Assessment of Electricity Savings in the U.S. Achievable through New Appliance/Equipment Efficiency Standards and Building Efficiency Codes (2010 - 2020)

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Assessment of Electricity Savings in the U.S. Achievable through New Appliance/Equipment Efficiency Standards and Building Efficiency Codes (2010 – 2020)

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EXECUTIVE SUMMARY

As part of a push toward a more energy efficient U.S. economy, activity at federal and state levels indicates that building efficiency codes and equipment efficiency standards are likely to become more stringent over the next decade. Electric utilities face challenges with regard to meeting future electricity demand and reducing carbon emissions and utility-administered energy efficiency programs are part of the solution. Many states now require utilities to meet a certain percentage of their electricity demand through efficiency and an increasing number of state regulators are implementing some form of revenue decoupling and/or performance incentives to encourage energy efficiency activities.

Building codes focus on reducing energy consumption in newly-constructed buildings, making them less energy intensive than older buildings. Federal or state appliance and equipment efficiency standards mandate minimum efficiency levels for energy using equipment, such as central air conditioners, lamps and ballasts, furnace fans, and “white-box” residential appliances -- resulting in lower consumption levels for all units purchased.

This paper discusses the effect of more stringent codes and standards on utility energy-efficiency activities. Codes and standards affect baseline electricity use, the amount of consumption expected to occur *before* utility-administered energy-efficiency programs become effective. New codes and standards displace traditional utility energy efficiency program savings potential and shift the baseline, or the starting point, leaving utilities with the harder to reach opportunities – higher cost, higher energy efficiency resources. The combination of higher incentive amounts to induce adoption and lower energy savings can diminish the ability of utilities to offer cost effective efficiency programs.

However, codes and standards are typically very cost effective. Achieving energy efficiency via a combination of more stringent codes and standards and utility efficiency programs suggests that utilities may want to consider incorporating a codes and standards program as part of their energy efficiency efforts in states where it makes sense to do so. It also suggests that state regulatory commissions may want to examine the role that utilities could play in advancing codes and standards and how their contributions could be recognized.

This paper quantifies the impact of future building codes and appliance/equipment efficiency standards on electricity consumption in the United States between 2010 and 2020 under two possible codes and standards scenarios—moderate and aggressive—intended to represent a range of possibilities in future legislative and regulatory actions surrounding changes in codes and standards:

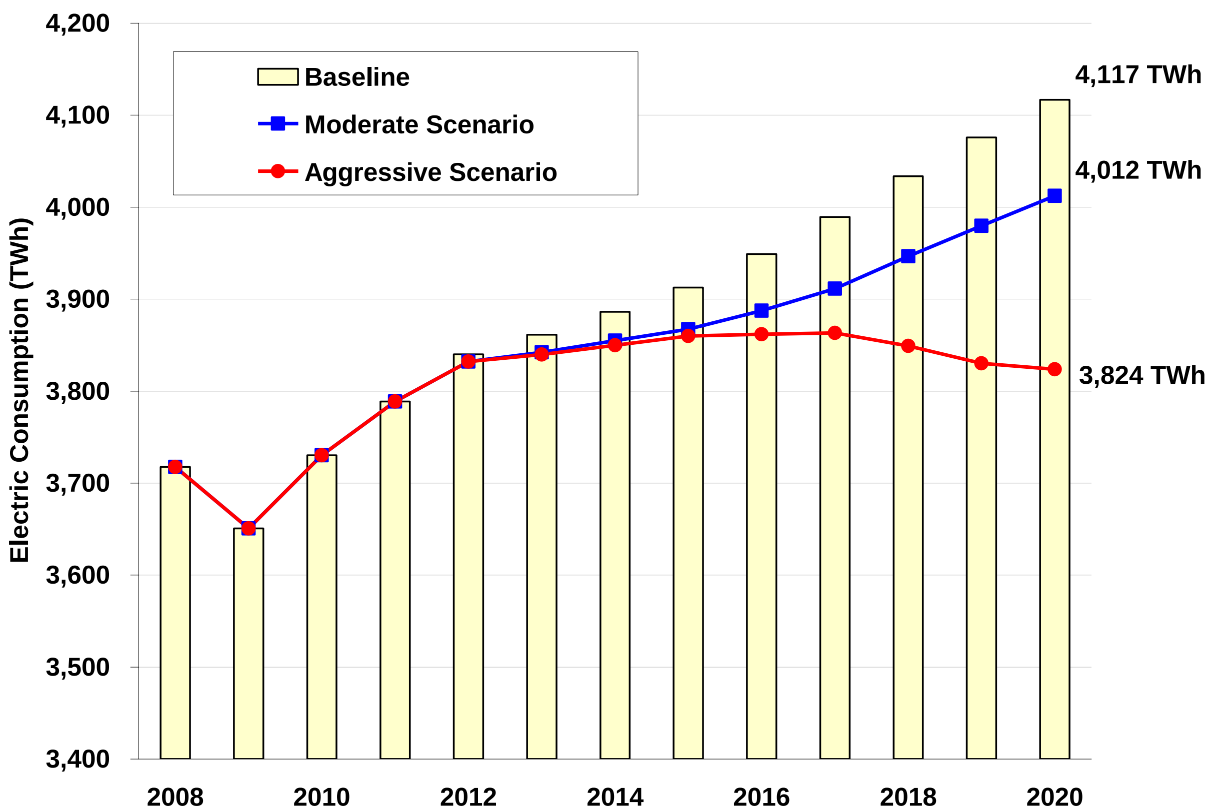
1. The moderate scenario represents our assessment of the appliance and equipment standards issued by DOE in mid-2009, the American Reinvestment and Recovery Act requirement that states adopt and enforce model building energy codes, as well as additional appliance and equipment standards with a high probability of taking effect through federal and state legislation in the near future. This is the low end of the range of estimated impacts. The moderate scenario assumes:
   - Building codes equivalent to IECC 2009 or ASHRAE 90.1 2007 code (100% compliance) are adopted by all states.
   - Appliance and equipment standards for items scheduled or overdue under DOE's rulemaking process as set forth by the Energy Policy Act of 2005 (EPACT 2005) and the Energy Independence and Security Act of 2007 (EISA 2007).
2. The aggressive scenario represents our assessment of the codes and standards that could take effect under a focused national effort. This is the high end of the range of estimated impacts. The aggressive scenario assumes:
   - Building codes as articulated in the current version of the Waxman-Markey Bill (HR2454, Sec. 201) are passed and all states adopt the building code with 100% compliance.
   - In addition to standards scheduled or backlogged under DOE (moderate scenario), standards expand to address all possible devices, with a second set of standards in later years of the forecast for some technologies (e.g., screw-in lamps, central air conditioners).

IMPACT OF CODES AND STANDARDS ON U.S. ELECTRICITY CONSUMPTION

Depending on the specific codes and standards adopted, our results show savings from codes and standards ranging from 104 TWh to 293 TWh by 2020 relative to the EIA Annual Energy

Outlook (AEO) baseline forecast.[1] This is equivalent to 2.5% to 7% of the baseline in 2020. In comparison, EPRI's estimated savings from energy efficiency programs range from 141 TWh (realistic achievable potential) to 372 TWh (maximum achievable potential) in 2020 relative to the AEO baseline (EPRI, 2009, Table ES-2). Figure E-1 shows the results of our analysis compared to the AEO baseline forecast. These results show that new codes and standards will significantly impact the electricity consumed in the U.S.

Figure E-1: Impact of Codes and Standards on Total U.S. Electricity Consumption (TWh)



Standards dominate the savings, providing 80% of the total energy savings in 2020. In comparison, codes provide 20% of the savings. Table E-1 presents the total electricity savings in the year 2020 under each of the scenarios. Although the aggressive scenario assumes all states adopt the new building code with 100% compliance, a scenario assuming 50% compliance

[1] EIA Annual Energy Outlook, April 2009, Reference Case

yielded savings from building codes that were lower, but not significantly lower. The key driver of energy savings is new equipment standards.

Table E-1: Summary of Codes and Standards Impacts in 2020: Residential, Commercial and Industrial Sectors*

Scenario	Electricity Use in 2020 (TWh)	Savings from Building Codes (TWh)	Savings from Equipment Standards (TWh)	Total Savings in 2020 (TWh)	% of Baseline
AEO Baseline Forecast	4,117				
Moderate Scenario	4,012	18	86	104	2.5%
Aggressive Scenario	3,824	59	234	293	7.1%

Note: the industrial sector analysis does not allow impacts from codes and standards to be isolated. Hence, we assume that 2/3 of the savings result from equipment standards in the industrial sector.

