



0000152867

RECEIVED

2014 APR 17 P 4 45

AZ CORP COMMISSION  
DOCKET CONTROL

Mail Station 9704  
PO Box 53999  
Phoenix, Arizona 85072-3999  
Tel 602-250-5671  
Elisa.Malagon@aps.com

April 17, 2014

ORIGINAL

Arizona Corporation Commission  
DOCKETED

APR 17 2014

Docket Control  
Arizona Corporation Commission  
1200 W. Washington  
Phoenix, AZ 85007

DOCKETED BY 

RE: Arizona Public Service Company's 2013 Demand Side Management Progress Report, Docket No. E-00000U-14-0049

On February 28, 2014, Arizona Public Service ("APS") filed its Annual Progress Report for 2013 with the Commission. In that filing, APS indicated that its Measurement Evaluation and Research ("MER") reports for 2013 would be filed separately. Attached please find APS's MER Verification Report (Attachment A) and APS's Codes and Standards MER Report (Attachment B) for 2013. Attachment A reflects the finalized savings results for APS's 2013 DSM program.

If you have any questions regarding this information, please contact Greg Bernosky at (602)250-4849.

Sincerely,



Lisa Malagon *for*

LM/cd  
Attachment

cc: Candrea Allen

# Attachment A

**NAVIGANT**

## **APS MER Verification Report**

**Program Year 2013**

**Prepared for:  
Arizona Public Service Company**



Navigant Consulting, Inc.  
1375 Walnut Street  
Suite 200  
Boulder, CO 80302

303.728.2500  
[www.navigant.com](http://www.navigant.com)

February 28, 2014



# NAVIGANT

## Table of Contents

<b>Introduction .....</b>	<b>1</b>
<b>Verification of 2013 APS-Reported Savings .....</b>	<b>1</b>
<b>The Measurement, Evaluation, and Research Process.....</b>	<b>2</b>
<b>2013 Verification Findings by Program.....</b>	<b>5</b>

## 2013 APS Savings Verification

### *Introduction*

Navigant Consulting, Inc. (Navigant) has completed a review and verification of the energy savings resulting from Arizona Public Service Company's (APS's) Demand-Side Management (DSM) programs for calendar year 2013. This report contains the results from that verification, which can be summarized as follows:

- » Navigant found that APS accurately applied Navigant-verified savings in the work papers that support their 2013 Annual Progress Report.<sup>1</sup>
- » However, APS slightly over-estimated annual savings for the Solutions for Business Programs and slightly under-estimated annual savings for the Consumer Products and Residential Existing HVAC [heating, ventilation, and air-conditioning] Programs, resulting in realization rates of 99.3 percent and 100.2 percent, respectively. The realization rate for the APS portfolio overall is 99.8 percent. This results in a verified reduction of 1,055 megawatt-hours (MWh), or 0.2 percent of the total savings, for the portfolio for the entire year.
- » Savings for the Consumer Products Program should be increased by 372 MWh to account for the appropriate baseline for reflector compact fluorescent lamps (CFLs). APS work papers did not account for exemptions to the Energy Independence and Security Act of 2007 (EISA) standards for types of reflector bulbs by applying a more stringent baseline.
- » Savings for the Residential Existing HVAC Program should be increased by 77 MWh to account for an additional 74 Duct Test and Repair rebates that were paid by the program implementation contractor in 2013, but not reported in the 2013 Annual Progress Report.
- » Savings for the Solutions for Business Program should be reduced by 1,504 MWh to account for an 83 percent adjustment factor for lighting projects rebated through the Express Solutions Program. This adjustment factor represents the difference between contractor-reported hours of use and those verified through a Navigant field metering study to determine performance variables of rebated lighting projects. In addition, Navigant made other minor adjustments to correct for a small number of discrepancies in the APS work papers.
- » Navigant finds that the reported savings for calendar year 2013 should be adjusted down by 1,055 MWh, from 538,841 MWh reported in the supporting work papers to 537,786 MWh verified in this Savings Verification Report.

### *Verification of 2013 APS-Reported Savings*

Navigant verified that APS's reported energy savings for calendar year 2013 are consistent with evaluation results and recommendations provided as part of the annual measurement, evaluation, and research (MER) process. Verification consisted of comparing measure level savings estimates from APS work papers<sup>2</sup> with recommended savings provided to APS by Navigant as part of the 2013 MER process. Specifically, Navigant reviewed APS savings estimates for consistency with a) baseline efficiency

---

<sup>1</sup> Reported savings are sourced from APS' Demand Side Management Status Report submitted August 30, 2013.

<sup>2</sup> Work papers supporting APS's DSM Annual Progress Report filed with the Arizona Corporation Commission.

# NAVIGANT

changes, b) program implementation modifications, c) new measure approved by the Arizona Corporation Commission (ACC) for implementation in 2013, and d) any discrepancies between APS estimates and Navigant-verified recommendations.

The results of Navigant's verification are presented in Table 1. The following describes the reported values in each column:

- » Column A – Reported savings for 2013 program activity as outlined in APS work papers that support the Annual DSM Progress Report to be submitted on February 28, 2014.
- » Column B – Reported savings for program activity occurring January through June 2013 as outlined in APS work papers that support the DSM Status Report filed with the ACC on August 30, 2013.
- » Column C – Reported savings for program activity occurring July through December 2013 as outlined in APS work papers that support the Annual DSM Progress Report to be submitted on February 28, 2014.
- » Column D – Navigant verified adjustments to APS work papers accounting for discrepancies between APS estimates and Navigant recommendations.
- » Column E – Verified reported savings estimates for 2013 APS program activity based on Navigant-verified findings and adjustments listed in Column D. Values are calculated by adding Column A and D.
- » Column F – The realization rate – or ratio of verified to reported savings – used to quantify the accuracy of APS reporting (i.e., a value of 100 percent is the most accurate). The realization rate is calculated by dividing the verified estimate by the reported value (i.e., Column E/Column A).

The realization rate of 100 percent for all programs demonstrates that APS accurately incorporated Navigant recommendations in the work papers that support the 2013 Annual Progress Report of annual energy savings at the generator. However, APS slightly over-estimated annual savings for the Solutions for Business Programs and slightly under-estimated annual savings for the Consumer Products and Residential Existing HVAC Programs, resulting in realization rates of 99.3 percent and 100.2 percent, respectively. Through this process, Navigant validated that the 538,841 MWh savings claimed in the supporting work papers should be adjusted down by 1,055 MWh (0.2 percent of the total savings) to 537,786 MWh.

## *The Measurement, Evaluation, and Research Process*

Navigant conducts research concurrent with the implementation of energy efficiency programs by APS. This formal evaluation process provides research-based findings on the estimated savings for programs and measures in the APS portfolio of DSM programs. MER research findings are based on extensive measurement and verification activities, including field metering, on-site inspection, customer surveys, contractor and trade ally interviews, focus groups, billing records analyses, and review of implementation tracking databases and documentation. Through the MER process, Navigant provides ongoing evaluation to APS with various tools. The research provided to APS is used to do the following:

- » Assess and verify non-coincident demand savings, coincident demand savings, annual energy savings, and lifetime energy savings claimed by APS in the previous year. In doing so, the

# NAVIGANT

accuracy of program savings results are verified through detailed analysis and performance measurement of savings as reported in APS's annual filing with the ACC.

- » Calculate cost-effectiveness at the program and portfolio level based on the Societal Cost Test (SCT).
- » Drive planning for MER activities for the current program year.
- » Refine savings and cost estimates at the program and measure level for the current program year. MER findings and recommendations inform APS savings claims, cost-effectiveness estimates, lost fixed cost recovery, and performance incentives for the current program year.
- » Inform program planning savings and cost estimates to support the APS implementation plan for the following program year.

Table 1. APS-Reported and 2013-MER-Report-Verified Annual Energy Savings (MWh) and Realization Rates – January through December 2013

Program	APS-Reported Savings			MER-Verified Adjustments and Savings		
	(A) January-December (MWh) <sup>3</sup>	(B) January - June (MWh) <sup>4</sup>	(C) July - December (MWh)	(D) 2013 Adjustments (MWh) <sup>5</sup>	(E) 2013 Verified (MWh)	(F) Realization Rate <sup>6</sup>
<b>RESIDENTIAL PROGRAMS</b>						
Consumer Products Program	154,233	72,693	81,540	372	154,605	100.2%
Residential Existing HVAC	12,063	4,667	7,396	77	12,140	100.6%
Home Performance with ENERGY STAR	5,404	3,069	2,335	0	5,404	100.0%
Residential New Construction	19,427	6,932	12,496	0	19,427	100.0%
Appliance Recycling	8,787	3,549	5,238	0	8,787	100.0%
Residential Behavioral	24,944	10,903	14,041	0	24,944	100.0%
Multifamily	9,487	3,209	6,278	0	9,487	100.0%
Shade Tree	351	89	262	0	351	100.0%
Low Income	1,491	550	940	0	1,491	100.0%
<b>Total Residential</b>	<b>236,186</b>	<b>105,660</b>	<b>130,526</b>	<b>449</b>	<b>236,636</b>	<b>100.2%</b>
<b>SOLUTIONS FOR BUSINESS PROGRAMS</b>						
Large Existing	184,207	65,288	118,919	-247	183,960	99.9%
Small Business	14,155	5,120	9,035	-899	13,255	93.6%
New Construction	15,513	3,664	11,848	-255	15,258	98.4%
Schools	13,481	4,668	8,813	-103	13,378	99.2%
Energy Information Services	25	18	7	0	25	100.0%
<b>Total Solutions For Business</b>	<b>227,381</b>	<b>78,758</b>	<b>148,622</b>	<b>-1,504</b>	<b>225,876</b>	<b>99.3%</b>
<b>Total EE Programs</b>	<b>463,567</b>	<b>184,419</b>	<b>279,147</b>	<b>-1,055</b>	<b>462,512</b>	<b>99.8%</b>
Codes & Standards	22,224	N/A	N/A	N/A	22,224	100.0%
DR Contribution	53,050	N/A	N/A	N/A	53,050	100.0%
<b>DSM Total</b>	<b>538,841</b>	<b>184,419</b>	<b>279,147</b>	<b>-1,055</b>	<b>537,786</b>	<b>99.8%</b>

<sup>3</sup> As reported in Annual Progress Report – March 2014.

<sup>4</sup> As reported in the APS Demand Side Management Status Report – August 2013. The reported savings for the Existing Homes Program are allotted proportionally to the Residential Existing HVAC and Home Performance Programs based on the annual reported savings for those programs.

<sup>5</sup> Adjustments account for discrepancies between APS estimates and Navigant recommendations.

<sup>6</sup> Realization Rate is calculated by dividing verified savings (Column G) by annual reported savings (Column A).

# NAVIGANT

## ***2013 Verification Findings by Program***

Navigant's findings from the review of APS work papers are as follows:

- » **Consumer Products Program**
  - APS accurately accounted for more efficient baselines for CFLs resulting from efficacy standards set by EISA.
  - APS accurately accounted for adjusting the residential pool pump baseline to reflect a respective 25 and 75 percent split between single speed and dual speed pumps due to changes in Arizona Legislation.
  - APS work papers did not account for exemptions to EISA standards for some types of reflector bulbs by applying a more stringent baseline. Navigant adjustments reflect this change.
- » **Residential Existing HVAC**
  - Savings estimates for the Duct Test and Repair measure were accurately updated by APS to include a mix of duct sealing jobs in manufactured homes and single-family homes.
  - APS work papers did not account for an additional 74 Duct Test and Repair rebates that were paid by the program implementation contractor in 2013. Navigant adjustments reflect savings for these additional rebates.
- » **Residential New Construction**
  - APS accurately accounted for baselines that are more efficient due to increased adoption of stringent building energy codes for single-family homes in jurisdictions within APS service territory.
- » **Home Performance with ENERGY STAR**
  - APS accurately adjusted savings for Air Sealing and Air Sealing & Attic Insulation measures to reflect the more stringent requirements for baseline infiltration rates and insulation levels set by the program.
- » **Appliance Recycling**
  - Savings were consistent with previous estimates and correctly reported by APS.
- » **Shade Trees**
  - APS accurately adjusted savings for Shade Trees based on a Navigant field study that exhibited improvements in compliance with planting requirements related to orientation and distance from the home.
- » **Residential Behavioral**
  - APS accurately reported savings based on Navigant verification.
- » **Multifamily Energy Efficiency Program**
  - APS accurately adjusted savings from low flow devices to account for the decrease of occupants per residence from 2.8 to 2.5, as consistent with the Home Performance with ENERGY STAR (HPwES) program<sup>7</sup>.

---

<sup>7</sup> Tracking data for the Multifamily Energy Efficiency Program does not include number of occupants per household. The MER team believes the HPwES database provides a better estimate than the census data used in previous year's analysis.

# NAVIGANT

- APS accurately adjusted savings from CFLs due to changes in the distribution of installed wattages.
- APS accurately accounted for baseline efficiencies for showerheads and “New Construction” measures based on local and federal codes and standards.
- » Low Income Weatherization Program
  - Navigant does not evaluate the Low Income Weatherization Program, as it is not in the Scope of Work in Navigant’s MER contract with APS. Values listed in the tables are based on APS-reported savings.
- » Solutions for Business Program
  - Navigant applied an adjustment factor of 83 percent to Express Solutions lighting projects based on a Navigant field study that compared metered operation hours of lighting fixtures at project sites to self-reported operation hours provided on the customer application. This is the main driver for adjustments to the Solutions for Business Program savings. In addition, Navigant made other minor adjustments to correct for a small number of discrepancies in the APS work papers.
- » Energy Information Services Program
  - No adjustments were made for this program. Savings were consistent with previous estimates and correctly reported by APS.
- » Codes and Standards Program
  - Savings reported by APS for Codes and Standards are consistent with, and were verified against, the APS Codes and Standards Report for 2013 submitted by Navigant.
- » Demand Response Contribution
  - Navigant does not conduct evaluation activities for this program and therefore did not provide a verification of APS-reported numbers. Values listed in the tables are consistent with APS-reported savings.

# Attachment B

**NAVIGANT**

## **APS Codes and Standards Report**

**Program Year 2013**

**Prepared for:  
Arizona Public Service Company**



Navigant Consulting, Inc.  
1375 Walnut Street  
Suite 200  
Boulder, CO 80302

303.728.2500  
[www.navigant.com](http://www.navigant.com)



February 17, 2014

## Table of Contents

<b>Executive Summary .....</b>	<b>1</b>
<b>1 General Service Lamps .....</b>	<b>4</b>
1.1 Description of the Standard .....	4
1.2 Potential Energy Savings .....	4
1.3 Gross Energy Savings .....	9
1.4 Net Energy Savings .....	9
1.5 Net C&S Program Savings .....	9
<b>2 Linear Fluorescent Lamps .....</b>	<b>11</b>
2.1 Description of the Standard .....	11
2.2 Potential Energy Savings .....	11
2.3 Gross Energy Savings .....	16
2.4 Net Energy Savings .....	16
2.5 Net C&S Program Savings .....	16
<b>3 Pool Pumps.....</b>	<b>18</b>
3.1 Description of the Standard .....	18
3.2 Potential Energy Savings .....	18
3.3 Gross Energy Savings .....	22
3.4 Net Energy Savings .....	23
3.5 Net C&S Program Savings .....	23
<b>4 Motors .....</b>	<b>24</b>
4.1 Description of the Standard .....	24
4.2 Potential Energy Savings .....	24
4.3 Gross Energy Savings .....	29
4.4 Net Energy Savings .....	30
4.5 Net Demand Savings .....	30
4.6 Net C&S Program Savings .....	31
<b>5 Residential New Construction .....</b>	<b>32</b>
5.1 Description of the Code .....	32
5.2 Potential Energy Savings .....	32
5.3 Gross Energy Savings .....	35
5.4 Net Energy Savings .....	36
5.5 Net C&S Program Savings .....	36
<b>6 Commercial New Construction.....</b>	<b>38</b>

# NAVIGANT

6.1	Description of the Code.....	38
6.2	Potential Energy Savings .....	38
6.3	Gross Energy Savings .....	43
6.4	Net Energy Savings.....	44
6.5	Net C&S Program Savings.....	44

## **Appendix A Codes and Standards Measurement and Evaluation Plan.....A-1**

A.1	Introduction .....	A-1
A.2	Determining Relevant Codes and Standards Updates .....	A-1
A.3	Developing an Approach for Evaluating Savings Estimates .....	A-2

