Energy Efficiency Potential Study for Pennsylvania

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List of Acronyms

ACEEE	American Council for an Energy-Efficient Economy
ASHP	Air source heat pump
BC	Benefit-cost
CBECS	Commercial Buildings Energy Consumption Survey
CVR	Conservative voltage reduction
DEER	Database for Energy Efficient Resources
DOE	Department of Energy
DSM	Demand-side management
EDC	Electric Distribution Company
EF	Energy factor
EIA	Energy Information Administration
EISA	Energy Independence and Security Act
EM&V	Evaluation, measurement, and verification
EPA	Environmental Protection Agency
EUL	Effective useful life
EUI	Energy Use Intensity
HSPF	Heating Seasonal Performance Factor
KW	Kilowatt
KWH	Kilowatt hour
MECS	Manufacturing Energy Consumption Survey
MEF	Modified energy factor
MET ED	Metropolitan Edison Company
MFG	Manufacturing
MPS	Market Potential Study
MW	Megawatt
MWH	Megawatt hour
NEEP	Northeast Energy Efficiency Partnerships
NREL	National Renewable Energy Lab
PA	Pennsylvania
PECO	PECO Energy Company
PENELEC	Pennsylvania Electric Company
PENN POWER	Pennsylvania Power Company
PPL	PPL Electric Utilities Corporation
PUC	Public Utility Commission
PY	Program year
RECS	Residential Energy Consumption Survey
SEER	Seasonal energy efficiency ratio
SWE	Statewide evaluator
T&D	Transmission and distribution
TRC	Total Resource Cost Test
TRM	Technical Reference Manual
WEST PENN	West Penn Power Company

Executive Summary

This report summarizes the energy efficiency potential analysis performed by the Pennsylvania Statewide Evaluator (SWE) Team from 2016 to 2025. This report presents the results of technical, economic, and achievable potential over 10 years (starting on June 1, 2016) for the residential, commercial, and industrial sectors. In addition, program potential for electric energy efficiency programs was calculated over five years.

STUDY OBJECTIVES AND SCOPE

This study examines the potential to reduce electric consumption and peak demand through the implementation of energy efficiency technologies and practices in residential, commercial, and industrial facilities, as well as associated activities in Pennsylvania.[1] This study assesses electric energy efficiency potential throughout the seven Pennsylvania investor-owned electric distribution company (EDC)[2] service areas over 10 years, from June 1, 2016 through May 31, 2025.

The main objectives of the study include:

- Evaluating the electric energy efficiency technical, economic, achievable, and program potential savings throughout the Commonwealth of Pennsylvania, and more specifically within the seven largest EDC service areas;
- Calculating the Total Resource Cost Test (TRC) benefit-cost ratio for the achievable potential savings for electric energy efficiency measures and programs, and determining the electric energy efficiency economic potential savings for Pennsylvania homes and businesses.

TYPES OF POTENTIAL ESTIMATED

The scope of this study distinguishes four types of energy efficiency potential: (1) technical, (2) economic, (3) achievable, and (4) program.

- **Technical Potential** is the theoretical maximum amount of energy use that could be displaced by efficiency, disregarding all non-engineering constraints such as cost-effectiveness and the willingness of end users to adopt the efficiency measures. Technical potential is constrained only by factors such as technical feasibility and applicability of measures. Under technical potential, the SWE Team assumed that 100% of new construction and burnout measures are adopted as those opportunities become available, while retrofit and early retirement opportunities are replaced incrementally (10% per year) until 100% of homes (residential) and square footage stock (nonresidential) are converted to the efficient measures over 10 years.
- **Economic Potential** refers to the subset of the technical potential that is economically cost-effective as compared to conventional supply-side energy resources. Economic potential follows the same adoption rates as technical potential. In addition, similar to technical potential, the economic scenario ignores market barriers to ensuring actual implementation of efficiency. Finally, economic potential only considers the costs of efficiency measures themselves, ignoring

[1] The residential sector analysis includes an estimation of low income potential. Similarly, the nonresidential sector analysis examines the potential from institutional facilities.
[2] EDCs evaluated within this study include Duquesne Light and Power, PPL Energy, PECO Energy, and the four First Energy Companies: Met-Ed, Penelec, PennPower, and West Penn Power.

any programmatic costs (e.g., marketing, analysis, administration) that would be necessary to capture them.[3]

- **Achievable Potential** is the amount of energy use that efficiency can realistically be expected to displace, assuming the most aggressive program scenario possible (e.g., providing end users with payments for the entire incremental cost of more efficient equipment). This is often referred to as *maximum achievable potential*. Achievable potential takes into account real-world barriers to encouraging end users to adopt efficiency measures, the non-measure costs of delivering programs (for administration, marketing, tracking systems, and monitoring and evaluation), and the capability of programs and administrators to boost program activity over time.[4] In addition to the maximum achievable scenario, this analysis includes a *base achievable potential* scenario that is based on historical incentive levels and the corresponding program adoption rates observed from the Pennsylvania EDCs and other regional utility demand-side management (DSM) programs. The base achievable potential scenario also uses willingness-to-participate surveys conducted for the 2014 Pennsylvania (PA) Public Utility Commission (PUC) residential and nonresidential baseline studies.
- **Program Potential** refers to the efficiency potential possible given specific program funding levels and designs. Program potential studies can consider scenarios ranging from a single program to a full portfolio of programs. A typical potential study may report a range of results based on different program funding levels. For this study, the SWE Team has opted to utilize a simple-scaling approach to estimate program potential given the available DSM budgets stipulated under Act 129[5]. More information on this calculation approach can be found in Section 1.10, "Program Potential," below.

APPROACH SUMMARY

The SWE Team used a "bottom-up" approach to estimate energy efficiency potential in the residential sector. Bottom-up approaches begin with characterizing the eligible equipment stock, estimating savings and screening for cost-effectiveness first at the measure level, then summing savings at the end-use and service-territory levels. In the commercial and industrial sectors, the SWE Team utilized the bottom-up modeling approach to first estimate measure-level savings and costs as well as cost-effectiveness, and then applied cost-effective measure savings to all applicable shares of energy load. Further details of the market research and modeling techniques utilized in this assessment are provided in Section 1, "Analysis Approach," below.

INCREMENTAL ANNUAL VS. CUMULATIVE ANNUAL SAVINGS

It is important to note the distinction between incremental annual savings and cumulative annual savings. Incremental annual savings are those that occur in a given year due to participation in energy efficiency programs in that given year. Cumulative annual energy savings are those that accumulate in any given year due to participation in energy efficiency programs in that given year, as well as participation in prior years, to the extent that participation in prior years continues to yield savings. Cumulative annual energy savings account for the fact that measures installed in prior years may have useful lives longer than one year, and therefore produce savings that persist into the future for some

[3] National Action Plan for Energy Efficiency, "Guide for Conducting Energy Efficiency Potential Studies" (November 2007), page 2-4.
[4] National Action Plan for Energy Efficiency, "Guide for Conducting Energy Efficiency Potential Studies" (Nov. 2007), page 2-4.
[5] Act 129 EE&C Phase II Implementation Order – Entered Aug. 3, 2012.The Act 129 Phase 2 EE&C Program Implementation Order. From the Public Meeting of August 2, 2012. Docket Nos. M-2012-2289411 and M-2008-2069887

time. However, cumulative annual energy savings also reflect savings decay – that is, savings that can no longer be counted in a given year once a measure is no longer operational or has "burned out."

One particularly important distinction between incremental annual savings and cumulative annual savings is that the sum of the incremental annual savings may be greater than the cumulative annual savings over an extended time frame due to measure savings decay. A detailed example of the potential difference between incremental annual savings and cumulative annual savings is discussed in Section 1.4, "Incremental Annual vs. Cumulative Annual Savings."

STUDY LIMITATIONS

As with any assessment of energy efficiency potential, this study necessarily builds on various assumptions and data sources, including the following:

- Energy efficiency measure lives, savings, and costs
- The discount rate for determining the net present value (NPV) of future savings
- Projected penetration rates for energy efficiency measures
- Projections of electric generation avoided costs for electric capacity and energy as defined in the 2009, 2011, and 2013 Pennsylvania PUC TRC Orders[6]
- Projections of transmission and distribution (T&D) avoided costs
- Future changes to codes and standards
- EDC load forecasts and assumptions on their disaggregation by sector, segment, and end use
- End-use saturations and fuel shares

While the SWE Team has sought to use the best and most current available data, there are assumptions for which a reasonable alternative would yield slightly different results. Furthermore, while the lists of energy efficiency measures examined in this study represent most commercially available measures, these measure lists are not exhaustive. Finally, the SWE Team did not attempt to place a dollar value on some difficult-to-quantify non-energy benefits arising from the installation of some measures, such as increased comfort or increased safety. These non-energy benefits may affect some customers' choices to implement one or more measures that may otherwise have been less cost-effective or only marginally cost-effective.

ENERGY EFFICIENCY POTENTIAL

Table ES-1 and Figure ES-1 summarize the achievable potential across all sectors as well as total annual program costs. Total maximum achievable potential for the region of the seven EDCs covered by Act 129 in 2020 and 2025 for energy efficiency is 7.5% and 13.2%, respectively, of 2010 kilowatt-hour (kWh) sales.[7]

[6] The PA PUC TRC Test Orders can be found on the PA PUC 129 website.

[7] For purposes of this study, the baseline period sales are forecast kWh sales for each EDC for the period June 1, 2009 through May 31, 2010. The SWE Team has selected the load for this year to be consistent with Act 129 of 2008, which required the EDCs to reduce electric consumption at least 1% by May 31, 2011, and 3% by May 31, 2013, relative to their forecast load for the period June 1, 2009 through May 31, 2010. All energy and demand savings are presented in this report at the end-consumer (meter) level unless specifically noted otherwise.

The SWE Team estimates that with the current annual spending cap,[8] the seven EDCs can achieve a combined annual savings equal to 0.8% to 1.0% of 2010 load per year. After accounting for measure savings decay and annual savings adjustments for codes and standards, the cumulative annual program potential in 2020 is 5,092,433 megawatt hours (MWh) or 3.5% of the baseline load.

Without a budget cap, annual savings could achieve roughly 1.2% to 2.0% of 2010 load in the base achievable and maximum achievable scenarios, respectively. On a cumulative annual basis, the base achievable potential is 4.6% of the baseline load in 2020 and the maximum achievable potential is 7.5% of baseline load in 2020.

