The Role of Building Energy Codes in the Clean Power Plan

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Contents

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Summary

Section 111(d) of the Clean Air Act (CAA) requires the Environmental Protection Agency (EPA) to establish "standards of performance," which means (42 US Code 7411):

"a standard for emissions of air pollutants which reflects the degree of emission limitation achievable through the application of the *best system of emission reduction* which (taking into account the cost of achieving such reduction and any nonair quality health and environmental impact and energy requirements) the Administrator determines *has been adequately demonstrated*." (emphasis added)

This provision prescribes the factors EPA must consider in its current rulemaking to regulate carbon dioxide (CO_2) emissions from existing power plants. In this paper we provide further support of our comment already submitted to the record, focusing on two aspects of the provision in order to determine whether building energy codes should be considered in setting the standards of performance. The first aspect we focus on is what it means for a control measure to be part of the "best" system of emission reduction (BSER). The second aspect is whether a control measure has been "adequately demonstrated."

We begin by identifying the elements or "test" that must be met in order for a control measure to qualify as both "best" and "adequately demonstrated."[1] We then apply these tests to building energy codes. This exercise leads us to two key findings:

1. The adoption and implementation of building energy codes is a "best" measure that is technically feasible, is cost effective, brings energy and emissions benefits, and promotes emission-reducing technologies.
2. The adoption and implementation of building energy codes is an "adequately demonstrated" control measure that is well established in the states, consistent with current trends, and can be relied on to reduce greenhouse gas emissions.

These findings show that the adoption and implementation of building energy codes is an emission control measure that should be included in the standard of performance that EPA sets for existing power plants under Section 111(d) of the Clean Air Act.

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[1] We do not address the broader question of what control measures can be considered part of a "system of emission reduction." This critical question was thoroughly discussed by EPA in the proposed rule (EPA 2014a). This discussion concludes that end-use energy efficiency is appropriately included in the system for achieving emission reductions available to existing power plants. In addition, EPA explains that while owners and operators of electric generating units (EGUs) may effectuate emission reduction measures directly or indirectly, "emissions reductions measures that the states themselves have the authority under state law to put in place may be considered to be part of the BSER." (EPA 2014b, 74). The memo goes on to clarify that "regardless of which entities undertake the measures . . . those measures have the effect of reducing CO_2 emissions from fossil fuel-fired EGUs," and therefore can be included in the BSER. (EPA 2014b, 75 and 75, footnote 59). Applying this guidance to building energy codes leads to the conclusion that codes are a system of emission reduction that EPA should consider in its rulemaking.

First Inquiry: Are Building Energy Codes a "Best" Measure That Should Be Included in the System of Emission Reduction Used to Set the Standards of Performance?

In this section we apply the elements of the Environmental Protection Agency (EPA) definition of "best" to building energy codes, and arrive at the conclusion that the adoption of building energy codes is a "best" measure.

WHAT IS "BEST"?

In its technical support documents to the proposed Clean Power Plan (CPP), EPA summarizes existing case law and outlines the following criteria for determining whether the system is the "best " (EPA 2014b, 37–38):

- The system of emission reduction must be technically feasible.
- The EPA must consider the amount of emissions reductions that the system would generate.
- The costs of the system must be reasonable. The EPA may consider the costs on the source level, the industry-wide level, and, at least in the case of the power sector, on the national level in terms of the overall costs of electricity and the impact on the national economy over time.
- The EPA must also consider that [Clean Air Act] Section 111 is designed to promote the development and implementation of technology.
- The EPA must also consider energy impacts, and, as with costs, may consider them both on the source level and on the nationwide structure of the power sector over time.

Below we discuss each criterion.

A System of Emission Reduction Must Be Technically Feasible

When setting the level of emission control that standards of performance achieve, EPA must consider what is technically feasible. Courts have clarified that this determination should be made using a forward-looking projection rather than the state of the art at present. Citing the District of Columbia Circuit, EPA's memo highlights the following quote:

"Section 111 looks toward what may fairly be projected for the regulatory future, rather than the state of the art at the present. . . . The Senate Report made clear that it did not intend that the technology 'must be in actual routine use somewhere.' . . . The Administrator may make a projection based on existing technology, that that projection is subject to the restraints of reasonableness and cannot be based on 'crystal ball' inquiry. . . . The question of availability is partially dependent on 'lead time,' the time in which the technology will have to be available." (EPA 2014b, 38–39, citing *Portland Cement Ass'n v. Ruckelshaus*, 486 F.2d 375, 391–92 [D.C. Cir. 1973]).

A recent example illustrating this point can be seen in the Carbon Pollution Standards for new fossil fuel–fired electric generating units (EGUs) (79 FR 1430). EPA found that partial carbon capture and sequestration (CCS) was adequately demonstrated for new fossil fuel–

fired steam EGUs and integrated gasification combined cycle (IGCC) units, in spite of citing only a handful of active applications of CCS technologies domestically.

In its CPP, EPA developed a "best practices" demand-side energy efficiency scenario to estimate potential carbon dioxide (CO_2) reductions. This scenario provides an estimate of the potential for sources and states to implement policies that increase investment in demand-side energy efficiency technologies and practices at reasonable costs. It does not represent an EPA forecast of business-as-usual impacts of state energy efficiency policies or an EPA estimate of the full potential of end-use energy efficiency available to the power system, but rather a feasible policy scenario showing the reductions in fossil fuel–fired electricity generation resulting from accelerated use of energy efficiency policies in all states consistent with a level of performance that has already been achieved or required by policies (e.g., energy efficiency resource standards) of the leading states.