## List of Figures, Tables, and Equations

### Figures:

Figure 1. NEMA Nationwide Incandescent and Halogen Sales (Thousands of Bulbs) .....	6
Figure 2. NEMA Nationwide T-12 and T-8 Lamp Sales (Thousands of Lamps) .....	13
Figure 3. Arizona Pool Pump Sales and Market Share Data – Manufacturer X .....	18
Figure 4. US Pool Pump Sales and Market Share Data without AZ – Manufacturer X.....	19
Figure 5. Single Speed Pump Market Share.....	21
Figure 6. C&S Advocacy Program Evaluation Protocol.....	A-2
Figure 7. Unit Energy Savings x Market Size = Potential Energy Savings.....	A-3
Figure 8. Potential Energy Savings and Gross Energy Savings .....	A-4
Figure 9. Adjustment for Natural Rates of Market Adoption .....	A-5
Figure 10. Adjustment for Net Program Savings, and Allocation by Utility .....	A-6
Figure 11. The C&S Evaluation Process over Time.....	A-6

### Tables:

Table 1. Code and Standard Updates in APS Territory .....	1
Table 2. Energy Savings Summary at Generator for 2013 Codes and Standards Programs .....	2
Table 3. Demand Savings Summary at Generator <sup>6</sup> for 2013 Codes and Standards Programs .....	3
Table 4. EISA 2007 Prescribed Standards for General Service Incandescent Lamps.....	4
Table 5. APS Territory Potential Energy Savings by Lumen Category in 2013 .....	5
Table 6. APS GSL Scaling Factors based on Electricity Sales by Sector.....	7
Table 7. Calculated Quantity of Incandescent and Halogen Sales by Region.....	7
Table 8. EPA Projections of Average Wattage per Bulb with EISA.....	8
Table 9. Navigant Projections of Average Wattage per Bulb without EISA.....	8
Table 10. Market Share by Lumen Category.....	8
Table 11. Technical Factor Adjustments by Sector.....	9
Table 12. 2013 APS Net Energy and Demand Savings at Generator from the EISA GSL Standard .....	10
Table 13. Summary of the Amended Energy Conservation Standards for General Service Fluorescent Lamps.....	11
Table 14. APS Linear Fluorescent Scaling Factors based on Electricity Sales by Sector .....	13
Table 15. Estimated Quantity of Avoided T-12 Sales by Region.....	14
Table 16. Summary of Lamp Types, Lamp Power, and Market Share.....	15
Table 17. Weighted Average Energy Consumption by Sector and Lamp Type .....	15
Table 18. Technical Factor Adjustments by Sector.....	15
Table 19. Linear Fluorescent Standard Compliance Rate Assumptions by Year.....	16
Table 20. 2013 APS Net Energy and Demand Savings at Generator from the Federal Linear Fluorescent Standard.....	17
Table 21. Residential Customers by Arizona Utility.....	20
Table 22. Annual Code Baseline Pump Consumption .....	22

Table 23. 2013 APS Net Energy and Demand Savings at Generator from the Title 44 Pool Pumps Standard.....	23
Table 24. Average Annual Energy Savings and Hours of Use for Motors Affected by EISA Standards ...	24
Table 25. 2013 APS Territory Potential Energy Savings from Electric Motors by Horsepower Category .	25
Table 26. Historic US Electric Motor Sales .....	26
Table 27. DOE Electric Motors Sales by Horsepower and Sector .....	27
Table 28. APS Motors Scaling Factors based on Electricity Sales by Sector .....	27
Table 29. 2013 Estimated Quantity of Motors Sales by Region .....	27
Table 30. Percent of Sales Affected by EISA Standards for Different Horsepower Categories .....	28
Table 31. 2003 Motors Shipments and Relative Weighting by Horsepower Category .....	28
Table 32. Technical Factor Adjustments for the Motors Analysis.....	28
Table 33. Percent of Motor Sales not Meeting EISA Standards before Implementation and in 2013.....	30
Table 34. Hours of Use, Energy Savings, and Demand Savings by Horsepower Category.....	31
Table 35. APS Net Energy and Demand Savings at Generator from the EISA Motors Standard .....	31
Table 36. 2013 APS Territory Potential Energy Savings by Housing Category .....	33
Table 37. 2013 APS New Residential Meter Installations by Climate Zone .....	33
Table 38. Modeled Annual Residential Electricity Consumption by Code Vintage .....	33
Table 39. Quantity of New Meters and Code Adoption Schedule for the Ten Jurisdictions with the Most New Meters within APS Territory .....	34
Table 40. Weight of New Meters and Modeled Code Consumption for Five Significant Jurisdictions within APS Territory .....	34
Table 41. Modeled Code Consumption Adjusted for Compliance Rates .....	35
Table 42. 2013 APS Territory Gross Energy Savings by Housing Category.....	36
Table 43. 2013 APS Net Energy and Demand Savings at Generator from Residential Building Codes.....	37
Table 44. Energy Use Intensity by Building Type, Code Vintage, and Climate Zone .....	40
Table 45. Summary of APS and DOE Building Types and Sizes .....	41
Table 46. Quantity of New Meters and Code Adoption Schedule for the Ten Jurisdictions with the most New Meters in APS Territory .....	42
Table 47. Quantity of New Meters and Code Adoption Schedule for the Eight Jurisdictions with New Codes in 2013 .....	42
Table 48. Coincidence Factors by Building Type .....	43
Table 49. Compliance Rate Assumptions for Commercial New Construction Codes.....	43
Table 50. 2013 APS Net Energy Savings at Generator from Commercial Building Codes, by Jurisdiction	44
Table 51. APS Net Energy Savings at Generator from Commercial Building Codes, by Building Type ...	45
Table 52. APS Net Demand Savings at Generator from Commercial Building Codes .....	45
Table 53. Relevant Code Updates in APS Territory.....	A-1

## Equations:

Equation 1. APS Territory-Wide Potential Energy Savings from the EISA GSL Standards (kWh) .....	4
Equation 2. APS Territory-Wide Potential Energy Savings from the DOE Linear Fluorescent Standards (kWh).....	12
Equation 3. Savings Claimed from Title 44 Calculation (MWh).....	20

# NAVIGANT

Equation 4. Avoided Single Speed Pumps Sales Calculation.....	21
Equation 5. Verified Claimed Savings Attributable to Title 44 Standard .....	22
Equation 6. APS-Territory-Wide Potential Energy Savings from the EISA Electric Motors Standards (kWh).....	25
Equation 7. APS-Territory-Wide Potential Energy Savings from the EISA Electric Motors Standards (kWh).....	29
Equation 8. Calculating the Percent of Motors Sales not Meeting EISA Standards in 2013.....	29
Equation 9. Calculating Annual Demand Savings from the EISA Motors Standard.....	30
Equation 10. APS-Territory-Wide Potential Energy Savings from Residential Building Codes (kWh) .....	32
Equation 11. Calculating Annual Demand Savings from the Residential Building Codes.....	35
Equation 12. Application of Compliance Rates to Adjust Modeled Consumption of Code-Compliant Homes .....	36
Equation 13. APS-Territory-Wide Potential Energy Savings from Commercial Building Codes (kWh) ...	38
Equation 14. Application of Compliance Rates to Adjust Modeled Consumption of Code-Compliant Buildings.....	44

## Executive Summary

As stated in section R14-2-2404 part E of the Electric Energy Efficiency Standards<sup>1</sup>,

*“An affected utility may count toward meeting the standard up to one third of the energy savings, resulting from energy efficiency building codes, that are quantified and reported through a measurement and evaluation study undertaken by the affected utility.”*

Furthermore, the Arizona Corporation Commission (ACC) allows Arizona Public Service (APS) to include savings “resulting from improved energy efficiency appliance standards.”<sup>2</sup> This report presents the results of Navigant Consulting, Inc.’s (Navigant’s) evaluation of net savings attributable to recent changes to building codes and appliance standards claimable by APS under these rulings.

A review of federal, state, and jurisdictional code changes in 2013 revealed the code and standard changes pertaining to measures and end-uses incentivized through APS’s portfolio of Demand Side Management (DSM) programs presented in Table 1.

**Table 1. Code and Standard Updates in APS Territory**

Measure/ End Use	Relevant APS Program	Relevant APS Measure	Old Code	New Code	Authority	Effective Year
General Service Lamps (GSLs)	Consumer Products	Compact Fluorescent Light Bulbs	None	EISA <sup>3</sup>	Federal	2012, 2013
Linear Fluorescent Lamps (LFL)	Solutions for Business	Premium T8s and T5s	EPACT 1992	DOE Federal Rulemaking <sup>4</sup>	Federal	2012
Pool pumps	Consumer Products	Variable Speed Pool Pumps	None	Title 44 <sup>5</sup>	State	2012
Motors	Solutions for Business	NEMA Premium Motors	EPACT 1992	EISA	Federal	2010

<sup>1</sup> Docket No. RE-00000C-09-0427 (Electric Energy Efficiency Rules) Title 14, Chapter 2, Article 24, section R14-2-2404.

<sup>2</sup> Docket No. E-01345A-11-0232; Decision No. 73089 pg. 56 Line 11

<sup>3</sup> Appliance Standards Awareness Project. General Service Lamps. <http://www.appliance-standards.org/node/6810>

<sup>4</sup> Department of Energy. “Energy Conservation Program: Energy Conservation Standards and Test Procedures for General Service Fluorescent Lamps and Incandescent Reflector Lamps; Final Rule.” July 14, 2009. [http://www1.eere.energy.gov/buildings/appliance\\_standards/pdfs/74fr34080.pdf](http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/74fr34080.pdf)

<sup>5</sup> Chapter 9, Article 19 Section 2 Part B.2.b

Measure/ End Use	Relevant APS Program	Relevant APS Measure	Old Code	New Code	Authority	Effective Year
Residential New Construction	ENERGY STAR Homes	ENERGY STAR Version 3 Homes	IECC 2003, 2006, 2009	IECC 2006, 2009, 2012	Jurisdictional	Various
Commercial New Construction	Solutions for Business	Whole Building Design	IECC 2003, 2006, 2009	IECC 2006, 2009, 2012	Jurisdictional	Various

Navigant evaluated savings from the code and standard updates in Table 1 based on the methodology outlined in Appendix A. A summary of the net code and standard (C&S) energy and demand savings at generator are included in Table 2 and Table 3. To calculate net C&S program savings for all codes and standards under consideration in 2013, Navigant used the ACC prescribed allowance of one-third.

**Table 2. Energy Savings Summary at Generator<sup>6</sup> for 2013 Codes and Standards Programs**

Program	Energy Savings (MWh)	
	Net Code Savings	C&S Program with one-third Allowance
General Service Lamps	32,596	10,865
Linear Fluorescents	10,929	3,643
Pool Pumps	3,555	1,185
Motors	3,990	1,330
Residential New Con	9,166	3,055
Commercial New Con	6,438	2,146
<b>Total</b>	<b>66,672</b>	<b>22,224</b>

<sup>6</sup> Generator savings are calculated using a line loss factor of 7% and 11.7% for energy and demand respectively, and a capacity reserve margin assumption of 15%.

**Table 3. Demand Savings Summary at Generator<sup>6</sup> for 2013 Codes and Standards Programs**

Program	Demand Savings (MW)	
	Net Code Savings	C&S Program with one-third Allowance
General Service Lamps	3.71	1.24
Linear Fluorescents	2.76	0.92
Pool Pumps	0.41	0.14
Motors	1.30	0.43
Residential New Con	4.66	1.55
Commercial New Con	1.61	0.54
<b>Total</b>	<b>14.45</b>	<b>4.82</b>

The remainder of this report details the calculations and data sources used for each measure category listed in Table 1. In each report section, the methodology used to determine savings by each end use is separated into the following steps:

- » Description of the Code or Standard – a qualitative description of the code or standard and how it affects energy use in APS territory
- » Potential Energy Savings – the total energy savings from the code or standard change in APS territory, derived from market data and assuming 100 percent compliance
- » Gross Energy Savings – potential energy savings adjusted for compliance rates
- » Net Energy Savings – gross energy savings adjusted for naturally occurring market adoption (NOMAD) of efficient appliances or building practices
- » Net Codes and Standards Program Savings – net energy savings from APS’s C&S program, adjusted for the ACC prescribed one-third allowance

## 1 General Service Lamps

### 1.1 Description of the Standard

The Energy Independence and Security Act<sup>7</sup> passed in 2007 raised standards for general service lamps, requiring lamps to use approximately 25-30 percent less energy than typical incandescent bulbs.<sup>8</sup> The standard is effective in 2012, 2013, and 2014 for different lumen ranges, according to Table 4 below. The standard is technology neutral, so the prescribed maximum wattages can be met by compact fluorescent lamps (CFLs), light emitting diodes (LEDs), and some advanced incandescent bulbs.

**Table 4. EISA 2007 Prescribed Standards for General Service Incandescent Lamps**

Rated Lumen Ranges	Maximum Rated Wattages	Minimum Rated Lifetime (hrs)	Effective Date
1490-2600	72	1000 hours	January 1, 2012
1050-1489	53	1000 hours	January 1, 2013
750-1049	43	1000 hours	January 1, 2014
310-749	29	1000 hours	January 1, 2014

### 1.2 Potential Energy Savings

Navigant's calculation of the potential energy savings represents a hypothetical scenario in which low-efficiency incandescent and halogen lamps covered under the standard are not sold after the effective date (full compliance). Potential energy savings were calculated using the following formula:

**Equation 1. APS Territory-Wide Potential Energy Savings from the EISA GSL Standards (kWh)**

$$\sum \left( \frac{N_{avdIncH} \times (W/bulb_{no-EISA} - W/bulb_{EISA}) \times (\% MShare_{lm}) \times (Factors_{sector})}{1000} \right) + Adjustment_{PI}$$

Where:

- $N_{avdIncH}$  = projection of the number of avoided incandescent and halogen bulb sales in APS territory in 2013 (approximately 6 million bulbs)
- $W/bulb_{no-EISA}$  = Watts per bulb in each lumen category, absent Energy Independence and Security Act (EISA) standards, shown in Table 9

<sup>7</sup> Energy Independence and Security Act of 2007. Public Law 110-140, 110<sup>th</sup> Congress. <http://www.gpo.gov/fdsys/pkg/PLAW-110publ140/html/PLAW-110publ140.htm>

<sup>8</sup> Appliance Standards Awareness Project. General Service Lamps. <http://www.appliance-standards.org/node/6810>

- $W/bulb_{EISA}$  = Watts per bulb in each lumen category, with EISA standards, shown in Table 8
- $\% MShare_{lm}$  = The APS market share (in percent) of one of the four lumen categories shown in Table 10
- $Factors_{sector}$  = Technical factors such as the heating, ventilation, and air-conditioning (HVAC) interaction factor, line loss factor, coincidence factor, capacity reserve adjustment, and hours of use; weighted by sector where appropriate
- $Adjustment_{PI}$  = A savings adjustment (in kWh) to account for program influence or the fact that National Electric Manufacturers Association (NEMA) national sales data does not include CFL sales influenced by the APS incentive program

In 2013, only two of the four lumen categories are affected by EISA standards, so the parenthetical term in Equation 1 produces two values. Total savings are the sum of these two values, plus the program influence adjustment as shown in Table 5. The inputs to Equation 1 are described in detail in the remainder of this section.

**Table 5. APS Territory Potential Energy Savings by Lumen Category in 2013**

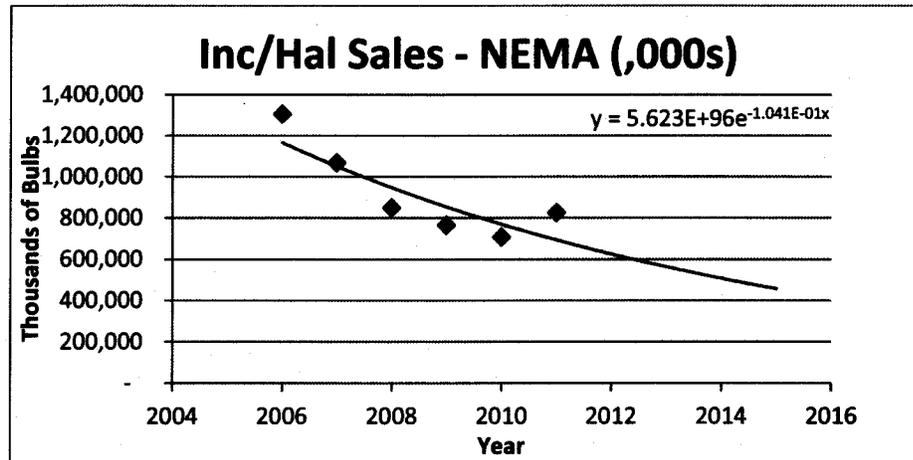
Calculation Element	APS Territory Potential Savings (kWh)
1490-2600 lumens	13,443,893
1050-1489 lumens	9,293,551
Program Influence Adjustment	9,858,412
<b>Total Potential Savings</b>	<b>32,595,857</b>

*Estimating Quantity of Avoided Bulb Sales ( $N_{avdIncH}$ )* – Using national sales data from the NEMA sales indices<sup>9</sup> and the US Department of Energy (DOE) standards rulemaking process<sup>10</sup>, Navigant fit an exponential function to the historic data (up until the effective date of the standard) in order to project sales of incandescent and halogen bulbs *absent the standard* for 2013 (Figure 1). These projections represent the avoided sales, or sales that would have occurred, absent the standard. In other words, in the presence of the standard, with full compliance, we assume that all of these incandescent and halogen bulb sales would be displaced by CFL or LED sales. Using this projection, Navigant estimates that the share of nationwide incandescent and halogen bulb sales reported by NEMA would have been approximately 550 million bulbs in 2013.