Table ES-1: Statewide Summary of Potential Savings and Costs by Scenario by Year

	2016	2017	2018	2019	2020	2025
Cumulative Savings Potential - MWh						
Technical	6,707,085	13,016,622	18,973,644	24,294,903	25,336,859	41,190,328
Economic	4,895,392	9,387,083	13,662,316	17,628,245	17,253,764	26,944,933
Maximum Achievable	2,761,211	5,438,518	8,133,238	10,772,462	10,983,129	19,357,092
Base Achievable	1,610,739	3,285,284	4,980,543	6,649,165	6,748,807	12,111,889
Program	1,217,554	2,480,941	3,758,994	5,015,090	5,092,433	-
Cumulative Savings Potential - % of 2010 Load						
Maximum Achievable	1.9%	3.7%	5.5%	7.3%	7.5%	13.2%
Base Achievable	1.1%	2.2%	3.4%	4.5%	4.6%	8.3%
Program	0.8%	1.7%	2.6%	3.4%	3.5%	-
Incremental Savings Potential - MWh						
Maximum Achievable	2,761,211	2,866,823	2,989,121	3,104,271	2,610,702	2,574,169
Base Achievable	1,610,739	1,725,249	1,836,917	1,943,976	1,665,279	1,794,256
Program	1,217,554	1,302,307	1,386,202	1,466,663	1,256,735	-
Incremental Savings Potential - % of 2010 Load						
Maximum Achievable	1.9%	2.0%	2.0%	2.1%	1.8%	1.8%
Base Achievable	1.1%	1.2%	1.3%	1.3%	1.1%	1.2%
Program	0.8%	0.9%	0.9%	1.0%	0.9%	-
EDC Program Costs - Million $						
Maximum Achievable	$581.8	$601.9	$619.9	$638.5	$607.0	$642.6
Base Achievable	$302.1	$316.2	$329.3	$342.6	$325.7	$361.6
Program	$228.7	$239.2	$249.1	$259.2	$246.4	n/a*

**Program potential was only estimated for five years to be consistent with a Phase III of Act 129. Program potential in 2025 would be part of Phase IV of Act 129*

[8] Program potential is estimated based on funding levels of 2% of 2006 utility electric revenues, as specified in Act 129 legislation.

Figure ES-1: Cumulative Annual Energy (MWh) Savings by Scenario by Year

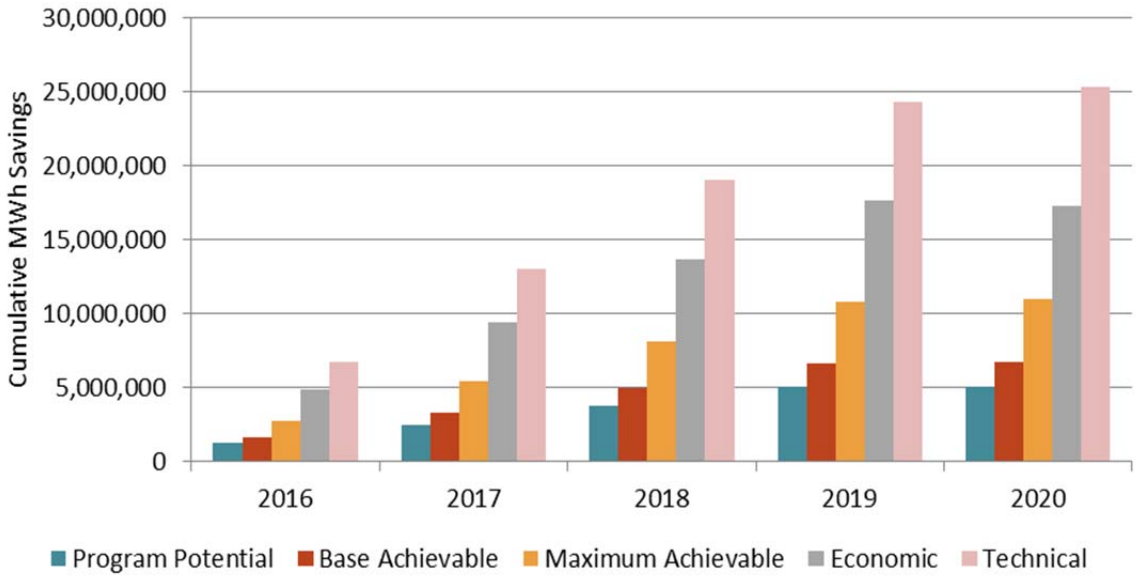


Figure ES-2 shows the cumulative annual energy (MWh) savings impacts for each potential scenario relative to the combined EDC load forecast for 2016 through 2025. The projected energy savings are estimated to be achieved through EDC program efforts and exclude savings due to codes and standards, which are incorporated in the EDCs' forecasts.[9]

Figure ES-2: 2016-2025 Statewide Energy (MWh) Forecast and Potential Savings Projections by Scenario

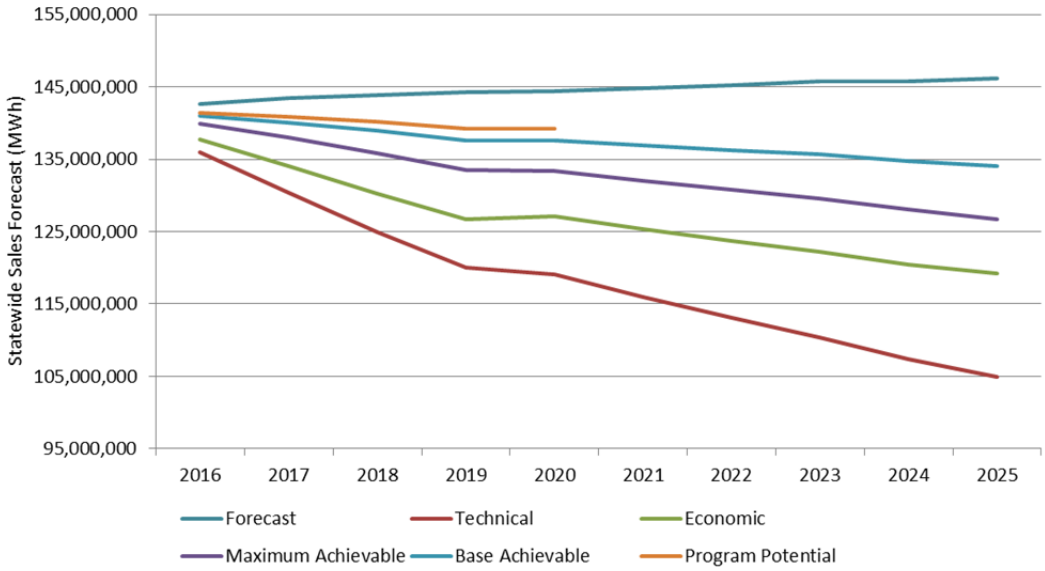


Table ES-2 presents the cumulative annual base achievable potential by customer class. Residential-sector savings represent 2.5% of the baseline load after five years and 4.5% after 10 years.

[9] Note that the lack of apparent growth in energy savings potential between 2019 and 2020 is not a result of reduced market adoption of efficient technologies, but the estimated impacts of the general service lighting backstop provision in Energy Independence and Security Act (EISA) of 2007 and the analysis' adjustment that the general service lighting baseline shifts to the compact fluorescent light (CFL) bulb in 2020. The shift in baseline technology impacts all installed bulbs, resulting in modest overall growth in potential from 2019 to 2020.

Nonresidential sector savings represent 2.1% of the baseline load after five years and 3.8% of the baseline in 2025.

Table ES-2: Statewide Cumulative Annual Potential by Customer Sector by Year

Base Achievable Potential	2016	2017	2018	2019	2020	2025
Cumulative Savings Potential - MWh						
Residential	953,810	2,005,954	3,087,372	4,149,256	3,722,120	6,587,083
Commercial	408,759	791,076	1,173,748	1,550,571	1,853,605	3,205,776
Industrial	248,169	488,254	719,423	949,338	1,173,082	2,319,030
Cumulative Savings Potential - % of 2010 Load						
Residential	0.7%	1.4%	2.1%	2.8%	2.5%	4.5%
Commercial	0.3%	0.5%	0.8%	1.1%	1.3%	2.2%
Industrial	0.2%	0.3%	0.5%	0.6%	0.8%	1.6%

Figure ES-3 shows the cumulative annual base achievable potential in 2020. The residential sector accounts for 55.2% of the base achievable savings in 2020. The commercial- and industrial-sector savings account for 27.5% and 17.4%, respectively, of the total base achievable potential in 2020.

Figure ES-3: Statewide 2020 Cumulative Annual Potential by Customer Sector

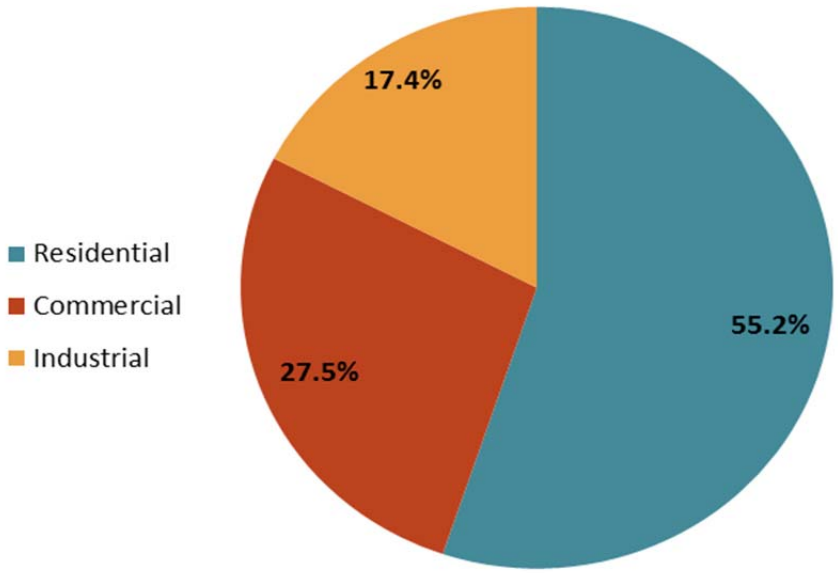


Table ES-3 shows the cumulative annual maximum achievable, base achievable, and program potential by EDC. Additional details of electric energy efficiency potential by EDC can be found in Sections 3.4, "Residential Potential by EDC;" 4.4, "Commercial Potential by EDC;" and 5.4, "Industrial Potential by EDC".

