Assessment of Electricity Savings in the U.S. Achievable through New Appliance/Equipment Efficiency Standards and Building Efficiency Codes (2010 - 2025)

IEE Whitepaper
May 2011

The EDISON FOUNDATION
INSTITUTE FOR Electric Efficiency

Advancing energy-efficiency and demand response among electric utilities.

Assessment of Electricity Savings in the U.S. Achievable through New Appliance/Equipment Efficiency Standards and Building Efficiency Codes (2010 – 2025)

IEE Whitepaper

May 2011

Prepared by

Ingrid Rohmund
Anthony Duer
Sharon Yoshida
Jan Borstein

Global Energy Partners, LLC

Lisa Wood
Adam Cooper

Institute for Electric Efficiency

TABLE OF CONTENTS

INTRODUCTION

Building codes and appliance standards are at the forefront of the energy agenda. Calendar year 2010 saw a flurry of activity in appliance and equipment standards, and a number of new appliance standards have gone through the rulemaking process and are now ―on the books.” Also, the American Council for an Energy-Efficient Economy (ACEEE), the Association of Home Appliance Manufacturers (AHAM), and the appliance manufacturers reached a consensus agreement, ***Energy Efficient and Smart Appliance Agreement of 2010***[1], that focused on six categories of residential white-goods appliances. While not yet ―official,” the agreement represents a firm commitment by the parties to increase efficiency of selected appliances.

This wave of activity has been incorporated into the Annual Energy Outlook (AEO), prepared each year by the Energy Information Administration (EIA). The 2011 Annual Energy Outlook includes an electricity forecast for the residential, commercial, and industrial sectors that is 3% lower in 2020 than the previous EIA forecast (AEO 2010)[2]. A major driver for the reduction in usage is the new set of standards, as well as the adoption of more stringent building codes.

This paper is an update to ***Assessment of Electricity Savings in the U.S. Achievable through New Appliance/Equipment Efficiency Standards and Building Efficiency Codes (2010-2020)***, released by IEE in December 2009. It uses the AEO 2011 forecast as the new baseline and takes a fresh look at what savings could be achieved through the adoption of new buildings codes and appliance and equipment efficiency standards beyond those embedded in the AEO baseline.[3] The results presented here provide insight into what level of energy efficiency can be achieved through codes and standards prior to the effects of utility demand-side management programs. Because this reduced, lower baseline will in turn impact utility program potentials, this analysis provides useful information for understanding the future DSM landscape.

---

[1] Agreement on Minimum Federal Efficiency Standards, Smart Appliances, Federal Incentives and Related Matters for Specified Appliances” Source: http://www.aham.org/ht/a/GetDocumentAction/i/49956

[2] AEO, available at http://www.eia.gov/forecasts/aeo/.

[3] See Appendix A for a comparison of AEO 2009, which was used for the December 2009 white paper, and AEO 2011.

Appliance and equipment efficiency standards entail mandated minimum efficiency levels for energy-using equipment, such as central air conditioners, lamps and ballasts, furnace fans, and residential white-goods appliances (e.g., refrigerators, dishwashers, clothes washers). Federal or state-level equipment standards result in lower consumption levels for all units purchased, both in new construction and existing buildings.

The results presented here quantify the impact of future building codes and appliance/equipment efficiency standards on electricity consumption in the United States. 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 that are adopted in a timely fashion 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 efficiency 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 efficiency codes and standards have two basic components: new building energy codes and new or expanded appliance and equipment efficiency standards. Because of the uncertainty inherent in the policy-making process, we developed two possible codes and standards scenarios for this paper — moderate and aggressive — intended to represent a range of possibilities in future legislative and regulatory actions surrounding codes and standards:

The two scenarios reflect the input of the authors as well as Steve Nadel from the American Council for an Energy-Efficient Economy (ACEEE) and Steve Rosenstock from the Edison Electric Institute (EEI).[4] The moderate scenario defines a plausible range of possible future outcomes that might even be considered ―likely.” It was developed by layering assumptions onto those embedded in the baseline forecast and by expanding the scope of appliances and equipment that codes and standards address. For example, the moderate scenario includes standards for commercial IT equipment, home electronics, furnace fans, and commercial refrigeration equipment. We say that this scenario can be considered ―likely” because it assumes standards

---

[4] Steve Nadel is the Executive Director of ACEEE. Steve Rosenstock is Manager, Energy Solutions at EEI.

requiring levels of efficiency that can be met by products already available in the marketplace, such as ENERGY STAR appliances. The aggressive scenario was developed by adding more aggressive efficiency assumptions onto those embedded in the moderate case. Some of the assumptions are quite aggressive and this scenario pushes the envelope. For example, the moderate case assumes that a new federal standard will raise the minimum SEER rating for a central air conditioner to 16, effective in 2022. Under the aggressive case, a new federal standard will raise the minimum SEER rating to 18, effective in 2022. The aggressive scenario also assumes a standard for residential and commercial general service lamps and linear tube lighting systems equivalent to 65 and 97 lumens per watt, respectively, that can be met by LED lighting systems currently available in the market. Tables B-2 to B-4 in Appendix B provide detailed assumptions for the residential, commercial, and industrial equipment and appliance standards assumed under the two scenarios in this paper.

For residential building codes in the moderate scenario, it is assumed that IECC 2012, with estimated energy savings of 25% compared to IECC 2006, goes into effect in 2016, and IECC 2015, with energy saving of 45%, goes into effect in 2019. The aggressive case uses the same assumptions as the moderate scenario until 2024, when it is assumed that a new code, with energy savings of 60%, goes into effect.[5] Again, the aggressive case pushes the envelope.

---

[5] DOE's multi-year program plan projects savings slightly higher savings than these values. Adjusted values were used in this analysis to model the imperfect implementation of the building codes. In addition, the authors recognize that issues related to code enforcement and code compliance can create a lag between when codes become effective and when the associated energy savings are actually realized. The scenarios do not explicitly take into account this lag in savings realization, which could be addressed via more aggressive local enforcement and/or utility programs to promote code compliance.

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 forecast for this analysis is the reference case from EIA’s Annual Energy Outlook 2011, April 2011 (AEO 2011)[6]. The forecast provides total U.S. electricity consumption from 2008 to 2035 and embodies the following factors:[7]

- Existing codes and standards as shown in Tables B-1 to B-4 in Appendix B.
    - 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)
    - Appliance and equipment standards approved in 2010.
- IECC 2009 and ASHRAE 90.1 2007 phased-in through 2018 and 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** and trends in appliance and equipment purchases in the forecast period; these impacts yield from:
    - Utility information and incentive programs,
    - State funding and regulatory mechanisms,
    - Funding for energy efficiency through the American Reinvestment and Recovery Act.

---

[6] AEO 2011 can be found at: http://www.eia.gov/forecasts/aeo/.

[7] With the exception of some technical data on unit efficiency as a function of standards (e.g., EISA 2007), all of these factors are implicit in the National Energy Modeling System (NEMS) modeling framework, which is used to develop the AEO. 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).

According to AEO 2011, electricity use across all sectors increases from 3,725 TWh in 2008 to 4,089 TWh in 2025, a change in consumption of 364 TWh (9.8% increase) over the 17-year period. This implies an annual growth rate of 0.55%. The baseline forecast is presented in Table 1, which shows sector-level results from Global Energy Partners' LoadMAP model, calibrated to the AEO 2011 at the aggregate level (See Appendix C for information on the study approach and the LoadMAP tool).

Table 1: Baseline Electricity Consumption by Sector, 2008, 2020, and 2025

Market Sector	2008 Usage (TWh)	Share of Total	2020 Usage (TWh)	Share of Total	2025 Usage (TWh)	Share of Total
Residential	1,380	37%	1,361	35%	1,426	35%
Commercial	1,336	36%	1,504	38%	1,596	39%
Industrial	1,009	27%	1,046	27%	1,066	26%
Total	3,725	100%	3,911	100%	4,089	100%

Source: LoadMAP model calibrated to AEO 2011 at aggregate level

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. In 2025, our results show significant savings from codes and standards ranging from 351 TWh (under the moderate scenario) to 556 TWh (under the aggressive scenario), which is equivalent to 8.6% and 13.6% of the baseline forecast, respectively. (See Table 2.) Note that standards dominate the savings, providing two-thirds of the total energy savings in the moderate scenario and roughly three-quarters of the total energy savings in the aggressive scenario.