In our 2015 analysis we looked at two cases. The Low Savings case assumes states implement current national model codes—the current state of the art. Hundreds of thousands of homes and commercial buildings are already being built to similar standards under ENERGY STAR®, Leadership in Energy and Environmental Design, and other programs and receive federal tax incentives and local rebates. The High Savings case is a forward-looking projection. It assumes that codes will continue to improve, though less quickly than they have recently, as better technologies and practices are more widely adopted. The technical feasibility of improved codes is shown by buildings today that go well beyond our projected codes. California's Title 24 codes are mandatory statewide for both commercial and residential structures and possess a level of stringency that well exceeds the energy efficiency of both the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1-2010 and the 2012 International Energy Conservation Code (IECC) requirements (BECP 2014). Additionally, there already are dozens of zero net energy commercial buildings (Cortese and Higgins 2014) and hundreds of zero net energy or zero energy–ready homes located throughout the United States (Gruder 2012).

The Magnitude of Emission Reductions Must Be Considered

There is a tremendous potential for CO_2 reductions to be achieved with the adoption and implementation of national model building energy codes. According to the Pacific Northwest National Laboratory (PNNL), activities related to the U.S. Department of Energy (DOE) Building Energy Code Program have saved 4 quads of source energy cumulatively from 1992 to 2012. These energy savings have reduced greenhouse gas (GHG) emissions by over 300 million metric tons (MMT) cumulatively from 1992 to 2012. (Livingston et al. 2014) The program is projected to save an additional 40.1 quads of source energy from 2013 to 2040.

We summarize the energy savings achieved from the adoption of building energy codes and potential for future savings in our original comments on the proposed CPP (ACEEE 2014, 7–12). The research consistently finds that the adoption and implementation of building energy codes produces substantial energy and emissions benefits.

Our own analysis complements existing research, showing that energy savings from building energy codes would result in significant reductions in CO_2 emissions. Here we estimate only emissions reductions due to electricity savings (reduced direct fuel use would result in further emissions abatement), and we use two different emissions rate estimates, one based on the Energy Information Administration's *Annual Energy Outlook* (*AEO*) regional projections for all generation unadjusted for impacts of the CPP, and one based on actual 2012 emissions from covered generation in each state. In the Low Savings case, in 2030 CO_2 emissions would be reduced by 76 MMT using *AEO* projections and 102 MMT if from covered generation. In the High Savings case, the 2030 emissions abatement would be 126 MMT or 169 MMT, respectively.

The Cost Must Be Reasonable

The implementation of building energy codes does add to the overall cost of constructing a new building; however, these upfront costs are paid off quickly through the energy savings that accrue to the building owners and operators. A large body of research has found that building energy codes are cost effective, meaning that the upfront investments are paid for with the reduced costs to the consumer. Several key studies are summarized below:

- In 22 separate state studies PNNL conducted for DOE on the cost effectiveness of ASHRAE Standard 90.1-2010 for commercial buildings, as compared to ASHRAE Standard 90.1-2007, 2010 was found to be cost effective, having an average simple payback for added construction costs ranging from 1.2 to 8.1 years (PNNL 2013).
- PNNL's 43 separate state studies for DOE on the cost effectiveness of and energy savings with new residential single-family and multifamily construction built in compliance with the 2012 IECC compared with either the 2006 IECC or 2009 IECC found cost-effective energy savings in each state as well, with the average simple payback period for added construction costs ranging from 2.6 to 8.4 years (DOE 2012a).
- A national study examined the energy savings and cost effectiveness of both the 2012 IECC and 2009 IECC compared with the 2006 IECC. It showed that implementation of the 2012 IECC would reduce energy consumption, on average, by 32.1% from that used by similar structures built in compliance with the 2006 IECC. When comparing the 2012 and 2006 IECCs, life-cycle cost savings averaged between $4,763 and $33,105, depending on the climate zone (DOE 2012b).
- Several studies by another organization also examined the incremental and avoided costs of energy associated with the 2012 IECC in states. They found average incremental added construction costs for the 2012 IECC would range between $798 and $3,375, depending on the climate zone. Annual energy savings in dollars were found to range between $185 and $707. A buyer who paid 20% down on a 30-year mortgage would reach the average break-even point and begin coming out ahead in cash flow at 7 to 52 months (BCAP 2012).
- The same organization also did 29 state studies on the incremental cost of the 2009 IECC, as well as on the energy savings attributable to the 2009 IECC. The studies found a national weighted average incremental cost of $840.77 per home. Average energy savings were $243.37 annually. The average break-even point for the 2009 IECC was found to be 10.25 months (BCAP 2009).

The costs to government agencies to implement and enforce building energy codes are much smaller. One survey reported that added costs of enforcing building energy codes are "typically $50 or less per home" and "typically less than $150 per commercial building" (Williams, Price, and Vine 2014).

Using this body of research, we have conducted our own analysis estimating how much building energy codes could contribute to meeting the goals of the CPP if they were included as part of the BSER. This analysis is based on well-demonstrated savings levels and the kind of building energy modeling that is typically used in estimating code savings. We modeled two cases: a Low Savings case that is based on current good practices on building energy codes and a High Savings case that is based on demonstrated possibilities for improvement.[2] The detailed assumptions and methodology we used in the analysis are fully described in the appendix.

The results of our 2015 analysis show that, although there is a significant cost to meeting the building energy codes, the savings in electric and natural gas bills over decades far outweigh the cost. Looking at new construction through 2030, and assuming the measures save energy for 30 years, we estimate a nationwide net savings of $149 billion in the Low Savings case and $228 billion in the High Savings case (net present value in 2011 dollars). The savings exceed the costs by a factor of 3.1 and 2.9, respectively. Our codes scenarios are cost effective in all states, with the benefit–cost ratio ranging from 2 in California to over 5 in Hawaii and much of New England.