<sup>9</sup>National Electric Manufacturers Association. "Incandescent Lamp Shipment Index." October, 2013 <http://www.nema.org/news/Pages/Incandescent-Lamp-Shipments-Wane-During-Second-Quarter.aspx>

<sup>10</sup> US Department of Energy. "General Service Incandescent Lamps Rulemaking." [http://www1.eere.energy.gov/buildings/appliance\\_standards/product.aspx/productid/61](http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/61)

Figure 1. NEMA Nationwide Incandescent and Halogen Sales (Thousands of Bulbs)



In order to allocate national market data to APS territory-specific savings values, Navigant applied various adjustment factors to NEMA bulb sales data. Manufacturer interviews conducted by Navigant indicate that NEMA sales data comprises 85 percent of the entire market for all bulbs in the US. Evaluations from California<sup>11</sup>, Illinois<sup>12</sup> and Vermont<sup>13</sup>, indicate that 90 percent of the shipments of general service lamps are destined for the residential sector, while 10 percent are installed in the commercial sector. Using national, state, and APS 2012 electricity sales data from the Energy Information Administration<sup>14</sup>, Navigant developed scaling factors for each relevant end-use sector (Table 6). Navigant applied these factors to the NEMA national sales data to estimate the share of bulbs distributed to customers in APS service territory (Table 7).

<sup>11</sup> The CPUC's evaluation of the Statewide Upstream Lighting used store intercepts and on-site visits to estimate the percent of bulbs that go into nonresidential settings. Their findings yielded a 94%/6% residential/nonresidential split. Source: **Final Evaluation Report: Upstream Lighting Program, Volume 1**. KEMA. 2010.

[http://www.energydataweb.com/cpucFiles/18/FinalUpstreamLightingEvaluationReport\\_2.pdf](http://www.energydataweb.com/cpucFiles/18/FinalUpstreamLightingEvaluationReport_2.pdf)

<sup>12</sup> ComEd's Plan Year 2 Residential ES Lighting program evaluation uses a 90%/10% residential/nonresidential split.

Source: **Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) – Evaluation Report: Residential Energy Star® Lighting**. Navigant Consulting, Inc. December, 2010.

[http://ilsag.org/yahoo\\_site\\_admin/assets/docs/ComEd\\_Res\\_Lighting\\_PY2\\_Evaluation\\_Report\\_2010-12-21\\_Final.12113928.pdf](http://ilsag.org/yahoo_site_admin/assets/docs/ComEd_Res_Lighting_PY2_Evaluation_Report_2010-12-21_Final.12113928.pdf)

<sup>13</sup> "Vermont assumes currently that 10.5% of CFLs rebated via the buy-down program are installed in commercial facilities." Source: Personal communication. TJ Poor, Energy Programs Specialist. Vermont Department of Public Service. March 23, 2010."

<sup>14</sup> US Energy Information Administration. Electricity Utility Sales and Revenue—EIA-826 Detailed Data File. Released July 31, 2013, accessed August 19, 2013. <http://www.eia.gov/electricity/data/eia826/>

**Table 6. APS GSL Scaling Factors based on Electricity Sales by Sector**

Scaling Factor	Residential	Commercial	Industrial
<b>NEMA Shipments by Sector</b>	90%	10%	0%
<b>Scalar – US to AZ<sup>15</sup></b>	2%	2%	1%
<b>Scalar - AZ to APS<sup>16</sup></b>	40%	43%	18%

**Table 7. Calculated Quantity of Incandescent and Halogen Sales by Region**

Region	Incandescent/Halogen Bulb Sales
<b>National</b>	649,691,677
<b>Arizona</b>	15,038,123
<b>APS</b>	6,086,439

*Unit Energy Savings ( $W/bulb_{no-EISA}$  and  $W/bulb_{EISA}$ )* – To determine the energy consumption of the typical code-compliant bulbs vs. pre-code equivalent bulbs, Navigant used a national analysis of the EISA standard conducted by the Environmental Protection Agency (EPA)<sup>17</sup>. This analysis projects the average bulb wattage (inclusive of code-compliant and non-compliant bulbs) for each lumen category between 2011 and 2014 (see Table 8). To determine a naturally occurring baseline without the standard, Navigant consulted internal lighting market experts to estimate how the market would have progressed absent the EISA standard (see Table 9). Note that the average wattage per bulb is the same for certain years and lumen categories because each phase of the EISA standard affects different lumen categories in different years. The cells affected by the standard are highlighted in light brown. The unit energy savings by lumen category were calculated by subtracting the counterfactual naturally occurring (no-EISA) baseline (Table 9) from the projected EISA scenario (Table 8). For example, in 2013, for bulbs between 1,490 and 2,600 lumens, the average savings per bulb is  $95 - 80 = 15$  watts.

<sup>15</sup> Based on Arizona’s share of total US electricity sales in each sector

<sup>16</sup> Based on APS’s share of total Arizona electricity sales in each sector

<sup>17</sup> Environmental Protection Agency. *Next Generation Lighting Programs: Opportunities to Advance Efficient Lighting for a Cleaner Environment*. [http://www.energystar.gov/ia/partners/manuf\\_res/downloads/lighting/EPA\\_Report\\_on\\_NGL\\_Programs\\_for\\_508.pdf](http://www.energystar.gov/ia/partners/manuf_res/downloads/lighting/EPA_Report_on_NGL_Programs_for_508.pdf)

**Table 8. EPA Projections of Average Wattage per Bulb with EISA**

Lumen Category	EISA Baseline (Average Watts per Bulb)			
	2011	2012	2013	2014
1490-2600	97	90	80	76
1050-1489	73	72	64	58
750-1049	59	58	55	49
310-749	39	39	37	33

**Table 9. Navigant Projections of Average Wattage per Bulb without EISA**

Lumen Category	No-EISA Baseline (Average Watts per Bulb)			
	2011	2012	2013	2014
1490-2600	97	96	95	94
1050-1489	73	72	71	70
750-1049	59	58	55	54
310-749	39	39	37	36

Market Share ( $MShare_{lm}$ ) – In order to determine how much of the overall market is comprised of bulbs in each lumen category, Navigant used the APS-incentive-program specific market share from historical program data, assuming it is reflective of the overall market for bulbs within APS service territory.

**Table 10. Market Share by Lumen Category**

Lumen Category	Watt Equivalent	Market Share
1490-2600	100 W	11%
1050-1489	75 W	16%
750-1049	60 W	66%
310-749	40 W	6%

Technical Factors ( $Factors_{sector}$ ) – Energy savings calculations included hours of use, line loss factors, HVAC interaction factors, coincidence factors, and diversity factors for both residential and commercial contexts listed in Table 11. All factors except the capacity reserve margin and line loss factor were weighted as 90 percent residential and 10 percent commercial.

**Table 11. Technical Factor Adjustments by Sector**

Factor	Residential	Commercial
<b>Hours of Use</b>	876	3508
<b>Line Loss Factor (Energy)</b>	7.0%	7.0%
<b>Line Loss Factor (Demand)</b>	11.7%	11.7%
<b>HVAC Interaction Factor (Energy)</b>	0.10	0.16
<b>HVAC Interaction Factor (Demand)</b>	0.30	0.19
<b>Coincidence Factor - APS</b>	0.06	0.65
<b>Diversity Factor - APS</b>	1.0	0.78
<b>Capacity Reserve Margin</b>	15%	15%

Program Influence Adjustment ( $Adjustment_{PI}$ ) - Direct Consumer Products program savings from the sale of CFLs are based on the adjusted baseline (with EISA influence) presented in Table 8. However, in absence of the APS program, the counterfactual baseline would be that presented in Table 9. Therefore, the introduction of the EISA standard provided a new, more efficient baseline, which reduced Consumer Products program savings. Because the NEMA sales data mentioned above only includes incandescent and halogen bulbs, and does not include the CFLs distributed through the program, the reduced program savings due to EISA needs to be included in the overall savings from the standard. According to analysis of program sales data, the EISA standard resulted in a reduction of 9,858,412 kWh in 2013 program savings. These savings were added to the standard savings, as they are a direct result of the EISA standard.

### 1.3 Gross Energy Savings

The Next Generation Lighting report developed by the EPA referenced above in Table 8 includes assumptions about compliance with the standard in the initial years of adoption. After reviewing the EPA analysis, Navigant did not apply any additional discounts for compliance rate for this analysis.

### 1.4 Net Energy Savings

Navigant's expert judgment of the counterfactual baseline absent the EISA standard is a reflection of the NOMAD of efficient appliances. As shown in Table 9, the NOMAD assumption is that the average wattage per bulb decreases by one watt per year absent EISA.

### 1.5 Net C&S Program Savings

Navigant calculated net C&S program savings for all codes and standards under consideration in 2013 as one-third of net energy savings, which is permitted under ACC R-14-2.

Navigant calculated net energy savings and net C&S program savings shown in Table 12 using the values and adjustments noted above in conjunction with Equation 1. The net energy savings equal the potential energy savings from Table 5 above, because no further compliance or NOMAD

adjustments were applied to potential savings. The net C&S program savings are the final savings claimed by APS and include the one-third allowance adjustment. APS can claim 10,865 MWh of energy savings and 1.24 MW of demand savings from the federal EISA general service lamp standard.

**Table 12. 2013 APS Net Energy and Demand Savings at Generator from the EISA GSL Standard**

	kWh	MWh
Net Energy Savings – Residential	25,883,346	25,883
Net Energy Savings - Commercial	6,712,510	6,713
Total Net Energy Savings	32,595,857	32,596
<b>Net C&amp;S Program Energy Savings</b>	<b>10,865,286</b>	<b>10,865</b>
	kW	MW
Net Demand Savings - Residential	2,517	2.52
Net Demand Savings - Commercial	1,195	1.20
Total Net Demand Savings	3,711	3.71
<b>Net C&amp;S Program Demand Savings</b>	<b>1,237</b>	<b>1.24</b>

## 2 Linear Fluorescent Lamps

### 2.1 Description of the Standard

The first standards for linear fluorescent lamps were enacted by Congress in the Energy Policy Act of 1992 (EPACT). DOE updated the standards in 2009, with an effective date of July 14 2012. Efficiency standards vary by type of lamp in terms of lumens per watt. For example, the standard for a 4-foot medium bipin with a color temperature of less than 4,500K (the most common lamp type) is 89 lumens per watt. In general, the new code requires that T12 lamps be converted to the more efficient T8 lamps. A summary of the energy conservation standards by bulb type is included in Table 13 below.

**Table 13. Summary of the Amended Energy Conservation Standards for General Service Fluorescent Lamps<sup>18</sup>**

Lamp Type	Correlated Color Temperature	Energy Conservation Standard (lm/W)
4-Foot Medium Bipin	≤4,500K	89
	>4,500K and ≤7,000K	88
2-Foot U-Shaped	≤4,500K	84
	>4,500K and ≤7,000K	81
8-Foot Slimline	≤4,500K	97
	>4,500K and ≤7,000K	93
8-Foot High Output	≤4,500K	92
	>4,500K and ≤7,000K	88
4-Foot Miniature Bipin Standard Output	≤4,500K	86
	>4,500K and ≤7,000K	81
4-Foot Miniature Bipin High Output	≤4,500K	76
	>4,500K and ≤7,000K	72

### 2.2 Potential Energy Savings

Navigant's calculation of the potential energy savings represents a hypothetical scenario in which T-12 linear fluorescents covered under the standard are not sold after the effective date (full compliance). Potential energy savings were calculated using the following formula:

<sup>18</sup> Department of Energy. "Energy Conservation Program: Energy Conservation Standards and Test Procedures for General Service Fluorescent Lamps and Incandescent Reflector Lamps; Final Rule." July 14, 2009. [http://www1.eere.energy.gov/buildings/appliance\\_standards/pdfs/74fr34080.pdf](http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/74fr34080.pdf)

**Equation 2. APS Territory-Wide Potential Energy Savings from the DOE Linear Fluorescent Standards (kWh)**

$$\frac{(N_{\text{avdT-12}} - \text{Adjustment}_{PI}) \times (W_{T-12} - W_{T-8}) \times \text{Factors}_{\text{sector}}}{1000}$$

Where:

- $N_{\text{avdT-12}}$  = projection of the number of avoided T-12 lamp sales in APS territory in 2013 (approximately 833,701 lamps; shown in Table 15)
- $\text{Adjustment}_{PI}$  = An adjustment to the number of avoided T-12 lamp sales to account for APS incentive program sales of T8, Premium T8, and T5 lamps<sup>19</sup>
- $W_{T-12}$  = Average wattage per lamp for T-12s being replaced by the standard, weighted by market share, shown in Table 17
- $W_{T-8}$  = Average wattage per lamp for T-8s that will replace T-12s under the standard, weighted by market share, shown in Table 17
- $\text{Factors}_{\text{sector}}$  = Technical factors such as the HVAC interaction factor, line loss factor, coincidence factor, capacity reserve adjustment, and hours of use; weighted by sector where appropriate

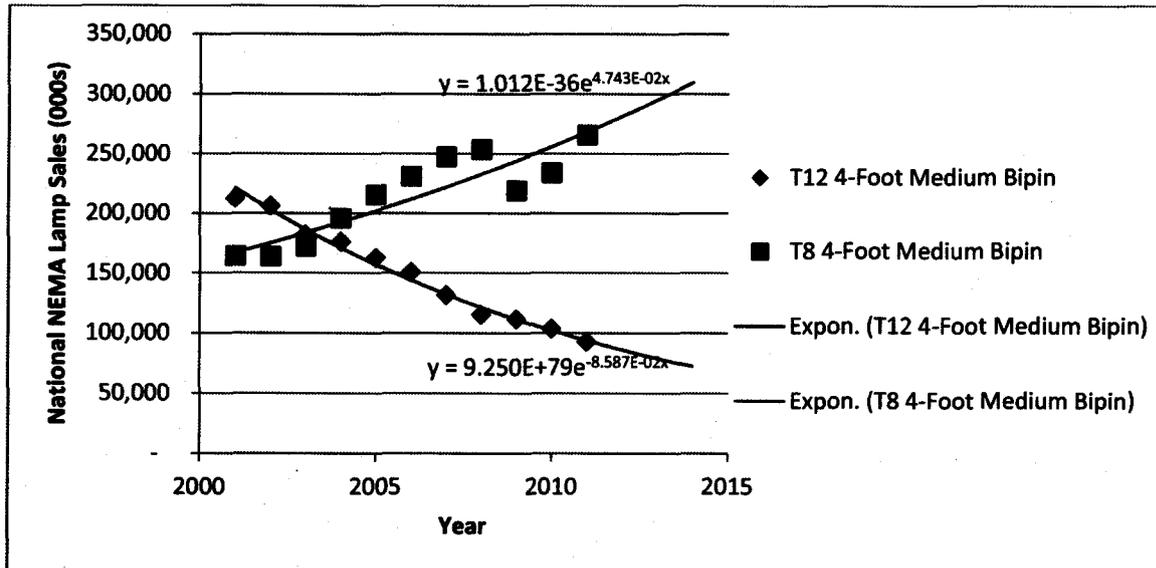
Estimating Quantity of Avoided Lamp Sales ( $N_{\text{avdT-12}}$ ) – Using national sales data from the NEMA sales indices<sup>20</sup> and the DOE standards rulemaking process<sup>21</sup>, Navigant fit an exponential function to the historic data (up until the effective date of the standard) in order to project sales of T-12 (non-compliant lamps) absent the standard for 2013 (Figure 2). These projections represent the avoided sales of T-12 lamps, or sales that would have occurred, absent the standard. In other words, in the presence of the standard, with full compliance, we assume that all of these T-12 sales are replaced by T-8 sales. Using this projection, Navigant estimates that the share of nationwide T-12 sales reported by NEMA would have been approximately 833,701 lamps in 2013.

<sup>19</sup> The purpose of the adjustment is to avoid double counting between incentive program and C&S program savings.