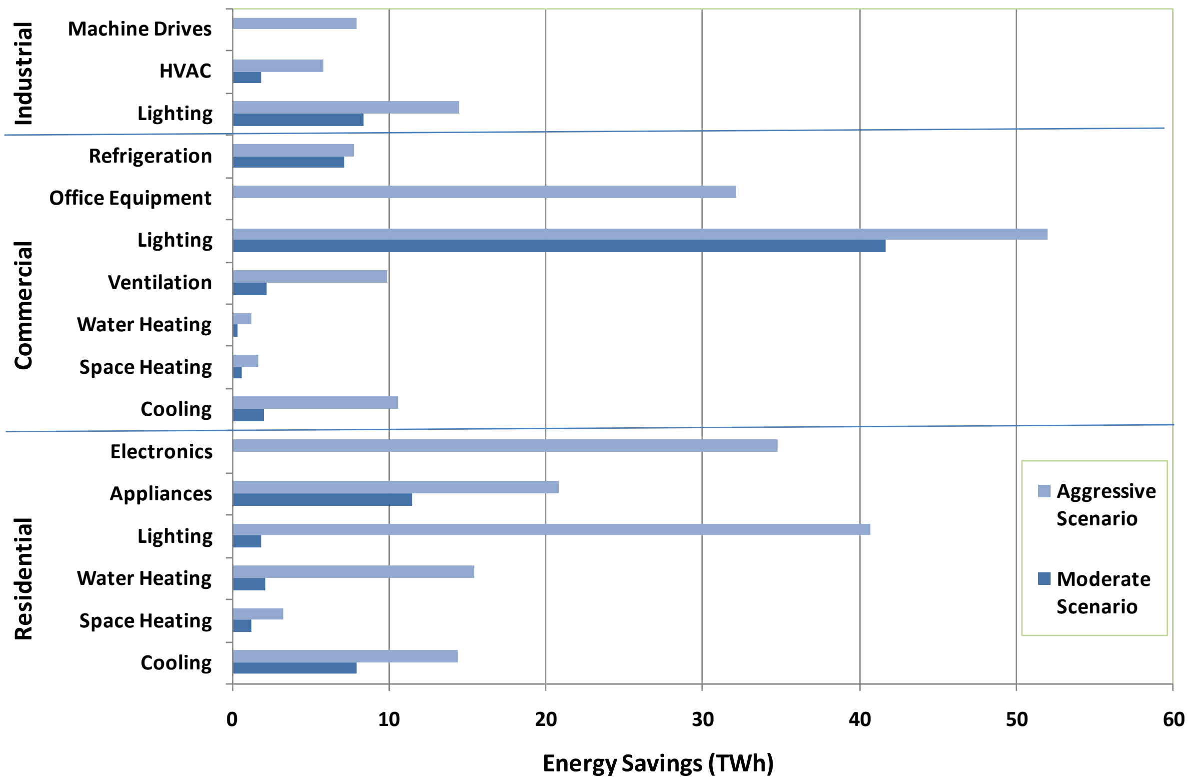
Figure E-2 presents the savings for the end uses with the largest savings impacts. The savings from commercial lighting standards dominates in both the moderate and aggressive scenarios. Under the aggressive scenario, residential lighting, consumer electronics, and office equipment also represent the potential for large savings.

Effects of Codes and Standards on Utility Energy Efficiency Programs

New codes and standards have major implications for utility-administered energy efficiency programs as well as for how state (and possibly federal) energy efficiency goals will be achieved. Codes and standards alter baseline electricity use, the amount of consumption expected to occur before utility-administered energy efficiency programs become effective. By shifting the starting point, new codes and standards can decrease the potential for utility programs in two ways.

First, the increase in baseline efficiency related to aggressive codes and standards displaces (or cannibalizes) some traditional utility programs by focusing on the same technologies. For example, EPRI estimates realistic achievable potential savings from commercial lighting programs of 53 TWh by 2020. In this paper, we estimate that new lighting standards mandating T8 lighting fixtures and CFL bulbs could result in 42 TWh to 52 TWh of savings – almost completely displacing the potential for existing programs.

Figure E-2: Savings by End Use and Scenario in 2020 (TWh)



Second, as codes and standards become more stringent, utility programs will have to focus on higher cost, higher energy efficiency resources. These higher efficiency resources will: (1) require higher incentive amounts to induce adoption; and (2) result in an energy savings impact that is smaller due to the higher baseline established by the new standard. And, although the utility may be well positioned to pursue the next set of opportunities by pushing the market to a new level of efficiency (such as to LED bulbs), it may not be cost effective to do so.

To achieve energy efficiency via a combination of more stringent codes and standards and utility efficiency programs, utilities should consider incorporating a codes and standards program as part of their energy efficiency portfolios in states where it makes sense to do so, following three precepts: 1) focus on the retrofit (existing building) market; 2) promote super-efficient technologies; and 3) incorporate utility-sponsored codes and standards into EE programs.

Utility involvement in supporting codes and standards is important because utilities are already involved in the local energy efficiency market, know the players, and know what next steps make the most sense. The specific opportunities for utility involvement will vary by state.

1. Focus on Retrofit Market

Table E-2 shows the energy consumption remaining after aggressive codes and standards take effect for each of the market segments. As shown, even after accounting for savings due to codes and standards, the technically possible savings potential in existing buildings (i.e., the retrofit market) is still significant. Arguably, the retrofit market is a tough market to cost effectively address. Yet, it presents a significant energy savings opportunity.

Table E-2: Energy Savings under Aggressive Codes and Standards Scenario (2020)

Market Segment	Baseline in 2020 (TWh)	Savings from Codes &Standards in 2020 (TWh)	% of Baseline	Remaining Usage (TWh)
Residential Existing Buildings	1,319	118	9%	1,201
Residential New Construction	157	18	11%	139
Commercial Existing Buildings	1,413	98	7%	1,315
Commercial New Construction	207	31	15%	176
Industrial Facilities	1,020	28	3%	992
Total*	**4,117**	**293**	**7%**	**3,824**

* Numbers do not sum exactly due to rounding.

2. Promote super-efficient technologies

Using incentives, utilities can encourage the development and adoption of advanced technologies that provide savings above and beyond the baseline levels required when such technologies make economic sense. These new technologies should be cost effective, available widely in the market, and poised to grow in terms of market share.

3. Incorporate Utility-Sponsored Codes and Standards into EE Programs

By working with regulators, advocacy groups, home builders, commercial building owners, equipment manufacturers, and consumers, utilities could play a key role in getting stakeholders aligned and supporting more aggressive building codes and appliance/equipment standards that make economic sense. In cases where there are opportunities for utilities to actively support new codes and standards, receiving some credit for the resulting energy efficiency reductions (e.g., as new standards take effect) will provide the appropriate incentive to keep pushing energy efficiency forward.

Specific opportunities for utilities to get involved in this process will vary quite significantly from state to state, however. In some states, there may be no opportunities for utility involvement.

CONCLUSION

As more stringent efficiency codes and standards are adopted to achieve savings, utilities and regulators will face the following challenges:

- Codes and standards will decrease the potential for existing utility-administered energy efficiency program savings significantly; identifying how to close the gap with cost effective new and emerging technologies will be essential.
- Regulators and utilities may need to rethink energy efficiency goals and targets for utilities.
- In an environment where codes and standards are achieving significant energy savings, utility earnings could be suppressed in the short run as sales decline. This could result in increasing rates in the long run but potentially lower bills as efficiency increases.
- If advancing energy efficiency nationwide is the main objective, state regulators, utilities, advocates, and government entities will need to identify how utility-administered energy efficiency programs and codes and standards can work together most effectively.

TABLE OF CONTENTS

EXECUTIVE SUMMARY .... **i**

INTRODUCTION **1**

THE BASELINE FORECAST **3**

IMPACT OF CODES AND STANDARDS ON U.S. ELECTRICITY CONSUMPTION **4**

RESULTS BY SECTOR **11**

RESIDENTIAL SECTOR 11

COMMERCIAL SECTOR 12

INDUSTRIAL SECTOR 14

IMPACT OF CODES AND STANDARDS ON UTILITY ENERGY EFFICIENCY PROGRAMS **16**

FOCUS ON RETROFIT (EXISTING BUILDING) MARKET 17

PROMOTE SUPER-EFFICIENT TECHNOLOGIES 19

INCORPORATE UTILITY-SPONSORED CODES AND STANDARDS INTO EE PROGRAMS 19

SUMMARY **20**

APPENDICES **22**

APPENDIX A ASSUMPTIONS ABOUT BUILDING CODES AND APPLIANCE STANDARDS **23**

APPENDIX B OVERVIEW OF MODELING APPROACH **28**

REFERENCES **29**

INTRODUCTION

Electric utilities face a shifting landscape with regard to electricity use, future generation sources, and energy efficiency efforts. Increasingly stringent environmental requirements and high capital costs for generation are causing prices to climb, "smart-grid" technologies are enabling dynamic pricing, national carbon emissions reduction goals are increasingly likely, and the federal government as well as states are keenly focused on energy efficiency. Specifically, many states now require utilities to meet a certain percentage of their electricity demand through efficiency and an increasing number of state regulators are implementing some form of revenue decoupling and/or performance incentives to encourage energy efficiency activities.

An important factor impacting the nationwide move toward a more energy-efficient economy is the adoption of new building codes and appliance and equipment efficiency standards. Building codes focus on reducing energy consumption in newly-constructed buildings, making them significantly less energy intensive than older buildings. Appliance and equipment efficiency standards mandate minimum efficiency levels for energy using equipment, such as central air conditioners, lamps and ballasts, furnace fans, and "white-box" residential appliances. Federal or state-level equipment standards result in lower consumption levels for all units purchased, both in new construction and existing buildings. In the current Administration, codes and standards are at the forefront of the energy agenda. Building codes and appliance/equipment standards are being discussed with increasing frequency in the federal policy arena and are likely to be part of a push at the federal level towards greater energy efficiency.

This paper quantifies the impact of future building codes and appliance/equipment efficiency standards on electricity consumption in the United States and discusses the effect of these codes and standards on utility energy-efficiency activities. Codes and standards affect baseline electricity use, the amount of consumption expected to occur *before* utility-administered energy-efficiency programs become effective. New codes and standards, therefore, shift the starting point and change the potential for savings from utility programs – at least in the short run. By understanding the magnitude of possible savings from new codes and standards and how these changes might be coordinated with utility-sponsored programs, electric utilities will be poised to play a central role in achieving greater energy-efficiency. The range of impacts will vary significantly by state and by utility.

New codes and standards have two basic components: new building codes and new or expanded appliance and equipment efficiency standards. Because of the uncertainty inherent in the policy-making process, in this paper, we developed two possible codes and standards scenarios—moderate and aggressive—intended to represent a range of possibilities in future legislative and regulatory actions surrounding changes in codes and standards.