Promotes the Development and Implementation of Technology

Building energy codes are mandatory policies that are designed to promote use of technologies that are readily available but not used as much as they should be. Often, a higher-efficiency technology has a higher upfront cost that inhibits the uptake of these better technologies in the market. Technology diffusion is difficult in the building industry in particular, because it includes tens of thousands of builders, most of them small businesses. Those builders and the designers decide upon the energy characteristics and must front their costs, but they do not pay the energy bills. This principal-agent problem leads to large

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[2] The savings estimates in our analysis assume the 2006 IECC for homes and ASHRAE Standard 90.1-2004 for commercial buildings. The Low Savings case assumes that states implement the current versions of the national model codes, the 2015 IECC and 90.1-2013, respectively, starting in 2017. The High Savings case further assumes a steady rate of improvement in the model codes in each three-year update cycle, and that states adopt these updates. The Low Savings case makes a conservative assumption that 25% of the energy savings that would occur with full compliance are lost. The High Savings case assumes that none of the savings are lost (not that compliance is perfect, but that it does not get worse). The building energy use estimates for baseline and current codes are based on building simulations that PNNL did for DOE with a stock set of different types of buildings designed to meet recent code versions and average climate conditions for various locations. These are weighted for each state. The overall amount of new construction by state was projected by PNNL based in part on the *AEO*, and includes additions and some major renovations to existing structures as well as new buildings. Cost estimates for building improvements to meet current codes are from PNNL where available, and are derived from those estimates for other states.

and persistent market failures in new construction markets, requiring public policies such as building energy codes.

Energy codes ensure adoption of technologies to provide a minimum level of efficiency. Codes in almost all states are based on national models that are developed by expert groups with broad stakeholder input, which ensures they can be met with available technologies. They also are performance standards (almost always with options to be met with whole-building or component performance), so they do not require specific technologies, and thus they do not restrict builder or consumer choices or give selective advantage to certain industry interests.

Without requiring specific technologies, codes have promoted development and implementation of many energy-saving technologies, such as low-emissivity windows, spray foam insulation, lighting sensors and controls, air conditioner and boiler economizers, and variable-speed escalators.

Energy Impacts Must Be Considered

A number of building modeling studies have considered the energy impacts of building energy codes:

- A 2014 study by PNNL concluded that ASHRAE Standard 90.1-2013 for commercial buildings will reduce the site energy intensity of commercial buildings by 7.6% on average nationally when compared to similar structures constructed in compliance with ASHRAE Standard 90.1-2010 (Halverson et al. 2014)
- A 2011 study by PNNL found average national site energy savings of 18.5% when constructing commercial buildings to ASHRAE Standard 90.1-2010 instead of 90.1-2007 (Halverson, Rosenberg, and Liu 2011).
- A 2013 PNNL study found that the 2012 IECC reduced energy costs in low-rise residential buildings by 32.1% on average nationally when compared to similar buildings built to comply with the 2006 IECC (Mendon, Lucas, and Goel 2013).

Additional studies have used actual building energy use to estimate the impacts of codes:

- A 2009 study from the Lawrence Berkeley National Laboratory found that states that adopted building codes followed by a significant amount of new construction have experienced detectable decreases in per capita residential electricity consumption, ranging from 3 to 5% in the year 2006 (Aroonruengsawat, Auffhammer, and Sanstad 2009).
- A 2011 study from the Climate Policy Initiative found a decrease of roughly 10% in energy use in homes built in states with codes equivalent to the 1992 Model Energy Code or better relative to households that were not built under such codes. The study estimated that building energy codes reduced residential primary energy consumption in the United States by 1.3% in 2008. Additionally, the study estimated that building energy codes reduced GHG emissions associated with the residential sector by 1.8% in 2008. (Deason and Hobbs 2011)

State and regional planners have found that codes are a reliable way to reduce electricity demand:

- The Northwest Power and Conservation Council estimated in its sixth power plan that building energy codes were reducing power demand by an average of about 700 megawatts in the Northwest (NWPCC 2010, figure 4-9).

In our own study of building energy codes adopted as a 111(d) compliance strategy, we found that nationwide incremental savings—the savings in a year from one year of new construction—are about 0.25% of electric sales in the Low Savings case and 0.5% of sales in the High Savings case (for comparison, EPA's estimate for building block 4 in the draft rule, which does not include savings from building codes, grows to incremental savings of 1.5% of sales). The annual savings from multiple years of construction are even greater because the savings are so long-lived. The Low Savings estimate for 2030 is 35% of the nationwide total of building block 4 energy efficiency savings estimates for that year in the draft rule, and the High Savings estimate is 59% of those savings. These savings are 5% and 9%, respectively, of 2012 covered generation nationwide. As shown in table 1, because new building construction lasts for decades, the savings will continue to grow after 2030.

Table 1. National electricity, pollution, and cost savings from building energy codes

	Low Savings case	High Savings case
2020 electricity savings (million megawatt-hours [MWh])	36	48
2030 electricity savings (million MWh)	139	232
2030 savings as a percentage of		
Efficiency in target	35%	59%
2012 covered generation	5%	9%
2030 baseline sales	3%	5%
2030 carbon dioxide reductions (MMT)		

	Low Savings case	High Savings case
Electric sector emissions rate	76	126
Covered generation emissions rate	102	169
Financial		
Net savings (billion $)	149	228
Benefit–cost ratio	3.1	2.9

For full state-by-state results, see Appendix B.

These savings are largely in addition to the savings from state energy efficiency resource standards (EERS) that EPA analyzed in its proposed rule. Only a few states (e.g., Arizona, California, Massachusetts, Minnesota, Rhode Island) include any code savings in their EERS calculations, and even these often include only a portion of them (Misuriello et al. 2012).