Table ES-3: Portfolio Cumulative Annual Energy (MWh) Savings Potential by EDC by Year

Energy Savings (MWh)	2016	2017	2018	2019	2020	2025
Duquesne						
Maximum Achievable	285,647	544,837	812,220	1,082,404	1,108,458	1,942,891
Base Achievable	157,396	311,143	471,211	634,725	643,125	1,163,372
Program	98,122	193,969	293,757	395,693	400,930	-
Program Pot. % of 2010 Load	***0.7%***	***1.4%***	***2.1%***	***2.8%***	***2.8%***	**-**
FE: Met-Ed						
Maximum Achievable	261,833	528,065	793,754	1,053,907	1,062,054	1,888,640
Base Achievable	155,337	324,825	494,558	661,276	663,303	1,194,683
Program	121,855	254,812	387,960	518,744	520,334	-
Program Pot. % of 2010 Load	***0.8%***	***1.7%***	***2.6%***	***3.5%***	***3.5%***	**-**
FE: Penelec						
Maximum Achievable	269,717	528,552	791,037	1,048,786	1,102,105	1,988,966
Base Achievable	159,219	322,125	488,661	653,344	686,459	1,264,572
Program	110,776	224,117	339,983	454,560	477,600	-
Program Pot. % of 2010 Load	***0.8%***	***1.6%***	***2.4%***	***3.2%***	***3.3%***	**-**
FE: Penn Power						
Maximum Achievable	80,213	158,685	238,108	316,236	314,269	556,141
Base Achievable	47,480	97,061	147,516	197,373	195,320	350,731
Program	34,843	71,229	108,256	144,844	143,337	-
Program Pot. % of 2010 Load	***0.7%***	***1.5%***	***2.3%***	***3.0%***	***3.0%***	**-**
FE: West Penn						
Maximum Achievable	387,907	769,658	1,156,091	1,535,348	1,555,824	2,809,555
Base Achievable	231,610	475,693	723,604	967,371	976,296	1,781,180
Program	117,829	242,004	368,126	492,141	496,681	-
Program Pot. % of 2010 Load	***0.6%***	***1.2%***	***1.8%***	***2.4%***	***2.4%***	**-**
PECO						
Maximum Achievable	716,473	1,392,114	2,068,374	2,722,126	2,762,128	4,752,131
Base Achievable	426,943	860,145	1,297,730	1,723,754	1,756,157	3,081,705
Program	429,556	865,409	1,305,672	1,734,303	1,766,904	-
Program Pot. % of 2010 Load	***1.1%***	***2.2%***	***3.3%***	***4.4%***	***4.5%***	**-**
PPL						
Maximum Achievable	759,422	1,516,607	2,273,655	3,013,654	3,078,290	5,418,768
Base Achievable	432,755	894,292	1,357,264	1,811,321	1,828,148	3,275,647
Program	304,572	629,401	955,240	1,274,804	1,286,646	-
Program Pot. % of 2010 Load	***0.8%***	***1.6%***	***2.5%***	***3.3%***	***3.4%***	**-**
Statewide Total						
Maximum Achievable	***2,761,211***	***5,438,518***	***8,133,238***	***10,772,462***	***10,983,129***	***19,357,092***
Base Achievable	***1,610,739***	***3,285,284***	***4,980,543***	***6,649,165***	***6,748,807***	***12,111,889***
Program	***1,217,554***	***2,480,941***	***3,758,994***	***5,015,090***	***5,092,433***	**-**
Program Pot. % of 2010 Load	***0.8%***	***1.7%***	***2.6%***	***3.4%***	***3.5%***	**-**

This study concludes that continuing electric energy efficiency programs in a Phase III of Act 129 will continue to be cost-effective for Pennsylvania ratepayers. Table ES-4 shows the TRC benefit-cost ratios for the maximum achievable, base achievable, and program potential based on a five-year implementation period beginning June 1, 2016. The TRC ratio statewide for the program potential scenario is 1.88.

Table ES-4: Statewide TRC Cost-Effectiveness Results by Scenario for 2016-2020

	NPV[10] Costs (Million $)	NPV Benefits (Million $)	NPV Net Benefits (Million $)	TRC BC Ratio[11]
Maximum Achievable	$3,412.7	$6,235.1	$2,822.4	1.83
Base Achievable	$2,233.3	$4,185.7	$1,952.4	1.87
Program	$1,692.0	$3,184.2	$1,492.3	1.88

Table ES-5 shows the five-year EDC costs to acquire the potential; the sum of the first-year MWh savings over the five-year period; and the estimated acquisition costs ($/MWh) for the maximum achievable, base achievable, and program potential scenarios. The program potential energy savings in Table ES-5 are therefore the sum of the incremental annual savings achieved in each of the years spanning 2016 through 2020. This total is different than the cumulative annual program potential savings estimate of 5,092,433 MWh shown in Tables ES-1 and ES-3 due to the differences in incremental annual savings and cumulative annual savings described above.

For the purposes of determining statewide acquisition costs from the base achievable costs and savings data, the SWE Team concludes that it is correct to divide the sum of the incremental annual savings data across the timeframe by the sum of the annual costs. This method maintains the integrity of the definition of an acquisition cost and aligns with actual EDC budgeting and planning practices. The differences in the sum of the incremental annual and cumulative annual program potential savings should be carefully considered when using this report to inform the establishment of future savings targets for Phase III of Act 129.

Table ES-5: Statewide Acquisition Costs by Scenario for 2016-2020

	2016-2020 Program Costs (Million $)	2016-2020 Program Savings (MWh)	Acquisition Cost ($/1st-YR MWh Saved)
Maximum Achievable	$3,644.3	14,332,129	$254.3
Base Achievable	$1,615.9	8,782,160	$184.0
Program	$1,222.5	6,629,460	$184.4

The five-year program potential energy savings and budget values are found in Table ES-6 for each EDC and the Commonwealth of Pennsylvania.

Table ES-6: Five-Year Program Potential Savings and Budget by EDC

	Portfolio Spending Ceiling (Million $)	Program Acquisition Costs ($/1st-YR MWh Saved)	2016-2020 Potential Savings (MWh)	% of 2010 Forecast
2016-2020 – Five-Year Program Potential				
Duquesne	$97.7	$186.9	522,837	3.7%
FE: Met-Ed	$124.3	$182.2	682,474	4.6%
FE: Penelec	$114.9	$191.9	598,704	4.2%
FE: Penn Power	$33.3	$176.1	189,107	4.0%
FE: West Penn	$117.8	$181.0	650,760	3.1%
PECO	$427.0	$184.7	2,311,387	5.9%
PPL	$307.5	$183.7	1,674,191	4.4%
Statewide	***$1,222.5***	***$184.4***	***6,629,460***	***4.5%***

[10] NPV: Net present value
[11] BC ratio: Benefit-cost ratio

ORGANIZATION OF THE REPORT

The remainder of this report is organized in seven sections as follows:

Section 1 Analysis Approach details the methodology used to develop the estimates of technical, economic, achievable, and program potential for electric energy efficiency savings.

Section 2 Characterization of Pennsylvania Service Areas provides an overview of the Pennsylvania EDC service areas and a brief discussion of the historical and forecasted electric energy sales by sector as well as peak demand.

Section 3 Residential Energy Efficiency Potential provides a breakdown of the technical, economic, and achievable potential in the residential sector.

Section 4 Commercial Energy Efficiency Potential provides a breakdown of the technical, economic, and achievable potential in the commercial sector.

Section 5 Industrial Energy Efficiency Potential provides a breakdown of the technical, economic, and achievable potential in the industrial sector.

Section 6 Portfolio Level Results and Program Energy Efficiency Potential Estimates provides detailed information on the program potential in the residential, commercial, and industrial sectors over the five-year period of June 2016 through May 2020.

Section 7 Conclusions and Recommendations presents the final discussion regarding the potential for energy efficiency savings in Pennsylvania.

1 Analysis Approach

This section describes the overall methodology the SWE Team utilized to conduct the Pennsylvania statewide electric energy efficiency potential study. The main objectives of this energy efficiency potential study is to estimate the technical, economic, achievable, and program potential for energy efficiency statewide for periods of five and 10 years beginning June 1, 2016; and to provide potential kWh and kW savings estimates for each level of energy efficiency potential (technical, economic, achievable, and program). This study does not examine potential peak load reduction and energy reductions from demand response programs, but rather will estimate demand savings and peak load reductions[12] associated with different types of energy efficiency potential.[13]

This electric energy efficiency potential study will provide results that are both statewide and specific to each of the seven Pennsylvania EDCs. To accomplish this objective, the SWE Team created a series of unique energy efficiency potential models for each of the seven EDCs and for each primary market sector (residential, commercial, and industrial).[14]

1.1 Overview of Approach

The SWE Team used a bottom-up approach to estimate energy efficiency potential in the residential sector. Bottom-up approaches begin with characterizing the eligible equipment stock, estimating savings and screening for cost-effectiveness first at the measure level, then summing savings at the end-use and service area levels. In the commercial and industrial sectors, the SWE Team utilized the bottom-up modeling approach to first estimate measure-level savings and costs as well as cost-effectiveness, and then applied cost-effective measure savings to all applicable shares of energy load. Further details of the market research and modeling techniques utilized in this assessment are provided in the following sections.

1.2 Forecast Disaggregation

This analysis of the potential for energy efficiency savings begins with utilizing the most recent and available electricity sales forecasts from Pennsylvania EDCs for a period of 10 years beginning June 1, 2016, which reflects annual energy reductions from Act 129 Phases I and II.

Disaggregated forecast data provides the foundation for the development of energy efficiency potential estimates for the commercial and industrial sectors. The SWE Team applied the measure-level savings factors discussed in the Technical Potential section below to the corresponding share of the EDC's energy load by sector (commercial, industrial, and government/nonprofit/institutional (GNI)), segment (building type), end use, and equipment type.

For the commercial and industrial sectors, the SWE Team disaggregated each EDC's baseline 2016-2025 load forecast using a top-down/bottom-up calibration analysis. The SWE Team conducted the top-down forecast disaggregation by applying EDC-specific segment and end-use consumption shares derived from

[12] Estimated peak load reductions will be estimated, to the extent practicable, consistent with the coincident summer peak period as defined in the 2014 TRM, (i.e., "…the period between the hour ending 15:00 Eastern Prevailing Time (EPT) and the hour ending 18:00 EPT during all days from June 1 through August 31, inclusive, that is not a weekend or federal holiday.")

[13] The SWE Team conducted a Demand Response (DR) Potential Study in parallel with the Energy Efficiency MPS. The SWE Team issued a separate report detailing the findings from the DR Potential Study. The PA PUC will provide guidance to the SWE Team on the allocation of the spending cap budget between energy efficiency (EE) and DR programs for Phase III.

[14] To the extent possible, modeling input assumptions for the potential study will be based on the results and findings from studies with statistically valid sampling designs and acceptable precision levels.

the 2014 Pennsylvania Non-Residential End-Use and Saturation Study to each EDC's load forecast. In this exercise, the SWE Team:

- Determined energy consumption per customer sector and segment in baseline year (2016).
- Disaggregated customer segment loads into end-use loads such as space cooling.
- Forecasted the 10-year end-use energy consumption by sector and segment through 2025.

