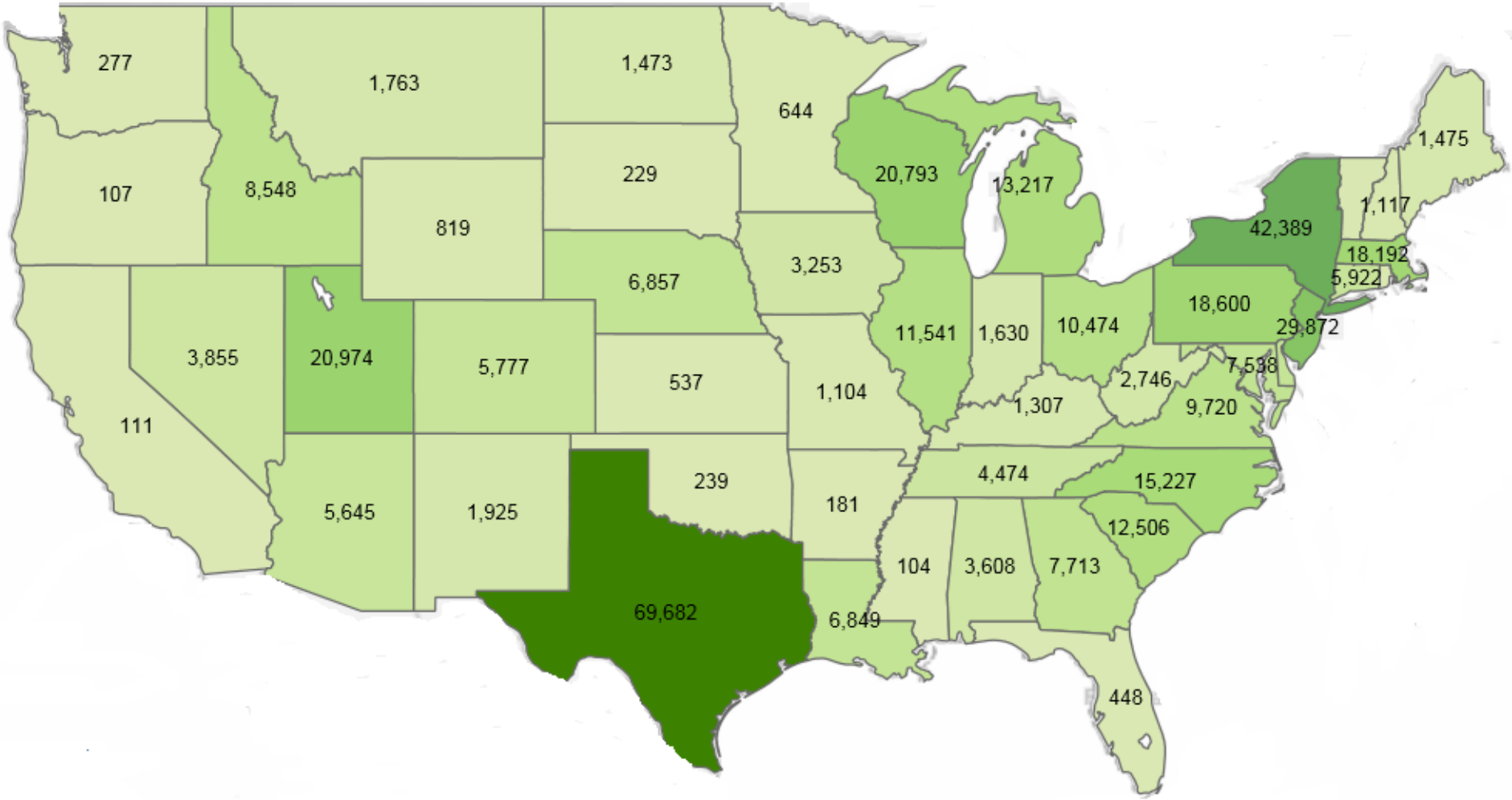
Projected savings by 2030 (cumulative)*:

- **14 quads** full fuel cycle energy savings
- **$125 billion** consumer cost savings
- **1 billion tons** of avoided CO_2 emissions
- Important component of President's Climate Action Plan



*Livingston, OV, PC Cole, DB Elliott and R Bartlett. 2013. *Building Energy Codes Program: National Benefits Assessment, 1992-2040*. PNNL-22610 Rev 1, Pacific Northwest National Laboratory, Richland, Washington.