Table 2: Summary of Codes and Standards Impacts in 2025: Residential, Commercial and Industrial Sectors

	Baseline Forecast (TWh)	**Moderate Scenario (TWh)**	**Aggressive Scenario (TWh)**
Electricity Use	**4,089**	3,738	3,533
Savings from Building Codes		123	129
Savings from Equipment Standards		228	427
Total Savings		**351**	**556**
Savings (% of Baseline)		8.6%	13.6%

In Figure 1, the bar chart represents the baseline forecast, which includes the impacts of existing codes and standards, naturally-occurring efficiency, and embedded energy efficiency. The lines represent the two codes and standards scenarios, which lead to a reduction in electricity consumption in 2025 to 3,738 TWh under the moderate scenario and a reduction to 3,533 TWh under the aggressive scenario. ***The moderate scenario offsets all the growth in the baseline forecast between 2008 and 2025. By 2025, the aggressive scenario results in a 5.2% decrease in electricity use compared to 2008.***

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

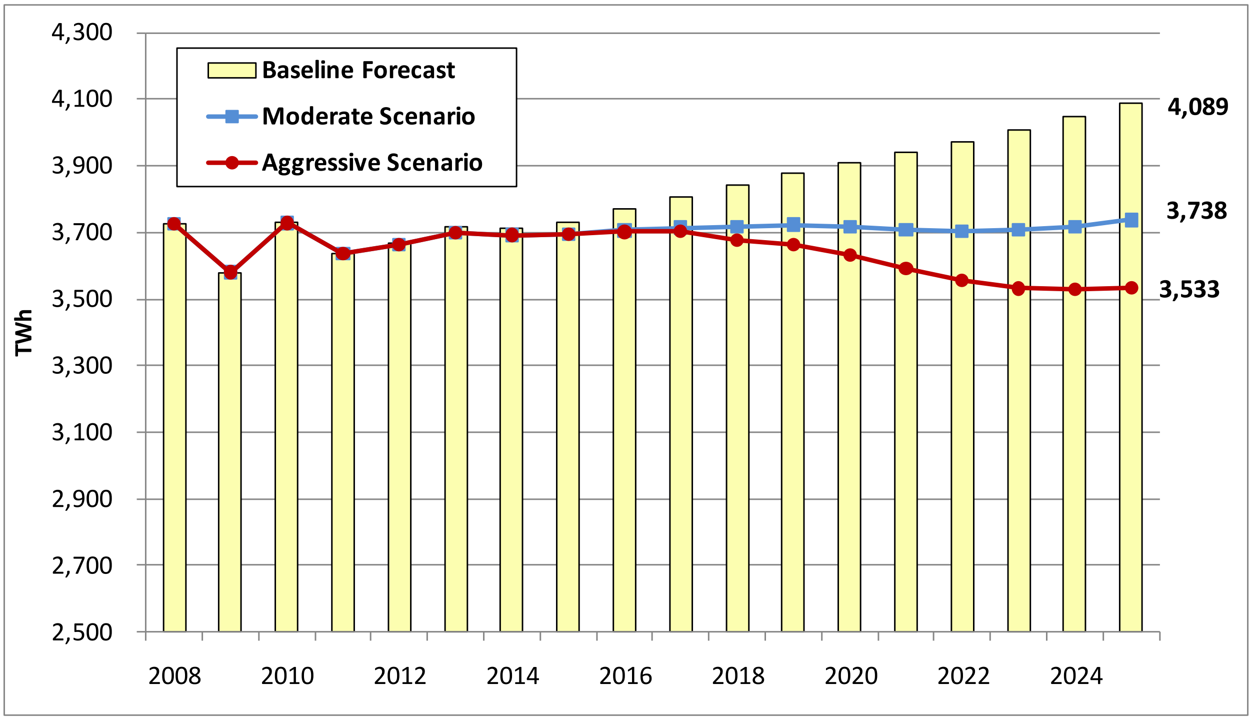


Figure 2 displays the energy consumption results under the baseline case and the two scenarios for each of the three market sectors: residential, commercial, and industrial. Figure 3 displays the allocation of the total savings by market sector in 2025. Under the moderate scenario, savings are split roughly equally between the residential and commercial sectors. In the aggressive scenario, the commercial sector dominates due to savings from commercial lighting and office equipment. In both scenarios, electricity savings in the industrial sector from codes and standards are modest, accounting for less than 20 percent of total savings. For decades, commercial lighting has been identified as a major opportunity for energy efficiency and large changes in lighting efficacy have already occurred. However, there is still significant savings potential in commercial lighting and the multiple standards for commercial lighting equipment, likely to be adopted by DOE, seek to realize these savings.

Figure 2: Electricity Consumption Forecast by Scenario and Sector in 2025 (TWh)

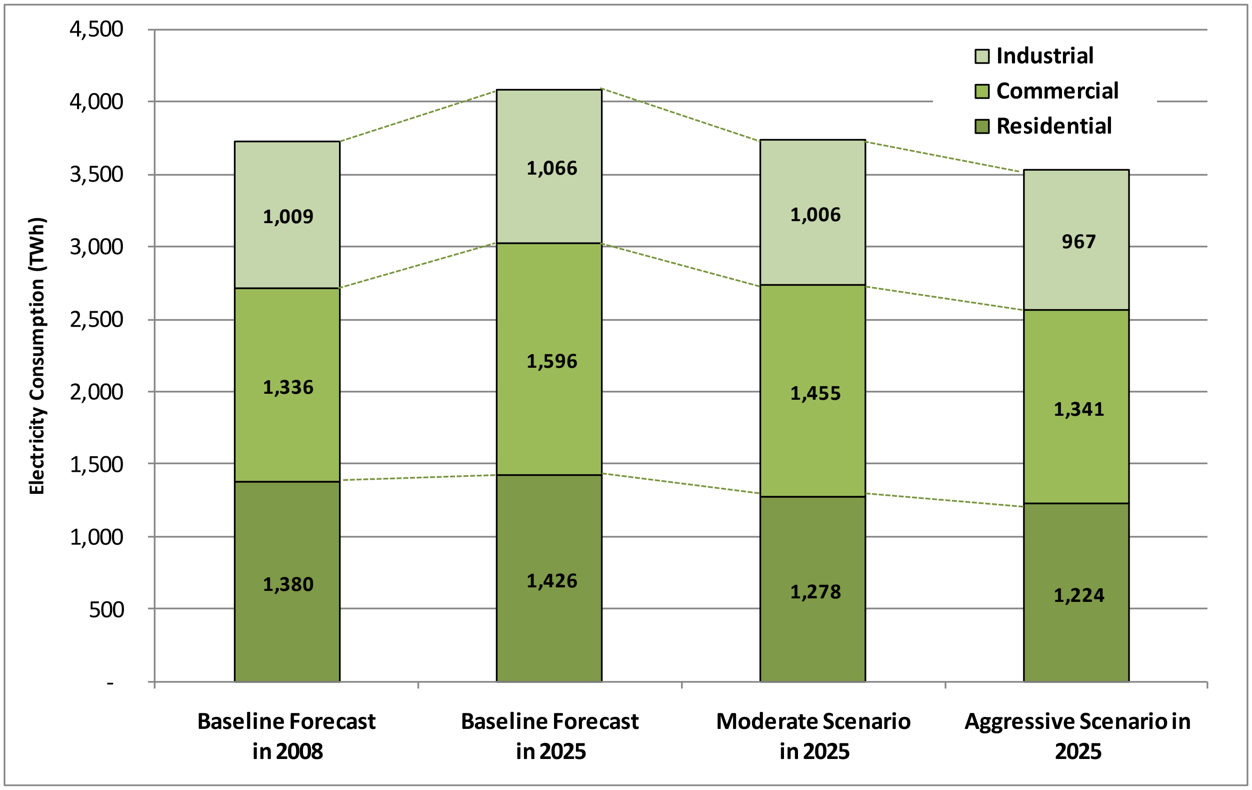


Figure 3: Electricity Savings by Scenario and Sector in 2025 (TWh)

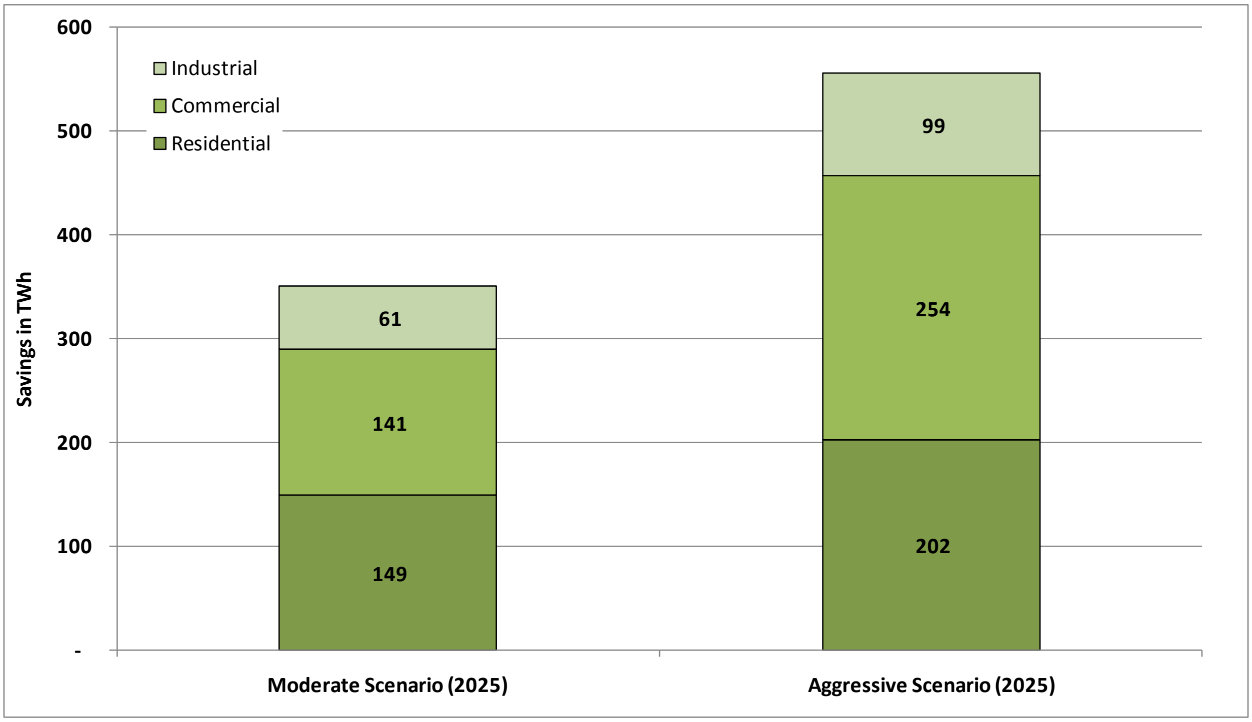


Figure 4 presents the savings for the end uses with the largest impacts in 2025. The prominence of commercial lighting in both scenarios is apparent. In the residential sector, savings from consumer electronics and lighting dominate both scenarios. In the industrial sector, savings from motors/machine drives dominate both scenarios. 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.