The SWE Team then constructed a bottom-up commercial and industrial forecast of consumption by equipment type, calibrating the forecast to the top-down disaggregated forecast by end use for each sector and segment. The SWE Team conducted this calibration by calculating the available stock (square feet) in the base year for each EDC, then multiplying stock against equipment energy use intensities EUIs after applying an end-use fuel share, end-use saturation, and equipment type saturation values derived from the 2014 Pennsylvania Baseline Study[15] and other regional sources as needed. The SWE Team calibrated this bottom-up estimate of energy consumption to the top-down energy consumption values by altering the equipment EUIs and/or available stock as needed.

The commercial sector, as defined in this analysis, was comprised of the following business segments:[16]

- Institutional
  - Education
  - Healthcare
  - Government/Public Service
  - Non-profit
  - Other Institutional
- Grocery
- Lodging
- Office
- Restaurant
- Retail
- Warehouse
- Miscellaneous

The industrial sector, as defined in this analysis, was comprised of the following industrial segments:[17]

- Manufacturing
  - Chemicals
  - Computers and Electronics
  - Food
  - Metals
  - Paper
  - Plastics
  - Other
- Mining
- Other Non-Manufacturing

[15] Two baseline studies (residential and nonresidential) were performed. *Pennsylvania Statewide Act 129 2014 Non-Residential End Use & Saturation Study.* April 2014 submitted by Nexant; and *2014 Pennsylvania Statewide Act 129 Residential Baseline Study.* April 2014 submitted by GDS Associates.

[16] These designations may fall into "small C&I" or "large C&I" rate schedules and Act 129 customer sectors for EDCs. Some of these segments may also qualify as "GNI."

[17] These designations may fall into "small C&I" or "large C&I" rate schedules and Act 129 customer sectors for EDCs. Some of these segments may also qualify as "GNI." In addition, some "agricultural" customers may have a residential rate schedule for some EDCs.

Although it is not necessary to develop a disaggregated residential sales forecast for each EDC based on the approach utilized in the residential sector, the SWE Team attempted to calibrate any building energy modeling outputs and end-use baseline energy consumption estimates so that total estimated residential energy consumption aligns with the EDC residential sector load forecasts.

1.3 MEASURE ANALYSIS

1.3.1 Summary

Energy efficiency measures considered in the study include all measures in the 2015 Pennsylvania Technical Reference Manual (TRM), as well as other energy efficiency measures based on the SWE Team's knowledge and current databases of electric end-use technologies and energy efficiency measures in other jurisdictions. The study includes measures and practices that are currently commercially available as well as emerging technologies. The commercially available measures are of the most immediate interest to energy efficiency program planners in Pennsylvania. Emerging technology research was focused on measures that are either commercially available but currently not widely accepted, or are not currently available but expected to be commercialized over the analysis timeframe.[18]

1.3.2 Number of Measures Evaluated

In total, the SWE Team analyzed 400 measure types. Many measures required multiple permutations for different applications, such as different building types, efficiency levels, decision types, and EDC. The SWE Team developed a total of 95,025 measure permutations for this study across the seven EDCs, and tested all measures for cost-effectiveness under the TRC. The parameters for cost-effectiveness under the TRC are discussed in detail later in Section 1.7.1, "Total Resource Cost Test." Of the permutations analyzed, roughly 50% or 46,634 measures had a measure TRC benefit-cost ratio of 1.0 or higher.[19]

Approximately 70% of all measures types included in this study are included in the 2015 Pennsylvania TRM. The SWE Team included 119 additional measure types to offer a more robust analysis of electric energy efficiency savings potential in Pennsylvania.

Table 1-1: Number of Measures Evaluated

	# of Measures	Total # of Measure Permutations	# with TRC ≥ 1
By Sector			
Residential	69	5,306	3,021
Commercial	209	76,636	34,912
Industrial	122	13,083	8,701
Total	***400***	***95,025***	***46,634***
By Source			
PA TRM	281	63,652	30,824
Secondary	119	31,373	15,810
Total	***400***	***95,025***	***46,634***

[18] For example, ENERGY STAR recently created a rating system for clothes dryers. High efficiency clothes dryers were included as an emerging technology.

[19] The residential included some low income-specific measures with a TRC ratio less than 1.0 in the economic and achievable potential analysis. Low income-specific measures with a TRC ratio of 0.25 or greater were retained in the residential analysis of economic and achievable potential.

1.3.3 Measure Characterization

A significant amount of data is needed to estimate the kWh and kW savings potential for individual energy efficiency measures or programs across the entire residential, commercial, and industrial sectors in Pennsylvania. The SWE Team utilized data specific to Pennsylvania when it was available and current. The SWE Team used the 2015 TRM, the SWE 2014 incremental cost database, and the SWE 2014 baseline study as the main sources of data for measure assumptions.[20] For measures not listed in the TRM or SWE 2014 incremental cost database, the SWE Team conducted secondary research to develop reasonable and supportable assumptions.

Measure Savings: The SWE Team utilized the 2015 TRM to inform calculations supporting estimates of annual measure savings as a percentage of base equipment usage. For custom measures and measures not included in the TRM, the SWE Team estimated savings from a variety of sources, including:

- Mid-Atlantic TRM and other existing deemed savings databases
- Building energy simulation software (such as BEopt or EQuest) and engineering analyses
- Scheduled changes in federal codes and standards
- Secondary sources such as the American Council for an Energy-Efficient Economy (ACEEE), Department of Energy (DOE), Energy Information Administration (EIA), ENERGY STAR©, and other technical potential studies
- Program evaluations conducted by Pennsylvania EDCs as well as other utilities and program administrators

Measure Costs: Measure costs represent either incremental or full costs, and typically include the incremental cost of measure installation. For purposes of this study, nominal measure costs were escalated by the general rate of inflation over time. One exception to this assumption will be an assumed decrease in costs for light emitting diode (LED) bulbs, and to a lesser extent, compact fluorescent light (CFL) bulbs over the study horizon. LED bulb consumer costs have been declining rapidly over the last several years and future cost projections predict a continued decrease in bulb costs.[21] The SWE Team's treatment of LED bulb costs and market penetration are discussed in greater detail in Section 1.3.5, "Review of LED Lighting Assumptions."

When available, the SWE Team obtained measure cost estimates from the 2014 PA Incremental Cost Database. For measures not in this database, the SWE Team used the following data sources:

- Secondary sources such as the ACEEE, ENERGY STAR, National Renewable Energy Lab (NREL), California Public Utility Commission (PUC) Incremental Cost Database, Northeast Energy Efficiency Partnership (NEEP) Incremental Cost Study, and other technical potential studies
- Retail store pricing (such as websites of Home Depot, Lowe's, and Grainger) and industry experts
- EDC program evaluation and market assessment reports
- EDC annual reports to the PA PUC
- RS Means Commercial Construction Materials

Measure Life: Measure life represents the number of years that energy using equipment is expected to operate. Pennsylvania's Act 129 caps the measure's life, when used in the TRC calculation, at a

[20] This analysis also incorporates the results of the 2014 residential and nonresidential lighting metering study. The results of this analysis were not available for inclusion in the 2015 TRM, but are to be reflected in the market potential estimates of Phase III EE and DR potential.
[21] 2014 DOE SSL Multi-Year Program Plan & NEEP Residential Lighting Strategy Report.

maximum of 15 years.[22] The SWE Team obtained measure life estimates from the 2015 PA TRM, and used the following data sources for measures not in the TRM:

- Manufacturer data
- Savings calculators and life-cycle cost analyses
- The California Database for Energy Efficient Resources (DEER) database
- Evaluation reports
- Surveys conducted by the EDCs
- Other consultant research or technical reports

Baseline and Efficient Technology Saturations: In order to assess the potential electric energy efficiency savings available, estimates of the current saturation of baseline equipment and energy efficiency measures are necessary. The SWE Team primarily obtained up-to-date measure or end-use and equipment saturation data from the following recent studies:

- 2014 PA PUC residential and nonresidential baseline studies (based on site surveys conducted by the SWE Team in the fall of 2013)
- Other recently completed home energy and appliance saturation surveys completed in Pennsylvania or similar regions, including EDC research studies
- EDC end-use fuel share forecasts
- Latest (2009) EIA Residential Energy Consumption Survey (RECS)
- Latest (2010) EIA Manufacturing Energy Consumption Survey (MECS)
- Latest (2003) EIA Commercial Buildings Energy Consumption Survey (CBECS)

Documentation for the development of energy efficiency measure assumptions in the residential, commercial, and industrial sectors is provided in the appendices of this report.

1.3.4 Treatment of Codes and Standards

Although this analysis does not attempt to predict how energy codes and standards will change over time, the analysis does account for the impacts of several known improvements to federal codes and standards. Although not exhaustive, key adjustments include:

- General Service lighting baselines reflect the minimum efficiency standards and schedule established in the Energy Independence and Security Act of 2007 (EISA 2007). As a result, the baseline efficiency for most general lighting was assumed to be a halogen bulb through May 31, 2020. Beginning in June 2020, the analysis reflects the adjustments included in the EISA 2007 backstop provision, and the general service lighting baseline shifts to the CFL bulb. This shift in baseline impacts all bulbs, including those installed prior to 2020.

- The baseline efficiency for air source heat pumps (ASHP) is anticipated to improve to 14 SEER/8.2 HSPF[23] in 2015. As the existing stock of ASHPs was estimated to turn over, the baseline efficiency was assumed to be the new federal standard.

- In 2015, the DOE makes amended standards effective for residential water heaters that required updated energy factors (EF) depending on the type of water heater and the rated storage volume. For electric storage water heaters with a volume greater than 55 gallons, the standards effectively require heat pumps for electric storage products. For storage tank water heaters with a volume of 55 gallons or less, the new standard (EF=0.948) becomes essentially the equivalent of today's efficient storage tank water heaters.

[22] Estimates of the natural replacement cycle of equipment with measure lives greater than 15 years were not capped in the potential modeling.
[23] SEER: Seasonal Energy Efficiency Ratio; HSPF: Heating Seasonal Performance Factor.