Market Impact: RES*check* Projects by State (2012 – 2015)



Total projects = 417,361

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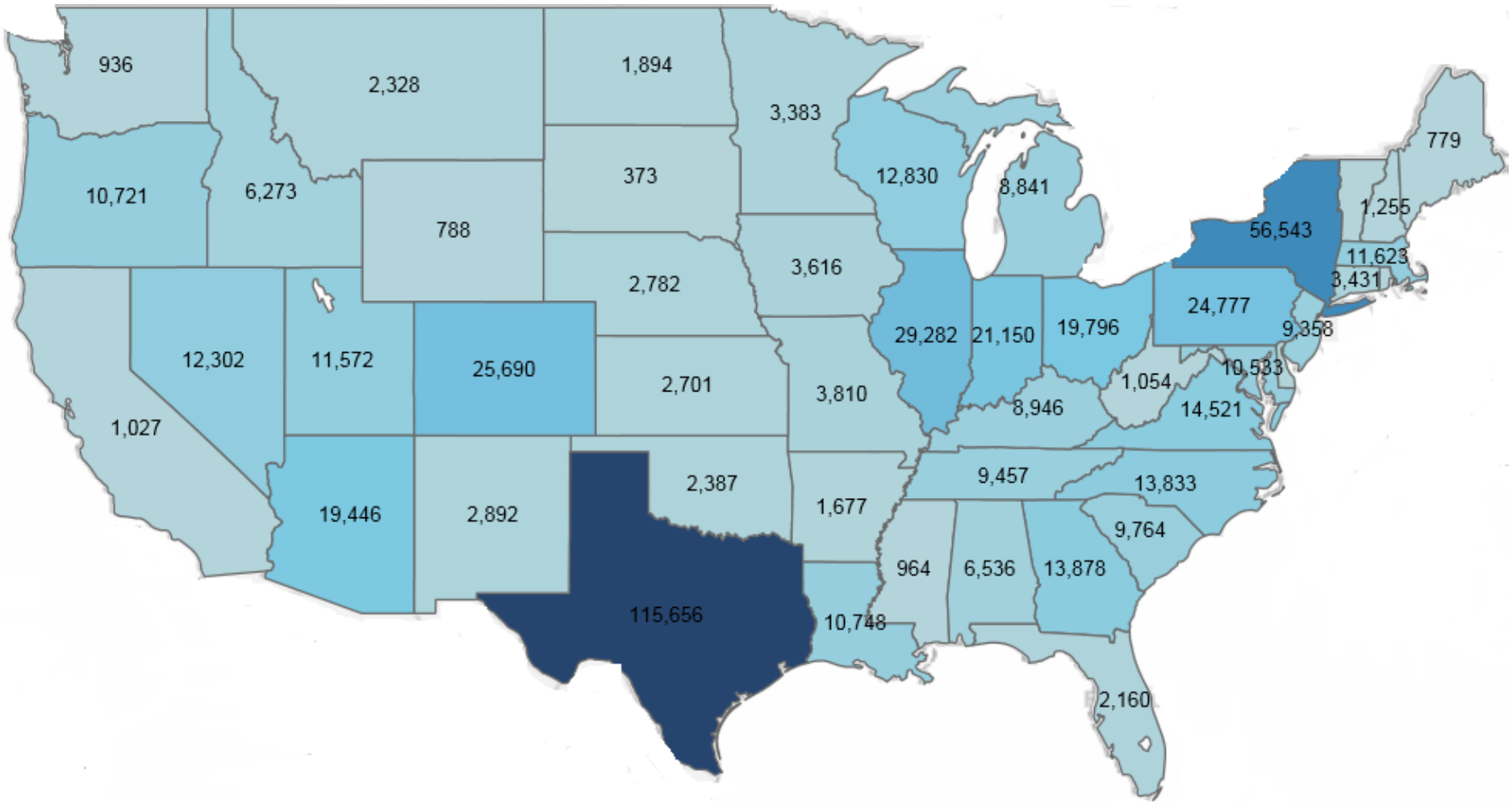
Market Impact: COM*check* Projects by State (2012 – 2015)



Total projects = 543,601

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Recognition

PNNL staff Vrushali Mendon was interviewed by **Energy Design Update** along with other PNNL technical experts. PNNL's vision on the future of codes was featured in the March Edition of EDU.