- In the commercial sector, lighting dominates savings potential due to the assumption that the system efficacy requirements under the moderate scenario will be 65 lumens per watt. This can be met using all ―Super T8s” in place of a combination of standard T8s and Super T8s that is present in the baseline forecast. In the aggressive scenario, the system efficacy requirement will increase to 97 lumens per Watt in 2018, which can be met by LED lamps.

- In the residential sector, electronics show the largest potential for energy savings. The moderate scenario for computers assumes a standard that requires a 40% savings in 2016, while the aggressive scenario assumes 50% savings, also in 2016. Color TVs are ripe for standards as well. In the moderate case, it is assumed that the Federal standard will align with the Tier 2 standard in California, requiring 50% savings in 2016. The aggressive scenario assumes a standard specification equivalent to 60% savings, also in 2016.

- Residential lighting, in the moderate case, is impacted by a new standard for general service lamps that requires a luminous efficacy of 50 lumens per watt (equivalent to current CFL lamps) in 2020. In the aggressive case, the 2020 standard calls for a minimum efficacy of 65 lumens per watt. As in the commercial sector, LED lamps meet this efficacy requirement.

- Commercial office equipment has sizeable efficiency potential. In the moderate scenario, the current ENERGY STAR equivalent efficiency is mandated for computers and servers by 2016. In the aggressive case, the mandated efficiency level is 15% better than ENERGY STAR, also in 2016.

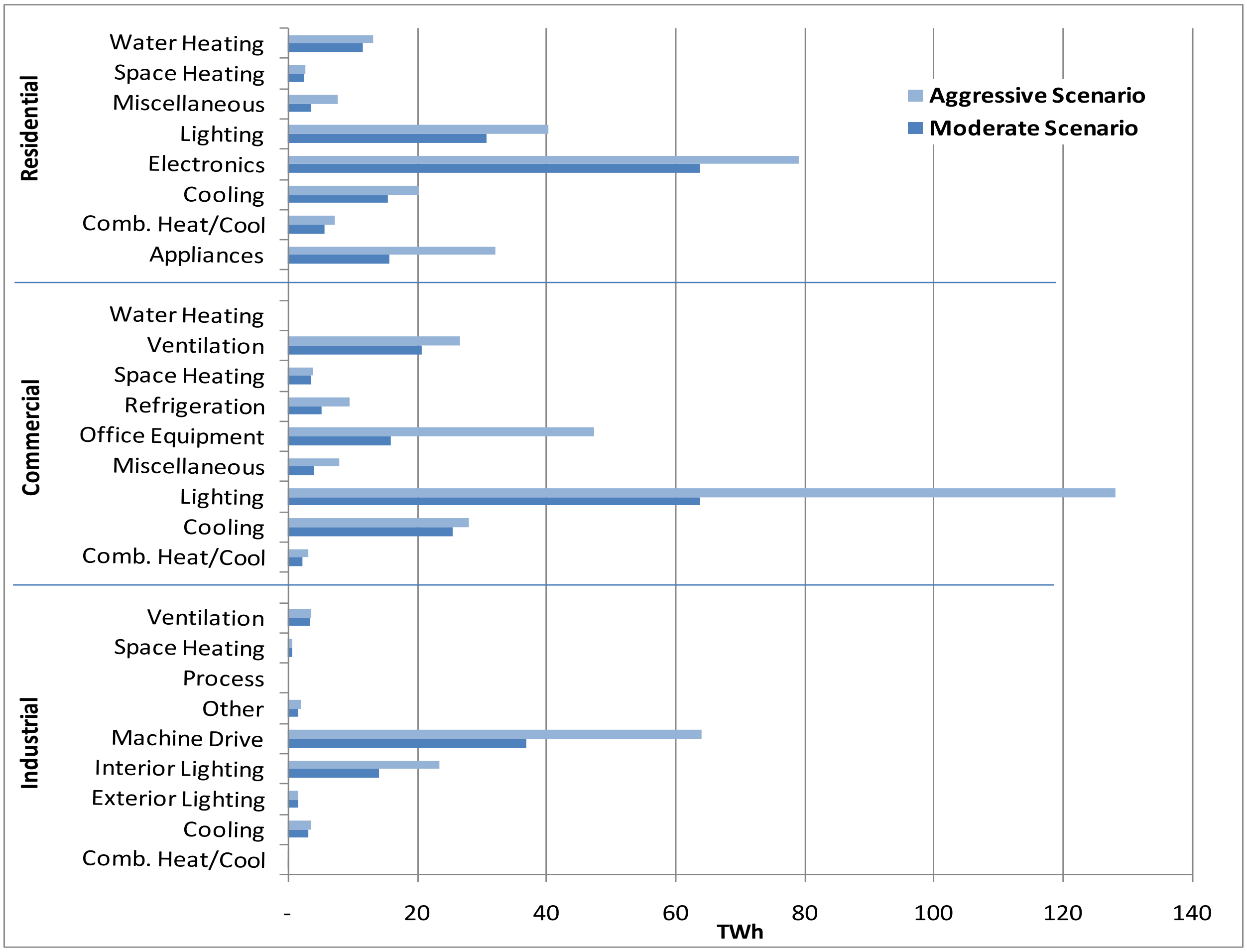
- Residential white-goods appliances continue to provide a significant opportunity for savings in spite of efficiency gains achieved by past standards.

- Commercial ventilation savings come from building codes, which are assumed to incorporate less energy-intensive air movement schemes into building design. Cooling savings also result from building codes and modest equipment standards.

- In the industrial sector, machine drives — primarily motors and air compressors — dominate potential energy savings as motors and air compressors transition to premium efficiency grade in the moderate case in 2015. The aggressive scenario tracks the moderate scenario until 2018 when super-premium grade becomes the standard. Lighting mirrors the requirements for fluorescent systems in the commercial sector and adds standards in 2015 and 2020 for HID lamps at 97 and 196 lumens per watt, respectively.

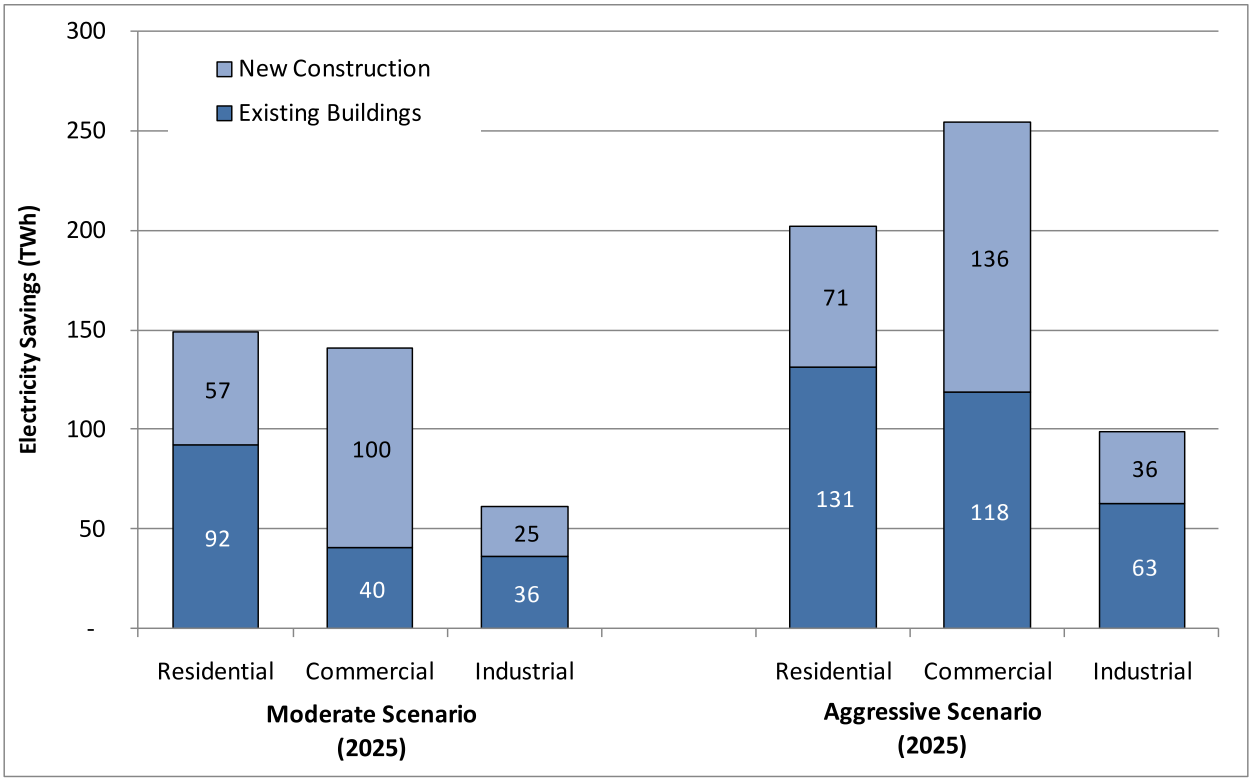
Table B-1 to Table B-4 in Appendix B provide details on the standards assumptions in the forecast.