1. The moderate scenario represents our assessment of the appliance and equipment standards issued by DOE in mid-2009, the American Reinvestment and Recovery Act requirement that states adopt and enforce model building energy codes, as well as additional appliance and equipment standards with a high probability of taking effect through federal and state legislation in the near future. This is the low end of the range of estimated impacts. The moderate scenario assumes:
    - Building codes equivalent to IECC 2009 or ASHRAE 90.1 2007 code (100% compliance) are adopted by all states.
    - Appliance and equipment standards for items scheduled or overdue under DOE's rulemaking process as set forth by the Energy Policy Act of 2005 (EPACT 2005) and the Energy Independence and Security Act of 2007 (EISA 2007).
2. The aggressive scenario represents our assessment of the codes and standards that could take effect under a focused national effort. This is the high end of the range of estimated impacts. The aggressive scenario assumes:
    - Building codes as articulated in the current version of the Waxman-Markey Bill (HR2454, Sec. 201) are passed and all states adopt the building code with 100% compliance.
    - In addition to standards scheduled or backlogged under DOE (moderate scenario), standards expand to address all possible devices, with a second set of standards in later years of the forecast for some technologies (e.g., screw-in lamps, central air conditioners).

These two scenarios define a plausible range of possible outcomes for the future. The aggressive scenario was developed by layering more aggressive assumptions onto those embedded in the moderate case. For example, the moderate case assumes that a new federal standard will raise the minimum SEER rating for residential air conditioners to 14, effective in 2014. Under the aggressive case, this standard is identical until 2019, when a new standard (SEER 15) is assumed to replace the 2014 standard and achieve additional savings. Tables 8, 9, and 10 in Appendix A provide detailed assumptions for the residential, commercial, and industrial equipment and appliance standards assumed under the two scenarios in this paper.

The implementation of the building code (IECC 2009) under the moderate scenario assumes a 15% reduction in energy usage and takes effect in 2013 in the analysis. Under the aggressive scenario, building codes take place in two phases following the approach in the Waxman-Markey bill. In our analysis, a lag is incorporated to capture the delay in code implementation. These two phases are assumed to take effect in 2013 (Waxman-Markey I) and 2017-2018 (Waxman-Markey II). The first phase prescribes a 30% reduction in energy usage in end uses addressed by building codes, while the second phase prescribes a 50% reduction in energy usage. Table 7 in Appendix A provides detailed assumptions for the two scenarios.

THE BASELINE FORECAST

The analysis begins with identification of a baseline forecast, which is the reference point for assessing the impacts of future codes and standards. The baseline for this study is the reference case from EIA's Annual Energy Outlook, April 2009 (AEO 2009), updated to reflect the provisions of the American Recovery and Reinvestment Act. The forecast provides total U.S. electricity consumption from 2008 to 2030 and includes the following factors:[2]

- Existing codes and standards
    - Both local and federal building codes,
    - Appliance standards officially signed (National Appliance Energy Conservation Act and DOE review process),
    - Other energy-relevant legislation (the Energy Improvement and Extension Act of 2008, EISA 2007, EPACT 2005),

[2] With the exception of some technical data on unit efficiency as a function of standards (e.g. EISA 2007), all of these effects are implicit in the National Energy Modeling System (NEMS) modeling framework. In other words, they are manifested as they affect average energy usage values that form the core of the demand-side modules within NEMS (only in the residential and commercial sectors).

- IECC 2009 and ASHRAE 90.1 2007 implemented in 2018.

- Naturally occurring efficiency
    - Technological improvements in energy-consuming equipment,
    - Conservation response to rising energy prices (based on usage elasticity),
    - Market trends toward "green" affecting both energy purchases and usage behaviors.
- Embedded demand-side management defined as future impacts of past programs but no new programs in the forecast period. These impacts yield from:
    - Utility information and incentive programs,
    - State funding and regulatory mechanisms,
    - New funding for energy efficiency through the American Reinvestment and Recovery Act.

According to AEO 2009, electricity use across all sectors increases from 3,718 TWh in 2008 to 4,117 TWh in 2020, a change in consumption of 399 TWh (9.7% increase) over the 12-year period. This implies an annual growth rate of 0.85%. The baseline forecast is presented in Table 1.

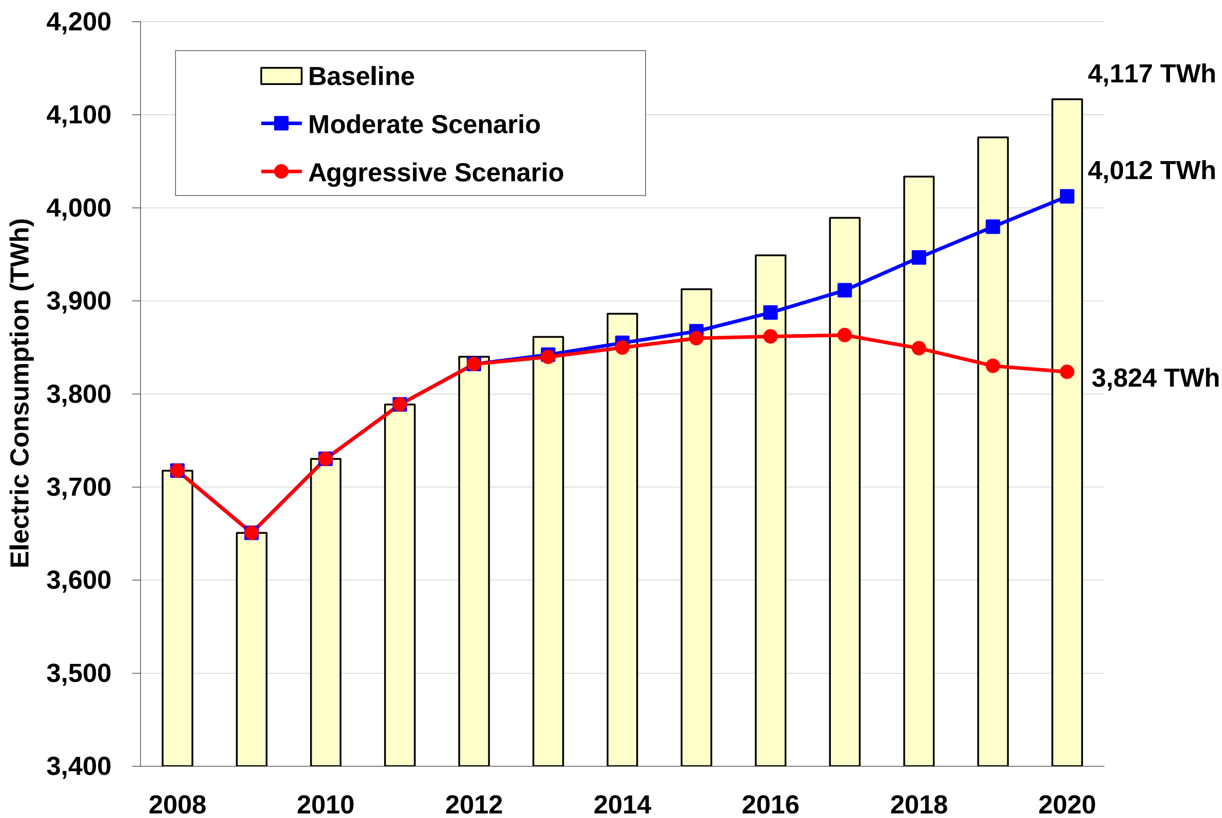
Table 1: Baseline Electricity Consumption by Sector, 2008 and 2020 (AEO 2009)

Market Sector	2008 Usage (TWh)	Share of Total	2020 Usage (TWh)	Share of Total
Residential	1,387	37%	1,476	36%
Commercial	1,358	37%	1,620	39%
Industrial	973	26%	1,020	25%
Total	**3,718**	**100%**	**4,117**	**100%**

IMPACT OF CODES AND STANDARDS ON U.S. ELECTRICITY CONSUMPTION

As described earlier, we quantified the impact of changes in codes and standards on electricity consumption under two scenarios – moderate and aggressive changes. Our results show savings from codes and standards ranging from 104 TWh (under the moderate scenario) to 293 TWh (under the aggressive scenario) by 2020. This is equivalent to 2.5% to 7% of the baseline forecast in 2020. To put these estimates in perspective, the recent EPRI study of the potential savings from energy efficiency programs in the U.S. estimated realistic achievable potential and maximum achievable potential of 141 TWh and 372 TWh, respectively, by 2020 relative to the 2008 AEO baseline forecast.[3] Hence, the potential savings achievable through codes and standards (ranging from 104 to 293 TWh by 2020) is significant. Figure 1 shows the results of our analysis compared to the AEO baseline forecast. The bar chart represents the AEO baseline forecast (AEO 2009) and includes the impacts of existing codes and standards, naturally-occurring efficiency, and embedded energy efficiency. The lines represent the impacts of the two codes and standards scenarios – a reduction in consumption to 4,012 TWh under the moderate scenario and a reduction to 3,824 TWh under the aggressive scenario.

Figure 1: Impact of Codes and Standards on Total U.S. Electricity Consumption (TWh)



[3] See EPRI 2009.

Table 2 presents the total electricity savings in the year 2020 under each of the scenarios. This analysis reveals that new codes and standards will significantly impact the electricity consumed in the U.S. Standards dominate the savings, providing 80% of the total energy savings in 2020. In comparison, codes provide 20% of the savings. Although the aggressive scenario assumes all states adopt the new building code with 100% compliance, a scenario assuming 50% compliance yielded savings from building codes that were lower, but not significantly lower. The key driver of energy savings is new equipment standards.