Energy Design Update

The Monthly Newsletter on Energy-Efficient Housing

VOL. 35, NO. 3 • MARCH 2015

PROFESSIONAL PERSPECTIVE

Looking into the Future with Pacific Northwest National Laboratory

Michael C. Baechler, Senior Project Manager
Srinivas Katipamula, Engineer
Vrushali V. Mendon, Engineer
Graham B. Parker, Engineer
Sarah H. Widder, Engineer

Product or technology you would most like to see arrive in the market in the near future…

(GP) Carbon dioxide (CO2) refrigerant heat pump water heaters (HPWH). This is a new technology coming from Asia, not yet commercialized in the US. This technology has a real potential, as it is not only very efficient, but it also mitigates major green house gas concerns. [Data from Japanese CO2 HPWHs shows a global warming potential 2,000 times less than synthetic refrigerants.] CO2 technology is also capable of combining water heating with space heating.

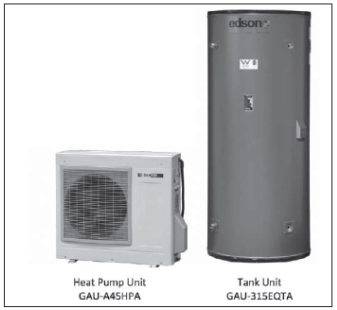

Figure 5. The Sanden heat pump water heater Model GAU-A45HPA uses carbon dioxide refrigerant to heat water within an outdoor condenser unit. That water is then pumped to an indoor hot water storage tank, where it is available for use within the home. Image from *http://www.sanden.com.au/iS_admin/files/Eco%20cute%20owner's%20manual%20version%206.pdf.*

We hope to demonstrate this technology in our PNNL Lab Homes soon (see Figure 5).

(SW) CO2 HPWH and combined space heating is a technology with great promise, especially in areas like the Pacific Northwest with a high percentage of electrically heated homes. We've seen HPWH grow in popularity and market penetration.

The US Department of Energy (DOE) recently published a rule mandating that large tank water heaters must be HPWH. This goes into effect soon. The next phase will be combining HPWH to heat your home. Combining makes sense – you get a lot of cost savings, avoid buying 2 heat pumps, and it enables more energy savings. This also offers lots of design flexibility, and can work in retrofit situations.

(GP) You can also realize savings by doing radiant and getting rid of ducting with HPWH in a home.

(SW) We're waiting on research from homes utilizing this technology. Other manufacturers have similar designs in the works. I look forward to this because it's a great fit for retrofit applications, especially for electrically heated homes. Combined water and space heat pumps should be happening in the next few years.

Another product, first available last year, is a heat pump clothes dryer (see Figure 6). That technology in and of itself is energy saving. Depending on the design, it can save more than 50% over a traditional dryer, and when we're chasing every available Btu, that's important. The combined water and space heat pump concept, once we can figure out how to do space heating and water heating off of a single compressor,

Figure 6. The LG DLHX4072W is a heat pump dryer currently available for the American market. Image from *http://www.lg.com/us/support-product/lg-DLHX4072W.*

takes us to the next logical step: how then can we design for 1 refrigerant loop and condensing unit that serves multiple loads in the home, including your dryer and refrigerator.

Technology-wise, the whole universe of how we deal with fenestration in a retrofit has seen a lot of activity: things like Low E storm windows (see Figure 7) and different types of insulation for windows. That's great, too – windows have long been viewed as holes in the building's envelope. This gives us more tools and options that are a lot more accessible for existing homes and weatherization programs. Storm win-

Figure 7. Modern Low-E storm windows leave behind the dated aesthetics and seasonal installation of older models. Many historic home programs promote the use of Low-E storm windows in order to preserve original windows while bringing building performance up to modern standards. Photo courtesy QUANTAPANEL; *http://www.quantapanel.com/index.php?option=com_content&view=article&id=76&Itemid=492.*

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Recognition (cont'd)

Appreciation letter from AIA:

For the AIA, partnerships in codes work are a primary key to success, and the DOE Building Energy Codes Program (BECP) and staff of the Pacific Northwest National Laboratory (PNNL) that help manage that program for DOE have been one of those important partners. In recent years our staff and members have benefitted greatly from the technical expertise and guidance of the team at BECP, for work on the International Energy Conservation Code and ASHRAE 90.1 and the International Green Construction Code.