- In March 2015, the DOE will amend the standards for residential clothes washers. The new standards will require the Integrated Modified Energy Factor (MEF) (ft^3/kWh/cycle) to meet certain thresholds based on the machine configurations. The ENERGY STAR specifications for residential clothes washers will also be amended to increase the efficiency of units that can earn the ENERGY STAR label. Version 7.0 of the ENERGY STAR specification is scheduled to go into effect in March 2015. These amended federal and ENERGY STAR standards have been factored into the study.
- In January 2015, the DOE will amend the standards for residential clothes dryers. The new standards will require the EF (pounds/kWh) to meet certain thresholds based on the machine configurations. There is also an ENERGY STAR specification in development for residential clothes dryers. Version 1.0 of the ENERGY STAR specification for residential clothes dryers is scheduled to go into effect in January 2015. The DOE-amended standards and the ENERGY STAR specification for residential clothes dryers have been factored into the study.
- In line with the phase-in of 2005 EPAct regulations, the baseline efficiency for general service linear fluorescent lamps was moved from the T12 light bulb to a T8 light bulb effective June 1, 2016, in PA Act 129.

1.3.5 Review of LED Lighting Assumptions

Although the SWE Team has partially discussed the treatment of general service screw-in LED lighting, it is important to review the various assumptions that were tailored throughout this analysis given the emerging market for LEDs and the overall importance of lighting to the EDCs' energy efficiency portfolios.

Savings: Screw-in LED bulbs were assumed to replace the current federal code baseline according to the EISA 2007. For the initial four years of the analysis (June 2016 through May 2020), LED bulb savings are calculated relative to a halogen bulb. For the final six years of the analysis, the SWE Team assumes the CFL bulb becomes the code baseline, and LED savings are calculated against the CFL bulb.

Costs: LED bulb costs are widely projected to decrease significantly over the next decade. Current estimates project standard LED screw-in bulbs at $4.00 by 2020 and $2.40 by 2030.[24] Similarly, LED reflector bulbs are assumed to decline to $7.00 in 2020 and $5.00 by 2030. Based on these declining projections, as well as the current price of LED bulbs and estimated interim price points, the SWE Team developed annual cost projections for standard and reflector screw-in LED bulbs. Table 1-2 shows the annual projections for a standard 60-watt equivalent LED screw-in bulb and a 65-watt equivalent LED reflector.

Table 1-2: Price Projections for Residential LED Lighting

Bulb Technology	2016	2017	2018	2019	2020	2025
LED Screw-In	$7.00	$6.00	$5.00	$4.38	$4.00	$3.20
LED Reflector	$13.60	$11.40	$9.20	$7.80	$7.00	$6.00

Market Acceptance: In an effort to recognize the increasing market adoption of LED bulbs and the increased focus on LED technologies in EDC energy efficiency programs, the SWE Team's potential analysis also projected an increasing focus on LED screw-in bulb technologies over CFL bulbs. Table 1-3

[24] Energy Information Administration. Technology Forecast Updates – Residential and Commercial Building Technologies, Reference Case. The 2014 DOE SSL Multi-Year Program Plan, NEEP Residential Lighting Strategy, and IMS Research (Does LED Lighting Have a Tipping Point?) all estimate the $4.00 LED standard screw-in bulbs price point in 2020.

shows the annual applicability of LED vs. CFL bulbs assumed in the residential sector.[25] For example, in 2017, 83% of all assumed efficient screw-in bulb installations will be LED. As noted above, the screw-in lighting baseline shifts to the CFL bulb in 2020, and all assumed efficient installations shift to LEDs at that time.

Table 1-3: Assumed Annual Applicability of LED Bulbs

Bulb Technology	2016	2017	2018	2019	2020
CFL Bulb	30%	17%	7%	7%	0%
LED Bulb	70%	83%	93%	93%	100%

1.4 INCREMENTAL ANNUAL VS. CUMULATIVE ANNUAL SAVINGS

It is important to note the distinction between incremental annual savings and cumulative annual savings. Incremental annual savings are those which occur in a given year due to participation in energy efficiency programs in that given year. Cumulative annual energy savings are those which accumulate in any given year due to participation in energy efficiency programs in that given year, as well as participation in prior years, to the extent that participation in prior years continues to yield savings. Cumulative annual energy savings account for the fact that measures installed in prior years may have useful lives longer than one year, and therefore produce savings that persist into the future for some time. However, cumulative annual energy savings also reflect savings decay – that is savings that can no longer be counted in a given year once a measure is no longer operational or has "burned out."

One particularly important distinction between incremental annual savings and cumulative annual savings is that the sum of the incremental annual savings may be greater than the cumulative annual savings over an extended time frame due to measure savings decay. Consider the example in Table 1-4 below. In the example, an energy efficiency program is offering rebates for the purchase of high efficiency televisions. The program runs for five years and obtains one participant per year. Each participant yields 100 kWh in savings a year and it is assumed that the television measures have a useful life of four years. Each year, the new participants in the program provide 100 kWh in incremental annual savings in the year in which they participate and the savings from these participants persist in subsequent years for the life of the television. A participant in Year 1 will yield 100 kWh incremental annual savings in Year 1. This participant will also continue to yield 100 kWh of savings in Years 2 through Year 4. Then, in Year 5, the 100 kWh savings from the first year participant will disappear as it will be assumed that the efficient television will burn out after four years. However, because there is a participant in Year 5, the cumulative annual savings will stay at 400 kWh – what was lost to equipment decay is being replaced by a new participant. The sum of the incremental annual savings in Year 5 is 500 kWh because it is the sum of the savings introduced in each year by the five total participants. The year-by-year incremental annual data and cumulative annual data are provided in the table below.

Table 1-4: Incremental Annual vs. Cumulative Annual Savings Example

Television Example	Year 1	Year 2	Year 3	Year 4	Year 5
Incremental Annual	100 kWh	100 kWh	100 kWh	100 kWh	100 kWh
Sum of Incremental Annual	100 kWh	200 kWh	300 kWh	400 kWh	500 kWh
Cumulative Annual	100 kWh	200 kWh	300 kWh	400 kWh	400 kWh

[25] Annual applicability factors based on the NEEP Residential Lighting Strategy. 2013-2014 Update. Table 6. Rate of In Program Bulbs.

1.5 POTENTIAL SAVINGS OVERVIEW

Potential studies often distinguish between several types of energy efficiency potential: technical, economic, achievable, and program. However, because there are often important definitional issues between studies, it is important to understand the definition and scope of each potential estimate as it applies to this analysis.

The first two types of potential, technical and economic, provide a theoretical upper bound for energy savings from energy efficiency measures. Still, even the best-designed portfolio of programs is unlikely to capture 100% of the technical or economic potential. Therefore, achievable potential and program potential attempt to estimate what savings may realistically be achieved through market interventions, when it can be captured, and how much it would cost to do so. Figure 1-1 illustrates the four most common types of energy efficiency potential.

Figure 1-1 Types of Energy Efficiency Potential[26]

<table>
<tr><td>Not Technically Feasible</td><td colspan="4">Technical Potential</td></tr>
<tr><td>Not Technically Feasible</td><td>Not Cost-Effective</td><td colspan="3">Economic Potential</td></tr>
<tr><td>Not Technically Feasible</td><td>Not Cost-Effective</td><td>Market & Adoption Barriers</td><td colspan="2">Achievable Potential</td></tr>
<tr><td>Not Technically Feasible</td><td>Not Cost-Effective</td><td>Market & Adoption Barriers</td><td>Program Design, Budget, Staffing, & Time Constraints</td><td>Program Potential</td></tr>
</table>

1.6 TECHNICAL POTENTIAL

Technical potential is the theoretical maximum amount of energy use that could be displaced by efficiency, disregarding all non-engineering constraints such as cost-effectiveness and the willingness of end users to adopt the efficiency measures. Technical potential is only constrained by factors such as technical feasibility and applicability of measures. Under technical potential, the SWE Team assumed that 100% of new construction and burnout measures are adopted as those opportunities become available (e.g., as new buildings are constructed they immediately adopt efficiency measures), while retrofit and early retirement opportunities are replaced incrementally (10% per year) until 100% of homes (residential) and stock (commercial and industrial) are converted to the efficient measures over a period of 10 years.

1.6.1 Core Equation for the Residential Sector

The core equation used in the residential sector energy efficiency technical potential analysis for each individual efficiency measure is shown in Equation 1-1 below.

[26] Reproduced from "Guide to Resource Planning with Energy Efficiency." November 2007. US Environmental Protection Agency (EPA). Figure 2-1.

Equation 1-1: Core Equation for Residential Sector Technical Potential

Where:

Base Case Equipment End-Use Intensity = the electricity used per customer per year by each base-case technology in each market segment. In other words, the base case equipment end-use intensity is the consumption of the electrical energy using equipment that the efficient technology replaces or affects.

Saturation Share = the fraction of the end-use electrical energy that is applicable for the efficient technology in a given market segment. For example, for residential water heating, the saturation share would be the fraction of all residential electric customers that have electric water heating in their household.

Remaining Factor = the fraction of equipment that is not considered to already be energy efficient. To extend the example above, the fraction of electric water heaters that is not already energy efficient.[27]

Applicability Factor = the fraction of the applicable units that is technically feasible for conversion to the most efficient available technology from an engineering perspective (e.g., it may not be possible to install CFLs in all light sockets in a home because the CFLs may not fit in every socket).[28]

Savings Factor = the percentage reduction in electricity consumption resulting from the application of the efficient technology.

1.6.2 Core Equation for the Nonresidential Sector

The core equation utilized in the nonresidential sector technical potential analysis for each individual efficiency measure is shown in Equation 1-2 below. The SWE Team developed a forecast of nonresidential square footage information for each building type for each EDC, sourced primarily from the 2014 Non-Residential End Use & Saturation Study.

Equation 1-2: Core Equation for Nonresidential Sector Technical Potential

[27] For purposes of this study, the remaining factor for replace-on-burnout measures was 100%. This assumes that all measures, regardless of current efficiency, are eligible to revert back to the code baseline at the time of replacement. This is uniquely different from the prior market potential study completed by the SWE Team which removed installed measures that were already energy efficient from the analysis pool. The assumption used in this analysis results in increased potential, but more closely aligns with the EDCs' ability to track savings at the gross savings level.

[28] In instances where there are two (or more) competing technologies for the same electrical end use, such as heat pump water heaters, water heater efficiency measures, high-efficiency electric storage water heaters and solar water heating systems, an applicability factor aids in determining the proportion of the available population assigned to each measure. In estimating the technical potential, measures with the most savings are given priority for installation. For all other types of potential, measures with the greatest TRC ratio are assigned installation priority.

Where:

Total Stock Square Footage by Building Type = the forecasted square footage level for a given building type (e.g., office buildings).

Base Case Equipment End-Use Intensity = the electricity used per square foot per year by each base-case equipment type in each market segment. In other words, the base case equipment end-use intensity is the consumption of the electrical energy using equipment that the efficient technology replaces or affects. The SWE Team obtained this end-use consumption data from such sources as the US EIA CBECS & MECS, Pennsylvania EDC data, the Pennsylvania TRM, and others.