<sup>20</sup> National Electric Manufacturers Association. "T5/T8/T12 Lamp Shipment Index."  
<http://www.nema.org/intelligence/pages/lamp-indices.aspx>

<sup>21</sup> US Department of Energy. "General Service Fluorescent Lamps Rulemaking."  
[http://www1.eere.energy.gov/buildings/appliance\\_standards/product.aspx/productid/70](http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/70)

**Figure 2. NEMA Nationwide T-12 and T-8 Lamp Sales (Thousands of Lamps)**



In order to allocate national market data to APS territory-specific savings values, Navigant applied multiple adjustment factors to NEMA lamp sales data. According to the DOE, NEMA sales data comprises 90 percent of the entire market for all lamps in the US. NEMA data also indicates that 80 percent of the shipments of linear fluorescent lamps are destined for the commercial sector, while 20 percent are installed in the residential sector. Using national, state, and APS 2012 electricity sales data from the Energy Information Administration<sup>22</sup>, Navigant developed scaling factors for each relevant end-use sector (Table 14). Navigant applied these factors to the NEMA national sales data to estimate the share of bulbs distributed to customers in APS service territory (Table 15).

**Table 14. APS Linear Fluorescent Scaling Factors based on Electricity Sales by Sector**

Scaling Factor	Residential	Commercial	Industrial
<b>NEMA Shipments by Sector</b>	20%	80%	0%
<b>Scalar – US to AZ<sup>23</sup></b>	2%	2%	1%
<b>Scalar - AZ to APS<sup>24</sup></b>	40%	43%	18%

<sup>22</sup> US Energy Information Administration. Electricity Utility Sales and Revenue—EIA-826 Detailed Data File. Released July 31, 2013, accessed August 19, 2013. <http://www.eia.gov/electricity/data/eia826/>

<sup>23</sup> Based on Arizona's share of total US electricity sales in each sector

<sup>24</sup> Based on APS's share of total Arizona electricity sales in each sector

**Table 15. Estimated Quantity of Avoided T-12 Sales by Region**

Region	Incandescent/Halogen Bulb Sales
<b>National</b>	87,369,053
<b>Arizona</b>	1,959,478
<b>APS</b>	833,701
<b>APS (adjusted)</b>	691,624

*Program Influence Adjustment ( $Adjustment_{PI}$ )*—APS administers both a prescriptive rebate and direct install program (Express Solutions) under their Solutions for Business (S4B) program, which provide incentives to customers for replacing T-12 lamps with High Performance T-8<sup>25</sup> and Premium T-8<sup>26</sup> lamps. Both programs claim verified savings from these lamp replacements. To avoid double-counting of savings directly claimed under the S4B program, Navigant subtracted the 142,077 lamps projected<sup>27</sup> to be installed due to the APS 2013 incentive programs from the 833,701 lamps of avoided sales in APS territory to calculate the adjusted avoided sales in Table 15.

*Unit Energy Savings ( $W_{T-12}$ ,  $W_{T-8}$ )* – Using data provided by DOE<sup>28</sup>, (Table 16), Navigant categorized linear fluorescent lamps into six groups. T12 and T8 lamps represent the baseline prior to ( $W_{T-12}$ ) and after the code change ( $W_{T-8}$ ), respectively. Navigant calculated a weighted average wattage for each lamp (Table 17) based on national market share estimates. Hours of use estimates are from extensive field metering of residential and commercial buildings in APS service territory and are noted in the APS Technical Reference Manual<sup>29</sup>.

<sup>25</sup> <http://library.cce1.org/content/cee-high-performance-t8-specification/>

<sup>26</sup> <http://library.cce1.org/content/reduced-wattage-t8-specification>

<sup>27</sup> At the time of the analysis, Navigant had program data through August 2013. Navigant applied the 2012 installation trend to the existing 2013 program data to project 2013 incentive program sales from September to December.

<sup>28</sup> Department of Energy. "General Service Fluorescent Lamps Standards and Test Procedures." [http://www1.eere.energy.gov/buildings/appliance\\_standards/product.aspx/productid/70](http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/70)

<sup>29</sup> Arizona Public Service. "Technical Reference Manual for APS Energy Efficiency Programs." Program Year 2013. Docket No. E-01345A-11-0224

**Table 16. Summary of Lamp Types, Lamp Power, and Market Share**

Lamp Type	System Power (W)	# of Lamps Per System	Per Lamp Power (W)	Market Share
40W T12 Electronic	107.7	3	35.9	30%
40W T12 Magnetic	129	3	43.0	30%
34W T12 Electronic	91.7	3	30.6	20%
34W T12 Magnetic	108	3	36.0	20%
T8 Electronic (replace 40W mag)	113.3	3	37.8	30%
T8 Electronic (replace 34W, 40W elec)	86.8	3	28.9	70%

**Table 17. Weighted Average Energy Consumption by Sector and Lamp Type**

Calculation	Commercial	Residential
Weighted Average T12 Wattage $W_{T-12}$	37.0	37.0
Weighted Average T8 Wattage $W_{T-8}$	31.6	31.6
HOU/yr	3005	876
Average Energy Savings (kwh/lamp)	16	5

*Technical Factors (Factors<sub>sector</sub>)* – Energy savings calculations included hours of use, line loss factors, HVAC interaction factors, coincidence factors, and diversity factors for both residential and commercial contexts listed in Table 18. All factors except the capacity reserve margin and line loss factor were weighted as 80 percent commercial and 20 percent residential.

**Table 18. Technical Factor Adjustments by Sector**

Factor	Commercial	Residential
Hours of Use	3005	876
Line Loss Factor (Energy)	7.0%	7.0%
Line Loss Factor (Demand)	11.7%	11.7%
HVAC Interaction Factor (Energy)	0.14	0.10
HVAC Interaction Factor (Demand)	0.15	0.30
Coincidence Factor - APS	0.65	0.06
Diversity Factor - APS	0.80	0.78
Capacity Reserve Margin	15%	15%

## 2.3 Gross Energy Savings

To estimate a compliance rate with the standard, Navigant consulted internal lighting market experts. In 2012, the compliance rate is low because the standard became effective in July of that year. Compliance rates are assumed to increase in 2013 to 75 percent. The compliance rate signifies that 75 percent of T12s in the market are shifted to T8s in 2013. The assumption is that 25 percent do not shift either due to a) exemptions in the definition of applicable fluorescent lamps, or b) the expected time for manufacturer stockpiles to diminish. In 2014, a 90 percent compliance rate is effectively full compliance, under the assumption that 10 percent of lamps are exempt from the standard. For the PY2013 analysis, gross energy savings are calculated as 75 percent of potential energy savings.

**Table 19. Linear Fluorescent Standard Compliance Rate Assumptions by Year**

Year	Compliance Rate
2012	25%
2013	75%
2014	90%

## 2.4 Net Energy Savings

Navigant's projection of the counterfactual baseline absent the linear fluorescent standard is a reflection of the NOMAD of efficient lamps. As shown in Figure 2, the exponential function used to project sales of T-12s from 2012-2014 represents the natural trend present in the market before the effects of the standard.

## 2.5 Net C&S Program Savings

Navigant calculated net C&S program savings for all codes and standards under consideration in 2013 as one-third of net energy savings, which is permitted under ACC R-14-2.

Navigant calculated net energy savings and net C&S program savings shown in Table 20 using the values and adjustments noted above in conjunction with Equation 2. The net C&S program savings are the final savings claimed by APS, and include the one-third allowance adjustment. APS can claim 3,643 MWh of energy savings and .92 MW of demand savings from the federal linear fluorescent standard.

**Table 20. 2013 APS Net Energy and Demand Savings at Generator from the Federal Linear Fluorescent Standard**

	kWh	MWh
Net Energy Savings – Residential	697,533	697
Net Energy Savings - Commercial	10,231,320	10,231
Total Net Energy Savings	10,928,853	10,929
<b>Net C&amp;S Program Energy Savings</b>	<b>3,642,951</b>	<b>3,643</b>
	kW	MW
Net Demand Savings - Residential	68	.07
Net Demand Savings - Commercial	2,696	2.70
Total Net Demand Savings	2,764	2.76
<b>Net C&amp;S Program Demand Savings</b>	<b>921</b>	<b>.92</b>

## 3 Pool Pumps

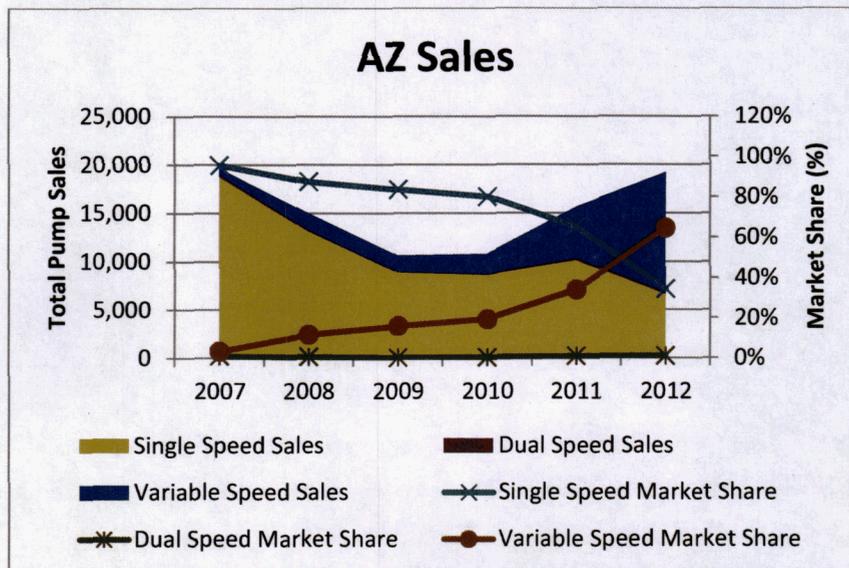
### 3.1 Description of the Standard

In 2009, Arizona passed a pool pump motor standard (State Legislation Title 44<sup>30</sup>) effective January 1, 2012. The standard requires residential pool pumps to be capable of operating at two or more speeds. The savings analysis is based on the energy use difference between non-compliant single speed pumps and Title 44 compliant dual or variable speed pumps.

### 3.2 Potential Energy Savings

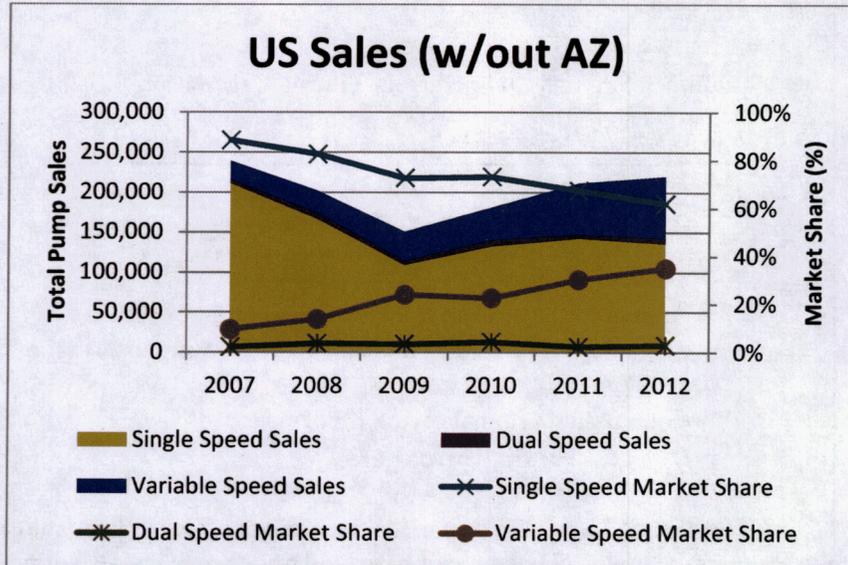
To estimate energy savings resulting from the appliance standard, Navigant compared pool pump sales within Arizona to sales in the rest of the United States. The analysis is based on Arizona and nationwide pool pump sales data for 2007-2012 provided by a pool pump manufacturer (Manufacturer X) with an estimated 56 percent market share within Arizona. Figure 3 and Figure 4 present Manufacturer X's gross sales data and related market share disaggregated by pump type—single, dual, or variable speed.

Figure 3. Arizona Pool Pump Sales and Market Share Data – Manufacturer X



<sup>30</sup> Chapter 9, Article 19 Section 2 Part B.2.b

Figure 4. US Pool Pump Sales and Market Share Data without AZ – Manufacturer X



An underlying assumption in this analysis is that nationwide sales outside of Arizona represent market behavior. This is a conservative estimate because this data may contain sales for areas with similar standards. Comparing Figure 3 and Figure 4 provided two major findings that drive the analysis.

First, there is no increase in market share of standard-minimum, dual speed pumps (DSPs) between 2011 and 2012 (approximately 1 percent) within Arizona. However, the market share of variable speed pump (VSP) sales within Arizona increased from 34.0 percent to 64.6 percent over that same period. Thus, consumers are choosing to exceed the requirements of the standard (i.e., DSPs) by installing VSPs. This has been confirmed through other evaluation activities carried out by Navigant—specifically the “mystery shop” exercise with Phoenix-area pool pump retailers found 15 of 16 shops reference Title 44 when promoting VSPs. As a result, the estimated impact of the standard is based on avoided non-compliant (i.e., single speed pump) sales rather than standard-minimum (i.e., dual speed pump) sales.

Second, 34.4 percent of pool pumps sold in Arizona in 2012 are single speed pumps (SSP). This suggests that the presence of the standard has not *completely* moved the baseline from a SSP to a DSP. The analysis accounts for this market share of SSPs by employing a “blended baseline” approach. In other words, the baseline pump consumption against which to measure savings is best represented as a mix of non-compliant SSPs and standard-minimum DSPs. For 2013, Navigant estimates this blended baseline from projected market share of non-compliant SSPs (approximately 25 percent) and compliant pumps<sup>31</sup> (approximately 75 percent) within APS service territory.

<sup>31</sup> Although 1% of the actual market is composed of DSPs, this analysis sums DSP and VSP market share to estimate the appropriate proportion of pumps that meet the minimum requirements of the standard.

Equation 3 summarizes Navigant’s analysis, which was used to estimate the savings APS can claim from Title 44.

### Equation 3. Savings Claimed from Title 44 Calculation (MWh)

$$\frac{N_{\text{avdSSP}} \times (kWh_{\text{SSP}} - kWh_{\text{standard}}) \times \left(\frac{1}{3}\right) \times (1 + LLF)}{1000}$$

Where:

- $N_{\text{avdSSP}}$  = avoided SSP sales in APS Territory
- $kWh_{\text{SSP}}$  = Annual kWh consumption of a non-compliant SSP
- $kWh_{\text{standard}}$  = Annual kWh consumption of an average pump in 2013 (i.e., Blended Baseline)
- $\left(\frac{1}{3}\right)$  = Commission order allowing 1/3 of standards savings
- $LLF$  = Line Loss Factor (7 percent)

*Avoided Single Speed Pump Sales ( $N_{\text{avdSSP}}$ )* – To estimate the number of SSPs that would have been sold in absence of the standard, ( $N_{\text{avdSSP}}$ ) Navigant compared the trends in SSP sales within APS service territory to that of the rest of the nation. Navigant made the following assumptions in this analysis:

- » Sales in APS territory would have mimicked the same general trend seen in all non-Arizona sales if Title 44 had not been implemented.
- » The available manufacturer data (56 percent market share) can be extrapolated to represent the entire Arizona market.
- » Market share of SSP sales by utility service territory for the three largest AZ utilities (APS, Salt River Project, and Tucson Electric Power) are proportional to number of residential customers as displayed in Table 21<sup>32</sup>.