Table 2: Summary of Codes and Standards Impacts in 2020: Residential, Commercial and Industrial Sectors*

Scenario	Electricity Use in 2020 (TWh)	Savings from Building Codes (TWh)	Savings from Equipment Standards (TWh)	Total Savings in 2020 (TWh)	% of Baseline
AEO Baseline Forecast	4,117				
Moderate Scenario	4,012	18	86	104	2.5%
Aggressive Scenario	3,824	59	234	293	7.1%

Note: the industrial sector analysis does not allow impacts from codes and standards to be isolated. Hence, we assume that 2/3 of the savings result from equipment standards in the industrial sector.

Below we summarize how our results compare to other recent codes and standards estimates.

- Recent analysis performed by ACEEE estimates the impacts of the building codes proposed under the Waxman-Markey Bill at 43 TWh in 2020. This is the mid-point of our savings estimates due to codes of 18 TWh (moderate scenario) and 59 TWh (aggressive scenario), assuming Section 201 of the Waxman-Markey Bill is signed into law (see ACEEE 2009).

- McKinsey estimates the potential electricity savings in non-government new buildings (residential and commercial sectors) to be 70 TWh in 2020. While the savings from codes and standards are not isolated in the report, McKinsey identifies building codes as central to the strategy for obtaining this target. For comparison, our estimate of savings through new building codes in these two sectors is lower and ranges from 15 TWh to 50 TWh (see McKinsey 2009).

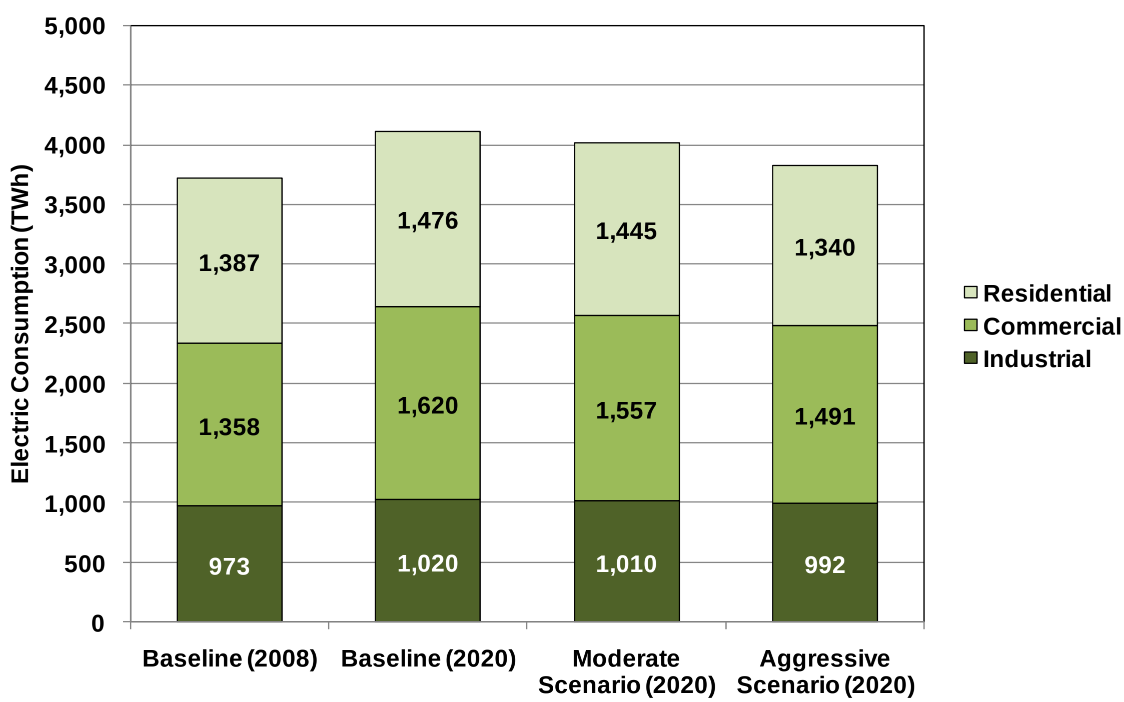
- A separate study by ASAP and ACEEE estimated the impact of new appliance standards likely to become effective in coming years at 100 TWh in 2020. The standards in the study are comparable to our moderate case, which estimates savings of 86 TWh due to standards (see ASAP and ACEEE, 2009).

- Although not directly comparable to this assessment because it includes all provisions of the legislation (carbon regulation, combined efficiency and renewable energy standard), EIA recently estimated the probable impacts of the Waxman-Markey Bill at 90 TWh by 2020 (see EIA 2009).

In summary, our results of the impacts of codes and standards on electricity savings in the U.S. are comparable to other recent studies.

The impact of future codes and standards on electricity consumption by sector is displayed in Figure 2. While the baseline forecast is expected to grow by 399 TWh over the period between 2008 and 2020 (i.e., from 3,718 TWh to 4,117 TWh), new codes and standards reduce the forecast by 104 TWh to 293 TWh.[4]

Figure 2: Electricity Consumption Forecast by Scenario and Sector (TWh) in 2020



[4] Note that the AEO baseline forecast does not account for electricity growth due to electric transportation or advanced electro-technologies in 2020 (see EPRI PRISM/MERGE Analyses 2009 Update).

Figure 3 displays the allocation of the total savings by market sector in 2020. Under the aggressive scenario, savings are split roughly equally between the residential and commercial sectors. In the moderate scenario, the commercial sector dominates due to savings from commercial lighting. For decades, commercial lighting has been identified as a major opportunity for energy efficiency. Multiple standards for commercial lighting equipment, likely to be adopted by DOE, seek to realize these savings.

Figure 3: Electricity Savings by Scenario and Sector in 2020 (TWh)

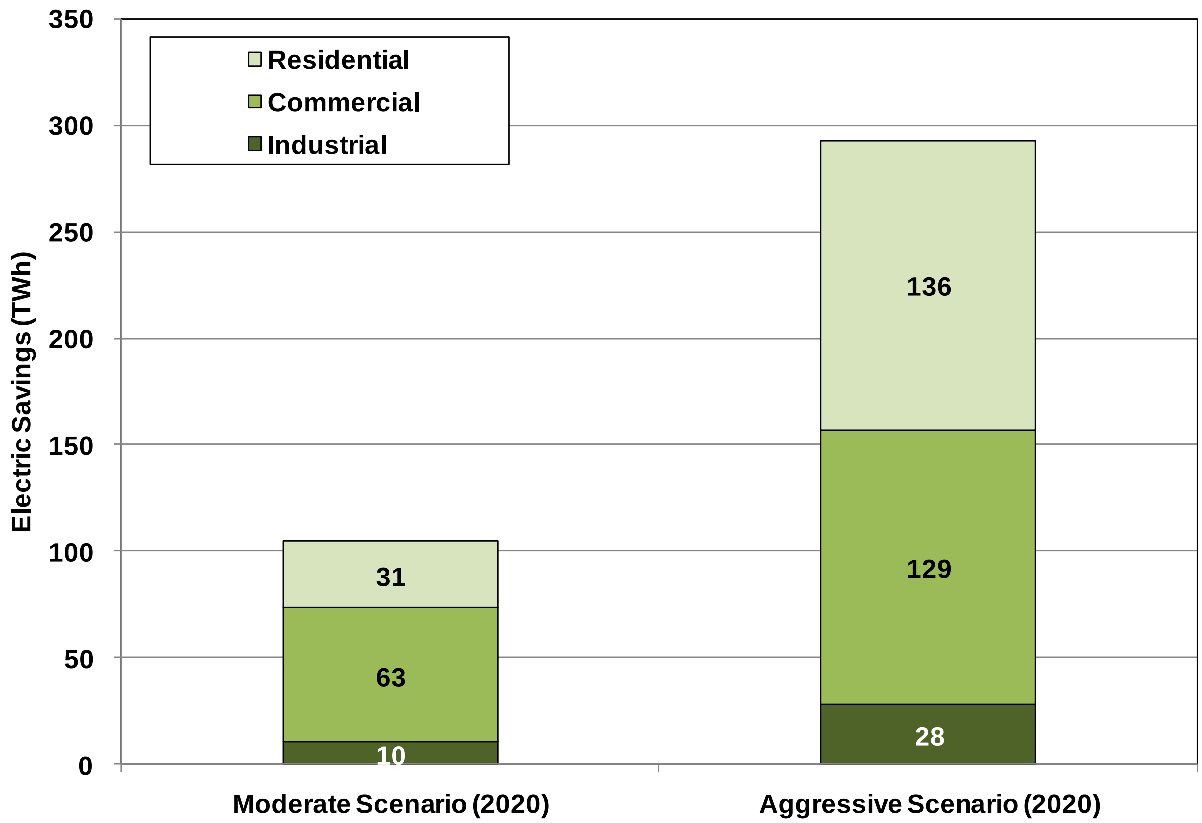


Figure 4 presents the savings for the end uses with the largest impacts. The prominence of commercial lighting in both the moderate and aggressive scenarios is apparent. In the residential sector, savings from consumer electronics and lighting dominate under the aggressive scenario. Tables 3, 4, and 5 show end-use savings as a percentage of the baseline forecast for each market sector. Below we summarize the key results.

- Commercial lighting dominates due to the assumptions that efficient "Super T8s" become the standard for all linear fluorescent applications and building codes reduce lighting usage in new construction buildings in 2013 and again in 2018.

- Residential lighting is not a factor in the moderate case due to the recent adoption (and inclusion in the baseline forecast) of EISA 2007 and its requirements for general service applications. But, a new standard that requires luminous efficacy comparable to compact fluorescent lamps is assumed in 2018.