Saturation Share = the fraction of the EDC equipment electrical energy that is applicable for the efficient technology in a given market segment. For example, for room air conditioners, the saturation share would be the fraction for a specific EDC of all space cooling kWh in a given market segment that is associated with room air conditioner equipment.

Remaining Factor = the fraction of the equipment or practice that is technically feasible for conversion to the efficient technology from an engineering perspective (e.g., it may not be possible to install VFDs on all motors in a given market segment).

Applicability Factor = the fraction of equipment that is not considered to already be energy efficient. For example, the fraction of electric water heaters that is not already energy efficient.

Savings Factor = the percentage reduction in electricity consumption resulting from the application of the efficient technology.

1.7 ECONOMIC POTENTIAL

Economic potential refers to the subset of the technical potential that is economically cost-effective (based on screening with the TRC) as compared to conventional supply-side energy resources. The SWE Team calculated the TRC benefit-cost ratios for this study according to the Pennsylvania PUC's TRC Orders.

The SWE Team pre-screened possible energy efficiency technologies and practices based on an understanding of which measures were likely to be cost-effective and in the interest of conserving time and effort for other aspects of the analysis. Measure screening allowed the SWE Team to remove measures that were not commercially available, were already at current code, or were not applicable to Pennsylvania. All measures that were not found to be cost-effective based on the results of the TRC were excluded from further analysis. The SWE Team then readjusted and applied allocation factors to the remaining measures that were cost-effective.

1.7.1 Total Resource Cost Test

The SWE Team utilized the 2009 and 2011 Pennsylvania PUC TRC Orders to determine the cost-effectiveness for energy efficiency measures in this potential study. The TRC measures the net costs of a DSM or energy efficiency measure or program as a resource option based on the total costs of the measure/program, including both the participants' and the utility's costs.

In general, the benefits calculated in the TRC usually include the avoided electric supply costs for the periods when there is an electric load reduction; savings of other resources such as fossil fuels and water; and applicable federal and state energy efficiency tax credits. However, consistent with Act 129

and the 2013 PA TRC Order, only the electricity savings and avoided operation and maintenance costs will be used to calculate the benefits for the PA TRC.[29]

Costs in the TRC (incremental or full cost depending on whether the measure was replaced on burnout or is an early replacement/retrofit) are the program costs paid by the utility (or program administrator) and the participants. Thus, all incremental equipment costs, installation, operation and maintenance, cost of removal, and program administration costs are included in this test regardless of who pays for them. In an effort to be consistent with the National Action Plan for Energy Efficiency's definition of economic potential, the SWE Team will not include marketing; analysis; administration; and evaluation, measurement, and verification (EM&V) costs for the measure cost-effectiveness screening conducted to develop the estimates of economic potential.[30] Although excluded from economic potential, these non-incentive costs will be included in the development of program acquisitions costs and estimates of the program costs related to achievable and program potential savings.

The PA TRC Order limits measure lives to a maximum of 15 years when calculating the TRC. Although select energy efficiency measures may have longer effective useful lives (EUL), the measure lives for purposes of cost-effectiveness calculations are capped at a maximum of 15 years.

1.7.2 Avoided Costs

The SWE Team based the avoided cost forecasts utilized for measure cost-effective screening and for reporting potential benefits on the Pennsylvania PUC's 2013 TRC Order and each EDC's avoided cost structure, including energy, transmission, distribution, and generation capacity avoided costs. Each EDC provided the latest available electric generation avoided cost projections, while the SWE Team developed the transmission and distribution (T&D) avoided cost projections used in this study. According to the latest PUC TRC Order, the discount rate used in the calculation of the Pennsylvania TRC is the utility's after-tax weighted average cost of capital. Avoided energy costs were differentiated by time and season where possible.

1.8 ACHIEVABLE POTENTIAL

Achievable potential is the amount of energy that can realistically be saved given various market barriers. Achievable potential takes into account real-world barriers to encouraging end users to adopt efficiency measures; the non-measure costs of delivering programs (for administration, marketing, analysis, and EM&V); and the capability of programs and administrators to boost program activity over time. Barriers include financial, customer awareness and willingness to participate in programs, technical constraints, and other barriers the "program intervention" is modeled to overcome. Additional considerations include political and/or regulatory constraints. The potential study evaluated two achievable potential scenarios:

- **Maximum Achievable** estimates achievable potential on paying incentives equal to 100% of measure incremental costs.
- **Base Achievable** estimates achievable potential on EDCs paying incentive levels (as a percent of incremental measure costs) comparable to those in effect from Program Year (PY) 1 through PY5 along with incentive-rate trends from other regional utilities. As discussed later in Section 2.3, "Phase I/II EDC Performance Benchmarking," incentives have historically been roughly

[29] Tax credits, while traditionally a benefit in the TRC are treated as a reduction to costs in the PA TRC , according to the TRC Order.
[30] National Action Plan for Energy Efficiency: Understanding Cost-Effectiveness of Energy Efficiency Programs.

57.5% of measure costs in the residential sector, and approximately 25% of measure costs in the commercial and industrial sectors.

While many different incentive scenarios could be modeled, the number of achievable potential scenarios was limited to the two scenarios described above due to the available budget for this potential study. The SWE Team analyzed the two selected achievable potential scenarios with different anticipated penetration curves or market acceptance models for each incentive level. In the maximum achievable scenario, the penetration curve is based on a maximum penetration assuming 100% funding of the measure incremental costs. Previous studies and actual program experience suggest that this curve can reach an asymptote not greater than 85% to 90% over a period of 20 years from the beginning of DSM programs in Pennsylvania under Act 129, as 100% of customers will not accept or adopt energy efficiency measures for various reasons.[31] The SWE Team also incorporated data collected in the recent Pennsylvania baseline studies on customer willingness to participate at various incentive levels (discussed in more detail below).

The base achievable potential scenario analyzed reflects the expected market adoption associated with the percentage of incremental costs reflected in current EDC incentive levels. Base achievable incentives were set at a percentage of incremental measure costs grounded upon an analysis of Program Year (PY) 1 through PY5 annual report data from the EDCs, as well as other utility regional trends. These two scenarios include forecasts of market penetration that take into account uncertainty based on consumers' willingness to participate in programs.

For new construction, energy efficiency measures can be implemented when each new home or building is constructed, thus the rate of availability will be a direct function of the rate of new construction. For existing buildings, energy efficiency potential in the existing stock of buildings will be captured over time through two principal processes:

1) As equipment replacements are made normally in the market when a piece of equipment is at the end of its effective useful life (referred to as "replace-on-burnout" or "turnover" vintage).
2) At any time in the life of the equipment or building (referred to as "retrofit" or "early replacement" vintage).

For the replace-on-burnout measures, the opportunity to replace existing equipment with high efficiency equipment is when equipment fails beyond repair or if the consumer is in the process of building or remodeling. Using this approach, only equipment that needs to be replaced in a given year will be eligible to be upgraded to energy efficient equipment.

For the retrofit measures, savings can theoretically be captured at any time; however, in practice, it takes many years to retrofit an entire stock of buildings, even with the most aggressive of energy efficiency programs.

1.9 ACHIEVABLE POTENTIAL MARKET PENETRATION RATES

In an effort to inform estimates of market adoption, the SWE Team analyzed both the historical achievements of the EDCs in prior Phase I and Phase II program years relative to estimates of economic potential, as well as willingness-to-participate research collected as part of the SWE baseline studies. The historical benchmarking estimated an initial "ground floor" market adoption rate while the willingness-to-participate research assisted in the development of long-term market adoption values.

[31] Driving Demand for Energy Efficiency: Hood River Conservation Project Case Study. LBNL. Additional examples suggesting high levels of program participation are included as an appendix.

1.9.1 Initial Year Market Adoption Rate

The SWE Team compared the historical achievements of the EDCs in PY3, PY4, and PY5 to the economic potential estimated by the 2012 SWE Market Potential Study (MPS) to derive an estimate of what percentage of the SWE-estimated economic potential was actually achieved by the EDCs in these years. The process of completing this comparison consisted of several steps. First, the SWE Team compiled the PY3, PY4, and PY5 kWh savings of each EDC as reported by the EDCs to calculate the total statewide gross verified savings for each year. Then, the SWE Team derived an estimate of economic potential for PY 5 based on the cumulative annual economic potential estimates from the 2012 SWE MPS. As PY3 and PY4 pre-dated the years included in 2012 SWE MPS, the SWE Team also generated an estimate of the economic potential in those years.

Once the SWE Team gathered the statewide PY3, PY4, and PY5 kWh savings and derived estimates of statewide economic potential in those years, the SWE Team was able to calculate the statewide gross verified savings as a percentage of economic potential. The SWE Team then took a simple average of these percentages across PY3, PY4, and PY5 to generate an assumption of the percentage of the economic potential that was actually achieved by the EDCs across the three-year timeframe. In the residential sector, the SWE Team found that the EDCs achieved 30% of the economic potential during that timeframe, while the nonresidential sector achieved 32% of economic potential, according to the methodology detailed above. The SWE Team used this estimate as a starting point for the first year in the market adoption ramp rates used in the base achievable scenario.

For the maximum achievable scenario, the initial year market adoption was adjusted higher based on the assumption that incentives were equal to 100% of the measure cost as well as research findings from the willingness-to-participate research. For example, in the nonresidential sector, the willingness-to-participate findings showed that customers were 2.25 times more likely to adopt an energy efficiency measure with a 100% incentive compared to a 25% incentive. The SWE Team then used this 2.25 multiplier against the base achievable first-year adoption value of 34% for nonresidential to come up with a maximum achievable initial year adoption rate of 76.5%.

1.9.2 Long-Term Market Adoption Rates

Estimating future market adoption of energy efficient technologies is a difficult and uncertain practice. In an effort to inform these estimates, the SWE Team conducted customer likelihood and willingness-to-participate research as part of the statewide baseline studies completed in 2014.[32] This research included questions to residential homeowners and nonresidential facility managers regarding their perceived willingness to purchase and install energy efficient technologies across various end uses and incentive levels. Although homeowners were asked about a limited number of specific technologies within end uses, the SWE Team extended these results across whole end uses. By contrast, facility managers were asked about a range of lighting technologies within the lighting end use.