**Table 21. Residential Customers by Arizona Utility**

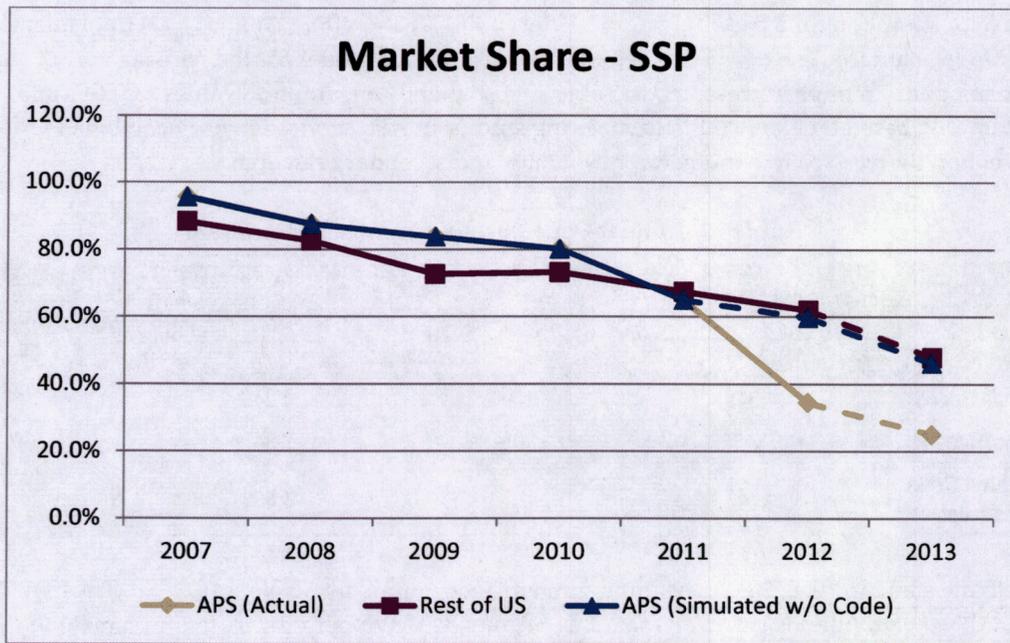
Utility	Residential Consumers	% Total
APS	996,422	45%
SRP	850,364	38%
TEP	365,768	17%

The change in market share of SSPs over the past 6 years - within Arizona (Yellow) and the rest of the US (Purple) - is displayed in Figure 5. In general, the market share of SSPs sold within AZ has followed the national trend until implementation of the Title 44 standard in 2012, where it drops significantly from approximately 65.0 percent to 34.4 percent. The Blue line represents the hypothetical sales of SSPs within AZ in absence of Title 44, resulting in an approximate market share of 46.2 percent. The precipitous decline in Arizona sales of SSPs in 2012 (Yellow line) is expected to flatten slightly in 2013, so Navigant conservatively assumed that SSPs make up 25 percent of the

<sup>32</sup> <http://www.eia.gov/electricity/data/eia861/index.html>

market in 2013 (i.e., pump sales are not fully compliant with Title 44). As a result, Navigant estimates that the difference between the projections of the Blue and Yellow lines in 2013 - approximately 21.2 percent - represents the number of SSP sales avoided due to Title 44.

**Figure 5. Single Speed Pump Market Share<sup>33</sup>**



Equation 4 is used to translate this change in market share to actual avoided pool pump sales. This equation first estimates the total number of pumps sold within AZ by dividing the 2013 projected total number of pumps sold by Manufacturer X (25,988) by their estimated market share (56 percent). This results in approximately 46,408 pumps. The difference in SSP market share between the hypothetical market in absence of the standard and the projected actual 2013 market (21.2 percent) is then applied to this number to estimate the total avoided SSP sales within AZ - approximately 9,823 pumps. Finally, the number of APS customers as a percentage of the total residential customers of the three largest AZ utilities (45 percent) is applied to arrive at the final estimate of 4,421 avoided SSP sales in 2013 within APS territory.

**Equation 4. Avoided Single Speed Pumps Sales Calculation**

$$\frac{N_{Pumps} \times \%_{SSP,APS} \times (\%_{SSP,Sim} - \%_{SSP,Actual})}{\%_{Manf}} = \frac{25,988 \times 45\% \times (46.2\% - 25.0\%)}{56\%} = 4,421$$

Where:

- $N_{SSP,AZ,Manf}$  = Gross AZ pump sales for Manufacturer X in 2012 (25,988)
- $\%_{SSP,APS}$  = percentage of total AZ SSP sales in APS Territory (45 percent)

<sup>33</sup> Dashed lines in Figure 5 represent sales projections; solid lines represent actual sales data.

- $\%_{SSP,Sim}$  = percentage of total AZ sales that are SSP absent the standard (46.2 percent)
- $\%_{SSP,Actual}$  = percentage of total AZ sales that are SSP (25.0 percent)
- $\%_{Manf}$  = percentage of total AZ market represented by Manufacturer X (56 percent)

*Unit Energy Savings ( $kWh_{SSP}$  and  $kWh_{standard}$ )* – This section discusses the estimates of annual energy consumption for a baseline pump before ( $kWh_{SSP}$ ) and after ( $kWh_{standard}$ ) implementation of the Title 44 standard. The derivation for annual consumption values for the “pre-standard” and “post-standard” pumps is presented in Table 22. Estimated consumption values for SSPs and DSPs are primarily based on Navigant field metering studies in APS service territory combined with information derived from manufacturer estimates and secondary research.

**Table 22. Annual Code Baseline Pump Consumption**

	Pre-Standard- 2011 ( $kWh_{SSP}$ )		Post-Standard-2013 ( $kWh_{standard}$ )	
	Annual Consumption (kWh)	Weighting	Annual Consumption (kWh)	Weighting
Single Speed	4,349	100%	4,349	25%
Dual Speed	3,347	0%	3,347	75%
<b>Blended Code Baseline</b>	<b>4,349</b>		<b>3,598</b>	

Prior to the standard (i.e., 2011), the minimum efficiency pump available was a SSP. Thus, the “pre-standard” consumption is based on that of a SSP, or 4,349 kWh per year. After implementation of the standard, the minimum efficiency pump available for installation is defined as a DSP. However, as discussed above, there are still a substantial number of SSPs being installed in Arizona. Therefore, this must be accounted for in the estimate of “post-standard” baseline annual energy consumption, and is estimated as the weighted average of 25 percent SSP and 75 percent DSP, or approximately 3,598 kWh per pump.

Applying the estimates of avoided SSP sales and consumption of pre-standard and post-standard code pumps to Equation 3 results in approximately 1,185 MWh in savings attributable to the Title 44 standard that can be claimed by APS. This calculation is presented below in Equation 5.

**Equation 5. Verified Claimed Savings Attributable to Title 44 Standard**

$$\frac{4,421 \times (4,349 - 3,598) \times \left(\frac{1}{3}\right) \times (1 + .07)}{1000} = 1,185 \text{ MWh}$$

### 3.3 Gross Energy Savings

As noted above, the assumption for 2013 is that 25 percent of sales in Arizona are non-compliant SSPs; therefore, the 75 percent compliance rate is factored into the analysis.

### 3.4 Net Energy Savings

Natural rates of market adoption are accounted for in Figure 5 as the APS simulated sales of SSPs without the standard. Without the standard, the market for SSPs would have naturally declined slowly. This is factored into the analysis by measuring the difference between the Blue and Yellow lines to estimate avoided sales.

### 3.5 Net C&S Program Savings

Navigant calculated net C&S program savings for all codes and standards under consideration in 2013 as one-third of net energy savings, which is permitted under ACC R-14-2.

Navigant calculated net energy savings and net C&S program savings shown in Table 23 using the values and adjustments noted above in conjunction with Equation 4 and Equation 5. The net C&S program savings are the final savings claimed by APS, and include the one-third allowance adjustment. APS can claim 1,185 MWh of energy savings and .14 MW of demand savings from the state Title 44 pool pump standard.

**Table 23. 2013 APS Net Energy and Demand Savings at Generator from the Title 44 Pool Pumps Standard**

	kWh	MWh
Total Net Energy Savings	3,554,595	3,555
<b>Net C&amp;S Program Energy Savings</b>	<b>1,184,865</b>	<b>1,185</b>
	kW	MW
Total Net Demand Savings	406	.41
<b>Net C&amp;S Program Demand Savings</b>	<b>135</b>	<b>.14</b>

## 4 Motors

### 4.1 Description of the Standard

The first standards for electric motors were enacted by Congress in EPACT. EISA, passed by Congress in 2007, amended EPACT electric motor standards and expanded the scope of covered motors. Navigant's savings analysis is based on the difference between previous EPACT efficiencies and the new EISA requirements. Effective December 2010, the EISA standard requires that general purpose electric motors (subtype I) meet "NEMA Premium" efficiency levels and that general purpose electric motors (subtype II), fire pump motors, and NEMA Design B general purpose electric motors meet "NEMA Energy Efficient" levels. "NEMA Premium" motors are more efficient than "NEMA Energy Efficient" motors.

For this analysis, Navigant adopted the same methodology used by the DOE for their National Impact Analysis of the effects of the standard. The energy assumptions in the DOE's analysis originate from an analysis published by the American Council for an Energy Efficient Economy (ACEEE), shown in Table 24.

**Table 24. Average Annual Energy Savings and Hours of Use for Motors Affected by EISA Standards<sup>34</sup>**

HP Bin	Annual Energy Savings/Motor (NEMA Efficient, kWh)	Annual Energy Savings/Motor (NEMA Premium, kWh)	Annual Operating Hours (h)
1 through 5 hp	149	82	2567
Greater than 5 through 20 hp	687	444	3113
Greater than 20 through 50 hp	1599	1039	3653
Greater than 50 through 100 hp	3544	1471	4663
Greater than 100 through 200 hp	3996	2608	4735
Greater than 200 through 500 hp	21103	7434	5444

### 4.2 Potential Energy Savings

Navigant's calculation of the potential energy savings represents a hypothetical scenario in which all electric motors sold after the effective date are in compliance with the new standard (full compliance). Potential energy savings were calculated using the following formula:

<sup>34</sup> Elliot, Neal R. "Impact of Proposed Increase to Motor Efficiency Performance Standards, Proposed Federal Motor Tax Incentives and Suggested New Directions Forward." *ACEEE Report Number IE073*, October 2007.

## Equation 6. APS-Territory-Wide Potential Energy Savings from the EISA Electric Motors Standards (kWh)

$$\sum (N_{\text{avgMotors}} \times kWh \frac{\text{savings}}{\text{motor}} \times \% \text{ Sales EISA} * \% \text{ MShare}_{\text{HP}} * \text{Factors})$$

Where:

- $N_{\text{avgMotors}}$  = projection of the number of "baseline" EPACT-compliant (old standard) electric motors sales in APS territory in 2013 (approximately 17,923) in absence of the standard
- $kWh \frac{\text{savings}}{\text{motor}}$  = Annual energy savings (kWh) per motor in each horsepower bin in two categories: NEMA Premium and NEMA Energy Efficient Table 9
- $\% \text{ Sales EISA}$  = The percentage of sales in each horsepower bin of motor types that are covered by EISA (general purpose electric motors, fire pump motors, and NEMA Design B motors)
- $\% \text{ MShare}_{\text{HP}}$  = The market share of each horsepower bin as a percentage of national sales.
- $\text{Factors}$  = Technical factors including the line loss factor, coincidence factor (demand), and capacity reserve margin

Applying the above formula for both NEMA Efficient and NEMA Premium motors across horsepower categories yields the potential energy savings shown in Table 25. Each element of the calculation is explained in further detail below. Note that, because the incentive program baseline changed from EPACT-complaint motors to EISA-compliant motors in 2012, there is no program influence adjustment applied to the motors analysis.

**Table 25. 2013 APS Territory Potential Energy Savings from Electric Motors by Horsepower Category**

Horsepower Bin	Potential Savings, NEMA Efficient (kWh)	Potential Savings, NEMA Premium (kWh)	APS Territory Total Potential Savings (kWh)
1 through 5 hp	272,140	522,842	794,982
Greater than 5 through 20 hp	552,584	997,584	1,550,168
Greater than 20 through 50 hp	361,942	474,384	836,326
Greater than 50 through 100 hp	282,473	204,733	487,206
Greater than 100 through 200 hp	173,679	136,355	310,034
Greater than 200 through 500 hp	681,518	-	681,518
<b>Total</b>	<b>2,324,336</b>	<b>2,335,896</b>	<b>4,986,448</b>

Estimating Quantity of Avoided Motor Sales ( $N_{\text{avoidMotors}}$ ) – Using national sales data from NEMA and the US Census<sup>35</sup>, Navigant calculated the number of electric motors sold in 2013. The best available Census data records number of motor shipments in each horsepower bin through 2003 (Table 26). Navigant used the NEMA sales index<sup>36</sup> – which uses 2003 as a base year - to project motor sales in 2013. This is consistent with the methodology used by DOE for their National Impact Analysis<sup>37</sup>.

**Table 26. Historic US Electric Motor Sales**

Year	NEMA Sales Index	US Motor Sales
2003	100	1,531,845
2006	141.5	2,167,561
2007	141.75	2,171,390
2008	139.5	2,136,924
2009	112.75	1,727,155
2010	118.5	1,815,236
2011	148.5	2,274,790
2012	147.5	2,259,471
2013	167.7	2,568,393

In order to allocate national market data to APS territory-specific savings values, Navigant applied various adjustment factors to NEMA motors sales data. DOE has data on motor sales by horsepower by sector (Table 27). Using this data, Navigant calculated a breakdown of motor sales by sector—72 percent commercial and 28 percent industrial. Using national, state, and APS 2012 electricity sales data from the Energy Information Administration<sup>38</sup>, Navigant developed scaling factors for each relevant end-use sector (Table 28). Navigant applied these factors to the NEMA national sales data to estimate the share of electric motors distributed to customers in APS service territory (Table 29).

<sup>35</sup> United States Census Bureau. "Industrial Report MA335-H Motors and Generators." 2003 Annual.

[http://www.census.gov/manufacturing/cir/historical\\_data/discontinued/ma335h/index.html](http://www.census.gov/manufacturing/cir/historical_data/discontinued/ma335h/index.html)

<sup>36</sup> National Electric Manufacturers Association. Motors Shipments Index. Third Quarter, 2013.

<http://www.nema.org/news/Pages/Motors-Shipments-Index-Rebounds-in-Third-Quarter-of-2013.aspx>

<sup>37</sup> United States Department of Energy. "Technical Support Document: Impacts on the Nation of the Energy Independence and Security Act of 2007." March 2009. <http://www.regulations.gov/#!documentDetail;D=EERE-2009-BT-STD-0010-0002>

<sup>38</sup> US Energy Information Administration. Electricity Utility Sales and Revenue—EIA-826 Detailed Data File. Released July 31, 2013, accessed August 19, 2013. <http://www.eia.gov/electricity/data/eia826/>

**Table 27. DOE Electric Motors Sales by Horsepower and Sector**

HP	Motor Sales by Sector		
	Industry	Agriculture	Commercial
1-5	26.11%	0.11%	73.78%
6-20	26.11%	0.11%	73.78%
21-50	26.11%	0.11%	73.78%
51-100	63.27%	6.98%	29.75%
101-200	76.03%	3.35%	20.62%
201-500	69.09%	3.03%	27.88%

**Table 28. APS Motors Scaling Factors based on Electricity Sales by Sector**

Scaling Factor	Residential	Commercial	Industrial
<b>NEMA Shipments by Sector</b>	0%	72%	28%
<b>Scalar – US to AZ<sup>39</sup></b>	2%	2%	1%
<b>Scalar - AZ to APS<sup>40</sup></b>	40%	43%	18%

**Table 29. 2013 Estimated Quantity of Motors Sales by Region**

Region	Motors Sales
<b>National</b>	2,568,393
<b>Arizona</b>	49,931
<b>APS</b>	17,923

Estimating the number of motors covered by the EISA standard (*% Sales EISA*) –EISA covers only general purpose electric motors (subtypes I and II), fire pump motors, and NEMA Design B motors. Therefore, not all sales of motors in 2013 are subject to the standards. To be consistent with the DOE analysis, Navigant used the following data from ACEEE to determine the percentage of motor sales affected by EISA.

<sup>39</sup> Based on Arizona's share of total US electricity sales in each sector

<sup>40</sup> Based on APS's share of total Arizona electricity sales in each sector

**Table 30. Percent of Sales Affected by EISA Standards for Different Horsepower Categories**

HP Bin	% of Sales Applicable to Standards in This Category	
	NEMA Efficient	NEMA Premium
1 through 5 hp	25%	65%
Greater than 5 through 20 hp	25%	65%
Greater than 20 through 50 hp	25%	65%
Greater than 50 through 100 hp	25%	65%
Greater than 100 through 200 hp	25%	65%
Greater than 200 through 500 hp	75%	0%

*Estimating the market share of each horsepower category ( $MShare_{HP}$ )* – The US Census data on motors sales in 2003 includes a breakdown of sales by horsepower (Table 31). Navigant used these data to determine the relative weights of each horsepower category, assuming that the mix of sales by horsepower remains consistent from year to year, and therefore is applicable in 2013.

**Table 31. 2003 Motors Shipments and Relative Weighting by Horsepower Category**

Horsepower Category	2003 Motor Shipments	Breakdown By HP
1 through 5 hp	931,936	61%
Greater than 5 through 20 hp	410,414	27%
Greater than 20 through 50 hp	115,497	8%
Greater than 50 through 100 hp	40,669	3%
Greater than 100 through 200 hp	22,177	1.4%
Greater than 200 through 500 hp	11,152	0.7%
Total	1,531,845	100%

*Technical Factors (Factors)* – Energy and demand savings calculations included line loss factors, coincidence factor, and capacity reserve margin listed in Table 32.

