Documenting the Expanding Benefits of Strong Energy Codes

How Energy Codes Impact Community Health

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Abstract

Building energy codes have a clear, well-understood impact on the energy use of a home, resulting in lower homeowner energy costs for the life of the building. However, the benefits of strong building energy codes extend far beyond traditional energy cost savings. Improved resilience, better indoor air quality and greater comfort are all being studied, and found, in buildings with more advanced energy codes. However, direct societal health benefits also accrue when more efficient building energy codes are adopted and enforced.

This paper will present the results of a recent residential study that examines the impact updating building energy codes can have on societal health. The research compares the health-associated benefits of a given states' adoption history, including state specific amendments, to a regular cycle of adopting the unamended IECC within a year of publication. The research methodology will be explained and results for multiple Midwestern states will be presented. The methodology and findings from this study contribute new, quantifiable, state-specific data that can be used to help recognize the full range of benefits energy efficiency provides to residents and communities.

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Introduction

The energy savings and cost effectiveness of each new residential model energy code (code), relative to the previous code, is determined by the US Department of Energy (DOE). However, the cumulative effect of delayed adoption is not considered, nor is the impact of any weakening amendments included in the code that is actually adopted. In some states, these two factors (cumulative savings and weakening amendments) create significant lost energy savings over the course of time – in some cases over $90 million dollars.

Importantly, lost energy savings are not the only negative impact of adoption delays and weakening amendments. The increased electric generation required to compensate for the delay or weakening of the adopted code has a negative impact on community health, particularly in states with coal plants in their generation mix. Similar to the increased energy costs, these health costs are cumulative. The monetized cumulative health costs can then be combined with the cumulative energy costs to produce a fuller picture of the impact of delayed code adoption and weakening amendments.

This paper analyzes the residential energy code adoption history of nine Midwestern states with mandatory statewide energy codes.[1] The impact of adoption timing and amendments to the adopted code are determined individually for each state. The lost energy savings and

[1] The nine states are Illinois, Indiana, Iowa, Kentucky, Michigan, Minnesota, Nebraska, Ohio and Wisconsin

corresponding monetized health impacts are then calculated for each state, as well as combined into a regional impact.

Background

While the timing of code adoption has varied from state to state, it is safe to say that energy codes were not widely updated in the Midwest until sometime after 2009. As part of receiving American Recovery Reinvestment Act (ARRA) funding (ARRA 2009), states were required to adopt minimum energy code standards, and all but two of the nine Midwestern states in the study had adopted a code at least as efficient as the 2009 International Energy Conservation Code (IECC) as of 2012.

Once the initial code was adopted, ARRA funds were released, and no further updates were required. This left each state on its own to determine if and when to adopt an updated code, and what, if any, amendments to include. Not unexpectedly a wide range of adoption cycles and amendments developed over the course of time. For example, Illinois law now mandates a code update on a three-year cycle (within a year of the publication of the newest IECC). At the other end of the spectrum, Indiana initially adopted the 2009 IECC in 2012, did not update the code until 2019 and included several substantially weakening amendments in the update.

The energy code regulates the amount of energy used for thermal comfort in new buildings and, as such, it is the defining code for indoor air quality. However, by regulating energy consumption, the energy code has a significant impact on outdoor air quality as well. Studies have found that over 70% of electric generation is attributable to buildings (EIA 2020). To quantify the connection between electric energy consumption and generation emissions, the U.S. Environmental Protection Agency (EPA) developed two tools that connect kilowatt-hour (kWh) reduction to electric generation emissions.[2] Recently EPA released a new Health Benefits per kWh (BPK) resource that ties reduced generation to monetized health benefits.[3] This paper discusses new research conducted by the Midwest Energy Efficiency Alliance (MEEA) that utilizes the BPK calculator to determine the monetized health impact of energy code adoption timing, including any amendments, for new single family homes at a statewide level for nine Midwestern states.

Residential Model Energy Code

The model energy code (IECC) is published by the International Code Council (ICC) on a three-year cycle, with the most recent code being the 2018 IECC. ICC publishes all their other model building codes (fire, plumbing, electric, etc.) on the same three-year cycle. The code requirements between codes are closely coordinated (e.g. coordinating the energy code and the mechanical code) to assure there are no ambiguous or conflicting requirements. The ICC utilizes a highly respected consensus process during code development that draws upon the

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[2] The tools referenced are AVERT https://www.epa.gov/statelocalenergy/avoided-emissions-and-generation-tool-avert, and COBRA https://www.epa.gov/statelocalenergy/co-benefits-risk-assessment-cobra-health-impacts-screening-and-mapping-tool

[3] Details on the BPK tool and the values can be found at: https://www.epa.gov/statelocalenergy/estimating-health-benefits-kilowatt-hour-energy-efficiency-and-renewable-energy

expertise of hundreds of building and safety experts from across North America to develop each new version of the code (ICC 2020). The residential 2018 IECC contains four distinct paths for demonstrating compliance with the code: Prescriptive, Total UA, Performances and Energy Rating Index (ERI). During the IECC development process, the various compliance paths allowed are analyzed to assure relatively equal energy savings regardless of the compliance path chosen.