Figure 4: Savings by End Use and Scenario in 2025 (TWh)



In Figure 5, we break out savings from codes and standards between new construction (post 2009) and existing buildings for each of the sectors and the two scenarios. As expected, residential and commercial buildings provide the largest savings, particularly in the new construction market where there is higher growth than in the industrial sector. Because the existing stock of homes and buildings is larger than the new construction market and because building codes affect new construction primarily, we expect the savings in existing buildings to be larger than in new construction. This holds true across the sectors and scenarios, except for the commercial sector in the moderate scenario, because the building codes in this scenario are relatively stronger than the appliance standards.

Figure 5: Electricity Savings by Building Vintage and Sector in 2025



RESULTS BY SECTOR

RESIDENTIAL SECTOR

The impacts of future codes and standards in the residential sector are presented in Table 3. Under the moderate scenario, new electronics standards are responsible for the largest impact, at 64 TWh by 2025. Lighting is second due to the additional standards for incandescent (general service), reflector, and linear fluorescent lamps that push the baseline technology for general service and fluorescent lamps to a system efficiency of 50 and 65 lumens per watt, respectively, after 2020. For the aggressive scenario, the relative results are the same: electronics show the largest savings followed by lighting.

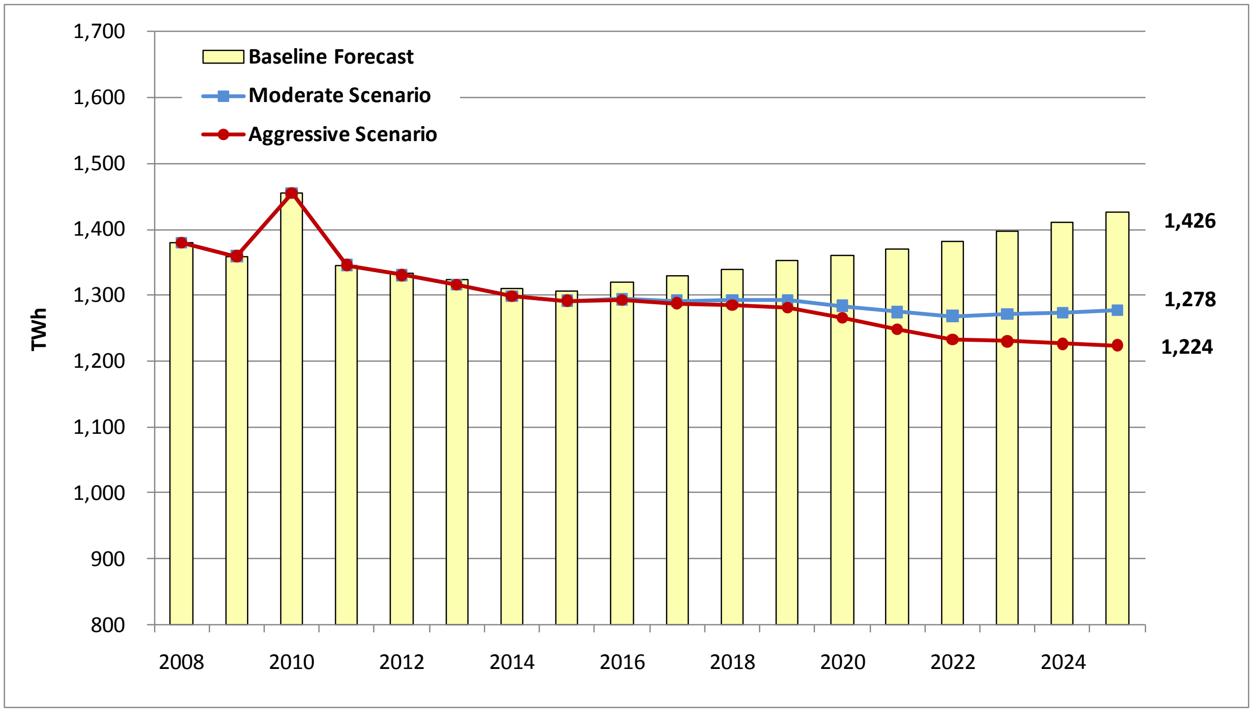
In the baseline forecast, residential usage is projected to increase by only 3% between 2008 and 2025. ***As shown in Figure 6, the moderate scenario reduces usage in absolute terms by 7% relative to 2008, while the aggressive scenario reduces usage by 11% relative to the 2008 baseline residential energy consumption of 1,380 TWh.***

Table 3: Residential Sector — Savings by End Use and Scenario in 2025

End Use	Baseline Forecast (TWh)	Moderate Scenario		Aggressive Scenario	
		Savings (TWh)	Savings (%)	Savings (TWh)	Savings (%)
Appliances	268	16	6%	32	12%
Combined Heating/Cooling	83	6	7%	7	9%
Cooling	205	15	8%	20	10%
Electronics*	201	64	32%	79	39%
Lighting	129	31	24%	40	31%
Miscellaneous*	338	4	1%	8	2%
Space Heating	52	2	5%	3	5%
Water Heating	150	12	8%	13	9%
Residential Total	**1,426**	**149**	**10%**	**202**	**14%**

* Electronics and miscellaneous end uses are currently not subject to any standards.

Figure 6: Residential Sector — Impact of Codes and Standards on Electricity Consumption (TWh)



Commercial Sector

Under the moderate scenario, electricity savings in the commercial sector are substantial, both in absolute terms (141 TWh) and as a percentage of the baseline forecast (9%). This is largely due to the assumed standards in the area of commercial lighting, contributing 64 of the total 141 TWh of savings in this scenario. Lighting savings grow significantly, from 64 to 128 TWh as aggressive standards, equivalent to LED lamps, are incorporated. 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.

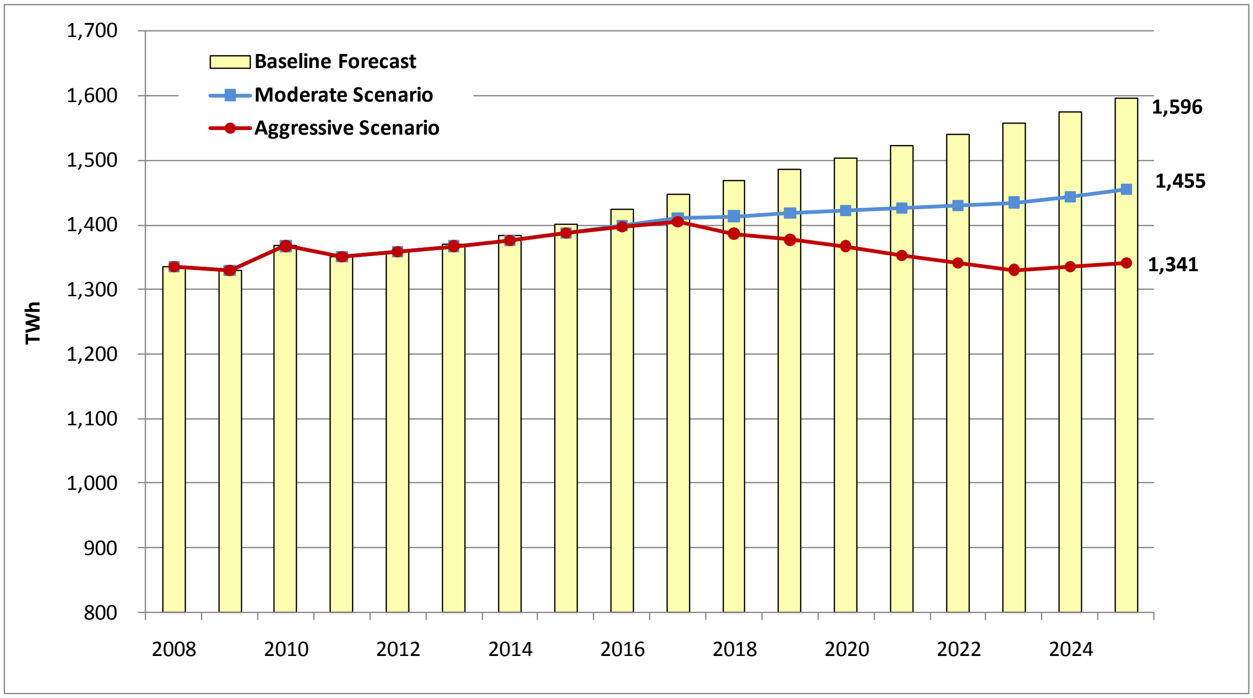
The commercial sector baseline forecast shows the largest increase of the three sectors. In absolute terms, usage increases by 19.5% between 2008 and 2025. ***As shown in Figure 7, the impact of the moderate scenario reduces the growth rate in the forecast substantially so that usage increases by just 9% over the 17-year horizon relative to the 2008 baseline commercial electricity consumption of 1,336 TWh. The aggressive scenario results in usage in 2025 that is about the same as it was in 2008.***

Table 4: Commercial Sector – Savings by End Use and Scenario in 2025

End Use	Baseline Forecast (TWh)	Moderate Scenario		Aggressive Scenario	
		Savings (TWh)	Savings (%)	Savings (TWh)	Savings (%)
Combined Heating/Cooling	17	2	13%	3	18%
Cooling	145	26	18%	28	19%
Lighting	327	64	19%	128	39%
Miscellaneous	575	4	1%	8	1%
Office Equipment*	179	16	9%	47	26%
Refrigeration	103	5	5%	9	9%
Space Heating	46	3	8%	4	8%
Ventilation	175	21	12%	27	15%
Water Heating	27	-	0%	-	0%
Commercial Total	**1,596**	**141**	**9%**	**254**	**17%**

* Office equipment is currently not subject to any standards.