**Table 32. Technical Factor Adjustments for the Motors Analysis**

Factor	Residential
Line Loss Factor (Energy)	7.0%
Line Loss Factor (Demand)	11.7%
Coincidence Factor	0.95
Capacity Reserve Margin	15%

## 4.3 Gross Energy Savings

Navigant's calculation of the gross energy savings accounts for the fact that not all motors covered under the standard will be sold at compliant levels of efficiency in 2013. Gross energy savings were calculated using the same formula as potential energy savings, with an added compliance element:

**Equation 7. APS-Territory-Wide Potential Energy Savings from the EISA Electric Motors Standards (kWh)**

$$\sum N_{\text{avoidMotors}} \times kWh \frac{\text{savings}}{\text{motor}} \times (\% \text{ Sales } NC_{\text{pre-std}} - \% \text{ Sales } NC_{\text{post-std}}) \times \% \text{ Sales } EISA \times \% MShare_{HP} \times \text{Factors}$$

Where:

- $N_{\text{avoidMotors}}$  = projection of the number of avoided electric motors sales in APS territory in 2013 (approximately 17,923)
- $kWh \frac{\text{savings}}{\text{motor}}$  = Annual energy savings (kWh) per motor in each horsepower bin in two categories: NEMA Premium and NEMA Energy Efficient Table 9.
- $\% \text{ Sales } NC_{\text{pre-std}}$  = percentage of sales in each horsepower bin not meeting EISA standards prior to adoption of the standard (2009)
- $\% \text{ Sales } NC_{\text{post-std}}$  = percentage of sales in each horsepower bin not meeting EISA standards in the year of analysis (2013)
- $\% \text{ Sales } EISA$  = The percentage of sales in each horsepower bin of motor types that are covered by EISA (general purpose electric motors, fire pump motors, and NEMA Design B motors)
- $\% MShare_{HP}$  = The market share of each horsepower bin as a percentage of national sales.
- $\text{Factors}$  = Technical factors including the line loss factor, coincidence factor (demand), and capacity reserve margin

To maintain consistency with the DOE National Impact Analysis, Navigant used estimates from ACEEE regarding the portion of motors that were not already EISA compliant before the standard ( $\% \text{ Sales } NC_{\text{pre-std}}$ ). After investigating compliance rates with similar standards nationwide, and consulting industry experts, Navigant determined that 80 percent compliance is a reasonable rate for 2013. Therefore, the following equation calculates the percent of sales not meeting EISA standards in 2013 ( $\% \text{ Sales } NC_{\text{post-std}}$ ), and the results are displayed in Table 33 below.

**Equation 8. Calculating the Percent of Motors Sales not Meeting EISA Standards in 2013**

$$\% \text{ Sales } NC_{\text{pre-std}} * (1 - .8) = \% \text{ Sales } NC_{\text{post-std}}$$

**Table 33. Percent of Motor Sales not Meeting EISA Standards before Implementation and in 2013**

HP Bin	% Sales Not Meeting EISA					
	NEMA Efficient			NEMA Premium		
	Pre-EISA Absent Standard	2013	Difference	Pre-EISA Absent Standard	2013	Difference
1 through 5 hp	67%	13%	54%	90%	18%	72%
Greater than 5 through 20 hp	67%	13%	54%	72%	14%	58%
Greater than 20 through 50 hp	67%	13%	54%	52%	10%	42%
Greater than 50 through 100 hp	67%	13%	54%	45%	9%	36%
Greater than 100 through 200 hp	67%	13%	54%	31%	6%	25%
Greater than 200 through 500 hp	33%	7%	26%	25%	5%	20%

#### 4.4 Net Energy Savings

Because the EISA standard applies to manufacturers of electric motors (rather than retailers or distributors), a compliance rate of 80 percent three years after the effective date of the standard is a conservative assumption. Therefore, Navigant did not apply an additional adjustment for NOMAD of energy efficient motors, assuming the compliance rate already accounts for this adjustment. Consequently, gross energy savings is equal to net energy savings in this analysis. Navigant identified the natural market adoption rate of efficient motors as an area for future research.

#### 4.5 Net Demand Savings

Net demand savings were calculated using the same methodology above, substituting  $kWh \frac{savings}{motor}$  with  $kW \frac{savings}{motor}$ . To develop  $kW \frac{savings}{motor}$  for each horsepower category, Navigant used the following equation. Results are displayed in Table 34.

#### Equation 9. Calculating Annual Demand Savings from the EISA Motors Standard

$$\left( \frac{kWh \frac{savings}{motor}}{HOU} \right) * (1 + LLF) * CF * (1 + CRM) = kW \frac{savings}{motor}$$

Where:

- $kWh \frac{savings}{motor}$  = Annual energy savings (kWh) per motor in each horsepower bin in two categories: NEMA Premium and NEMA Energy Efficient (Table 34)
- $HOU$  = Hours of use by horsepower category, shown in Table 24
- $1 + LLF$  = accounting for the line loss factor (11.7 percent)
- $CF$  = accounting for the coincidence factor (.95)
- $1 + CRM$  = accounting for the capacity reserve margin (15 percent)

$$kW \frac{\text{savings}}{\text{motor}}$$

= Annual demand savings per motor in each horsepower bin in two categories: NEMA Premium and NEMA Energy Efficient shown in Table 34

**Table 34. Hours of Use, Energy Savings, and Demand Savings by Horsepower Category**

HP Bin	Annual Operating Hours (h)	NEMA Energy Efficient		NEMA Premium	
		Annual Energy Savings/Motor (kwh)	Annual Demand Savings/Motor (kw)	Annual Energy Savings/Motor (kwh)	Annual Demand Savings/Motor (kw)
1 through 5 hp	2567	149	0.07	82	0.04
Greater than 5 through 20 hp	3113	687	0.27	444	0.17
Greater than 20 through 50 hp	3653	1599	0.53	1039	0.35
Greater than 50 through 100 hp	4663	3544	0.93	1471	0.38
Greater than 100 through 200 hp	4735	3996	1.03	2608	0.67
Greater than 200 through 500 hp	5444	21103	4.73	7434	1.67

#### 4.6 Net C&S Program Savings

Navigant calculated net C&S program savings for all codes and standards under consideration in 2013 as one-third of net energy savings, which is permitted under ACC R-14-2.

Navigant calculated net energy savings and net C&S program savings shown in Table 35 using the values and adjustments noted above in conjunction with the equations listed in this section. The net C&S program savings are the final savings claimed by APS, and include the one-third allowance adjustment. APS can claim 1,330 MWh of energy savings and .43 MW of demand savings from the federal EISA motors standard.

**Table 35. APS Net Energy and Demand Savings at Generator from the EISA Motors Standard**

Energy	kWh	MWh
Total Net Energy Savings	3,989,744	3,990
<b>Net C&amp;S Program Energy Savings</b>	<b>1,329,915</b>	<b>1,330</b>
Demand	kW	MW
Total Net Demand Savings	1,300	1.30
<b>Net C&amp;S Program Demand Savings</b>	<b>433</b>	<b>.43</b>

## 5 Residential New Construction

### 5.1 Description of the Code

Throughout the United States, each state adopts a version of the International Energy Conservation Code (IECC). The IECC code is updated at three-year intervals, and covers energy-related aspects of new construction practices. As a home rule state, each jurisdiction (i.e., county or city) in Arizona has the option to adopt its own version of the IECC. Consequently, in APS territory, there is a mixture of IECC code vintages from 2003 to 2012. Navigant's energy savings analysis is based on a combination of proposed code changes within APS service territory and energy simulation modeling.

### 5.2 Potential Energy Savings

Navigant's calculation of the potential energy savings represents a hypothetical scenario in which a new building code in a particular jurisdiction is 100 percent effective on the day the code is implemented (full compliance). Potential energy savings were calculated using the following formula:

**Equation 10. APS-Territory-Wide Potential Energy Savings from Residential Building Codes (kWh)**

$$\sum (\% \text{ NewMeters} \times (\text{kWh/year}_{\text{oldcode}} - \text{kWh/year}_{\text{newcode}}) * \text{Factors}$$

Where:

- % NewMeters* = The number of new meters installed in a particular jurisdiction as a percent of the total residential (single-family or multifamily) meters installed by APS in 2013
- kWh/year<sub>oldcode</sub>* = Annual consumption (kWh) of code-compliant homes in a jurisdiction prior to adoption of a more stringent code
- kWh/year<sub>newcode</sub>* = Annual consumption (kWh) of code-compliant homes in a jurisdiction after the adoption of a more stringent code
- Factors* = Technical factors such as the line loss factor (energy 7 percent; demand 11.7 percent), coincident demand ratio (3.71; for demand calculations only), and capacity reserve adjustment (.15)

The equation applies to both single-family and multifamily new meters, summed across all jurisdictions within APS territory. Using the formula above, Navigant calculated potential energy savings from residential building codes as approximately 18 million kWh in 2013, as shown in Table 36.

**Table 36. 2013 APS Territory Potential Energy Savings by Housing Category**

Housing Category	APS Territory Potential Savings (kWh)
Single-Family	16,764,761
Multifamily	367,451
<b>Total Potential Savings</b>	<b>17,132,211</b>

*Unit Energy Savings (kWh/year<sub>oldcode</sub> and kWh/year<sub>newcode</sub>)* – After examining the breakdown of new meters installed by climate zone (Table 37), Navigant used one calibrated energy model for single-family and multifamily homes in climate zone 2B to represent the “typical” home in APS territory.

**Table 37. 2013 APS New Residential Meter Installations by Climate Zone**

Climate Zone	2013 New Single-Family Meters	2013 New Multifamily Meters	Total New Meters	New Meters as a Percent of Total
2B	7,197	3,240	10,437	89.7%
3B	29	3	33	0.3%
4B	742	14	756	6.5%
5B	297	117	413	3.6%
<b>Total</b>	<b>8,265</b>	<b>3,374</b>	<b>11,639</b>	<b>100.0%</b>

To determine unit energy savings per new meter by code vintage, Navigant used a suite of DOE2 energy models with code-compliant inputs, calibrated to monthly APS billing data with Phoenix weather. The simulated consumption of each code-compliant home is shown in Table 38.

**Table 38. Modeled Annual Residential Electricity Consumption by Code Vintage**

Code Version	Modeled Single-Family Annual Consumption for Phoenix (kWh)	Modeled Multifamily Annual Consumption for Phoenix (kWh)
2003 IECC	19,663	8,427
2006 IECC	18,743	8,088
2009 IECC	17,068	7,749
2012 IECC	13,380	7,411

*Quantity of New Homes(% NewMeters)* – Navigant investigated the code adoption schedules of 104 jurisdictions in which APS installed new meters in 2013. Navigant considered a code effective in 2013 if the jurisdiction enforced the code before July 1. If the code was enforced after July 1, Navigant considered the code effective in 2014 and beyond. Table 39 shows the code adoption schedules of the

ten jurisdictions in APS territory that had the most single-family meters installed in 2013. This analysis accounts for all jurisdictions in APS territory. These ten are displayed as an example.

**Table 39. Quantity of New Meters and Code Adoption Schedule for the Ten Jurisdictions with the Most New Meters within APS Territory**

Jurisdiction	Single-Family New Meters	Multifamily New Meters	Code Adoption Schedule		
			2012	2013	2014
Goodyear	1339	0	2006 IECC	2006 IECC	2006 IECC
Peoria	1069	0	2006 IECC	<b>2012 IECC</b>	<b>2012 IECC</b>
Buckeye	1003	0	2006 IECC	<b>2009 IECC</b>	<b>2009 IECC</b>
Surprise	686	2	2006 IECC	2006 IECC	<b>2012 IECC</b>
Phoenix	617	2234	2006 IECC	2006 IECC	<b>2012 IECC</b>
Yuma	515	113	2003 IECC	<b>2012 IECC</b>	<b>2012 IECC</b>
Scottsdale	316	131	2006 IECC	<b>2012 IECC</b>	<b>2012 IECC</b>
Cave Creek	305	64	2009 IECC	2009 IECC	<b>2012 IECC</b>
Florence	285	0	2006 IECC	2006 IECC	2006 IECC
Prescott	273	4	2006 IECC	<b>2012 IECC</b>	<b>2012 IECC</b>

Navigant evaluated only the jurisdictions with new codes effective in 2013. As an example, of the ten largest jurisdictions in APS territory, five contributed to C&S program savings in 2013, as shown in Table 40. The single-family new meter weight is the new meters in each jurisdiction expressed as a percent of all APS new meters installed in 2013. As stated in Equation 10, the savings algorithm is the difference between the consumption of the old code (2012 effective code) and the new code (2013 effective code) multiplied by the new meter weight.

**Table 40. Weight of New Meters and Modeled Code Consumption for Five Significant Jurisdictions within APS Territory**

Jurisdiction	Single-Family New Meter Weight	Modeled Single-Family Consumption (kWh)		
		2012	2013	2014
Peoria	12.9%	18,743	<b>13,380</b>	<b>13,380</b>
Buckeye	12.1%	18,743	<b>17,068</b>	<b>17,068</b>
Yuma	6.2%	19,663	<b>13,380</b>	<b>13,380</b>
Scottsdale	3.8%	18,743	<b>13,380</b>	<b>13,380</b>
Prescott	3.3%	18,743	<b>13,380</b>	<b>13,380</b>

To calculate demand savings, Navigant applied a coincident demand ratio derived from energy models created for measurement and evaluation of APS's ENERGY STAR Homes Program according to Equation 11.

**Equation 11. Calculating Annual Demand Savings from the Residential Building Codes**

$$\left(\frac{kWh\ savings}{8760}\right) * (1 + LLF) * CDR * (1 + CRM) = kW\ savings$$

Where:

- $\frac{kWh\ savings}{8760}$  = Total energy savings (kWh) divided by the number of hours in a year
- $1 + LLF$  = accounting for the demand line loss factor (11.7 percent)
- $CDR$  = accounting for the coincident demand ratio (3.71)
- $1 + CRM$  = accounting for the capacity reserve margin (15 percent)

### 5.3 Gross Energy Savings

After informal interviews with APS staff familiar with building practices in Arizona, and a survey of code compliance studies conducted throughout the United States, Navigant developed a compliance rate to account for the fact that building practices can take significant time to adapt to a code change. The compliance rate increases each year after adoption of a new code. As shown in Table 41, the analysis assumes 50 percent compliance in the first year of adoption, with full compliance achieved by the fourth year after adoption. The compliance rate affects the modeled consumption of each code-compliant home according to Equation 12.

**Table 41. Modeled Code Consumption Adjusted for Compliance Rates**

Old Code and New Code	Compliance Adjusted Consumption (kWh)			
	Year 1	Year 2	Year 3	Year 4
2003 to 2006	19,203	18,973	18,881	18,743
2003 to 2009	18,365	17,717	17,457	17,068
2003 to 2012	16,521	14,950	14,322	13,380
2006 to 2009	17,906	17,487	17,319	17,068
2006 to 2012	16,061	14,720	14,184	13,380
2009 to 2012	15,224	14,302	13,933	13,380
<b>Compliance Rates</b>	<b>50%</b>	<b>75%</b>	<b>85%</b>	<b>100%</b>

**Equation 12. Application of Compliance Rates to Adjust Modeled Consumption of Code-Compliant Homes**

$$kWh_{oldcode} + ((kWh_{newcode} - kWh_{oldcode}) * Compliance Rate)$$

Where:

- $kWh_{oldcode}$  = Modeled consumption (kWh) of a home that complies with the old code
- $kWh_{newcode}$  = Modeled consumption (kWh) of a home that complies with the new code
- Compliance Rate* = Degree to which building practices comply with the new code on an energy use basis, expressed as a percentage (50 percent in 2013)

Table 42 shows the gross energy savings from residential codes in 2013 after applying the compliance rate adjustments to all jurisdictions.

**Table 42. 2013 APS Territory Gross Energy Savings by Housing Category**

Housing Category	APS Territory Gross Savings (kWh)
Single-Family	8,382,380
Multifamily	183,725
<b>Total Gross Savings</b>	<b>8,566,106</b>

### 5.4 Net Energy Savings

Navigant did not apply any adjustments to account for NOMAD of efficient building practices. Therefore, in this analysis, net savings are the same as gross savings.

### 5.5 Net C&S Program Savings

Navigant calculated net C&S program savings for all codes and standards under consideration in 2013 as one-third of net energy savings, which is permitted under ACC R-14-2.

Navigant calculated net energy savings and net C&S program savings shown in Table 43 using the values and adjustments noted above in conjunction with the equations listed in this section. The net energy savings equal the gross energy savings from Table 42 above, because no further compliance or NOMAD adjustments were applied to potential savings. The net C&S program savings are the final savings claimed by APS, and include the one-third allowance adjustment. APS can claim 2,990 MWh of energy savings and 1.52 MW of demand savings from the jurisdictional IECC residential building codes.