Once an edition of the IECC has been published, DOE conducts an analysis to determine the energy savings relative to the previous model code. The specific, minimally compliant prescriptive measures of the code are inputted into standard residential building computer models and the energy use of the home is derived (Taylor, Mendon and Fernandez 2015). This analysis is done for each of the energy code climate zones, and the overall efficiency of the new code is determined. DOE then issues a formal declaration regarding the new code. For example, the most recent DOE determination stated that the 2018 IECC is 1.91% more efficient than the 2015 IECC in terms of source energy savings (DOE 2019).

State Residential Energy Code Adoption

In the Midwest—or more specifically, in the states MEEA serves[4]—nine out of thirteen states have mandatory statewide energy codes. Eight of the states adopt the code through an administrative process unique to each state. The lone exception is Nebraska, which adopts their codes through a legislative process. The other four MEEA states (Kansas, Missouri, North Dakota and South Dakota) are home-rule states where the energy code, if any, is adopted at the local level. An overview of each state's adoption process, and amendments to their current residential energy code, is found in Table 1 below.

Table 1. State Residential Energy Code Adoption Comparison, 2009-2019

State	Process	Agency	Current Code	Amendments	Date Effective
Illinois	Administrative	Capital Development Board	2018 IECC	Yes	2019
Indiana	Administrative	Department of Homeland Security, Fire Prevention and Building Safety Commission	2009 IECC	No	2012
Iowa	Administrative	State Fire Marshall, Building Codes Advisory Council	2012 IECC	No	2014
Kentucky	Administrative	Department of Housing, Buildings & Construction, Division of Building Code Enforcement	2009 IECC	Yes	2011

[4] For more information about MEEA, visit: https://www.mwalliance.org/about/mission-vision

State	Process	Agency	Current Code	Amendments	Date Effective
Michigan	Administrative	Licensing and Regulatory Affairs, Bureau of Construction Codes	2015 IECC	Yes	2016
Minnesota	Administrative	Department of Labor and Industry, Construction Codes Advisory Council	2012 IECC	Yes	2015
Nebraska	Legislative	Urban Affairs Committee	2009 IECC	Unamended	2010
Ohio	Administrative	Board of Building Standards	2009 IECC	Yes	2012
Wisconsin	Administrative	Department of Safety and Public Services	2009	Unamended	2016

Methodology

The goal of this research was to determine the cumulative monetized impact (both energy costs and health costs) of energy code adoption for individual states. In order to determine this, several critical factors need to be considered: the energy use of homes built to the adopted code, the volume of yearly home construction, the timeline of code adoptions in each state, effective date of any code updates and any amendments made to the model code. However, before the "as adopted" models could be developed, the modifications each state made to each edition of the adopted code had to be determined, and before the comparative analysis could be run, the effective date for each code adopted had to be known. MEEA has tracked code adoption, including amendments, for each of its states since 2008, so the needed data was readily available.

Energy Simulation Models

To determine the energy use of homes in the study, state specific energy "simulation sets" were developed in the Building Energy Optimization Tool (BEopt)[5] for each of the 9 states.[6] BEopt is a free online modeling software developed by the National Renewable Energy Laboratory that provides detailed analyses of residential homes based on specified house characteristics. BEopt uses EnergyPlus, a simulation engine created and used by the U.S. Department of Energy to conduct analyses on energy codes (BEopt 2020).

Each simulation set developed included "code minimum" models configured to the minimum prescriptive inputs found in the model energy codes (2006-2018 IECC) for all climate zones in the state. Additionally, "as adopted" models accounting for local amendments to the code adopted by the state were developed and included in the simulation set.

[5] This study used BEopt Version 2.8

[6] For the purposes of this study a "simulation set" means a full set of models, developed for each state (2006 model + 2009 + 2012 + 2015 + 2018 + state specific models for each adopted code).

The models were developed following a methodology established by the US DOE (single-family, 2-stories, conditioned basement) (Taylor, Mendon and Fernandez 2015). An energy consumption analysis was run for each model to determine kWh and Therm usage. The modeled energy usage was then expanded statewide by multiplying by the number of new home permits for each year studied.