Once the SWE Team established historical market adoption rates for the initial year of the analysis, the SWE Team utilized likelihood and willingness-to-participate data to estimate the long-term (10-year) market adoption potential for both the maximum and base achievable scenarios. Figure 1-2 presents the long-term market adoption rates assumed for the residential sector. When incentives are assumed to

[32] For a more complete description of this research, reference the 2014 statewide baseline studies completed for both the residential and nonresidential sectors.

be 100% of the measure cost, long-term market adoption ranged from 80% to 85%.[33] For the base achievable potential scenario (incentives assumed to be 57.5% of the measure cost), the long-term market adoption rates ranged from 40% for building shell measures (insulation) to 85% for appliances (refrigerators). The SWE Team assumed a linear ramp rate over 10 years from the initial year market adoption rate (30%) to the various long-term market adoption rates for each specific end use.

Figure 1-2: Long-Term Market Adoption Rates based on Residential Willingness-to-Participate Survey Results

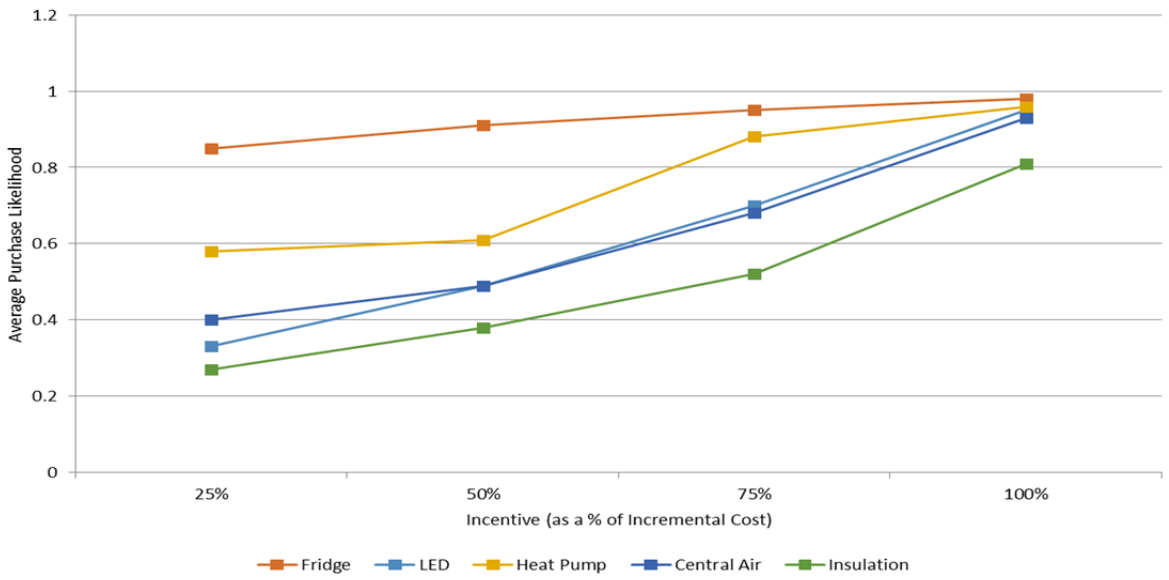
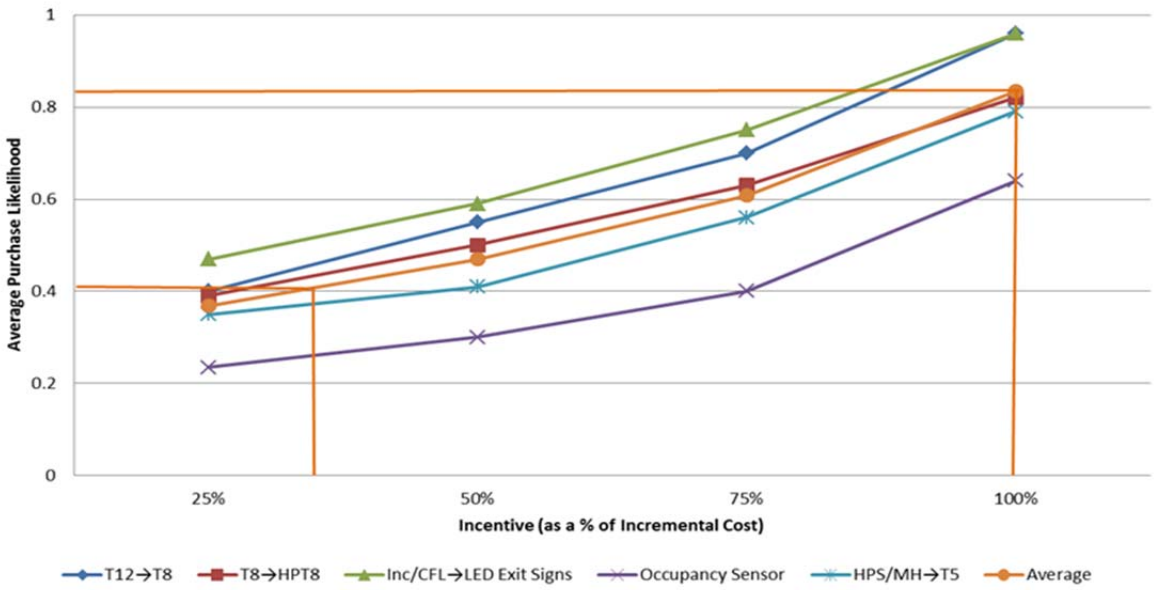


Figure 1-3 shows the willingness-to-participate survey results and long-term market adoption rate for the nonresidential sector. The average long-term adoption rate for the base achievable scenario (which assumes a 35% incentive rate) was estimated to reach 41% at the end of the 10-year period, while the maximum achievable scenario (with a 100% incentive rate) was estimated to reach an average adoption rate of 83% after 10 years. The SWE Team then applied a linear growth rate from the analysis' first-year adoption rate of 34% to reach the 10-year long-term adoption rate of 41% under the base achievable scenario, while the maximum achievable scenario achieved 83% adoption in the tenth year.

[33] Although the willingness to participate research indicated willingness levels above 85% at the 100% of incremental cost incentive level, the SWE capped long term market adoption rates at 85%.

Figure 1-3: Long-Term Market Adoption Rates based on Nonresidential Willingness-to-Participate Survey Results



1.10 PROGRAM POTENTIAL

While the identified achievable potential includes energy efficiency potential available in the marketplace, it was vital to isolate the portion that could be realistically acquired through EDC programs. It is important to recognize that there are program constraints such as available program funding (cost caps), how much time is available to deliver programs or reach a compliance target, NTG factors, consumer willingness to participate in programs or adopt measures, and the possibility of specific "set-asides" for the low income and institutional sectors.

The SWE Team analyzed program potential using an achievable-to-program potential "scaling" analysis based on Act 129 funding caps. This approach had the added benefit of not imposing any direct program design decisions on the EDCs. Act 129 set the annual funding levels for DSM at no more than 2% of 2006 Pennsylvania utility electric revenues (for the EDCs subject to Act 129). Therefore, the SWE Team calculated the program potential estimate for the five-year period ending in 2020 as follows:

a) First, the SWE Team calculated technical potential.

b) Then, the SWE Team calculated economic potential (TRC benefit-cost testing was applied at this step).

c) Next, the SWE Team calculated achievable potential (penetration rate forecasts were applied to economic potential to arrive at achievable potential). The achievable potential estimates are based on forecasts of kWh and kW savings estimates from 2016 through 2025 for all cost-effective energy efficiency measures. The achievable potential estimates are provided for each individual energy efficiency measure, and for all measures combined. Based on the savings associated with the measures included in the base achievable potential scenario, the SWE Team then developed portfolio acquisition costs (by summing the five-year annual incremental administrative plus incentive costs, divided by the five-year sum of incremental annual energy savings).

d) Finally, the SWE Team calculated program potential based on a target annual utility energy efficiency budget that is 2% of annual utility revenues in the year 2006. The calculated kWh and kW base achievable potential estimates were scaled up or down across the board with a single factor until the utility costs for the program potential scenario were equal to 2% of annual utility revenues in 2006. When the budget and the savings are scaled to the 2% utility spending target, the development of the program potential estimate is complete.

2 Characterization of Pennsylvania Service Areas & Phase I/II Program Offerings

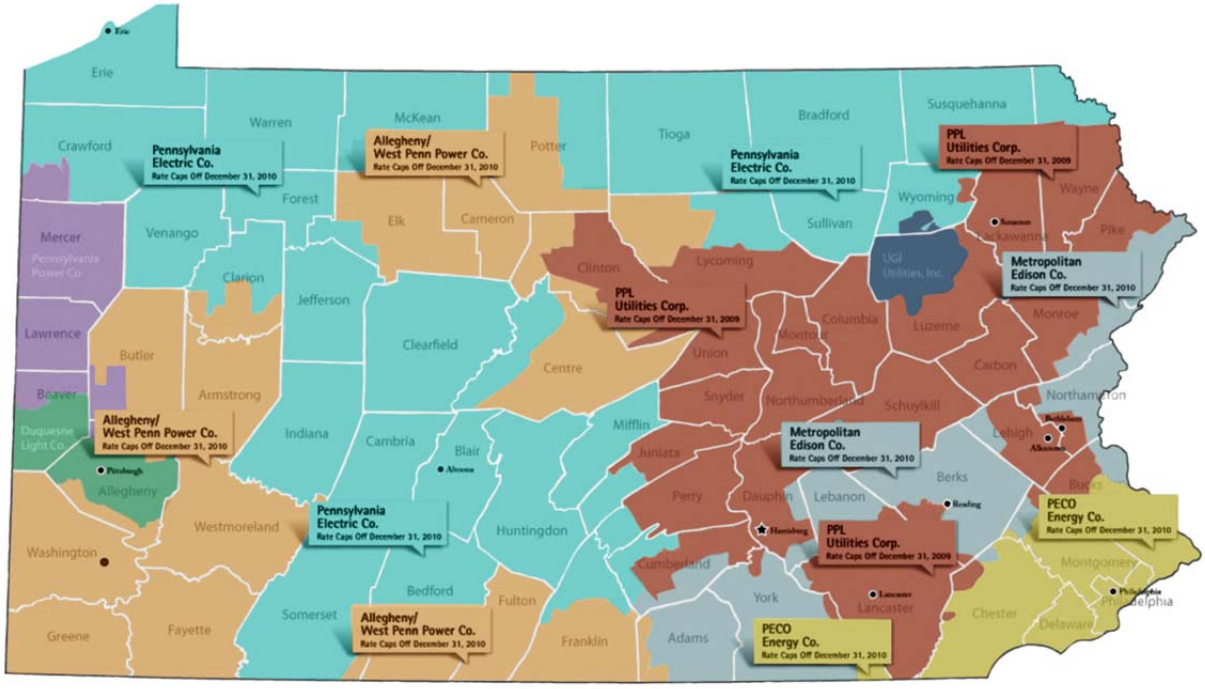
The following section provides a brief overview of the seven EDC service areas included under Act 129, their forecasted load, and a brief overview of their performance for Phase I and Phase II to date (i.e., PY1 through PY5).