**Table 43. 2013 APS Net Energy and Demand Savings at Generator from Residential Building Codes**

	kWh	MWh
Net Energy Savings – Single-Family	8,382,380	8,382
Net Energy Savings - Multifamily	183,725	183
Total Net Energy Savings	9,165,733	9,166
<b>Net C&amp;S Program Energy Savings</b>	<b>3,055,244</b>	<b>3,055</b>
	kW	MW
Net Demand Savings – Single-Family	3,551	3.55
Net Demand Savings - Multifamily	78	.08
Total Net Demand Savings	4,662	4.66
<b>Net C&amp;S Program Demand Savings</b>	<b>1,554</b>	<b>1.55</b>

## 6 Commercial New Construction

### 6.1 Description of the Code

Throughout the United States, each state adopts a version of the IECC. The IECC code is updated at three-year intervals and covers energy-related aspects of new construction practices. The commercial equivalent of IECC is ASHRAE 90.1. The 2004, 2007, and 2010 versions of ASHRAE 90.1 accompany the 2006, 2009, and 2012 versions of IECC respectively<sup>41</sup>. As a home rule state, each jurisdiction in Arizona (i.e., county or city) has the option to adopt its own version of IECC/ASHRAE 90.1. Consequently, in APS territory, there is a mixture of all ASHRAE 90.1 code vintages from 2004 to 2010.

### 6.2 Potential Energy Savings

Navigant's calculation of the potential energy savings represents a hypothetical scenario in which a new building code in a particular jurisdiction is 100 percent effective on the day the code is implemented (full compliance). Potential energy savings were calculated using the following formula:

**Equation 13. APS-Territory-Wide Potential Energy Savings from Commercial Building Codes (kWh)**

$$\sum \left( \frac{kWh}{year} / sqft_{oldcode,Btype} - \frac{kWh}{year} / sqft_{newcode,Btype} \right) * Factors_{Btype}$$

Where:

$\frac{kWh}{year} / sqft_{oldcode,Btype}$  = The Energy Use Intensity (EUI) in kWh per square foot of floor space, by building type, in a jurisdiction prior to adoption of a more stringent code

$\frac{kWh}{year} / sqft_{newcode,Btype}$  = The EUI in kWh per square foot of floor space, by building type, in a jurisdiction after adoption of a more stringent code

$Factors_{Btype}$  = Technical factors such as the line loss factor (energy 7 percent; demand 11.7 percent), coincidence factors (by building type), and capacity reserve adjustment (15 percent)

The equation applies to 23 different building types, summed across all jurisdictions within APS territory. Using the formula above, Navigant calculated potential energy savings from commercial building codes as 9,903,850 kWh in 2013.

Unit Energy Savings  $\left( \frac{kWh}{year} / sqft_{oldcode,Btype} \text{ and } \frac{kWh}{year} / sqft_{newcode,Btype} \right)$  –To determine unit energy savings per square foot of new commercial floor space by building type, climate zone, and code

<sup>41</sup> For a detailed discussion of the parallels between IECC and ASHRAE90.1, see: US Department of Energy. "Building Energy Codes 101: An Introduction." February 2010. PNNL-SA-70586.

vintage; Navigant used a suite of commercial prototype building energy models with code-compliant inputs provided by DOE<sup>42</sup>. The simulated consumption of each code-compliant building by type and climate zone is shown in Table 44.

APS provided Navigant with a list of new meters installed in commercial facilities in 2013. This list included a building type designation determined by APS. By examining the APS definition and DOE definition of each building type, Navigant assigned corresponding DOE building types to each APS designation as shown in Table 45.

Similarly, the DOE prototype models are built to national average sizes by each building type. In order to obtain region-specific size data for each building type, Navigant used a combination of data from third-party databases maintained by Dodge Construction and CoStar. When lacking sufficient building size data, Navigant used the DOE prototype sizes, as shown in Table 45.

Navigant investigated the code adoption schedules of 75 jurisdictions in which APS installed new meters in 2013. Navigant considered a code effective in 2013 if the jurisdiction enforced the code before July 1. If the code was enforced after July 1, Navigant considered the code effective in 2014 and beyond. As an example, Table 46 shows the code adoption schedules of the ten jurisdictions in APS territory that had the most commercial new meters installed in 2013.

Navigant evaluated only the jurisdictions with new codes effective in 2013. From the 75 jurisdictions examined, eight contributed to C&S program savings in 2013, as shown in Table 47. In each jurisdiction, the new meters were further disaggregated by building type, and the appropriate EUIs were applied according to climate zone, building type, and code vintage.

---

<sup>42</sup> US Department of Energy. "Commercial Prototype Building Models." Building Energy Codes Program. November 1<sup>st</sup>, 2012. [http://www.energycodes.gov/development/commercial/90.1\\_models](http://www.energycodes.gov/development/commercial/90.1_models)

Table 44. Energy Use Intensity by Building Type, Code Vintage, and Climate Zone

DOE Prototype Model	DOE Building Area	Electricity Use (kWh/sq ft)														
		ASHRAE 90.1 2004					ASHRAE 90.1 2007					ASHRAE 90.1 2010				
		CZ 2B	CZ 3B	CZ 4B	CZ 5B	CZ 2B	CZ 3B	CZ 4B	CZ 5B	CZ 2B	CZ 3B	CZ 4B	CZ 5B			
Secondary School	210,886	17.2	14.3	13.1	12.4	16.0	13.3	12.3	11.7	12.8	10.8	10.0	9.4			
Strip Mall	22,500	20.3	17.4	16.1	15.4	19.1	15.7	14.8	14.1	15.0	12.6	12.0	11.5			
Primary School	73,959	18.1	15.6	14.5	13.5	17.0	14.7	13.7	13.0	13.9	11.9	11.2	10.7			
Stand-alone Retail	24,692	20.0	16.7	15.7	15.4	17.5	15.7	14.9	14.2	13.8	12.5	12.0	11.5			
Medium Office	53,628	14.1	12.2	12.1	12.2	13.6	11.8	11.5	11.6	10.4	8.8	8.5	8.4			
Large Hotel	122,120	24.6	19.3	17.1	16.0	22.6	18.8	16.9	15.9	20.1	17.1	15.7	14.7			
Full Service Restaurant	5,502	67.9	60.5	56.5	54.1	65.4	58.5	54.5	51.9	49.3	44.0	38.8	37.4			
Hospital	241,501	30.7	27.8	27.2	25.9	30.5	27.7	27.1	26.0	24.9	23.1	22.8	21.8			
Quick Service Restaurant	2,501	76.5	66.9	62.4	60.0	77.5	68.0	62.7	59.5	68.2	59.6	53.7	51.9			
Small Hotel	40,096	16.0	14.8	14.1	13.7	15.3	14.2	13.7	13.4	13.6	12.7	12.3	12.0			
Outpatient Healthcare	40,946	38.7	37.0	36.8	35.3	36.8	35.1	34.5	33.4	30.2	28.4	27.6	26.0			
Warehouse	52,045	5.9	4.6	4.3	4.3	5.8	4.6	4.3	4.3	4.6	3.4	3.1	3.2			

**Table 45. Summary of APS and DOE Building Types and Sizes**

APS Designation	DOE Prototype Model	DOE Building Area (sq ft)	AZ Building Area (sq ft)
College/University	Secondary School	210,886	153,985
Department Store	Strip Mall	22,500	18,225
Elementary School	Primary School	73,959	114,960
Grocery/Convenience Store	Stand-alone Retail	24,692	18,225
Halls	Medium Office	53,628	28,190
High School	Secondary School	210,886	114,960
Hotel	Large Hotel	122,120	73,712
Indust/Mfg/Process	Full Service Restaurant	5,502	4,668
Inpatient Facility	Hospital	241,501	126,965
Jr High/Middle School	Secondary School	210,886	114,960
Laundry/Cleaning Service	Quick Service Restaurant	2,501	2,501
Motel	Small Hotel	40,096	73,712
Office	Medium Office	53,628	28,190
Outpatient Facility	Outpatient Healthcare	40,946	40,946
Resort	Large Hotel	122,120	73,712
Restaurant or Bar	Full Service Restaurant	5,502	5,407
Retail – Exterior Entry	Stand-alone Retail	24,692	15,002
Retail – Int/Ext Entry	Stand-alone Retail	24,692	15,002
Retail – Interior Entry	Strip Mall	22,500	15,002
Spa/Gymnasium	Small Hotel	40,096	73,712
Take-Out Food	Quick Service Restaurant	2,501	2,501
Warehouse	Warehouse	52,045	55,704
Wholesale-Type Store	Warehouse	52,045	55,704

**Table 46. Quantity of New Meters and Code Adoption Schedule for the Ten Jurisdictions with the most New Meters in APS Territory**

Jurisdiction	Commercial New Meters	ASHRAE 90.1 Code Adoption Schedule		
		2012	2013	2014
Phoenix	72	2004	2004	2010
Scottsdale	49	2004	2010	2010
Goodyear	20	2004	2004	2010
Prescott	20	2004	2004	2010
Surprise	19	2004	2004	2004
Casa Grande	15	2004	2004	2010
Peoria	14	2004	2004	2010
Glendale	12	2004	2010	2010
Buckeye	8	2004	2004	2007
Avondale	7	2007	2007	2010

**Table 47. Quantity of New Meters and Code Adoption Schedule for the Eight Jurisdictions with New Codes in 2013**

Jurisdiction	Commercial New Meters	ASHRAE 90.1 Code Adoption Schedule		
		2012	2013	2014
Scottsdale	49	2004	2010	2010
Glendale	12	2004	2010	2010
Tempe	7	2004	2007	2010
Coolidge	3	2004	2010	2010
Paradise Valley	3	2004	2010	2010
Arizona City	1	2004	2010	2010
Chino Valley	1	2004	2010	2010
Superior	0	2004	2010	2010

*Factors* – Energy and demand savings calculations included line loss factors (7 percent energy and 11.7 percent demand), coincidence factors (by building type), and capacity reserve margins (.15, demand only). Navigant derived coincidence factors from the hourly output of the DOE prototype energy models, using APS peak hours of non-holiday weekdays between 4pm and 6pm June to August. Navigant determined a coincidence factor by building type (Table 48) and multiplied energy savings by the coincidence factor to calculate demand savings.

**Table 48. Coincidence Factors by Building Type**

DOE Prototype Model	Coincidence Factor
Secondary School	0.00020
Strip Mall	0.00024
Primary School	0.00015
Stand-alone Retail	0.00026
Medium Office	0.00017
Large Hotel	0.00015
Full Service Restaurant	0.00020
Hospital	0.00011
Quick Service Restaurant	0.00018
Small Hotel	0.00018
Outpatient Healthcare	0.00015
Warehouse	0.00012

**6.3 Gross Energy Savings**

After informal interviews with APS staff familiar with building practices in Arizona, and a survey of code compliance studies conducted throughout the United States, Navigant developed a compliance rate to account for the fact that building practices can take significant time to adapt to a code change. As shown in Table 49, the analysis assumes 65 percent compliance in the first year of adoption, with full compliance achieved by the fourth year after adoption. Annual EUI adjustments are based on the increasing compliance rates, as calculated in Equation 14.

**Table 49. Compliance Rate Assumptions for Commercial New Construction Codes**

	Year 1	Year 2	Year 3	Year 4
Compliance Rates	65%	75%	90%	100%

## Equation 14. Application of Compliance Rates to Adjust Modeled Consumption of Code-Compliant Buildings

$$kWh_{oldcode} + ((kWh_{newcode} - kWh_{oldcode}) * Compliance Rate)$$

Where:

- $kWh_{oldcode}$  = Modeled consumption (kWh) of a building that complies with the old code
- $kWh_{newcode}$  = Modeled consumption (kWh) of a building that complies with the new code
- Compliance Rate* = Degree to which building practices comply with the new code on an energy use basis, expressed as a percentage (65 percent in 2013)

### 6.4 Net Energy Savings

Navigant did not apply any adjustments to account for NOMAD of efficient building practices. Therefore, in this analysis, net savings are the same as gross savings.

### 6.5 Net C&S Program Savings

Navigant calculated net C&S program savings for all codes and standards under consideration in 2013 as one-third of net energy savings, which is permitted under ACC R-14-2.

Application of these adjustments yielded net energy savings and net C&S program savings by jurisdiction shown in Table 50 and by building type shown in Table 51. Demand savings are shown in Table 52. The net C&S program savings are the final savings claimed by APS, and include the one-third allowance adjustment. APS can claim 2,146 MWh of energy savings and .57 MW of demand savings from the jurisdictional IECC residential building codes.

**Table 50. 2013 APS Net Energy Savings at Generator from Commercial Building Codes, by Jurisdiction**

Jurisdiction	Commercial New Meters	Net Energy Savings (kWh)	Net Energy Savings (MWh)
Scottsdale	49	4,644,044	4644.0
Glendale	12	1,075,839	1075.8
Tempe	7	177,972	178.0
Coolidge	3	218,887	218.9
Paradise Valley	3	194,949	194.9
Arizona City	1	78,947	78.9
Chino Valley	1	46,863	46.9
<b>Total</b>	<b>76</b>	<b>6,437,502,524</b>	<b>6438</b>

**Table 51. APS Net Energy Savings at Generator from Commercial Building Codes, by Building Type**

Building Type	Commercial New Meters	Net Energy Savings (kWh)	Net Energy Savings (MWh)
Retail – Exterior Entry	133	2,821,088	2821.1
Elementary School	10	1,021,174	1021.2
Office	75	885,030	885.0
Outpatient Facility	11	734,031	734.0
Restaurant or Bar	28	391,396	391.4
Jr. High / Middle School	1	355,337	355.3
Grocery / Convenience Store	6	125,810	125.8
Hotel	2	103,636	103.6
<b>Total</b>	<b>266</b>	<b>6,437,502,524</b>	<b>6438</b>

**Table 52. APS Net Demand Savings at Generator from Commercial Building Codes**

	kWh	MWh
Total Net Energy Savings	6,437,502,524	6438
<b>Net C&amp;S Program Energy Savings</b>	<b>2,145,834,175</b>	<b>2146</b>
	kW	MW
Total Net Demand Savings	1,610	1.61
<b>Net C&amp;S Program Demand Savings</b>	<b>574</b>	<b>.54</b>

## Appendix A Codes and Standards Measurement and Evaluation Plan

### A.1 Introduction

As stated in section R14-2-2404 part E of the Electric Energy Efficiency Standards<sup>43</sup>,

*“An affected utility may count toward meeting the standard up to one third of the energy savings, resulting from energy efficiency building codes, that are quantified and reported through a measurement and evaluation study undertaken by the affected utility.”*

Furthermore, the ACC allows APS to include savings “resulting from improved energy efficiency appliance standards.”<sup>44</sup> The following memo presents Navigant’s proposed methodology to evaluate APS’s savings claims from recent changes to building codes and appliance standards.

### A.2 Determining Relevant Codes and Standards Updates

A review of federal, state, and jurisdictional code changes in 2012 revealed the following code updates of interest to APS:

**Table 53. Relevant Code Updates in APS Territory**

Measure	Old Code	New Code	Authority	Effective Year
General Service Lamps	None	EISA <sup>45</sup>	Federal	2012
Linear fluorescents	EPACT 1992	EISA <sup>46</sup>	Federal	2012
Pool pumps	None	Title 44 <sup>47</sup>	State	2012
Motors	EPACT 1992	EISA	Federal	2010
Residential New Construction	IECC 2003, 2006, 2009 (by jurisdiction)	IECC 2006, 2009, 2012 (by jurisdiction)	Jurisdictional	Various
Commercial New Construction	IECC 2003, 2006, 2009 (by jurisdiction)	IECC 2006, 2009, 2012 (by jurisdiction)	Jurisdictional	Various

The first four rows in Table 53 are standards that apply to specific appliances across building types. The last two rows are energy codes that set minimum requirements for the energy systems of a particular building by building type. C&S are established at the federal, state, or jurisdictional level. Establishing C&S at the federal level is typically a complex, long term and nationwide effort. Statewide C&S efforts

<sup>43</sup> Docket No. RE-00000C-09-0427 (Electric Energy Efficiency Rules) Title 14, Chapter 2, Article 24, section R14-2-2404.

<sup>44</sup> Docket No. E-01345A-11-0232; Decision No. 73089 pg. 56 Line 11

<sup>45</sup> Appliance Standards Awareness Project. General Service Lamps. <http://www.appliance-standards.org/node/6810>

<sup>46</sup> Energy Independence and Security Act of 2007. Public Law 110-140, 110<sup>th</sup> Congress.