Cumulative Energy Savings Captured

Lost energy savings due to delayed adoption of, or modifications to, the energy code are cumulative in nature. The higher energy use of a home built under an older code persists for the life of the home (or in this instance the life of the study period). In other words, the lost energy savings of a home built to 2009 IECC standards in the year 2013 (by which time the state could have reasonably adopted the 2012 IECC) would be lost again, year after year, for the remaining study period. For illustrative purposes only, a graphic representation of the calculation of cumulative savings is found below in Table 2. In this example, the state adopted the unamended 2009 IECC in 2011 (getting full credit for the years 2011 and 2012) and the unamended 2012 IECC, or newer code, sometime after 2014. For the purposes of the graphic, it is assumed the statewide energy use delta between the 2006 IECC and the 2009 IECC is 150 units of energy, and between the 2009 IECC and the 2012 is 100 units of energy.

Table 2. Cumulative Lost Energy Savings

Year	2010	2011	2012	2013	2014	**Cumulative Lost Savings**
Code in Force	2006	2009	2009	2009	2009	
Lost Energy Savings	150	150	150	150	150	750
		0	0	100	100	200
			0	100	100	200
				100	100	200
					100	100
Total Lost Energy Savings	150	150	150	450	550	**1,450**

Using the outputs from the "as adopted" code models, an analysis was done to determine the cumulative energy savings captured by each state. In order to calculate the energy use statewide, the number of homes built each year in each state was determined using permit data for each state from the U.S. Census Building Permits Survey (Census Bureau 2020). Construction volume was assigned to their respective IECC climate zone for each state by sorting construction volume by county for each state (matching the granularity of IECC climate zones).

Given the impetus for code adoption brought about through ARRA funding, 2009 was chosen as the start year for the study. The authors determined that sufficient 2019 data would be available for the study, so 2019 was selected as the final assessment year. With 2009 chosen as the start year, a baseline code needed to be established in order to give appropriate credit to states for the adoption of the 2009 IECC. The energy code in place in 2008 was determined for each state and based on that information, the 2003 IECC was a selected as the representative baseline for the study.

The cumulative lost energy savings were calculated against the 2003 IECC baseline based on the timing of code adoptions in each state. To account for presumed greater non-compliance immediately after a new code was adopted, a realization rate was included in the energy savings calculations. A base rate of 80% was used for the year a code was adopted. The realization was then increased by 2% each year until a new code was adopted.

Lost Energy Savings

Lost energy savings were calculated for the code in place against the code that could have been adopted. A model code adoption timeline was created, in which where each state adopted the unamended model code within a year of publication. The cumulative kWh and Therms savings were calculated for each state in this scenario. The cumulative energy savings were compared to determine the lost energy savings for each state due to a delayed adoption cycle or adopted amendments.

EPA's Health Benefits per Kilowatt Hour Values

The BPK is a screening level resource that provides a dollar value of health benefit for each kWh saved based on regional generation mixes as of 2017 (EPA 2019a). BPK builds upon other EPA health-related tools, including the avoided Emissions and Generation Tool (AVERT) and the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA), and provides screening values for the ten AVERT regions in the U.S. It is important to note that BPK values are based on $PM_{2.5}$ emissions in the regional electric generation mix. The health impacts of other generation emissions / pollutants like CO_2 and ozone are not included in the BPK values, nor are the impacts from using natural gas or propane as a heating source in a home.

BPK provides monetized health benefit values for four different project types – Uniform EE, EE at Peak, Solar and Wind. Since code required energy efficiency features are, in general, permanently installed passive measures, uniform EE project values were used in the analysis. While improved energy codes have an impact on peak demand, these effects have not been well studied. Additionally, the peak demand impacts of the specific state modifications to the code have not been assessed. Therefore, peak demand impacts were not included as part of this study.

Of the states included in the study, Indiana, Iowa, Minnesota and Ohio each fell within a single AVERT region, so the monetized health saving values could be used directly. However, the state boundaries for five states (Illinois, Kentucky, Michigan, Nebraska and Wisconsin) were in two regions. In order to determine the appropriate value to use, the AVERT values from each region in each state were weighted and averaged to create a single AVERT region value, and in turn, a single BPK value for each state. States were assigned to AVERT regions as per Appendix G of the AVERT User Manual v.2.3 (EPA 2019b).

Results

With the total lost kWh savings for each state being determined, the monetized health impact could be calculated using the BPK resource. Using the state specific BPK values developed, determining the monetized health impact for each state is simply a matter of multiplying the lost kWh savings by the BPK state specific value. The result is the monetized health benefits lost due to the state specific code adoption timing and amendments.