- Commercial office equipment, while not currently under consideration by DOE for standards in the next four years, contains sizeable efficiency potential. In the aggressive scenario, a standard that limits standby wattage and requires a certain level of power management is assumed in 2016.

- Residential electronics are similar to commercial office equipment. There is an expectation that both technology and rulemaking will benefit from "spillover" from commercial office equipment, resulting in new standards to improve efficiency.

- Residential cooling savings result from the assumption that the minimum federal standard for central air conditioning units becomes SEER 14, the window unit standard becomes the current Energy Star rating, and building codes reduce new construction air conditioning usage in 2013 and again in 2017.

- Residential white goods appliances (e.g., refrigerators, dishwashers, clothes washers) continue to provide a significant opportunity for savings in spite of efficiency gains achieved by past standards.

- Commercial ventilation savings come from building codes, which are assumed to incorporate less energy-intensive air movement schemes into building design.

- Residential water heating savings result from an increased energy factor for electric storage water heaters under the moderate scenario, with an additional standard that mandates efficiency comparable to that of heat pump water heaters, effective in 2019.

Appendix A, Tables 8, 9, and 10 provide details on the standards assumptions in the forecast.

For the commercial and residential sectors, we breakout savings attributable to codes versus standards for each of the two scenarios for new construction (post 2009) and existing buildings (see Figure 5). The modeling approach used for the industrial sector does not isolate building codes and equipment standards; hence we estimate that 2/3 of the savings result from equipment standards in the industrial sector.

Figure 4: Savings by End Use and Scenario in 2020 (TWh)

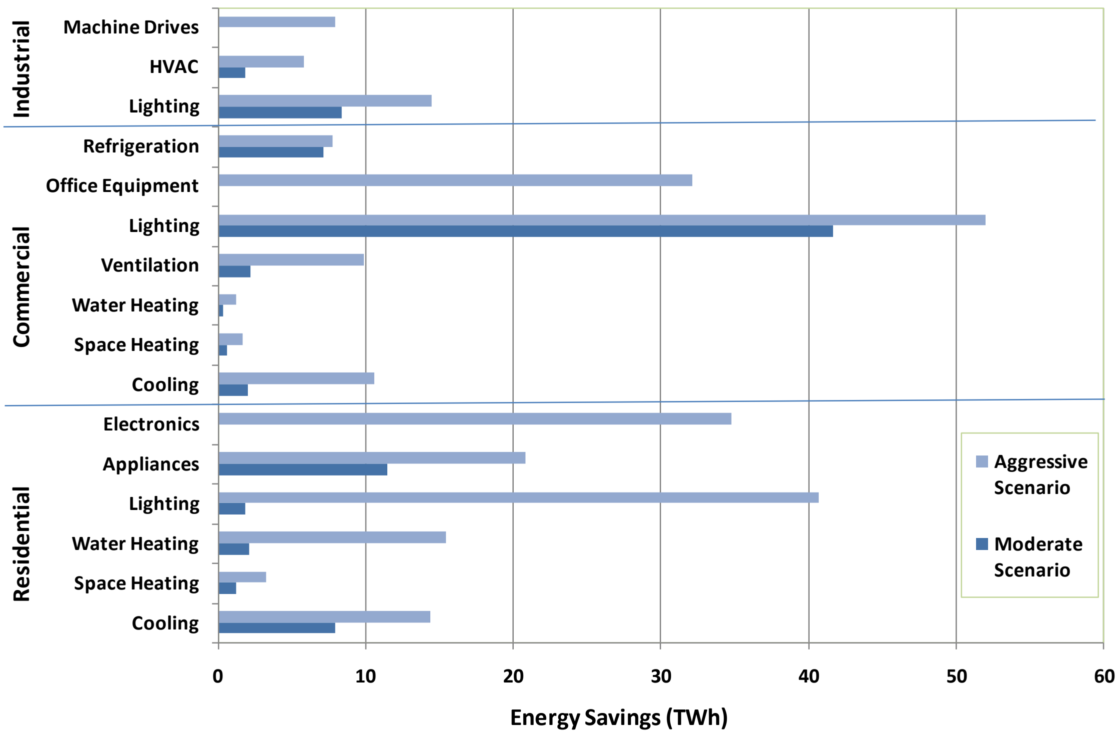
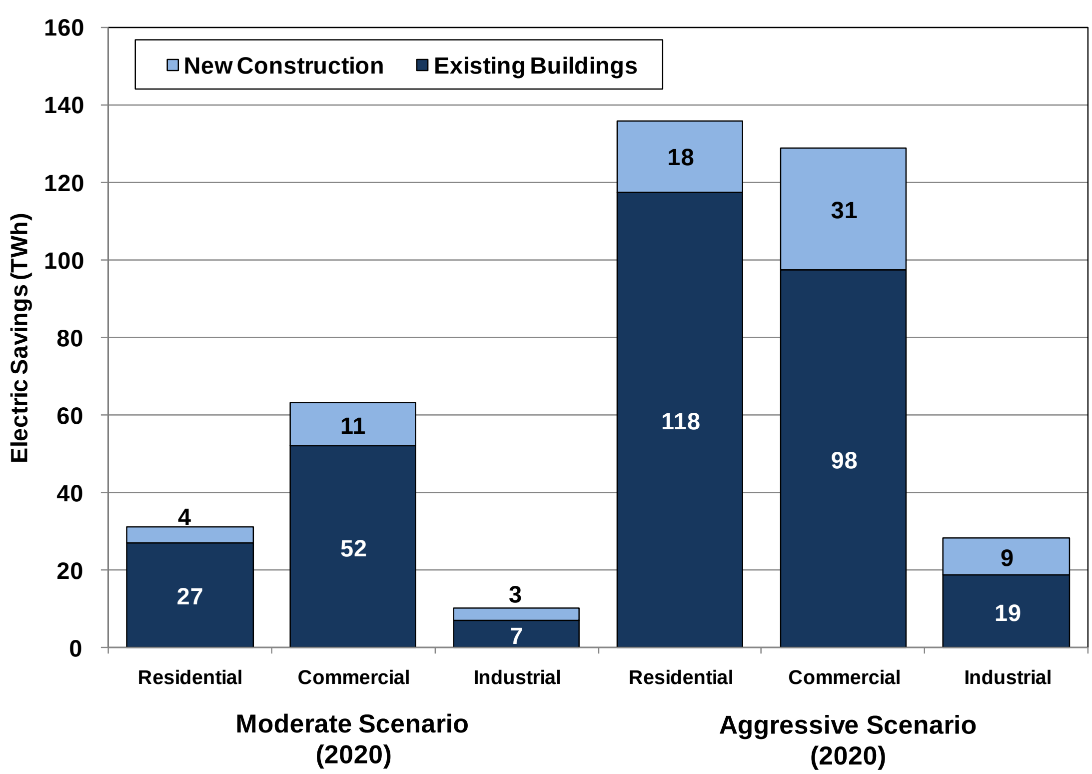


Figure 5: Electricity Savings by Building Vintage and Sector in 2020



RESULTS BY SECTOR

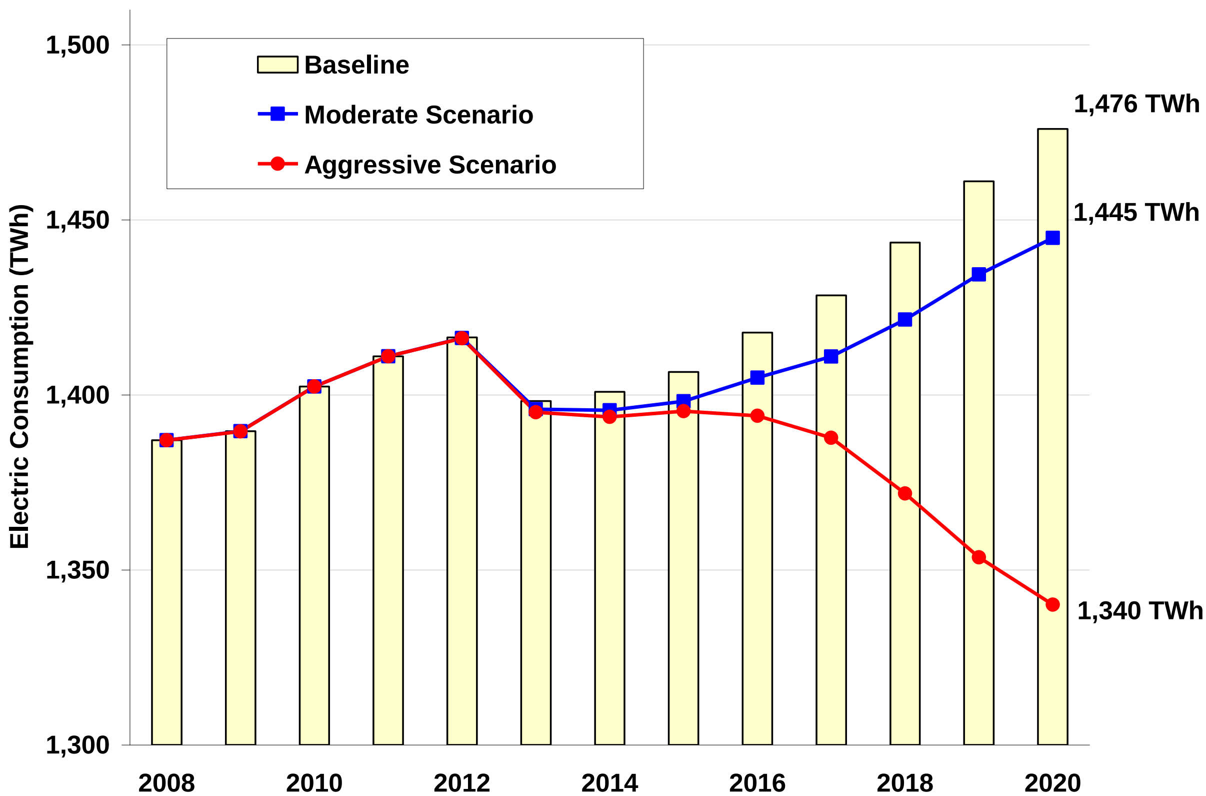
RESIDENTIAL SECTOR

The impacts of future codes and standards are presented in Table 3. Under the moderate scenario, new appliance standards are responsible for the largest impact, at 11 TWh by 2020. Lighting shows small savings because the effects of EISA 2007 are included in the baseline forecast, and no additional standards are assumed. For the aggressive scenario, lighting savings dominate followed by consumer electronics. In the aggressive scenario, an additional standard is assumed for general service lighting, raising the minimum luminous efficacy to that of a compact fluorescent lamp (approximately 60 lumens/Watt).