Figure 7: Commercial Sector – Impact of Codes and Standards on Electricity Consumption (TWh)



INDUSTRIAL SECTOR

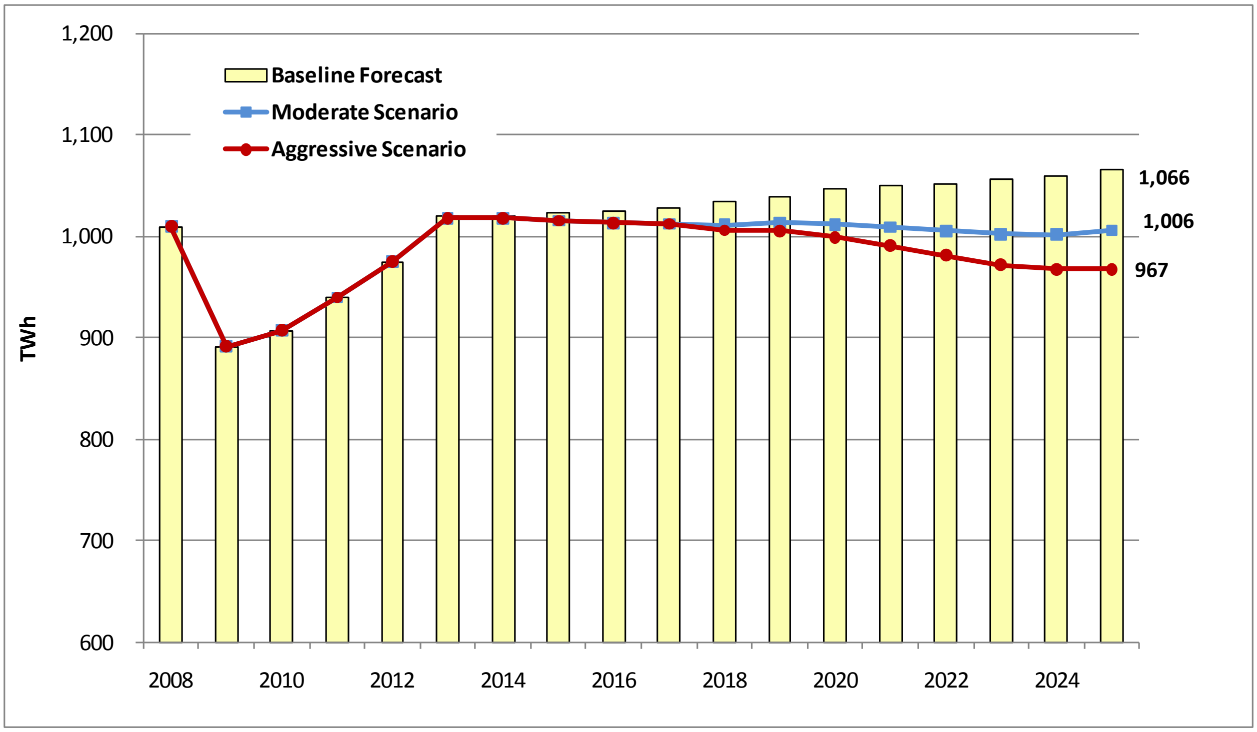
Electricity consumption in the industrial sector is related more to end-use process equipment than to the building envelope and construction as overall building energy use is dominated by machine drive (primarily motors and air compressors) and process equipment. Therefore, the impact of aggressive building energy codes is very limited. However, building codes are a factor and are captured in the HVAC and lighting impacts shown in Table 5. In addition, both scenarios assume improvements in motor efficiency, which contributes approximately 37 TWh to the industrial impact in the moderate scenario and 64 TWh in the aggressive scenario. While the improvement in efficiency is often only a few percent, the abundance of machine drives in industrial applications leads to significant savings from this standard. This is especially evident in the aggressive scenario which is represented by both premium efficiency and super-premium efficiency motors as opposed to the NEMA standards.

Table 5: Industrial Sector – Savings by End Use and Scenario in 2025

End Use	Baseline Usage	Moderate Scenario		Aggressive Scenario	
	(TWh)	Savings (TWh)	Savings (%)	Savings (TWh)	Savings (%)
HVAC	105	7	7%	8	8%
Interior Lighting	72	14	19%	23	33%
Machine Drives (Motors)	518	37	7%	64	12%
Process	291	0	0%	0	0%
Other	81	3	4%	4	4%
Industrial Total	**1,066**	**61**	**6%**	**99**	**9%**

Figure 8 shows that the baseline forecast in the industrial sector increases 6% over the 17-year horizon. ***The moderate scenario results in zero growth between 2008 and 2025, while the aggressive scenario reduces usage by 4% relative to the 2008 baseline industrial electricity consumption of 1,009 TWh.***

Figure 8: Industrial Sector — Impact of Codes and Standards on Electricity Consumption (TWh)



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. Depending on the specific codes and standards adopted, under an aggressive scenario, electricity savings could be as high as 14% (i.e., 556 TWh) of the baseline electricity forecast in 2025. The more likely moderate scenario anticipates savings of 9% in 2025 (i.e., 351 TWh). ***Savings of this magnitude will completely offset the anticipated growth in demand in the residential, commercial, and industrial sectors combined, eliminating the need for additional power plants to serve these sectors.***

For utility programs, changes in efficiency standards and building codes may make it increasingly challenging to achieve energy savings through traditional energy efficiency programs, particularly those that target individual appliances and equipment. In essence, new codes and standards reap some of the "low-hanging fruit" and lower the baseline against which savings are measured. In response, utility programs may need to turn to measures with higher costs per kWh of energy or kW of demand shifted/saved. For example, opportunities in the retrofit building market continue in the forecast because building codes do not address existing facilities unless buildings are considerably renovated. However, the retrofit building market is currently the most difficult segment to engage so this will be a challenge. On the other hand, as the importance of codes and standards grows, utilities may find new opportunities to partner with local governments and trade allies to increase understanding of and enforcement of the more rigorous and complex building codes. In addition, utilities may be able to work with manufacturers on new standards. As utilities engage proactively in the codes and standards process, they may also be able to ―gain credit" for some of the savings from codes and standards in meeting their efficiency goals, creating a win-win situation. In fact, some states have already set up approaches for integrating codes and standards with utility energy efficiency programs. [8]

---

[8] For additional information on this topic, please see IEE whitepaper, ―Crediting Energy Savings from Utility Sponsored Codes and Standards Programs" (Forthcoming, May 2011).

APPENDIX A
COMPARISON OF AEO 2009 AND AEO 2011

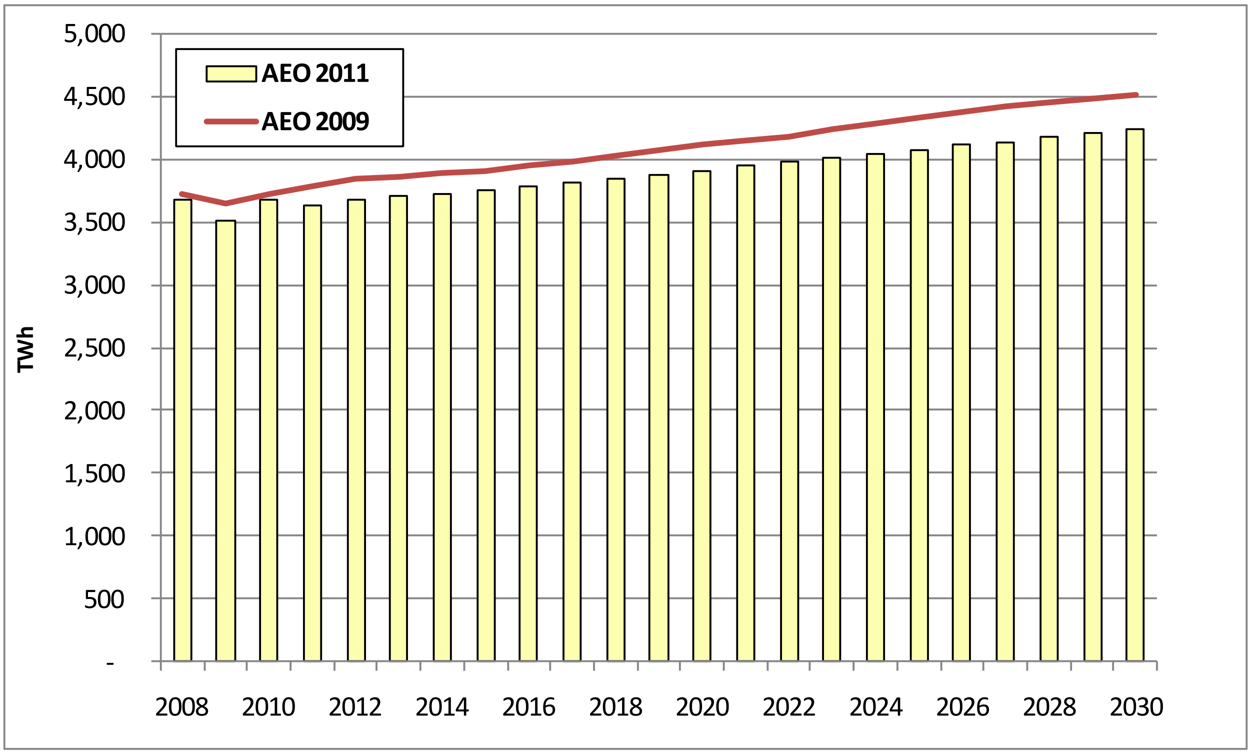
Table A-1 and Figure A-1 compare AEO 2009 forecast, used for the 2009 IEE White Paper, and AEO 2011, used in this paper. In 2030, the AEO 2011 forecast is 5% lower than the 2009 forecast. The AEO 2011 forecast includes:

- The assumed standards for six categories of residential white-goods appliances from the consensus agreement reached by the American Council for an Energy-Efficient Economy (ACEEE), the Association of Home Appliance Manufacturers (AHAM), and the appliance manufacturers in the fall of 2010
- Residential central air conditioning standard equivalent to SEER 14 beginning in 2015
- Room air conditioning standard equivalent to EER 11.0 beginning in 2014

Table A-1: Comparison of Annual Energy Outlook Forecasts for Residential, Commercial, and Industrial Sectors (TWh)

Year	AEO 2009	AEO 2011	Difference
2008	3,717	3,724	-0.2%
2010	3,730	3,741	-0.3%
2015	3,912	3,793	3.0%
2020	4,116	3,958	3.8%
2025	4,335	4,122	4.9%
2030	4,511	4,291	4.9%
% Increase (2008-2030)	21%	15%	
Average annual growth rate	0.9%	0.6%	

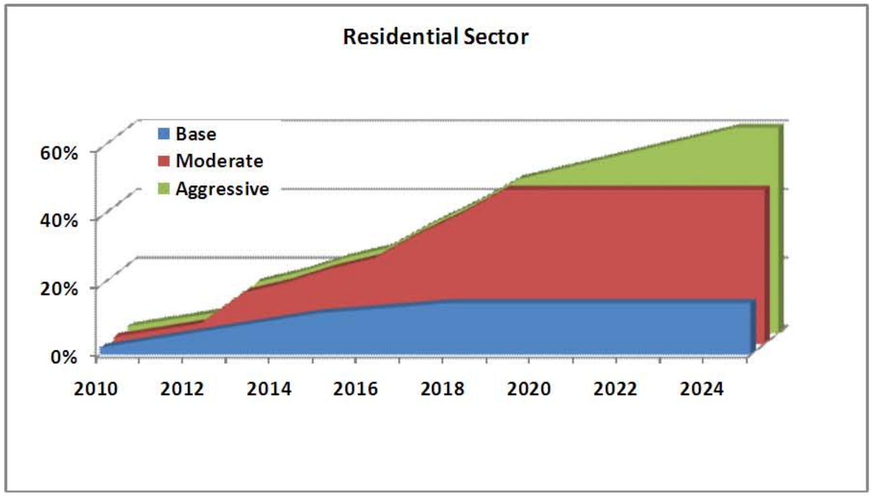
Figure A-1: AEO 2009 and AEO 2011 Forecasts for the Residential, Commercial and Industrial Sectors

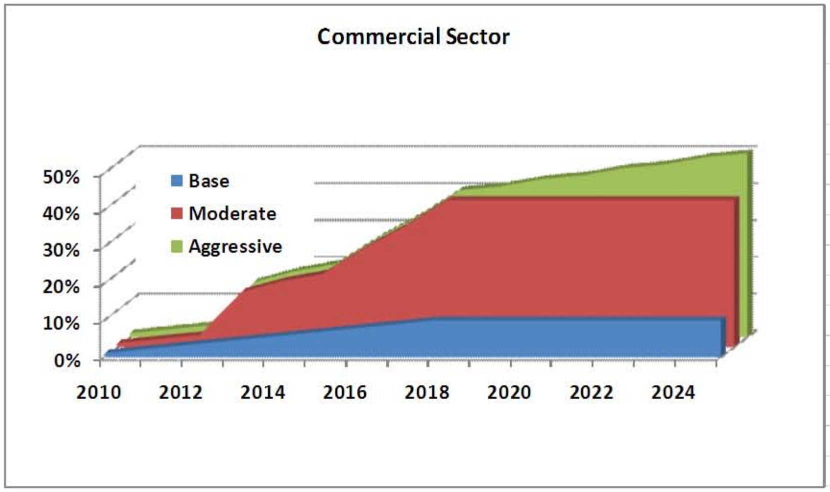


APPENDIX B
ASSUMPTIONS ABOUT BUILDING CODES AND APPLIANCE STANDARDS

The tables in Appendix B provide detail on the codes and standards assumed under the moderate and aggressive codes and standards scenarios. Table B-1 presents the building code assumptions by sector. Table B-2 through Table B-4 provides detailed assumptions about the appliance and equipment standards under the two scenarios.

Table B-1: Assumed Savings by Sector – Building Code Assumptions





Residential	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Base Case	IECC 2006/IECC 2009 (15% phased-in)								IECC 2009 (15% savings)							
Moderate Case	IECC 2006			IECC 2009 (15%)			IECC 2012 (25%)			IECC 2015 (45%)						
Aggressive Case	IECC 2006			IECC 2009 (15%)			IECC 2012 (25%)			IECC 2015 (45%)					60% Savings	

Commercial	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Base Case	2004 ASHRAE 90.1/2007 ASHRAE 90.1 (10% phased-in)								2007 ASHRAE 90.1 (10%)							
Moderate Case	2004 ASHRAE 90.1			2007 ASHRAE (15%)		2010 ASHRAE 90.1 (20%)			2013 ASHRAE 90.1 (40%)							
Aggressive Case	2004 ASHRAE 90.1			2007 ASHRAE (15%)		2010 ASHRAE 90.1 (20%)			2013 ASHRAE 90.1 (40%)							50% Savings

Table B-2: Assumed Savings by Sector and End Use — Building Code Assumptions

Residential Sector

End Uses	Scenario	Code	Savings %	Effective Date
Cooling, Space Heating, Water Heating, Lighting	Base Case	IECC 2006/IECC 2009	15% by 2017	2018
		IECC 2009	15%	2018
	Moderate Case	IECC 2009	15%	2013
		IECC 2012	25%	2016
		IECC 2015	45%	2019
	Aggressive Case	IECC 2009	15%	2013
		IECC 2012	25%	2016
		IECC 2015	45%	2019
		NA	60%	2024

Commercial Sector

End Uses	Scenario	Code	Savings %	Effective Date
Cooling, Space Heating, Ventilation, Water Heating, Lighting	Base Case	2004/2007 ASHRAE 90.1	10% by 2018	2018
		2007 ASHRAE 90.1	10%	2018
	Moderate Case	2007 ASHRAE 90.1	15%	2013
		2010 ASHRAE 90.1	20%	2015
		2013 ASHRAE 90.1	40%	2018
	Aggressive Case	2007 ASHRAE 90.1	15%	2013
		2010 ASHRAE 90.1	20%	2015
		2013 ASHRAE 90.1	40%	2018
		NA	50%	2025

Table B-3: Residential Appliance and Equipment Standards Assumptions

Base level
1st Standard (relative to Base)
2nd Standard (relative to Base)
3rd Standard (relative to Base)
4th Standard (relative to Base)

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Central AC	Baseline	SEER 13					SEER 14										
	Moderate	SEER 13					SEER 14							SEER 16			
	Aggressive	SEER 13					SEER 14							SEER 18			
Room AC	Baseline	EER 9.8				EER 11.0											
	Moderate	EER 9.8				EER 11.0								EER 12.0			
	Aggressive	EER 9.8				EER 11.0								EER 12.5			
Heat Pump	Baseline	SEER 13.0/HSPF 7.7					SEER 14.0/HSPF 8.0										
	Moderate	SEER 13.0/HSPF 7.7					SEER 14.0/HSPF 8.0					SEER 15.0/HSPF 8.2					
	Aggressive	SEER 13.0/HSPF 7.7					SEER 14.0/HSPF 8.0					SEER 16.0/HSPF 8.5					
Water Heater (<=55 gallons)	Baseline	EF 0.90					EF 0.95										
	Moderate	EF 0.90					EF 0.95							EF 0.96			
	Aggressive	EF 0.90					EF 0.95				EF 0.97						
Water Heater (>55 gallons)	Baseline	EF 0.90					Heat Pump Water Heater										
	Moderate	EF 0.90					Heat Pump Water Heater										
	Aggressive	EF 0.90					Heat Pump Water Heater										
Incandescent Lamps	Baseline	Incandescent				Advanced Incandescent - tier 1 (20 lumens/watt)						Advanced Incandescent - tier 2 (45 lumens/watt)					
	Moderate	Incandescent				Advanced Incandescent - tier 1 (20 lumens/watt)						Advanced Incandescent - tier 3 (50 lumens/watt)					
	Aggressive	Incandescent				Advanced Incandescent - tier 1 (20 lumens/watt)						65 lumens/watt (equivalent to current CFLs)					
Reflector Lamps	Baseline	Incandescent (9.5 watts/lumen)															
	Moderate	Incandescent		Advanced Incandescent (13 lumens/watt)								45 lumens/watt					
	Aggressive	Incandescent		Advanced Incandescent (13 lumens/watt)								70 lumens/watt					
Linear Fluorescent	Baseline	T8															
	Moderate	T8								65 lumens/watt (can be met with Super T-8 lamps)							
	Aggressive	T8								97 lumens/watt (equivalent to next-generation LED)							
Refrigerator	Baseline	NAECA Standard				25% savings											
	Moderate	NAECA Standard				25% savings						30% savings					
	Aggressive	NAECA Standard				25% savings						40% savings					
Freezer	Baseline	NAECA Standard				25% savings											
	Moderate	NAECA Standard				25% savings						30% savings					
	Aggressive	NAECA Standard				25% savings						40% savings					

Table B-3: Residential Appliance and Equipment Standards Assumptions (cont.)