The cumulative lost kWh savings were calculated in each state in the study from 2009-2019. Using an average cost per kWh[7] over the last 10 years for each state, the cumulative lost energy costs were calculated. The analysis showed that $294,766,689 in energy savings have been lost in the Midwest from delayed code adoptions and amendments to the code. Table 3 shows the results from each state in this study.

Table 3. Cumulative Lost kWh Savings, 2009 - 2019

State	A kWh Use - Model Code	B kWh Use - Adopted Code	C Cumulative Lost Savings - kWh *(B-A)*	D Lost kWh Savings - $
Illinois	393,706,670	365,232,807	28,473,864	$3,395,224
Indiana	793,890,782	289,761,675	504,129,107	$55,459,243
Iowa	339,320682	283,350,593	55,970,089	$6,270,889
Kentucky	930,242,506	488,301,950	441,940,556	$43,177,592
Michigan	489,788,199	324,066,400	165,721,799	$23,366,774
Minnesota	816,155,319	468,627,261	347,528.058	$40,914,478
Nebraska	459,731,996	241,126,123	218,605,873	$22,000,495
Ohio	806,168,314	512,688,508	293,479,806	$35,255,729
Wisconsin	647,871,109	165,399,048	482,472,060	$64,926,265

From the lost kWh savings, the BPK resource was used to determine the monetized health benefits lost from delayed code adoptions and amendments. Across the states studied, $129,871,490 have been missed in health-related benefits alone. Table 4 shows the health benefits lost for each state in this study.

Table 4. Cumulative Lost Health Benefits, 2009 – 2019

State	C Cumulative Lost kWh Savings	E BPK State Value (3% Discount Rate)	F Monetized Lost Health Benefits - $ *(C*E)*
Illinois	28,473,864	0.0534	$3,062,096
Indiana	504,129,107	0.0573	$28,886,598
Iowa	55,970,089	0.0509	$2,848,878

[7] Average costs per kWh were from the Energy Information Administration's Electricity Data Browser for each state in the study. Costs were averaged over the last 10 years of available data (2009-2019).

State	C Cumulative Lost kWh Savings	E BPK State Value (3% Discount Rate)	F Monetized Lost Health Benefits - $ *(C*E)*
Kentucky	441,940,556	0.0317	$13,991,926
Michigan	165,721,799	0.0573	$9,495,859
Minnesota	347,528.058	0.0538	$17,689,178
Nebraska	218,605,873	0.0509	$11,127,039
Ohio	293,479,806	0.0573	$16,816,393
Wisconsin	482,472,060	0.0538	$25,953,523

Adding the Lost Energy Savings Cost with the Monetized Lost Health Benefits, shown below in Table 5, gives a fuller indication of the societal costs of delayed or modified code adoption – a regional cost of $424,638,179.

Table 5. Societal Costs of Delayed / Modified Energy Code Adoption, 2009 - 2019

State	D Lost kWh Savings - $	F Monetized Lost Health Benefits - $	G Aggregate Societal Cost - $ *(D+F)*
Illinois	$3,395,224	$3,062,096	$6,457,320
Indiana	$55,459,243	$28,886,598	$84,345,841
Iowa	$6,270,889	$2,848,878	$9,119,766
Kentucky	$43,177,592	$13,991,926	$57,169,519
Michigan	$23,366,774	$9,495,859	$32,862,633
Minnesota	$40,914,478	$17,689,178	$58,603,636
Nebraska	$22,000,495	$11,127,039	$33,127,534
Ohio	$35,255,729	$16,816,393	$52,072,122
Wisconsin	$64,926,265	$25,953,523	$90,879,788

Conclusion

This study demonstrates that there are significant kWh energy savings and monetized health savings being lost due to delays and modifications in residential energy code adoption. Further, the combined cumulative lost savings over the last decade runs to over $90,000,000 for an individual state and approaches half a billion dollars for the nine-state region included in the study. And these costs do not include multi-family or commercial construction. Even so, it should be noted that these are conservative estimates and do not include the health impacts of associated CO_2 or ozone emissions. It is hoped that the ability to quantify cost of delaying energy code adoption, or modifying the model code, will provide useful information to states as they consider the full range of costs and benefits associated with updating residential energy codes.

Next Steps

There are numerous opportunities to expand on this work. Identifying the kWh and monetized health impact of common modifications to the energy code would provide an important data point for states to consider in their code adoption deliberations. Developing a methodology to assess home rule states would provide critical information for code adoption deliberations in all jurisdictions. Expanding the methodology to include multi-family and commercial buildings would provide a much fuller picture of the lost kWh savings and monetized health impacts of energy code adoption. Lastly, modifying the methodology to assess energy improvements in existing commercial buildings could provide a boost to the adoption of Building Energy Performance Standards.

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