Table 3: Residential Sector – Savings by End Use and Scenario in 2020

End Use	**Baseline Forecast**	**Moderate Scenario**		**Aggressive Scenario**	
	(TWh)	**Savings (TWh)**	**Savings (%)**	**Savings (TWh)**	**Savings (%)**
Cooling	261	8	3%	14	6%
Space Heating	78	1	2%	3	4%
Water Heating	143	2	1%	15	11%
Lighting	152	2	1%	41	27%
Appliances	291	11	4%	21	7%
Electronics	183	0	0%	35	19%
Miscellaneous	368	7	2%	7	2%
Residential Total	**1,476**	**31**	**2%**	**136**	**9%**

Figure 6: Residential Sector – Baseline Forecast and Codes and Standards Scenarios



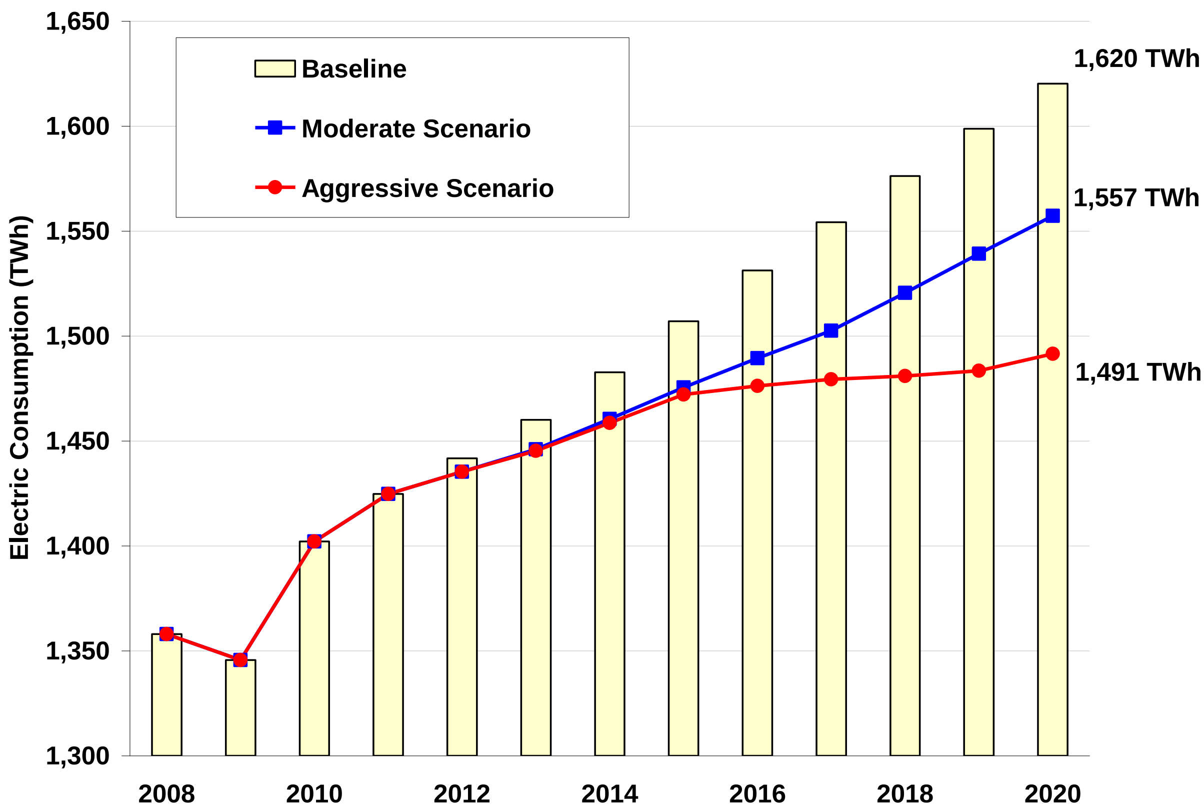
Commercial Sector

Under the moderate scenario, savings are the largest in the commercial sector, both in absolute terms (63 TWh) and as a percentage of the baseline forecast (4%). This is largely due to the assumed standards in the area of commercial lighting, contributing 42 of the total 63 TWh of savings in this scenario. In absolute terms, lighting savings do not grow significantly as aggressive codes and standards are considered, but lighting is still significant in terms of overall savings. Aggressive assumptions about power management in office equipment lead to sizeable savings for this end use. Building code changes influence savings in building shell measures and HVAC systems.

Table 4: Commercial Sector – Savings by End Use and Scenario in 2020

End Use	Baseline Forecast	Moderate Scenario		Aggressive Scenario	
	(TWh)	Savings (TWh)	Savings (%)	Savings (TWh)	Savings (%)
Cooling	168	2	1%	11	6%
Space Heating	52	1	1%	2	3%
Water Heating	28	0	1%	1	4%
Ventilation	182	2	1%	10	5%
Lighting	333	42	12%	52	16%
Office Equipment	184	0	0%	32	18%
Refrigeration	108	7	7%	8	7%
Miscellaneous	566	9	2%	14	2%
Commercial Total	**1,620**	**63**	**4%**	**129**	**8%**

Figure 7: Commercial Sector – Baseline Forecast and Codes and Standards Scenarios



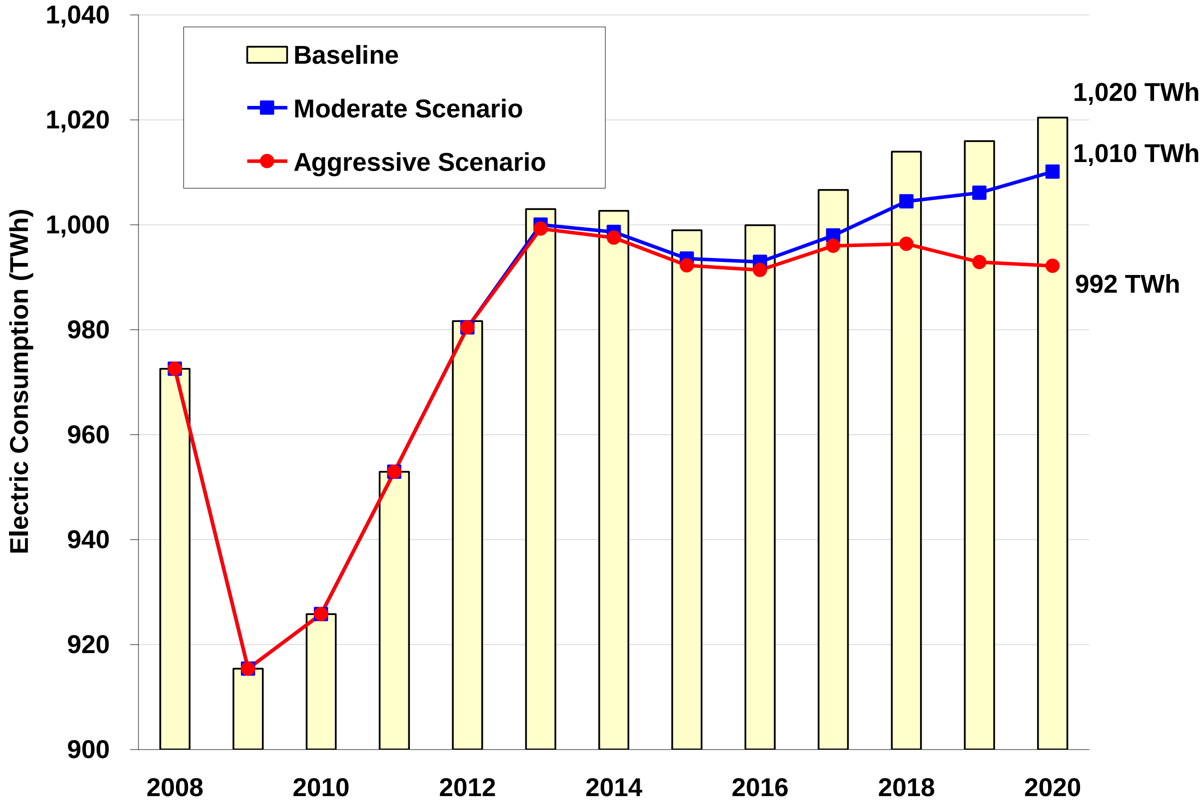
INDUSTRIAL SECTOR

Electricity consumption in the industrial sector is related more to end-use equipment than to the building envelope and construction. Therefore, the impact of aggressive building codes is not as strong. However, building codes are a factor and are captured in the HVAC and lighting impacts shown in Table 5. In addition, the aggressive case assumes a universal improvement in motor efficiency, which contributes approximately 8 TWh to the total industrial impact. While the improvement in efficiency is often only a few percent (typically represented by premium efficiency motors as opposed to the NEMA standard), the abundance of machine drives in industrial applications leads to significant savings from this standard.