FINDING OF FIRST INQUIRY

In order to determine whether building energy codes are a "best" measure that should be included in the system of emission reduction used to set the standards of performance that will regulate CO_2 emissions from existing power plants, we evaluated five elements identified by EPA guidance and existing case law. We evaluated a large body of literature and conducted our own detailed assessment and modeling exercise. We found that

1. Building energy codes are technically feasible.
2. Building energy codes can generate substantial reductions in GHG emissions.
3. The costs of adopting and implementing building energy codes are reasonable.
4. Building energy codes promote the development and implementation of technology.
5. The energy impacts of building energy codes benefit the entire electric grid.

These findings support a conclusion that building energy codes should be included in the best system of emission reduction for regulating CO_2 from existing power plants.

Second Inquiry: Are Building Energy Codes an Adequately Demonstrated Technology for Reducing Carbon Dioxide Emissions?

WHAT IS "ADEQUATELY DEMONSTRATED"?

In the Technical Support Documents to the CPP, EPA describes the existing guidance and case law that inform what control measures are "adequately demonstrated." EPA explains that "the measures in each of the building blocks are 'adequately demonstrated' because they are each well-established in numerous states, and many of them have already been relied on to reduce GHGs and other air pollutants from fossil fuel-fired EGUs. It should be emphasized that these measures are consistent with current trends in the electricity sector."[3]

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[3] EPA also explains that end-use energy efficiency is "adequately demonstrated" because it has "been relied on to reduce costs in general, assure reliability, and implement pre-existing pollution control requirements in the

Based on this guidance, the "test" we apply to determine whether building energy codes are adequately demonstrated asks

1. Are building energy codes well-established policy?
2. Is adoption of building energy codes consistent with current trends in states?
3. Are building energy codes being relied on to reduce GHGs?

Building Energy Codes Are Well-Established Policy and Adoption of Updated Codes Is Consistent with Current Trends in States

Building energy codes are already in place and common across the majority of the United States. As of December 1, 2014, 39 states have mandatory statewide residential energy codes, 41 states have mandatory statewide commercial codes, 11 states and the District of Columbia have adopted the 2012 IECC for residential buildings, and 16 states and the District of Columbia already have ASHRAE 90.1-2010 in place for commercial buildings.[4]

Adoption of building energy codes is already widespread and the adoption of updated codes is a trend that will continue. The 2009 American Recovery and Reinvestment Act offered stimulus funds to states through the State Energy Program (SEP) if they certified that they planned to adopt building energy codes that meet or exceed the 2009 IECC for residential buildings and ASHRAE Standard 90.1-2007 for commercial buildings and large multifamily structures.[5] All 50 states accepted SEP funding and submitted letters from their governors binding them to these commitments (Shapiro 2013). Since then a few states have adopted statewide energy codes for the first time, and many have updated their codes.

Already Relied on to Reduce GHG Emissions from Fossil Fuel–Fired EGUs

Building energy codes have been used to reduce GHG emissions throughout the country. As referenced earlier, PNNL has found that building energy codes have already contributed to the reduction of more than 300 MMTs of GHGs cumulatively from 1992 to 2012 (Livingston et al. 2014). A few examples of cities and states that are currently relying on building energy codes to reduce GHG emissions are listed below.

CHICAGO, ILLINOIS

In Chicago's Climate Action Plan, the city assumes that 30% of its overall reduction in GHG emissions will come from improved energy efficiency in buildings as well as improvements to the city's building energy codes (City of Chicago Sustainability Council 2014). The city expects to reduce GHG emissions by 1.13 trillion tons of CO_2 equivalent just from updates to building codes (Chicago Climate Task Force 2008).

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least cost manner."(EPA 2014b, 71). We do not address these elements because EPA has already found them to be met by end-use efficiency, of which building energy codes are a subset.

[4] See the Building Codes Assistance Project's website for a complete map tracking code adoption in all states.

[5] Additionally, states that accepted SEP funds were required to commit to monitoring building energy code compliance annually, and to implement a plan to reach 90% code compliance by 2017.

MARYLAND

Maryland's Greenhouse Gas Reduction Plan, finalized in 2013, aims to reduce GHG emissions in the state by 25% from 2006 levels by 2020 using a variety of measures, including improvements to Maryland's building energy codes. The state's Department of the Environment predicts that full implementation of the green building sector initiatives, which includes these code improvements, will result in a potential emission reduction of 3.2 MMT of CO_2 equivalent annually (MDE 2015).

MIAMI-DADE COUNTY, FLORIDA

According to the Climate Change Action Plan of Miami-Dade County, an essential strategy to reduce the GHG emissions of Florida's largest metropolitan area will be "enforcing the Florida Energy Code and implementing recommended alterations to the existing code." Miami projects that emissions reduced through code improvements will total 76,630 million tons of CO_2 equivalent over the five-year "GreenPrint" period (2010–2015) (Miami-Dade County 2010).

MINNESOTA

In 2012 Minnesota committed to making improvements to the state's building energy codes as one of several measures to reduce GHG emissions. The Department of Commerce estimated that the improvements made will result in at least 10% increased energy savings for nonresidential buildings and 13% increased energy savings for residential buildings, with concurrent reductions in GHG emissions (MDOC and MPCA 2012).

NEW YORK, NEW YORK

New York City created the Green Codes Task Force in 2010, in partnership with the United States Green Building Council (USGBC) (Urban Green Council 2010). The task force is charged with updating New York City's various building codes, including health, energy, fire, and so on, in order to provide for greater building and grid resiliency, as well as lower emissions from and energy consumption by the buildings sector. Improvements made to the New York City green codes as a result of USGBC's recommendations will reduce carbon emissions in 2030 by 5% (Urban Green Council 2014)

OREGON

The state undertook efforts to increase the stringency of building codes as one of several initiatives to reduce GHGs. In addition, the city of Portland has a stated goal of achieving zero net GHG emissions in all new buildings by 2030. They will be depending in part on updates to the Oregon building code for this goal (ODOT 2011; City of Portland, Bureau of Planning and Sustainability 2009).