THE AMERICAN INSTITUTE OF ARCHITECTS

26 March 2015

Pacific Northwest National Laboratory
P.O. Box 999
Richland, WA 99352

Re: Building Energy Codes Program (BECP) - AIA Testimonial

To Whom it May Concern:

For the AIA, partnerships in codes work are a primary key to success, and the DOE Building Energy Codes Program (BECP) and staff of the Pacific Northwest National Laboratory (PNNL) that help manage that program for DOE have been one of those important partners. In recent years our staff and members have benefitted greatly from the technical expertise and guidance of the team at BECP, for work on the International Energy Conservation Code and ASHRAE 90.1 and the International Green Construction Code.

In 2010, Building Energy Codes Resource Guide, Commercial Buildings for Architects provided our members with a comprehensive overview of Standard 90.1, a much needed resource to architects which the group produced in a tight timeline demonstrating operational excellence and a high level of collaboration. We feature the guide on our website and have distributed it to our components and members looking for an excellent first look at the code.

More recently, we had the opportunity to create targeted education on energy codes for our members, which was placed on our new AIAU site. Codes and standards education is in high demand and Mr. Conover went out of his way to ensure that the creation of the session was packed with highly relevant technical content, and presented it in collaboration with our staff using a challenging format, with great ease and interest.

AIA welcomes, with great enthusiasm, future opportunities to join with the BECP in the creation of resources for architects. It has simply been an honor and a pleasure to work with the team.