Table 5: Industrial Sector – Savings by End Use and Scenario in 2020

End Use	Baseline Usage	Moderate Scenario		Aggressive Scenario	
	(TWh)	Savings (TWh)	Savings (%)	Savings (TWh)	Savings (%)
HVAC	96	2	2%	6	6%
Lighting	71	8	12%	14	20%
Machine Drive	520	0	0%	8	2%
Process Heating	202	0	0%	0	0%
Other	131	0	0%	0	0%
Industrial Total	**1,020**	**10**	**1%**	**28**	**3%**

Figure 8: Industrial Sector – Baseline Forecast and Codes and Standards Scenarios



IMPACT OF CODES AND STANDARDS ON UTILITY ENERGY EFFICIENCY PROGRAMS

An important question about codes and standards from the perspective of electric utilities is:

> *How do aggressive codes and standards affect the potential for obtaining energy efficiency through utility-sponsored energy efficiency programs? How could codes and standards and EE programs work together to achieve efficiency?*

First, it is important to note that aggressive codes and standards will displace (or cannibalize) traditional utility energy efficiency program potential by shifting the baseline for efficiency. Hence, the potential remaining for the utility to capture under existing programs will be significantly smaller, and potentially zero. As an example of how this occurs, compare the energy savings achievable by codes and standards presented in this paper to the recent EPRI study of energy-efficiency program potential in the U.S. for a single end use, commercial lighting.[5] The realistic achievable potential savings from commercial lighting programs in the EPRI study is 53 TWh by 2020. In this paper, we estimate that new lighting standards could result in 42 TWh (moderate) to 52 TWh (aggressive) of savings – almost a complete displacement of existing program potential. The reason for this is that the new lighting standards focus on the same technologies as the utility programs (T8s, CFLs). The result is that savings from the traditional utility program will be displaced by the new standard. The same holds true for other end uses and technologies. An increase in codes and standards will decrease the potential savings that utility programs can achieve significantly.[6]

Second, as stringent codes and standards shift the baseline, or the starting point, they provide an opportunity for utilities to expand their energy efficiency efforts but make it more expensive to do so. As codes and standards capture the "low-hanging fruit," utilities are left with the harder-to-reach opportunities. For example, if a utility has a CFL program today with a goal of achieving 1,000 MWh of energy efficiency savings per year and the standard changes next year

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[5] See EPRI 2009, Table ES-2.

[6] This paper focuses solely on the potential savings from codes and standards but does not provide estimates of how much this would displace existing utility energy efficiency programs.

so that CFLs become the standard bulb, the utility must now find a new lighting technology, such as LEDs, to meet its energy savings goals. However, the cost of an LED bulb is much higher than a CFL so LEDs are typically not a cost effective replacement at this time (depending on the cost of electricity and usage). Hence, the lighting market potential may now be zero for the utility. Although the utility may be well positioned to pursue the next set of opportunities by pushing the market to a new level of efficiency (such as to LED bulbs), the cost effectiveness of these new opportunities may not make it feasible to pursue them (at least not at this time).

As codes and standards become more stringent, utility programs will have to focus on higher cost, more aggressive energy-efficiency resources. These higher efficiency resources will likely: (1) require higher incentive amounts to induce adoption; and (2) result in an energy savings impact that is smaller due to the higher baseline established by the new standard. The combination of these two factors can diminish the ability for the utility to offer cost effective efficiency programs.

Achieving energy efficiency via a combination of more stringent codes and standards and utility efficiency programs suggests that utilities may want to consider incorporating a codes and standards program as part of their energy efficiency portfolios in states where it makes sense to do so (this is discussed in more detail below). It also suggests that state regulatory commissions may want to examine the role that utilities could play in advancing codes and standards and how their contribution could be recognized.

FOCUS ON RETROFIT (EXISTING BUILDING) MARKET

Table 6 shows the energy consumption remaining after aggressive codes and standards take effect for each of the market segments. As shown, even after accounting for savings due to codes and standards, the technically possible savings potential in existing buildings (i.e., the retrofit market) is still significant. Total remaining usage is 1,201 TWh in existing residential buildings and 1,315 TWh in existing commercial buildings. While the savings from codes and standards in residential and commercial new construction represent 13.5% of the baseline forecast, the savings from codes and standards in existing residential and commercial buildings represent only 8% of the baseline. Arguably, the retrofit market is a tough market to cost effectively address. Yet, it presents a significant energy savings opportunity.

Table 6: Energy Savings under Aggressive Codes and Standards Scenario (2020)

Market Segment	Baseline in 2020 (TWh)	Savings from Codes & Standards in 2020 (TWh)	% of Baseline	Remaining Usage (TWh)
Residential Existing Buildings	1,319	118	9%	1,201
Residential New Construction	157	18	11%	139
Commercial Existing Buildings	1,413	98	7%	1,315
Commercial New Construction	207	31	15%	176
Industrial Facilities	1,020	28	3%	992
Total*	**4,117**	**293**	**7%**	**3,824**

* Numbers do not sum exactly due to rounding.

Opportunities to improve efficiency in existing commercial buildings are likely to be comprehensive and custom in nature and tied to overall building consumption, such as the following:

- Lighting retrofit projects involving de-lamping, applying sensors, and optimizing usage to match needs;
- HVAC measures in commercial buildings including comprehensive system upgrades and/or retro-commissioning;
- Advanced energy management/optimization tools for commercial and residential buildings (continuous building commissioning);
- Leveraging incentive dollars through performance-based energy contracting mechanisms (through ESCOs).

Because of the relative magnitude of the existing buildings market, by focusing on a comprehensive program approach, utilities are likely to find “another layer” of cost effective efficiency opportunities, likely representing “deeper” efficiency (e.g., whole-system retro-commissioning as opposed to replacing individual fan motors and sealing ducts).

There is no simple solution for retrofitting large numbers of existing residential buildings. Utilities and state entities will be experimenting with different approaches for the residential retrofit market in their own energy-efficiency programs and using DOE stimulus funds over the next few years.

PROMOTE SUPER-EFFICIENT TECHNOLOGIES

Using incentives, utilities can encourage the development and adoption of advanced technologies that provide savings above and beyond the baseline levels required when such technologies make economic sense. These new technologies should be cost effective, available widely in the market, and poised to grow in terms of market share. Examples of such technologies include:

- Ductless "mini-split" heat pumps and air conditioners;
- LED and OLED lighting;
- "Best-in-class" appliances, such as multi-drawer refrigerators and freezers;
- Advanced water heaters (heat pump water heaters, solar thermal, geothermal);
- Zero net energy homes.

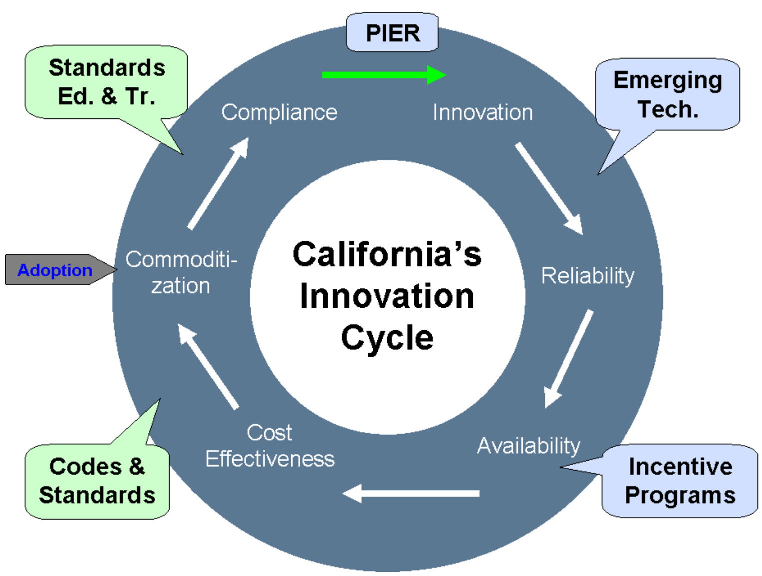
More stringent appliance and equipment standards will affect the economics of these advanced technologies. First, under a more stringent standard the efficient technology is compared to a new baseline with a likely higher cost; hence, although the cost differential may be smaller, the incremental savings are also reduced. Second, as the new standard takes hold in the marketplace, economies of scale typically reduce the cost of designing and manufacturing the appliance or the equipment. Because the same companies often manufacture the hyper-efficient options, scale economies can be expected to "spillover" in the form of lower costs for all efficiency levels manufactured.

INCORPORATE UTILITY-SPONSORED CODES AND STANDARDS INTO EE PROGRAMS

Utility involvement in supporting codes and standards is important because utilities are already involved in the local energy efficiency market, know the players, and know what next steps make the most sense. However, the specific opportunities for utilities to get involved in this process will vary quite significantly from state-to-state and, in some states, there may be no opportunities for utility involvement.

By working with regulators, advocacy groups, home builders, commercial building owners, equipment manufacturers, and consumers, utilities could play a key role in getting stakeholders aligned and supporting more aggressive building codes and appliance/equipment standards that make economic sense. In cases where there are opportunities for utilities to actively support new codes and standards, receiving some credit for the resulting energy efficiency reductions (e.g., as new standards take effect) will provide the appropriate incentive to keep pushing energy efficiency forward. As shown in Figure 9, the State of California has a process in place where the utility's role in advancing new codes and standards is an integrated part of the energy efficiency lifecycle. As shown, utility programs incent new efficient technologies available in the marketplace. Once a new standard becomes effective, the previous new technology becomes the new baseline and is commoditized. The resulting savings from the utility's efforts in advancing new codes/standards are counted toward its energy efficiency goals; specifically, in California, utilities submit a business case to state regulators supporting their role in the process.