2030 CHALLENGE

The 2030 Challenge is an initiative created by Architecture 2030, a nonprofit established in 2002 whose mission is to reduce GHG emissions from the building sector while simultaneously advancing a sustainable and resilient built environment. In the 2030 Challenge, cities and states pledge to reduce the GHG emissions associated with their buildings to zero by the year 2030. Architecture 2030 has advocated for stringent building energy codes as a means to reach this goal (Mazria and Kershner 2008). The U.S. Conference of Mayors, the National Association of Counties, and the National Governors Association all formally committed to the 2030 Challenge, and the U.S. Conference of Mayors subsequently adopted a series of resolutions supporting strong building energy codes (Architecture 2030 2011).

FINDING OF SECOND INQUIRY

In order to determine whether building energy codes are an adequately demonstrated technology for reducing CO_2 emissions, we applied the key tests EPA describes in its CPP guidance. In looking at practices in states and localities around the nation and through our own analysis, we found that

1. Building energy codes are well-established policy.
2. The adoption and implementation of building energy codes is consistent with current trends in states.
3. Building energy codes are already being relied on to reduce GHGs.

These findings lead to the conclusion that building energy codes are an adequately demonstrated technology for reducing CO_2 emissions.

Conclusion

We found that building energy codes 1) qualify as both a "best" measure in the system of emission reductions available for reducing CO_2 emissions from existing power plants, and 2) are an adequately demonstrated technology for reducing CO_2 emissions from power plants. Building energy codes squarely fulfill the requirements that EPA must weigh when determining emissions control measures that are appropriate for inclusion in a standard of performance under Section 111(d) of the CAA. We strongly encourage EPA to include building energy codes when setting the standards of performance that existing power plants must achieve in the final 111(d) rule and providing guidance to states on how to meet the standard.

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Appendix A. Codes Analysis Detailed Assumptions and Methodology

The goal of this analysis is to estimate how much electricity savings states could achieve through building energy codes in the context of the CPP. We looked at two cases: The Low Savings case assumes code stringencies and compliance that have been clearly demonstrated and should be achievable by all states today. The High Savings case assumes rates of improvement that have been demonstrated and should be achievable by all states over time. The analysis relies as much as possible on building-level simulations and state-level aggregation by the Pacific Northwest National Laboratory.

KEY ASSUMPTIONS: STRINGENCY AND COMPLIANCE

Baseline

Because EPA's draft rule explicitly allows new electricity savings from existing state policies to be counted in building block 4, we did not use current state codes as a baseline from which to count energy savings. Instead we adopted a uniform national baseline that has been widely used by ASHRAE and DOE, among others, in quantifying code improvements: the 2006 IECC for residential buildings and ASHRAE Standard 90.1-2004 for commercial buildings (DOE 2010; Thornton et al. 2011). Since we are using these as base levels of energy usage for counting savings, not policies implemented in specific locations, we do not adjust these levels for compliance.

These code versions precede the recent rapid improvements in the IECC and Standard 90.1. Thus adopting a baseline a couple of code cycles earlier would not make a large difference in the savings, but an earlier baseline would have less good analysis upon which to base savings estimates. One could instead use a later baseline, the 2009 IECC and 90.1-2007, which are levels that all states agreed they would try to adopt in response to a provision in the American Recovery and Reinvestment Act, and that many states have adopted. Thus it is closer to reflecting current codes, rather than no codes. The more stringent baseline would on average cut 2030 savings in the Low Savings case by 22%; however, if one added 5% extra energy use to this baseline to account for noncompliance with the codes (see below), then the savings would be trimmed by only 5%; if one added 10% extra energy to the baseline, savings would be 11% higher than with the baseline we used.

Code Improvements

The Low Savings case assumes that states adopt codes equivalent to the 2015 IECC for homes and ASHRAE Standard 90.1-2013 for commercial buildings, the current versions of the national model energy codes. These model codes were issued after extensive review under the IECC and ASHRAE consensus processes, respectively. The 2015 IECC is very similar to the 2012 IECC, which is already being implemented in several states (the largest difference is a new optional compliance pathway). The analysis counts savings under these codes starting with construction in 2017.

Both of the national models are updated on three-year cycles. The High Savings case assumes that state codes are updated on the same schedule. Based on PNNL analysis cited in the main text, in the last three code cycles the residential IECC achieved an estimated 33% average total savings in covered energy costs, and Standard 90.1 achieved an estimated 28%

average total savings in whole-building energy costs (the codes do not cover plug loads and some other energy uses). The High Savings case assumes 5% savings in each code cycle in residential covered energy costs and 5% savings in each cycle in commercial whole-building energy costs, a somewhat slower, but still ambitious, rate of improvement. The exception is 90.1-2016, for which we assume the ASHRAE committee will meet its goal of additional savings of 10% of 90.1-2004 energy use (about 14% savings compared to the current standard) (Misuriello 2014). For comparison, the default assumptions in the PNNL estimator (see below) are for 5% residential and 7% commercial savings in each code cycle.

Compliance Energy Impacts

Not all buildings fully comply with energy codes, and it is widely recognized that noncompliance can reduce energy savings. In recent years there has been much more focus on increasing and measuring compliance. However, few studies have tried to measure the energy impacts of noncompliance or the change in compliance levels as codes become more stringent, and those studies have used different metrics and methodologies. Studies have found energy use of up to about 20% above what it would be with full compliance, and as low as 11% *below* the code level (NYSERDA 2014; DNV KEMA, Energy and Resource Solutions, and APPRISE 2012; Cadmus Group 2014; KEMA et al. 2010; NMR et al. 2012). A series of pilot studies using an energy-based checklist approach from PNNL, and hence a unique associated metric, found 64–87% compliance with residential codes and 85–96% compliance with commercial codes, but PNNL will soon pilot a revised methodology (DOE 2013a). After reviewing the literature, a recent study assumed two possible cases for an initial starting point on compliance, one with 11% and one with 4% excess energy use, and modeled achieving 100% compliance (Stellberg 2013).