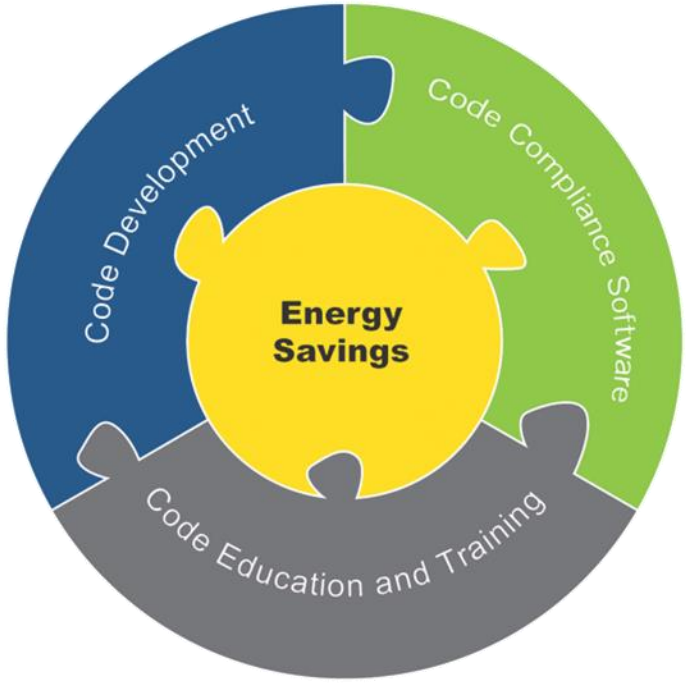
Sincerely,

Jessyca Henderson, AIA
Managing Director, Institute Policy and Strategy

1735 New York Avenue, NW
Washington, DC 20006-5292
Information Central: 800-242-3837

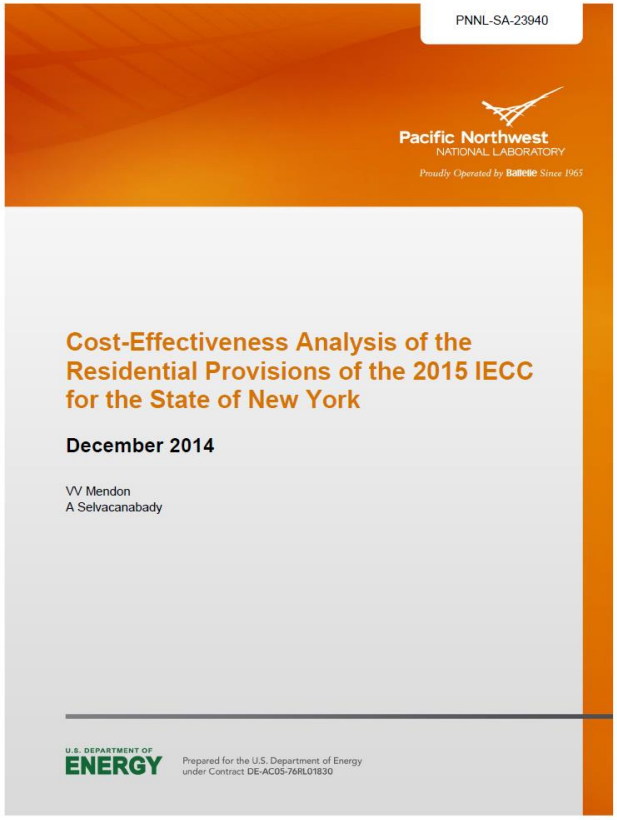
Integration and Collaboration

- Participate in the national codes and standards development processes to ensure the model codes provide the most energy efficient and cost-effective benefits to the consumer.
- Collaborate through the National Energy Codes Collaborative, including NASEO, REEOs and BCAP.
- Actively engage stakeholders through workshops and webinars to get immediate market feedback.



Integration and Collaboration (cont'd)

- Provide objective information resources and technical guidance to states and localities to accelerate adoption and increase code compliance.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Cost-Effectiveness Analysis of the Residential Provisions of the 2015 IECC for the State of New York

December 2014

VV Mendon
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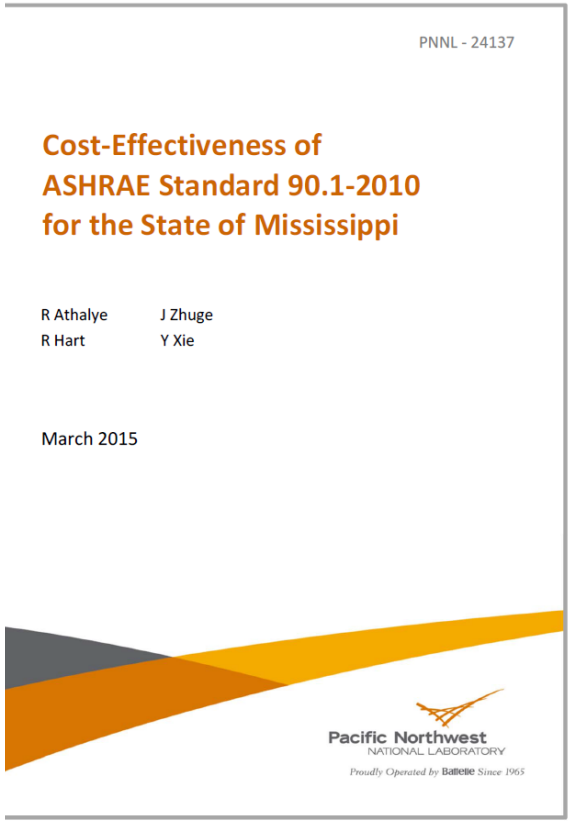
Prepared for the U.S. Department of Energy under Contract DE-AC05-76RL01830