Figure 9. California's Energy Efficiency Innovation Cycle Includes Both Utility Incentive Programs and Codes and Standards



SUMMARY

As part of a push toward a more energy efficient U.S. economy, activity at the federal and state levels indicates that building efficiency codes and appliance/equipment efficiency standards are likely to become more stringent over the next decade. Depending on the specific energy codes and standards adopted, under an aggressive scenario, electricity savings could be as high as 7% (i.e., 293 TWh) of the AEO baseline electricity forecast in 2020; this represents significant energy savings. In comparison, EPRI's estimated savings achievable from energy efficiency programs range from 141 TWh (realistic achievable potential) to 372 TWh (maximum achievable potential) in 2020 relative to the AEO baseline (EPRI, 2009, Table ES-2). New codes and standards have major implications for utility energy efficiency programs as well as for how state (and possibly federal) energy efficiency goals will be achieved.

Specifically, as more stringent efficiency codes and standards are adopted to achieve savings, utilities and regulators will face the following challenges:

- Codes and standards will decrease the potential for existing utility-administered energy efficiency program savings significantly by displacing existing savings potential and shifting the baseline; identifying how to close the gap with cost effective new and emerging technologies will be essential.

- In an environment where codes and standards are becoming more stringent, regulators and utilities may need to rethink energy efficiency goals and targets for utilities.

- In an environment where codes and standards are achieving significant energy savings, utility earnings could be suppressed in the short run as sales decline. This could result in increasing rates in the long run but potentially lower bills as efficiency increases.

- If advancing energy efficiency nationwide is the main objective, state regulators, utilities, advocates, and government entities will need to identify how utility-administered energy efficiency programs and codes and standards can work together most effectively. As one example, the State of California has developed an energy efficiency innovation cycle to address this relationship. However, there may be other approaches for meeting this challenge.

APPENDICES

APPENDIX A
ASSUMPTIONS ABOUT BUILDING CODES AND APPLIANCE STANDARDS

The tables in Appendix A provide detail on the codes and standards assumed under the moderate and aggressive codes and standards scenarios. Table 7 presents the building code assumptions by sector. Under the aggressive cases, two phases of building codes are assumed, following the approach proposed in the Waxman-Markey Bill. These two phases are assumed to take effect in 2013 (Waxman-Markey I) and 2017-2018 (Waxman-Markey II) and build on each other. Tables 8 through 10 provide detailed assumptions about the appliance and equipment standards under the two scenarios.

Table 7: Assumed Savings by End Use – Building Code Assumptions

Residential End Use	Moderate Scenario	Aggressive Scenario	
	IECC 2009	Waxman-Markey I (2013)	Waxman-Markey II (2017-2018)
Cooling	15%	30%	50%
Space Heating	15%	30%	50%
Water Heating	NA	30%	50%
Lighting	NA	30%	50%
Total	**15%**	**30%**	**50%**
Commercial End Use	**Moderate Scenario**	**Aggressive Scenario**	
	IECC 2009	**Waxman-Markey I (2013)**	**Waxman-Markey II (2017-2018)**
Cooling	15%	30%	50%
Space Heating	15%	30%	50%
Ventilation	15%	30%	50%
Water Heating	15%	30%	50%
Lighting	15%	30%	50%
Office Equipment	NA	NA	NA
Refrigeration	NA	30%	50%
Miscellaneous	NA	30%	50%
Total	**15%**	**30%**	**50%**
Industrial End Use	**Moderate Scenario**	**Aggressive Scenario**	
	IECC 2009	**Waxman-Markey I (2013)**	**Waxman-Markey II (2017-2018)**
HVAC	15%	30%	50%
Lighting	15%	30%	50%
Total	**15%**	**30%**	**50%**

Table 8: Residential Appliance and Equipment Standards Assumptions

End Use	Technology	Moderate Scenario		Aggressive Scenario	
		Standard	Year Effective	Standard	Year Effective
Cooling	Central AC/HP	SEER 14	2014	SEER 15	2019
	Window AC	EER 10.8	2014	EER 11.5	2019
Space Heating	Heat Pump	HSPF 8.2	2014	HSPF 9.3	2019
Water Heating	Water Heater	EF 0.95	2013	Heat Pump WH	2019
Lighting	Interior Screw-in	Adv. Incandescent	2012	CFL	2018
	Exterior Screw-in	Adv. Incandescent	2012	CFL	2018
	Reflector Lamps	Adv. Incandescent	2015	CFL	2018
	Torchiere	Adv. Incandescent	2015	CFL	2018
	Linear Fluorescent	Super T8	2012		
Appliances	Refrigerator	2010 Code	2013	2014 Code	2017
	Freezer	2010 Code	2013	2014 Code	2017
	Dishwasher			Energy Star	2017
	Clothes Washer	MEF 2.0	2015		
	Clothes Dryer	Moisture Sensor (10%)	2014	15% More Efficient	2019
	Cooking			13% More Efficient	2017
Electronics	Personal Computer			Energy Star	2016
	Color TV			Energy Star	2016
Miscellaneous	Furnace Fan	Permanent Magnetic Motor	2016		

Color Key for References

Ka-Boom Report (ACEEE and ASAP)	EISA 2007 - Included in Baseline (EISA)	Waxman-Markey Bill (HR 2454)	GEP Assumption

Table 9: Commercial Appliance and Equipment Standards Assumptions

End Use	Technology	Moderate Scenario		Aggressive Scenario	
		Standard	Year Effective	Standard	Year Effective
Cooling	Central Chiller			15% More Efficient (1.11 kW/ton)	2018
	Packaged AC/HP			EER 11.5	2018
	Window AC	EER 10.8	2014	EER 11.5	2019
Space Heating	Heat Pump			COP 4.0	2018
Ventilation	Air Handling System			Variable Air Volume	2018
Water Heating	Water Heater			EF 0.95	2015
Lighting	Interior Screw/pin	Adv. Incandescent	2012	CFL	2018
	Linear Fluorescent	Super T8	2012		
	Exterior Lighting	Various	2012	HID	2016
Office Equipment	Personal Computer			Energy Star	2016
	Server			Energy Star	2016
	Display			Energy Star	2016
	Printer/Copier			Energy Star	2016
Refrigeration	Walk-in Refrigeration	20% More Efficient	2015		
	Reach-in Refrigeration	Pending ES 2.0 Standard	2016		
	Vending Machines	DOE EL 5	2012		
	Icemaker			15% More Efficient	2015
Miscellaneous	Food Service Equipment			2010 Code	2018
	Transformers	Efficiency = 98.4%	2016		
	Small Motors	Efficiency = 70.9%	2013		
	Commercial Laundry	1.72 MEF and 8.5 WF	2013		

Color Key for References

Ka-Boom Report (ACEEE and ASAP)	EISA 2007 - Included in Baseline (EISA)	Waxman-Markey Bill (HR 2454)	GEP Assumption

Table 10: Industrial Appliance and Equipment Standards Assumptions

End Use	Technology	Moderate Scenario		Aggressive Scenario	
		Standard	Year Effective	Standard	Year Effective
Machine Drive	All Motors			Premium Efficiency	2018
HVAC	All Equipment			9% More Efficient	2018
Lighting	Screw/pin	Adv. Incandescent	2012	CFL	2018
	Linear Fluorescent	Super T8	2012		
	HID Lighting			25% More Efficient	2018

Color Key for References

Ka-Boom Report (ACEEE and ASAP)	EISA 2007 - Included in Baseline (EISA)	Waxman-Markey Bill (HR 2454)	GEP Assumption

APPENDIX B
OVERVIEW OF MODELING APPROACH

To perform this analysis, the Load Management Analysis and Planning tool (LoadMAP™), developed by Global Energy Partners, LLC, was utilized. LoadMAP was used for EPRI's 2009 "Assessment of Achievable Potential from Energy Efficiency and Demand Response Programs in the U.S. (2010-2030.)," as well as numerous utility studies of energy-efficiency and demand response potential. LoadMAP has the following key features:

- Embodies the basic principles of rigorous end-use models (such as EPRI's REEPS and COMMEND) but in a more simplified, accessible form.
- Includes stock-accounting algorithms which treat older, less efficient appliance/equipment stock separately from newer, more efficient equipment. Equipment is replaced according to the measure life defined by the user.
- Isolates new construction from existing equipment and buildings and treats purchase decisions for new construction, replacement upon failure, early replacement, and non-owner acquisition separately.
- Uses a simple logic for appliance and equipment decisions. Some models embody decision models based on efficiency choice algorithms or diffusion models. While these have some merit, the model parameters are difficult to estimate or observe and sometimes produce anomalous results that require calibration or even overriding. The outlined approach allows the user to drive the appliance and equipment choices year by year directly in the model. This flexible approach allows users to import the results from diffusion models or to input individual assumptions. The framework also facilitates sensitivity analysis.
- Includes appliance and equipment models customized by end use. For example, the logic for lighting equipment is distinct from refrigerators and freezers.
- Accommodates various levels of segmentation. Analysis can be performed at the sector level (e.g., total residential) or for customized segments within sectors (e.g., housing type or income level).

For this analysis, model inputs consistent with the AEO forecast were developed and the forecast results were calibrated to AEO forecast results. To assess the two codes and standards scenarios, model inputs were modified according to the details provided in Appendix A. Additional details are available from Global Energy Partners upon request.

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