For our analysis in the Lower Savings case we used a conservative assumption that 25% of the expected energy savings would be lost due to noncompliance. We can convert to the metric used above: With the baseline at the code level (not adjusted for compliance), this corresponds to average energy use in homes 12% above the 2015 IECC level, and energy use in commercial buildings 10% above the 90.1-2013 level. In the Higher Savings case we assume 5% of the energy savings would be lost, corresponding to about 2% excess energy use on average for residential and commercial buildings. As compliance is likely to become more difficult as codes become more stringent, achieving this level of savings would likely require greater compliance efforts.

MODELING INPUTS

Energy Use

Energy use estimates under different codes are based on PNNL building energy simulations done for DOE. PNNL has recently prepared estimators intended to allow utilities and states to estimate savings due to improved compliance with codes (DOE 2014a). The methodology was developed for impact estimates PNNL did for DOE's Building Energy Code Program (Livingston et al. 2014). PNNL simulated electricity and natural gas/oil use in each state (in some cases in multiple climate zones) in model single-family and multifamily homes under the 2006, 2009, and 2012 IECC, and in 13 types of commercial buildings under 90.1-2004, -2007, and -2010. They aggregated these results in each state using weightings for each building type and climate zone to obtain an average energy use per home and per square foot of commercial building space.

For the 2015 IECC and 90.1-2013, PNNL has estimated an overall percentage energy savings nationwide (0.9% and 8.7%, respectively, in energy costs) (Halverson et al. 2014; Mendon et al. 2014). In the absence of state-level estimates, we applied these uniformly to all states and energy sources. The potential savings from future model codes described above were applied similarly.

We assumed that the lifetime of all savings would be 30 years. Although buildings typically last for many decades and some equipment is replaced after a few years, this is a period frequently used in building life-cycle cost analysis and is appropriate for a building-level average (DOE 2013b, 2014b). Thus there is no degradation of savings by 2030; the lifetime only applies to the life-cycle cost analysis.

Construction

For its estimators, PNNL also provided projections of residential and commercial construction by state, which are used here. These are based on state-level permit and construction data and *Annual Energy Outlook* regional forecasts. In addition to new buildings, they include estimates for building additions, and for commercial buildings they include some major renovations. Building energy codes typically cover building alterations as well as new buildings, and the amount of construction in existing buildings can be as great as in new buildings. As not all alterations are included in them, the construction projections are conservative.

Added Building Costs

The added cost to meet the codes was also based on PNNL estimates. PNNL has estimated the cost of meeting the 2012 IECC and in some cases the 2009 IECC for roughly 40 states and has estimated the cost of meeting 90.1-2010 in about 20 states (PNNL 2013; DOE 2012a). These costs are based on the prescriptive pathways in the codes and on the model buildings used in the energy simulations (for commercial buildings, a subset of five of the building types). PNNL took the component and labor costs from RS Means data and various studies, taking into account regional variation.

For states without PNNL estimates of cost, we estimated residential costs based on the same code climate zone requirements, state-level building mix from PNNL, and construction cost multiplier used by PNNL; therefore, these estimates should be very close to those of PNNL. We did not have the same data for commercial buildings and took weighted averages of the PNNL estimates by census region, adjusted with the same construction cost multiplier used in the residential analysis. Although this is a somewhat rough approximation, it should be sufficient to look at the cost effectiveness. We used census rather than climate regions because of better correlation with PNNL's costs, which for commercial buildings vary at least as much with building type as with climate.

For future codes, it is difficult to know the cost because the specific code changes have not been determined (and for the 2015 IECC and 90.1-2013 there are not yet good cost estimates, but the costs and savings are relatively small). Thus the cost estimates for the Higher Savings case must be regarded as somewhat speculative. We assumed that in each state the cost per percentage energy savings for each code update would remain constant. But as the codes improve, the energy savings decrease for a given percentage change. Thus the cost per unit of energy saved as well as the time required for simple payback slowly increase.

In addition to the building costs, we also include implementation costs for the codes: $100 per home and $0.015 per square foot for commercial buildings. A recent PNNL survey (though not of a representative sample) found average enforcement costs of $49 per home and $139 per commercial building (for the average commercial building of 19,100 square feet, this would be $0.007 per square foot), not including fringe pay, travel, or training (Williams, Price, and Vine 2014). Higher spending may be needed to improve compliance, but the effect on this analysis would be small, as enforcement accounts for a small part of overall costs.

Energy Prices

We used the state-level electricity and natural gas price projections from our *Change Is in the Air* report (Hayes et. al 2014). These were based on state average energy prices in 2011 from the Energy Information Administration (EIA) State Energy Data System, with price changes based on the regional projections in EIA's *Annual Energy Outlook*. Further details are in the earlier report.

Emissions Rates

We used two estimates of electricity CO_2 emission rates by state. To estimate overall electric sector emissions rates, we used regional projections from the *Annual Energy Outlook*, dividing emissions from the electric sector by electric generation in the sector for each region. To account for losses of electricity in the electric grid, we multiplied by a factor based on electric sales from the grid from the domestic electric sector divided by generation from the sector delivered to the grid. States that include significant portions of multiple regions in the electric forecast were given a weighted average based on electric sales in the state by region. For Alaska and Hawaii, which are not in the regional forecasts, we used 2010 data from EPA's Emissions and Generation Resource Integrated Database.