PNNL - 24137

Cost-Effectiveness of ASHRAE Standard 90.1-2010 for the State of Mississippi

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March 2015

Pacific Northwest
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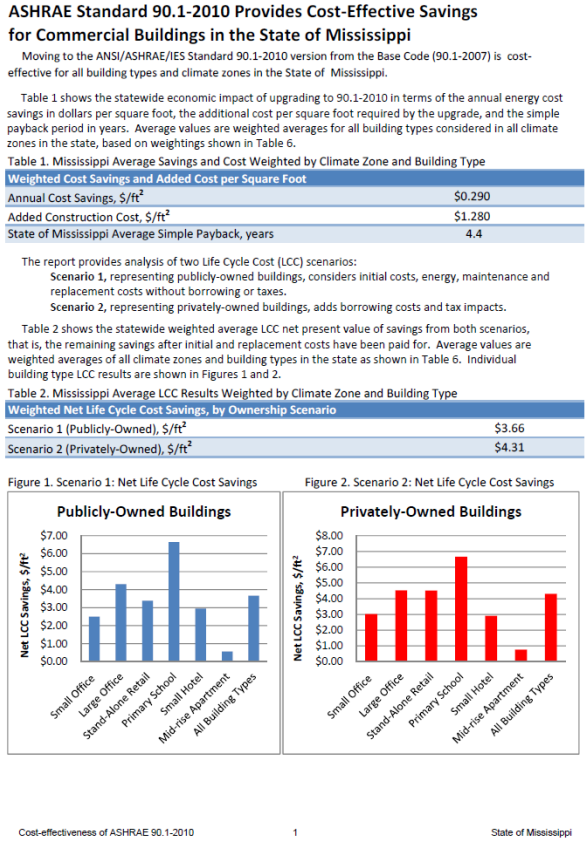
ASHRAE Standard 90.1-2010 Provides Cost-Effective Savings for Commercial Buildings in the State of Mississippi

Moving to the ANSI/ASHRAE/IES Standard 90.1-2010 version from the Base Code (90.1-2007) is cost-effective for all building types and climate zones in the State of Mississippi.

Table 1 shows the statewide economic impact of upgrading to 90.1-2010 in terms of the annual energy cost savings in dollars per square foot, the additional cost per square foot required by the upgrade, and the simple payback period in years. Average values are weighted averages for all building types considered in all climate zones in the state, based on weightings shown in Table 6.

Table 1. Mississippi Average Savings and Cost Weighted by Climate Zone and Building Type

Weighted Cost Savings and Added Cost per Square Foot	
Annual Cost Savings, $/ft²	$0.290
Added Construction Cost, $/ft²	$1.280
State of Mississippi Average Simple Payback, years	4.4

The report provides analysis of two Life Cycle Cost (LCC) scenarios:

Scenario 1, representing publicly-owned buildings, considers initial costs, energy, maintenance and replacement costs without borrowing or taxes.

Scenario 2, representing privately-owned buildings, adds borrowing costs and tax impacts.

Table 2 shows the statewide weighted average LCC net present value of savings from both scenarios, that is, the remaining savings after initial and replacement costs have been paid for. Average values are weighted averages of all climate zones and building types in the state as shown in Table 6. Individual building type LCC results are shown in Figures 1 and 2.

Table 2. Mississippi Average LCC Results Weighted by Climate Zone and Building Type

Weighted Net Life Cycle Cost Savings, by Ownership Scenario	
Scenario 1 (Publicly-Owned), $/ft²	$3.66
Scenario 2 (Privately-Owned), $/ft²	$4.31

Figure 1. Scenario 1: Net Life Cycle Cost Savings

Figure 2. Scenario 2: Net Life Cycle Cost Savings

Cost-effectiveness of ASHRAE 90.1-2010 1 State of Mississippi

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Integration and Collaboration (cont'd)

- Collaborate with BTO's Commercial Building Integration Programs to carry the ready-for-the-mainstream technologies to code process.

Detroit Metropolitan Airport
New lighting: 0.06 W/sf
Saving: 7 million kWh annually

Mall of America Parking Garage
New lighting: 0.076 W/sf
Saving: 7 million kWh annually

Next Steps and Future Plans

Development

- Feasibility study of future residential codes: identify target first cost to advance residential codes cost-effectively
- Release 2015 IECC residential prototype building models and supporting documentation
- Update DOE's building energy codes cost-effectiveness methodology
- Code change proposals and supporting analyses for Standard 90.1-2016 and 2018 IECC

Adoption

- Residential: assist DOE with release of 2015 IECC Determination
- Residential: complete cost-effectiveness analysis of 2015 IECC and publish report
- Commercial: complete the energy saving analysis of 2015 IECC and publish report
- All: interactive tools for users to create customized state-specific code cost analysis report

Compliance

- Release RES*check*/COM*check* software to support 2015 IECC
- Long-term strategy for compliance software
- Conduct energy analysis on residential field study
- Conduct a research study on commercial compliance

REFERENCE SLIDES

Project Budget

Project Budget: see table below

Cost to Date: $1.7M (Oct 2014 through Mar 2015)

Budget History					
FY2014 (past)		FY2015 (current)		FY2016 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$4.0M	$0	$2.8M	$0	$2.66M	$0

Project Plan and Schedule