▧	Today's Efficiency or Standard Assumption
▧	1st Standard (relative to Base)
▧	2nd Standard (relative to Base)
▧	3rd Standard (relative to Base)
▧	4th Standard (relative to Base)

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Dishwasher	Baseline	**355 kWh/yr**			**307 kWh/yr (14% savings)**												
	Moderate	**355 kWh/yr**			**307 kWh/yr (14% savings)**					**280 kWh/yr**							
	Aggressive	**355 kWh/yr**			**307 kWh/yr (14% savings)**					**280 kWh/yr**							
Clothes Washer	Baseline	**MEF 1.26 for top loader**					**MEF 1.72**			**MEF 2.0**							
	Moderate	**MEF 1.26 for top loader**					**MEF 1.72**			**MEF 2.4**							
	Aggressive	**MEF 1.26 for top loader**					**MEF 1.72**			**MEF 2.8**							
Clothes Dryer	Baseline	**EF 3.01**					**EF 3.17**										
	Moderate	**EF 3.01**					**EF 3.17**						**15% savings**				
	Aggressive	**EF 3.01**					**EF 3.17**						**Heat Pump Clothes Dryer**				
Range/Oven	Baseline	**Conventional**															
	Moderate	**Conventional**										**13% savings**					
	Aggressive	**Conventional**										**Induction, Halogen Burners**					
Microwave	Baseline	**Conventional**															
	Moderate	**Conventional**								**Reduced Standby Power**							
	Aggressive	**Conventional**								**Reduced Standby Power + 15% savings**							
Computer	Baseline	**Conventional/Energy Star**															
	Moderate	**Conventional/Energy Star**						**40% savings**									
	Aggressive	**Conventional/Energy Star**						**50% savings**									
Color TV	Baseline	**Conventional/Energy Star**															
	Moderate	**Conventional/Energy Star**						**50% savings (CA Tier 2 Standard)**									
	Aggressive	**Conventional/Energy Star**						**60% savings (new Energy Star)**									
Set-Top Boxes	Baseline	**Conventional**															
	Moderate	**Conventional**							**15% savings**								
	Aggressive	**Conventional**							**30% savings**								
External Power Supply	Baseline	**2008 Standard per EISA 2007**															
	Moderate	**2008 Standard per EISA 2007**			**30% savings**												
	Aggressive	**2008 Standard per EISA 2007**			**30% savings**				**40% savings**								
Battery Charger	Baseline	**Conventional**															
	Moderate	**Conventional**				**30% savings**											
	Aggressive	**Conventional**				**30% savings**				**40% savings**							
Furnace Fan	Baseline	**Conventional**															
	Moderate	**Conventional**						**20% savings**									
	Aggressive	**Conventional**						**30% savings**					**40% savings**				

Table B-4: Commercial Appliance and Equipment Standards Assumptions

⬜ Base level
🟦 1st Standard (relative to Base)
🟫 2nd Standard (relative to Base)
🟩 3rd Standard (relative to Base)
🟧 4th Standard (relative to Base)

<table>
<tr><th></th><th></th><th>2010</th><th>2011</th><th>2012</th><th>2013</th><th>2014</th><th>2015</th><th>2016</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th></tr>
<tr><td rowspan="3">Central Chiller</td><td>Baseline</td><td colspan="16">2007 ASHRAE 90.1</td></tr>
<tr><td>Moderate</td><td colspan="3">2007 ASHRAE 90.1</td><td colspan="13">5% savings</td></tr>
<tr><td>Aggressive</td><td colspan="3">2007 ASHRAE 90.1</td><td colspan="5">5% savings</td><td colspan="8">10% savings</td></tr>
<tr><td rowspan="3">Packaged Terminal AC/HP</td><td>Baseline</td><td colspan="2">EPACT 1992 Std</td><td colspan="14">EER 11.0/11.2</td></tr>
<tr><td>Moderate</td><td colspan="2">EPACT 1992 Std</td><td colspan="7">EER 11.0/11.2</td><td colspan="7">EER 11.8</td></tr>
<tr><td>Aggressive</td><td colspan="2">EPACT 1992 Std</td><td colspan="7">EER 11.0/11.2</td><td colspan="7">EER 12.5</td></tr>
<tr><td rowspan="3">Roof Top Units</td><td>Baseline</td><td colspan="16">EER 11.0/11.2</td></tr>
<tr><td>Moderate</td><td colspan="8">EER 11.0/11.2</td><td colspan="8">EER 11.8</td></tr>
<tr><td>Aggressive</td><td colspan="8">EER 11.0/11.2</td><td colspan="8">EER 12.5</td></tr>
<tr><td rowspan="3">Room AC</td><td>Baseline</td><td colspan="4">EER 9.8</td><td colspan="12">EER 11.0</td></tr>
<tr><td>Moderate</td><td colspan="4">EER 9.8</td><td colspan="8">EER 11.0</td><td colspan="4">EER 12.0</td></tr>
<tr><td>Aggressive</td><td colspan="4">EER 9.8</td><td colspan="8">EER 11.0</td><td colspan="4">EER 12.5</td></tr>
<tr><td rowspan="3">Heat Pump</td><td>Baseline</td><td colspan="16">EER 11.0/COP 3.3</td></tr>
<tr><td>Moderate</td><td colspan="8">EER 11.0/COP 3.3</td><td colspan="8">EER 11.5/COP 3.4</td></tr>
<tr><td>Aggressive</td><td colspan="8">EER 11.0/COP 3.3</td><td colspan="8">EER 13.0/COP 3.6</td></tr>
<tr><td rowspan="3">Air Handling System</td><td>Baseline</td><td colspan="16">Constant Air Volume/Variable Air Volume</td></tr>
<tr><td>Moderate</td><td colspan="16">Constant Air Volume/Variable Air Volume</td></tr>
<tr><td>Aggressive</td><td colspan="8">Constant Air Volume/Variable Air Volume</td><td colspan="8">Variable Air Volume</td></tr>
<tr><td rowspan="3">Incandescent Lamps</td><td>Baseline</td><td colspan="3">Adv Incand - tier 1</td><td colspan="13">Advanced Incandescent - tier 2 (45 lumens/watt)</td></tr>
<tr><td>Moderate</td><td colspan="3">Adv Incand - tier 1</td><td colspan="7">Advanced Incandescent - tier 2 (45 lumens/watt)</td><td colspan="6">Advanced Incandescent - tier 3 (50 lumens/watt)</td></tr>
<tr><td>Aggressive</td><td colspan="3">Adv Incand - tier 1</td><td colspan="7">Advanced Incandescent - tier 2 (45 lumens/watt)</td><td colspan="6">65 lumens/watt (equivalent to current CFLs)</td></tr>
<tr><td rowspan="3">Reflector Lamps</td><td>Baseline</td><td colspan="16">Halogen (14.6 lumens/watt)</td></tr>
<tr><td>Moderate</td><td colspan="2">Halogen (14.6 LPW)</td><td colspan="8">Advanced Halogen (18 lumens/watt)</td><td colspan="6">45 lumens/watt</td></tr>
<tr><td>Aggressive</td><td colspan="2">Halogen (14.6 LPW)</td><td colspan="8">Advanced Halogen (18 lumens/watt)</td><td colspan="6">67 lumens/watt</td></tr>
<tr><td rowspan="3">Linear Fluorescent</td><td>Baseline</td><td colspan="16">T8 /Super T8</td></tr>
<tr><td>Moderate</td><td colspan="8">T8</td><td colspan="8">65 lumens/watt (can be met using Super T-8 lamps)</td></tr>
<tr><td>Aggressive</td><td colspan="8">T8</td><td colspan="8">97 lumens/watt (next generation of LED lamps)</td></tr>
<tr><td rowspan="3">High Intensity Discharge</td><td>Baseline</td><td colspan="16">75 lumens/watt</td></tr>
<tr><td>Moderate</td><td colspan="5">75 lumens/watt</td><td colspan="5">97 lumens/watt</td><td colspan="6">196 lumens/watt</td></tr>
<tr><td>Aggressive</td><td colspan="5">75 lumens/watt</td><td colspan="5">97 lumens/watt</td><td colspan="6">196 lumens/watt</td></tr>
<tr><td rowspan="3">Computer</td><td>Baseline</td><td colspan="16">Conventional/Energy Star</td></tr>
<tr><td>Moderate</td><td colspan="6">Conventional/Energy Star</td><td colspan="10">40% savings</td></tr>
<tr><td>Aggressive</td><td colspan="6">Conventional/Energy Star</td><td colspan="10">50% savings</td></tr>
</table>

Table B-4: Commercial Appliance and Equipment Standards Assumptions (cont.)