To estimate emissions rates for covered generators, we divided total 2012 emissions by 2012 generation for the generators in each state using data from the draft rule. We multiplied all rates by 1.0751 to account for losses in the grid (again from the draft rule). We did not subtract for power imported to the state. Note that neither estimate includes changes to emissions rates due to the CPP.

Financing and Life-Cycle Analysis

We assume that all the additional cost of meeting the codes is financed in mortgages. For homes we assume 30-year financing at the *Annual Energy Outlook* projected 10-year Treasury note interest rate plus 2%. This corresponds to a real interest rate of about 4.25–4.5% in most years. DOE in its code analyses assumes 30-year financing at a real interest rate of 3.3% (nominal rate of 5%), but also assumes 10% down payment and includes an interest tax deduction. For commercial buildings, we assume 30-year financing at the 10-year Treasury rate plus 4%. Although individual loans are often of shorter duration, costs are typically refinanced.

Net present value calculations include the loan payments (as all costs are financed) and electricity and natural gas savings, all discounted back to 2014 with a real discount rate (after inflation) of 5%. EPA's Regulatory Impact Analysis used 3% and 7% discount rates; DOE uses its mortgage interest rate. Benefit–cost ratios compare the present value of the energy savings to the present value of the loan payments.

All financial impacts are given in 2011 dollars (though we generally did not know the vintage dollars of cost estimates, so we did not adjust those). Present values are discounted to 2014.

Appendix B. State-by-State Building Codes Analysis Results

Table B1. 2020 and 2030 electricity savings by state, both cases

	Low Savings case				High Savings case			
	2020 electricity savings (MWh)	2030 electricity savings (MWh)	2020 incremental savings as % of baseline sales	2030 incremental savings as % of baseline sales	2020 electricity savings (MWh)	2030 electricity savings (MWh)	2020 incremental savings as % of baseline sales	2030 incremental savings as % of baseline sales
Alabama	633,000	2,413,000	0.18%	0.17%	829,000	3,941,000	0.29%	0.33%
Alaska	114,000	436,000	0.50%	0.46%	150,000	716,000	0.79%	0.90%
Arizona	1,283,000	4,996,000	0.44%	0.39%	1,687,000	8,334,000	0.70%	0.77%
Arkansas	319,000	1,227,000	0.18%	0.16%	417,000	1,964,000	0.27%	0.31%
California	2,808,000	10,730,000	0.28%	0.25%	3,728,000	18,678,000	0.48%	0.52%
Colorado	710,000	2,765,000	0.33%	0.30%	935,000	4,669,000	0.54%	0.61%
Connecticut	229,000	863,000	0.21%	0.20%	304,000	1,516,000	0.36%	0.42%
Delaware	221,000	850,000	0.52%	0.51%	285,000	1,301,000	0.76%	0.90%
District of Columbia	145,000	558,000	0.35%	0.32%	191,000	944,000	0.56%	0.66%
Florida	3,324,000	12,775,000	0.40%	0.35%	4,377,000	21,511,000	0.65%	0.71%
Georgia	1,773,000	6,815,000	0.34%	0.31%	2,327,000	11,186,000	0.55%	0.60%
Hawaii	185,000	709,000	0.52%	0.50%	245,000	1,227,000	0.87%	1.06%
Idaho	222,000	865,000	0.24%	0.23%	291,000	1,432,000	0.38%	0.45%
Illinois	953,000	3,637,000	0.18%	0.17%	1,265,000	6,341,000	0.31%	0.36%
Indiana	695,000	2,655,000	0.18%	0.17%	920,000	4,542,000	0.29%	0.35%
Iowa	375,000	1,432,000	0.22%	0.21%	491,000	2,342,000	0.34%	0.41%
Kansas	298,000	1,141,000	0.20%	0.19%	392,000	1,875,000	0.32%	0.37%

	Low Savings case				High Savings case			
	2020 electricity savings (MWh)	2030 electricity savings (MWh)	2020 incremental savings as % of baseline sales	2030 incremental savings as % of baseline sales	2020 electricity savings (MWh)	2030 electricity savings (MWh)	2020 incremental savings as % of baseline sales	2030 incremental savings as % of baseline sales
Kentucky	537,000	2,047,000	0.15%	0.14%	702,000	3,295,000	0.24%	0.27%
Louisiana	552,000	2,122,000	0.17%	0.16%	724,000	3,498,000	0.27%	0.31%
Maine	105,000	391,000	0.25%	0.23%	139,000	668,000	0.41%	0.48%
Maryland	926,000	3,562,000	0.41%	0.38%	1,210,000	5,739,000	0.63%	0.73%
Massachusetts	358,000	1,345,000	0.17%	0.16%	476,000	2,355,000	0.29%	0.35%
Michigan	607,000	2,316,000	0.16%	0.15%	799,000	3,877,000	0.26%	0.30%
Minnesota	542,000	2,070,000	0.21%	0.20%	710,000	3,373,000	0.33%	0.39%
Mississippi	356,000	1,358,000	0.19%	0.18%	467,000	2,251,000	0.30%	0.35%
Missouri	529,000	2,025,000	0.17%	0.16%	696,000	3,348,000	0.28%	0.32%
Montana	83,000	323,000	0.15%	0.14%	108,000	525,000	0.24%	0.28%
Nebraska	246,000	940,000	0.22%	0.21%	323,000	1,571,000	0.36%	0.43%
Nevada	620,000	2,410,000	0.46%	0.43%	820,000	4,096,000	0.76%	0.88%
New Hampshire	112,000	420,000	0.28%	0.26%	148,000	722,000	0.47%	0.55%
New Jersey	526,000	1,988,000	0.19%	0.17%	696,000	3,421,000	0.32%	0.36%
New Mexico	225,000	875,000	0.25%	0.22%	296,000	1,454,000	0.39%	0.44%
New York	826,000	3,121,000	0.16%	0.15%	1,099,000	5,562,000	0.28%	0.34%
North Carolina	1,956,000	7,533,000	0.39%	0.35%	2,549,000	12,006,000	0.60%	0.67%
North Dakota	214,000	815,000	0.41%	0.40%	276,000	1,238,000	0.60%	0.71%
Ohio	902,000	3,445,000	0.16%	0.15%	1,196,000	5,947,000	0.27%	0.31%