<http://www.gpo.gov/fdsys/pkg/PLAW-110publ140/html/PLAW-110publ140.htm>

<sup>47</sup> Chapter 9, Article 19 Section 2 Part B.2.b

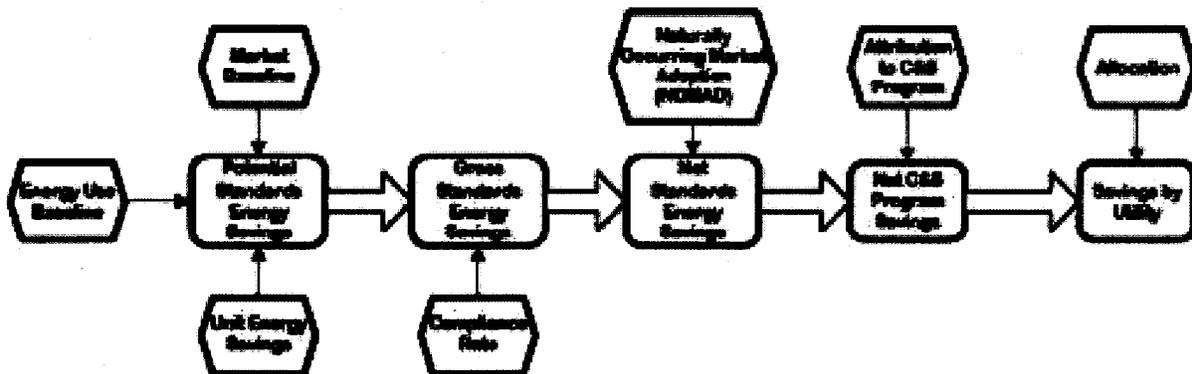
are more localized, and therefore responsive to influence from stakeholders and utilities within the state. At the jurisdictional level, city and county governments may look to the utilities that serve their territory for guidance and support in the C&S process. Evaluation of C&S programs should consider these differences when calculating the portion of savings that could be attributed to the utilities' efforts.

### A.3 Developing an Approach for Evaluating Savings Estimates

Determining savings from C&S is a relatively new practice that is still under development throughout the United States. So far, only a few state utility commissions allow constituent utilities to claim savings from C&S upgrades, but support for fulfilling statewide efficiency goals through C&S programs is on the rise<sup>48</sup>. Navigant strives to estimate savings claims as accurately as possible given budget and data constraints. Inevitably, assumptions will arise, in which case Navigant will err on the conservative side, knowing that our approach in Arizona will be reviewed closely on a local and national level among the energy efficiency community. As C&S programs in Arizona and nationwide become more established, Navigant will continue to refine the C&S evaluation methodology based on best practices and available data.

Practitioners in California have developed an industry standard C&S program evaluation protocol, which Navigant proposes to use as a template for C&S program evaluations (see Figure 6). All of the following factors warrant consideration, but may not be assessed for each measure of interest based on availability of data, the specific characteristics of the measure, and the relative magnitude of the C&S savings for each measure. The remainder of this memo explains the process outlined in Figure 6.

Figure 6. C&S Advocacy Program Evaluation Protocol



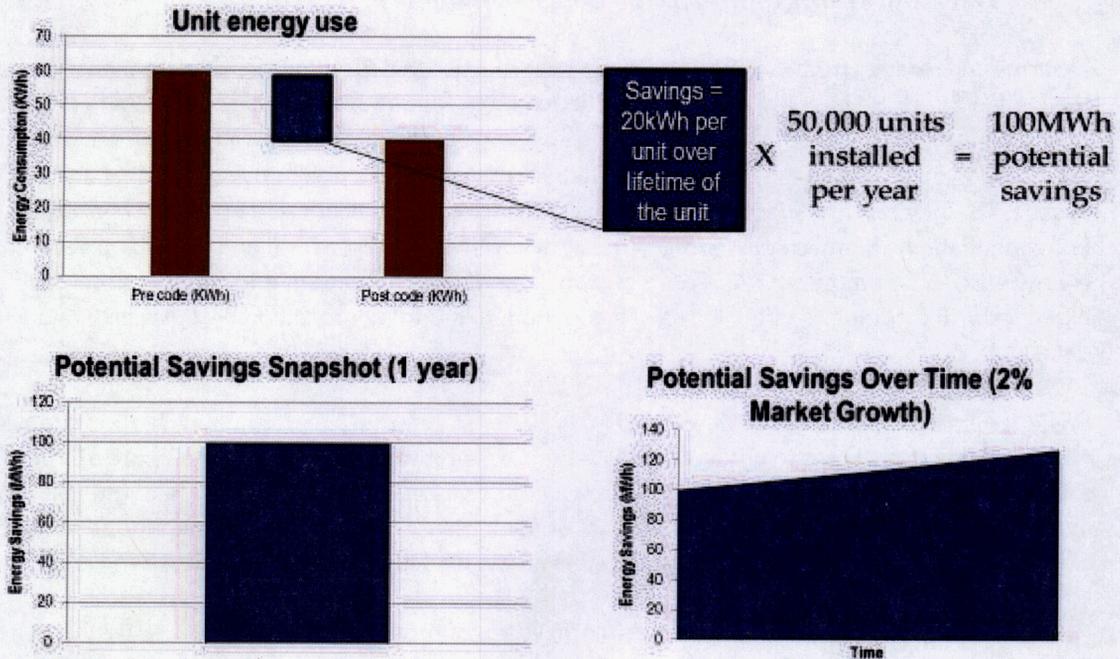
Source: 2008 ACEEE Summer Study on Energy Efficiency in Buildings<sup>49</sup>

<sup>48</sup> For a review of the latest developments in C&S programs by state see Misuriello, H. *Building Energy Code Advancement through Utility Support and Engagement*. ACEEE Report number A126, December 2012.

<sup>49</sup> Lee, A. et al. *Utility Codes and Standards Programs: How Much Energy do they Save?* 2008 ACEEE Summer Study on Energy Efficiency in Buildings.

1. Potential Energy Savings: the energy savings estimated if all buildings were in full compliance with the new code or standard. Figure 7 graphically represents the components of a potential energy savings calculation.<sup>50</sup>

**Figure 7. Unit Energy Savings x Market Size = Potential Energy Savings**



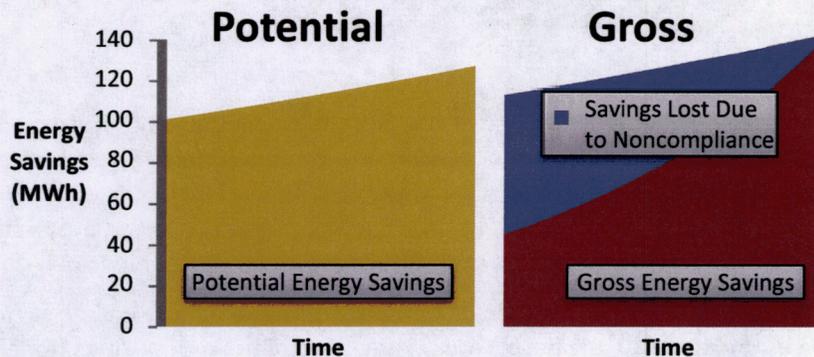
- a. Energy Use Baseline: Baseline energy use data related to the building or appliance of interest. This information is used to establish how many buildings or appliances in the underlying market were code compliant, not code compliant, or exceeded compliance prior to adoption of the new code.
  - b. Market Baseline: the number of actual units built/sold in the year prior to the code implementation and the year after the code implementation. This information, along with the compliance rate, will be used to determine avoided sales (i.e., the number of pre-code appliances or buildings that were not purchased or built as a result of the code implementation). Navigant will consider the market baseline as part of the NOMAD, as depicted in Figure 1) analysis in step 3. Navigant will adjust the market baseline with program data provided by APS to avoid double-counting any units that were installed by program participants.
  - c. Unit Energy Savings: Consumption of code-compliant units vs. pre-code units.
2. Gross Energy Savings: Potential energy savings discounted by code compliance rates. In the year after code adoption, the compliance rate is likely to be significantly less than 100 percent as the market adapts to new regulations. A utility can achieve greater savings by supporting code

<sup>50</sup> Figures 2-6 are for illustrative purposes only and do not reflect actual data from any measures.

compliance in its service territory. In Figure 8, the compliance rate begins at 40 percent and grows to full compliance over time, thereby reducing the savings lost due to noncompliance.

- a. Compliance Rate: The degree to which the code update is realized within the actual market for new buildings or appliances. The compliance rate helps to determine a new “blended baseline” after code adoption. The blended baseline accounts for the mix of code-compliant units and non-code-compliant units in the market.

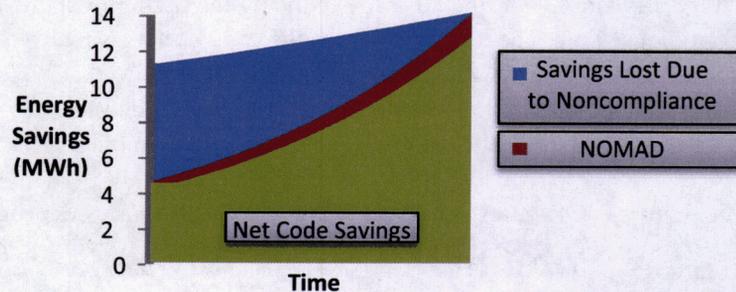
**Figure 8. Potential Energy Savings and Gross Energy Savings**



3. Net Energy Savings: gross savings discounted by assumptions about natural rates of market and C&S adoptions, as well as C&S compliance rates.<sup>51</sup> Figure 9 illustrates this adjustment, starting with gross energy savings and removing a “slice” for NOMAD.
  - a. Naturally Occurring Market Adoption: The rate of adoption of energy efficient measures that would have happened anyway, absent the C&S revision. NOMAD is depicted in the figures to illustrate the concept. However, to maintain consistency with the evaluation methodology of other APS programs, the net-to-gross ratio is assumed to be 1, meaning there are no market effects or naturally occurring rates of market adoption considered in our C&S analysis.

<sup>51</sup> Some versions of this analysis include an intermediate step. For instance, the first step is referred to as Potential Energy Savings, the second step is Gross Energy Savings which is adjusted by the code compliance rate only, and the third step is Net Energy Savings adjusted from Gross by NOMAD (see Misuriello, H. *Building Energy Code Advancement through Utility Support and Engagement*. ACEEE Report number A126, December 2012). This methodology isolates the market effects in a single distinct step, rather than including them with NOMAD and NOSAD as we have outlined in this memo. The end result is equivalent.

**Figure 9. Adjustment for Natural Rates of Market Adoption**



- b. Naturally Occurring Standards Adoption (NOSAD): Navigant has experience conducting expert interviews to determine the counterfactual case for standards adoption (e.g., when a code or standard would have been updated absent the effect of utility efforts). This information is used to determine the period over which savings from C&S can be claimed. NOSAD effects are illustrated in Figure 11.
4. Net Program Savings: a quantification of a utility's efforts to achieve energy savings through C&S updates. In Figure 10, the purple area is one-third of net code savings from Figure 9.
  - a. Net C&S program savings: After net standard savings are determined, the savings resulting from utility's efforts must be determined. In Arizona, pursuant to the rule established by the ACC, a utility may count up to 1/3 of the energy savings resulting from C&S updates within its service territory as verified by measurement and evaluation. Navigant will apply the ACC prescribed rate of one-third until further direction on the appropriate level or method of attribution is provided.
5. Savings by Utility: In Figure 10, the net program savings are divided between utilities serving customers within the C&S authority that passes the new code or standard, if more than one utility is serving customers in the authority of interest.
  - a. Allocation: Savings can only be claimed for effects that occur within APS service territory. Ideally, Navigant will obtain APS service territory-specific data on appliance and new construction markets (i.e., for residential new construction, the number of residential new meters set by APS in a particular year). Often, the available data includes areas outside of APS service territory (i.e., statewide pool pump sales), in which case allocation must be determined. This allocation can be accomplished based on the number of customers each utility serves relative to the total market population or other proxies appropriate to the situation.

Figure 10. Adjustment for Net Program Savings, and Allocation by Utility

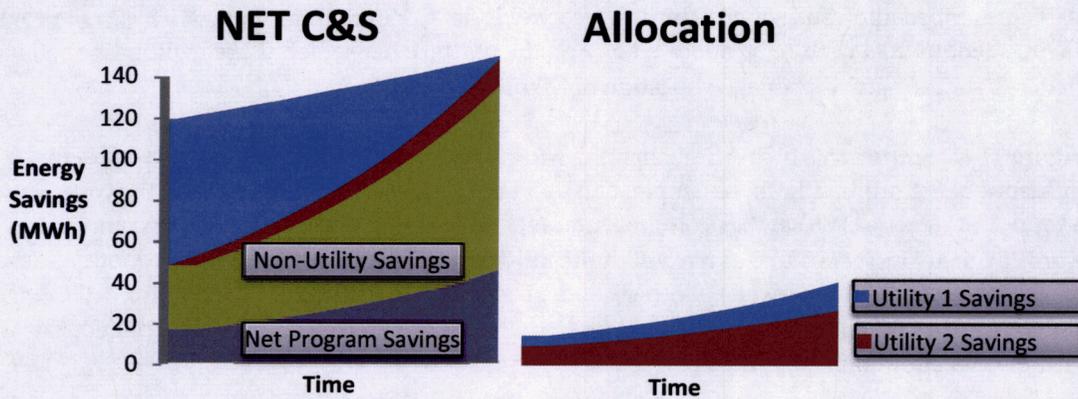
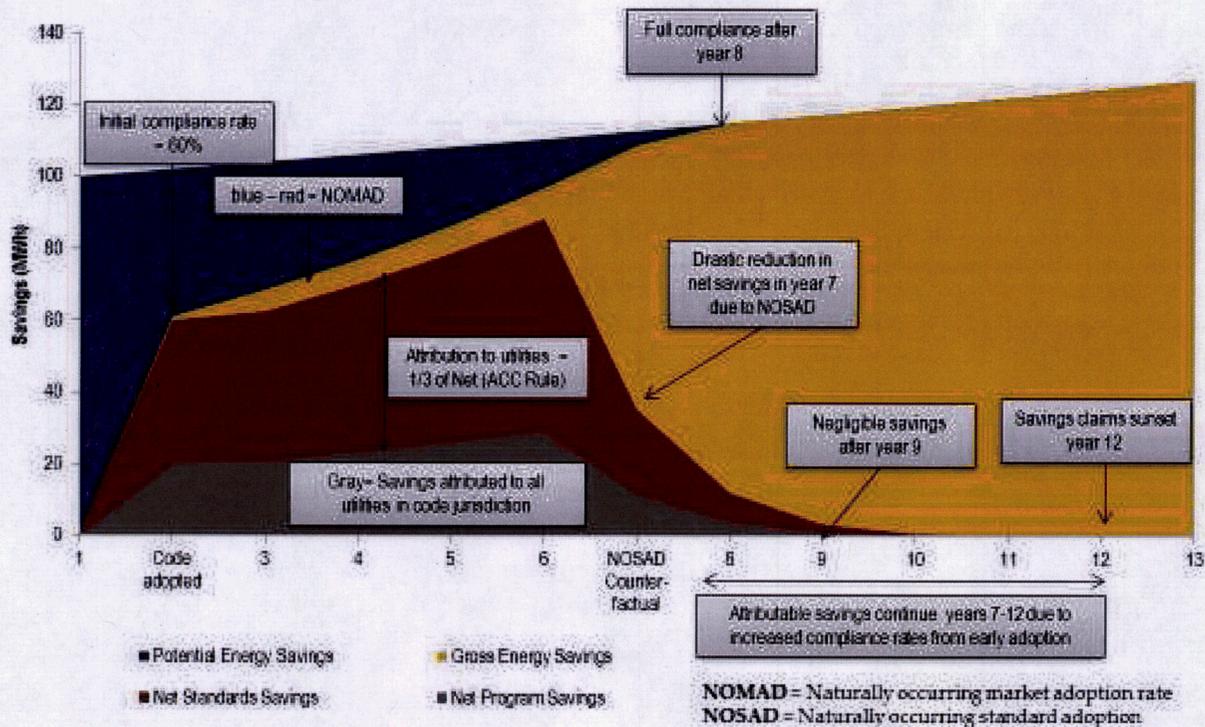


Figure 11 is a longitudinal summary of all of the various steps in the C&S evaluation process, including consideration of the NOSAD rate.

Figure 11. The C&S Evaluation Process over Time



This figure illustrates energy savings for a hypothetical “widget” code adopted in year 2 with an initial compliance rate of 60 percent. Potential energy savings increase every year as the market size of widgets grows at 2 percent per year. It takes seven years for the market of new widgets to comply completely with the adopted code (100 percent compliance), at which point gross savings equals potential savings.

# NAVIGANT

Discounting gross savings by NOMAD yields net savings. Net savings are determined by applying the ACC prescribed allowance of one-third, which yields net C&S program savings. These net program savings would then need to be allocated among the utilities that serve the area within the code authority (federal, state, or jurisdictional—allocation not shown).

Figure 11 also represents NOSAD—when the widget code would have been adopted absent the influence of the utilities. In this example, NOSAD occurs in year 7, five years after the code was actually adopted. However, C&S savings continue after NOSAD, due to the increased code compliance rates that were “banked” in years 2 to 6 as a result of the utilities’ efforts to encourage code adoption earlier than it would have occurred otherwise. In other words, NOSAD does not immediately cancel all C&S savings, since it is assumed that the NOSAD would have begun with only a 60 percent compliance rate in the first year of C&S adoption.