Today's Efficiency or Standard Assumption
1st Standard (relative to Base)
2nd Standard (relative to Base)
3rd Standard (relative to Base)
4th Standard (relative to Base)

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Server	Baseline	Conventional															
	Moderate	Conventional						Energy Star									
	Aggressive	Conventional						Energy Star + 15% savings									
Monitor	Baseline	Conventional															
	Moderate	Conventional															
	Aggressive	Conventional								Energy Star							
Printer/Copier	Baseline	Conventional															
	Moderate	Conventional															
	Aggressive	Conventional								Energy Star							
Walk-in	Baseline	EISA 2007 Standard															
	Moderate	EISA 2007 Standard					15% savings										
	Aggressive	EISA 2007 Standard					15% savings								20% savings		
Reach-in	Baseline	EPACT 2005 Standard															
	Moderate	EPACT 2005 Standard						15% savings									
	Aggressive	EPACT 2005 Standard						15% savings		20% savings							
Supermarket and	Baseline	EPACT 2005 Std		25% savings													
	Moderate	EPACT 2005 Std		25% savings						30% savings							
	Aggressive	EPACT 2005 Std		25% savings				40% savings									
Vending Machines	Baseline	EPACT 2005 Std		50% savings													
	Moderate	EPACT 2005 Std		50% savings													
	Aggressive	EPACT 2005 Std		50% savings						55% savings							
Icemaker	Baseline	2010 Standard															
	Moderate	2010 Standard						15% savings									
	Aggressive	2010 Standard						15% savings									25% sav
Low-V Transformers	Baseline	NEMA 2007 Standard															
	Moderate	NEMA 2007 Standard						98.4% Efficiency									
	Aggressive	NEMA 2007 Standard						98.4% Efficiency						98.6% Efficiency			
Small Motors	Baseline	62.3% Efficiency					70% Efficiency										
	Moderate	62.3% Efficiency					70% Efficiency										
	Aggressive	62.3% Efficiency					70% Efficiency							80% Efficiency			
Commerial Laundry	Baseline	MEF 1.26			MEF 1.6												
	Moderate	MEF 1.26			MEF 1.6												
	Aggressive	MEF 1.26			MEF 1.6					MEF 2.4							

Table B-5: Industrial Appliance and Equipment Standards Assumptions

Base level
1st Standard (relative to Base)
2nd Standard (relative to Base)
3rd Standard (relative to Base)
4th Standard (relative to Base)

<table>
<tr><th></th><th></th><th>2010</th><th>2011</th><th>2012</th><th>2013</th><th>2014</th><th>2015</th><th>2016</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th></tr>
<tr><td rowspan="3">Motors</td><td>Baseline</td><td colspan="16">EISA 2007 Standards</td></tr>
<tr><td>Moderate</td><td colspan="5">EISA 2007 Standards</td><td colspan="11">Premium Efficiency</td></tr>
<tr><td>Aggressive</td><td colspan="5">EISA 2007 Standards</td><td colspan="3">Premium Efficiency</td><td colspan="8">Super Premium Efficiency</td></tr>
<tr><td rowspan="3">Central Chiller</td><td>Baseline</td><td colspan="16">2007 ASHRAE 90.1</td></tr>
<tr><td>Moderate</td><td colspan="3">2007 ASHRAE 90.1</td><td colspan="13">5% savings</td></tr>
<tr><td>Aggressive</td><td colspan="3">2007 ASHRAE 90.1</td><td colspan="5">5% savings</td><td colspan="8">10% savings</td></tr>
<tr><td rowspan="3">Packaged Terminal AC/HP</td><td>Baseline</td><td colspan="2">EPACT 1992 Std</td><td colspan="14">EER 11.0/11.2</td></tr>
<tr><td>Moderate</td><td colspan="2">EPACT 1992 Std</td><td colspan="7">EER 11.0/11.2</td><td colspan="7">EER 11.8</td></tr>
<tr><td>Aggressive</td><td colspan="2">EPACT 1992 Std</td><td colspan="7">EER 11.0/11.2</td><td colspan="7">EER 12.5</td></tr>
<tr><td rowspan="3">Roof Top Units</td><td>Baseline</td><td colspan="16">EER 11.0/11.2</td></tr>
<tr><td>Moderate</td><td colspan="8">EER 11.0/11.2</td><td colspan="8">EER 11.8</td></tr>
<tr><td>Aggressive</td><td colspan="8">EER 11.0/11.2</td><td colspan="8">EER 12.5</td></tr>
<tr><td rowspan="3">Heat Pump</td><td>Baseline</td><td colspan="16">EER 11.0/COP 3.3</td></tr>
<tr><td>Moderate</td><td colspan="8">EER 11.0/COP 3.3</td><td colspan="8">EER 11.5/COP 3.4</td></tr>
<tr><td>Aggressive</td><td colspan="8">EER 11.0/COP 3.3</td><td colspan="8">EER 13.0/COP 3.6</td></tr>
<tr><td rowspan="3">Air Handling System</td><td>Baseline</td><td colspan="16">Constant Air Volume/Variable Air Volume</td></tr>
<tr><td>Moderate</td><td colspan="16">Constant Air Volume/Variable Air Volume</td></tr>
<tr><td>Aggressive</td><td colspan="8">Constant Air Volume/Variable Air Volume</td><td colspan="8">Variable Air Volume</td></tr>
<tr><td rowspan="3">Incandescent Lamps</td><td>Baseline</td><td colspan="3">Adv Incand - tier 1</td><td colspan="13">Advanced Incandescent - tier 2 (45 lumens/watt)</td></tr>
<tr><td>Moderate</td><td colspan="3">Adv Incand - tier 1</td><td colspan="7">Advanced Incandescent - tier 2 (45 lumens/watt)</td><td colspan="6">Advanced Incandescent - tier 3 (50 lumens/watt)</td></tr>
<tr><td>Aggressive</td><td colspan="3">Adv Incand - tier 1</td><td colspan="7">Advanced Incandescent - tier 2 (45 lumens/watt)</td><td colspan="6">65 lumens/watt (equivalent to current CFLs)</td></tr>
<tr><td rowspan="3">Linear Fluorescent</td><td>Baseline</td><td colspan="16">T8/Super T8</td></tr>
<tr><td>Moderate</td><td colspan="8">T8</td><td colspan="8">65 lumens/watt (can be met using Super T-8 lamps)</td></tr>
<tr><td>Aggressive</td><td colspan="8">T8</td><td colspan="8">97 lumens/watt (next generation of LED lamps)</td></tr>
<tr><td rowspan="3">High Intensity Discharge</td><td>Baseline</td><td colspan="16">75 lumens/watt</td></tr>
<tr><td>Moderate</td><td colspan="5">75 lumens/watt</td><td colspan="5">97 lumens/watt</td><td colspan="6">196 lumens/watt</td></tr>
<tr><td>Aggressive</td><td colspan="5">75 lumens/watt</td><td colspan="5">97 lumens/watt</td><td colspan="6">196 lumens/watt</td></tr>
<tr><td rowspan="3">Low-V & Medium Transformers</td><td>Baseline</td><td colspan="16">NEMA 2007 Standard</td></tr>
<tr><td>Moderate</td><td colspan="6">NEMA 2007 Standard</td><td colspan="10">98.4% Efficiency</td></tr>
<tr><td>Aggressive</td><td colspan="6">NEMA 2007 Standard</td><td colspan="6">98.4% Efficiency</td><td colspan="4">98.6% Efficiency</td></tr>
</table>

APPENDIX C
OVERVIEW OF MODELING APPROACH

To perform this analysis, the Load Management Analysis and Planning tool (LoadMAP^{TM}), developed by Global Energy Partners, was utilized. LoadMAP was developed in 2007 and has been used for numerous studies of energy efficiency and demand response potential for utilities, state agencies and other organizations. It 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 that 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. LoadMAP allows the user to drive the appliance and equipment choices year by year directly in the model, which allows us to easily align with the AEO forecasts.
- 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 2011 forecast were developed and the forecast results were calibrated to AEO 2011 forecast results. To assess the two codes and standards scenarios, model inputs were modified according to the details provided in Appendix B. Additional details are available from Global Energy Partners upon request.

APPENDIX D
REFERENCES

AHAM, ―Today's Energy Standards for Refrigerators Reflect Consensus by Advocates, Industry to Increase Appliance Efficiency," September 27, 2010 press release, <http://www.aham.org/ht/a/GetDocumentAction/i/50432>.

American Council for an Energy-Efficient Economy (ACEEE). ―HR. 2454 Addresses Climate Change Through a Wide Variety of Energy Efficiency Measures." 1 June 2009. <http://www.aceee.org/energy/national/HR2454_Estimate06-01.pdf>.

American Council for an Energy-Efficient Economy, ―Ka-BOOM! The Power of Appliance Standards, Opportunities for New Federal and Appliance and Equipment Standards", July 2009

Appliance Standards Awareness Project: http://www.standardsasap.org/

Energy Independence and Security Act of 2007. Pub. L. 110-140. 19 December 2007. Stat. 121.1492.

Energy Information Administration, ―Annual Energy Outlook 2011-ER", December 2010, http://www.eia.doe.gov/forecasts/aeo/early_introduction.cfm#key

Energy Information Administration, ―EIA Technology Forecast Updates – Residential and Commercial Building Technologies – Reference Case, Second Edition (Revised)", Navigant Consulting, September 2007

Energy Information Administration, ―EIA Technology Forecast Updates – Residential and Commercial Building Technologies – Reference Case", Navigant Consulting, September 2008

Institute for Electric Efficiency, ―Assessment of Electricity Savings in the U.S. Achievable through New Appliance/Equipment Efficiency Standards and Building Efficiency Codes (2010-2020)", December 2009.

U.S. Department of Energy's Appliances and Commercial Equipment Standards Program: http://www1.eere.energy.gov/buildings/appliance_standards/index.html

U.S. Department of Energy, ―Multi Year Program Plan – Building Regulatory Programs - Energy Efficiency and Renewable Energy, Building Technologies Program", October 2010

For more information contact:

Institute for Electric Efficiency
701 Pennsylvania Avenue, N.W.
Washington, D.C. 20004-2696
1.202.508.5440
www.edisonfoundation.net/iee

The EDISON FOUNDATION | INSTITUTE FOR Electric Efficiency