	Low Savings case				High Savings case			
	2020 electricity savings (MWh)	2030 electricity savings (MWh)	2020 incremental savings as % of baseline sales	2030 incremental savings as % of baseline sales	2020 electricity savings (MWh)	2030 electricity savings (MWh)	2020 incremental savings as % of baseline sales	2030 incremental savings as % of baseline sales
Oklahoma	578,000	2,224,000	0.26%	0.24%	754,000	3,513,000	0.39%	0.44%
Oregon	401,000	1,533,000	0.22%	0.19%	530,000	2,621,000	0.36%	0.40%
Pennsylvania	886,000	3,353,000	0.16%	0.15%	1,169,000	5,684,000	0.26%	0.31%
Rhode Island	66,000	248,000	0.23%	0.22%	87,000	423,000	0.39%	0.45%
South Carolina	978,000	3,764,000	0.31%	0.29%	1,272,000	5,915,000	0.47%	0.53%
South Dakota	121,000	462,000	0.28%	0.27%	157,000	730,000	0.43%	0.50%
Tennessee	882,000	3,361,000	0.23%	0.21%	1,155,000	5,500,000	0.36%	0.41%
Texas	4,155,000	15,974,000	0.30%	0.27%	5,445,000	26,202,000	0.46%	0.54%
Utah	450,000	1,757,000	0.40%	0.37%	591,000	2,930,000	0.63%	0.75%
Vermont	32,000	116,000	0.15%	0.14%	42,000	202,000	0.26%	0.30%
Virginia	1,458,000	5,613,000	0.37%	0.37%	1,907,000	9,105,000	0.58%	0.71%
Washington	1,032,000	3,947,000	0.28%	0.25%	1,359,000	6,652,000	0.46%	0.51%
West Virginia	164,000	631,000	0.14%	0.14%	214,000	1,011,000	0.22%	0.26%
Wisconsin	479,000	1,828,000	0.19%	0.18%	631,000	3,091,000	0.31%	0.37%
Wyoming	84,000	329,000	0.12%	0.11%	110,000	542,000	0.19%	0.22%
National	**36,274,000**	**139,115,000**	**0.26%**	**0.24%**	**47,691,000**	**231,588,000**	**0.41%**	**0.48%**

Table B2. Net present value and benefit–cost ratio results, both cases

	Low Savings case		High Savings case	
	NPV savings (million $)	Benefit–cost ratio	NPV savings (million $)	Benefit–cost ratio
Alabama	2,117	2.95	3,248	2.78
Alaska	867	4.33	1,316	3.90
Arizona	5,016	3.15	7,926	2.98
Arkansas	1,183	3.21	1,745	2.94
California	9,959	2.11	15,906	2.00
Colorado	3,871	3.12	5,804	2.83
Connecticut	1,546	4.86	2,488	4.44
Delaware	1,063	4.71	1,540	4.32
District of Columbia	754	6.74	1,220	6.55
Florida	9,607	2.59	15,442	2.48
Georgia	5,386	2.86	8,278	2.68
Hawaii	2,220	6.10	3,747	5.84
Idaho	974	2.95	1,416	2.68
Illinois	4,202	3.31	6,535	2.98
Indiana	3,474	3.69	5,398	3.36
Iowa	1,620	3.69	2,372	3.27
Kansas	1,325	4.35	1,997	3.94
Kentucky	1,993	3.46	2,970	3.13
Louisiana	1,799	2.81	2,799	2.65
Maine	900	5.98	1,364	5.46
Maryland	3,885	3.83	5,839	3.49
Massachusetts	2,725	5.71	4,282	5.20
Michigan	3,375	4.00	5,075	3.62
Minnesota	2,363	3.21	3,435	2.88
Mississippi	1,334	3.29	2,096	3.10
Missouri	2,223	3.70	3,327	3.34
Montana	532	3.50	779	3.22
Nebraska	983	3.97	1,495	3.60
Nevada	2,069	2.42	3,141	2.23
New Hampshire	855	6.81	1,346	6.29
New Jersey	3,382	3.98	5,198	3.60

	Low Savings case		High Savings case	
	NPV savings (million $)	Benefit-cost ratio	NPV savings (million $)	Benefit-cost ratio
New Mexico	1,180	3.53	1,778	3.25
New York	6,546	3.99	10,172	3.51
North Carolina	5,990	2.79	8,813	2.58
North Dakota	977	4.28	1,396	3.96
Ohio	4,925	4.00	7,695	3.62
Oklahoma	2,026	3.18	2,975	2.93
Oregon	1,529	2.45	2,259	2.22
Pennsylvania	4,662	3.91	7,045	3.51
Rhode Island	378	5.28	593	4.80
South Carolina	3,261	3.13	4,865	2.97
South Dakota	552	4.03	799	3.65
Tennessee	2,559	2.88	3,873	2.66
Texas	15,176	3.00	23,316	2.81
Utah	1,885	2.81	2,779	2.57
Vermont	339	6.18	516	5.65
Virginia	5,151	3.46	7,758	3.20
Washington	4,138	2.59	6,008	2.33
West Virginia	633	3.52	949	3.21
Wisconsin	2,828	3.84	4,236	3.44
Wyoming	526	3.42	752	3.07
National	**148,866**	**3.12**	**228,099**	**2.88**