2.1 EDC AREAS

There are currently eleven EDCs that provide energy to Pennsylvania customers. The focus of this analysis is on the seven largest EDCs, including: Duquesne Light Company (Duquesne), Metropolitan Edison Company (Met-Ed), Pennsylvania Electric Company (Penelec), Pennsylvania Power Company (Penn Power), West Penn Power Company (West Penn), PECO Energy Company (PECO), and PPL Electric Utilities Corporation (PPL).

Figure 2-1 shows the service areas for each of the seven Pennsylvania EDCs included in this study. Each EDC's service area varies in size and demographics.

Figure 2-1: Pennsylvania EDC Service Area Map



2.2 2010 HISTORICAL LOAD & STATEWIDE LOAD FORECAST

2.2.1 2010 Historical Load

Table 2-1 presents the forecasted energy (MWh) sales by EDC and customer class for the period beginning June 2009 and ending May 2010. The SWE Team has selected the load of this year to be consistent with Act 129 of 2008, which required the EDCs to reduce electric consumption at least 1% by May 31, 2011, and 3% by May 31, 2013, relative to their forecast load for the period June 1, 2009 through May 31, 2010. Savings targets for Phase II of Act 129 were also established based on the

2009/2010 forecast load. Consequently, the savings potential estimates in this report have also been compared to the 2009/2010 forecast load for each EDC.

Table 2-1: 2009/2010 Energy (MWh) Forecast Sales by EDC and Customer Sector

EDC	Residential	Commercial	Industrial	Total
Duquesne	4,188,344	7,081,429	2,815,727	14,085,500
FE: Met-Ed	6,199,448	4,126,943	4,538,643	14,865,033
FE: Penelec	4,882,328	4,261,919	5,255,052	14,399,300
FE: Penn Power	1,845,141	1,162,174	1,765,619	4,772,933
FE: West Penn	7,931,627	5,533,913	7,473,127	20,938,667
PECO	14,009,363	20,961,102	4,415,535	39,386,000
PPL	15,136,306	12,829,784	10,248,276	38,214,367
Statewide	***54,192,558***	***55,957,264***	***36,511,978***	***146,661,800***

2.2.2 Statewide Load Forecast

As discussed earlier, a critical first step in the modeling process is to disaggregate each EDC's load by sector. As shown in Figure 2-2, the statewide annual MWh sales are distributed fairly evenly among the residential, commercial, and industrial sectors, with approximately 35% of annual MWh sales from 2016 through 2025 in each of the residential and commercial sectors, and 30% of annual MWh sales in the industrial sector. The MWh sales forecast grows at a compound annual growth rate of 0.24% per year across all sectors over the 10-year forecast.

Figure 2-2: Statewide Energy (MWh) Sales Forecast by Sector from June 2016-May 2025

2.3 PHASE I/II EDC PERFORMANCE BENCHMARKING

The SWE Team conducted an extensive review of all available information pertaining to the EDCs' Phase I and Phase II energy efficiency program performance. The SWE Team reviewed each of the EDC's filed annual reports (PY1 through PY5) and collected various data points including verified savings, EDC expenditures, and participant costs to establish benchmarking data on EDC performance through the first five years of their DSM programs under Act 129. Metrics tracked include the following:

1) Incentive expenditures as a percentage of incremental costs
2) Administrative costs ($/kWh saved)
3) Acquisition costs ($/kWh saved)
4) Savings as a percentage of 2010 load

The purpose of this step was to understand historical program delivery and performance, and to help inform estimates of achievable and program potential. Because this study focuses on energy efficiency potential only, demand management programs, renewable energy programs, conservation voltage reduction (CVR) programs, and other programs not involving energy efficiency savings were excluded from this analysis. Only the costs and savings for the applicable energy efficiency programs were captured when rolling up the metrics discussed below.

Table 2-2 shows the average statewide incentive rate for PY1 through PY5 as 57% of incremental costs for residential, 24% for nonresidential, and 33% across the entire portfolio. In addition, the EDCs are spending an average of $0.069 for each kWh saved in non-incentive costs across their portfolios. The SWE Team used these numbers to help inform the achievable base incentive rate in the potential modeling, as well as the administrative cost per kWh saved when calculating the acquisition costs associated with the achievable base scenario.

Table 2-2: Statewide Cumulative Five-Year Program Savings and Costs by Sector

Sector	Verified Impact (MWh)	Total Incentive $	Total Admin $	Participant $	Incentive Rate	Admin Cost $/1st-YR kWh-saved
Residential	3,210,689	$177,832,506	$244,418,083	$309,659,924	57%	$0.076
Nonresidential	2,829,403	$206,874,090	$170,480,829	$853,868,453	24%	$0.060
Portfolio	***6,040,092***	***$384,706,596***	***$414,898,912***	***$1,163,528,376***	***33%***	***$0.069***

Table 2-3 shows the acquisition costs per first-year kWh saved by sector by year across all EDCs. Throughout the first five years of program offerings, the EDCs are acquiring each first-year kWh of energy efficiency savings for roughly $0.16/kWh.

Table 2-3: Statewide Annual Incremental Acquisition Costs by Sector, by Program Year ($/1YR kWh saved)

Sector	PY1	PY2	PY3	PY4	PY5
Residential	$0.114	$0.123	$0.149	$0.111	$0.161
Nonresidential	$0.172	$0.134	$0.140	$0.129	$0.169
Portfolio	***$0.126***	***$0.128***	***$0.144***	***$0.121***	***$0.164***

Table 2-4 shows the annual incremental savings by sector as a percentage of 2010 load in each sector. As the programs have matured, the EDCs have increased their savings from 0.21% of 2010 sales in PY1 to 1.25% of 2010 sales in PY4. However, savings as a percent of 2010 load declined in the first year of Phase II.

Table 2-4: Statewide Annual Incremental Savings as a % of 2010 load by Sector by Year

Sector	PY1	PY2	PY3	PY4	PY5
Residential	0.5%	1.6%	1.4%	1.5%	1.2%
Nonresidential	0.1%	0.7%	0.8%	1.1%	0.5%
Portfolio	***0.21%***	***1.1%***	***1.0%***	***1.3%***	***0.7%***

While these performance metrics are informative and point to successes on the part of the EDCs to capture large amounts of energy efficiency at reasonable costs, they also reflect savings associated with "low-hanging fruit" such as CFLs and linear fluorescent T8 lamps. The savings percentage and acquisition costs are also indicative of lighting savings (which accounted for the majority of PY1 through PY5 savings) with a lower baseline. That is, the savings were obtained before federal lighting standards raised the efficiency of a large share of the residential and commercial lamps, including the phase-out of standard incandescent bulbs and T12 linear fluorescent lamps and magnetic ballasts. These improved codes and standards are not only expected to erode savings potential in these lighting programs, but also increase the cost for lighting programs and drive EDCs to deeper DSM savings in other non-lighting end uses.

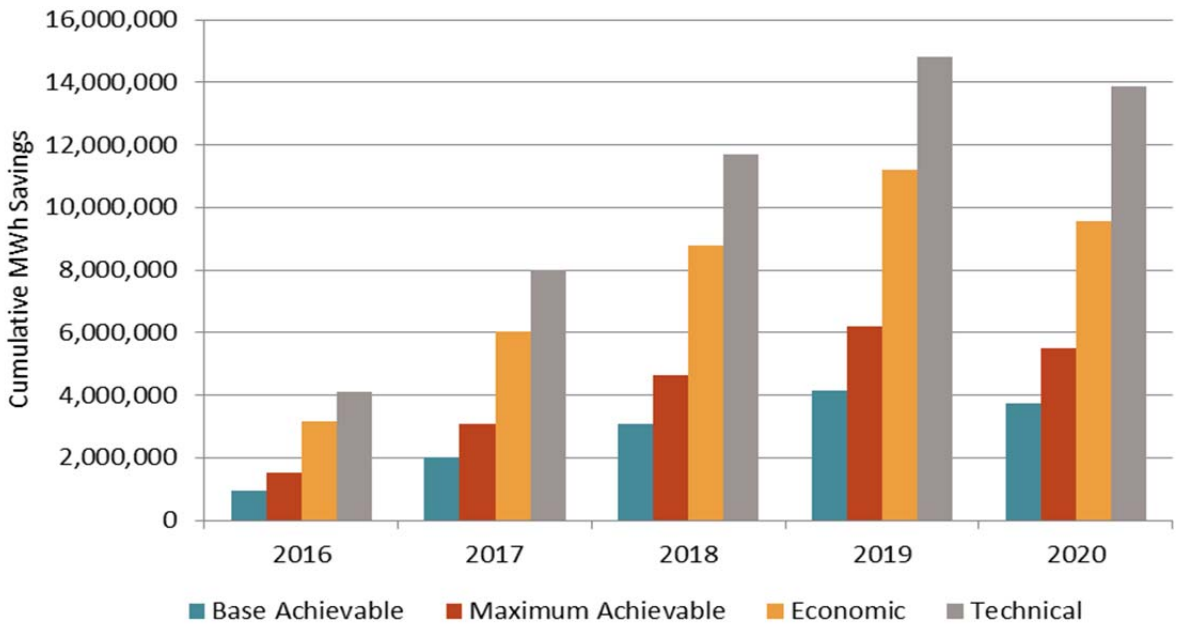
3 Residential Energy Efficiency Potential

This section of the report presents the estimates of electric technical, economic, and achievable potential for the Commonwealth of Pennsylvania as well as for each EDC service area. Program potential is discussed separately in Section 6 of this report. Electric energy efficiency savings, cost estimates, and benefit-cost estimates are presented in this section.

3.1 SUMMARY

Figure 3-1 summarizes the electric energy efficiency savings potential for the residential sector for all seven EDCs combined across the state. The five-year cumulative annual energy savings potential under the base achievable scenario amounts to 3,722,120 MWh and 506 MW by 2020, representing a possible 6.9% reduction of 2010 load in the residential sector.

Figure 3-1: Residential Cumulative Annual Savings Potential by Scenario by Year



The slight decrease in potential from 2019 to 2020 is a result of a significant baseline shift in residential lighting efficiency from a halogen bulb in 2019 to a CFL bulb in 2020, and the associated decrease in savings opportunities for LED technologies. This shifting efficiency baseline assumption was discussed earlier in Section 1.3.4, "Treatment of Codes and Standards."

Table 3-1 also presents the same estimates for electric energy efficiency savings potential for the residential sector, but includes a look at 10-year cumulative energy savings as well as demand savings potential resulting from the implementation of energy efficiency measures.

Technical potential, which reflects the adoption of all energy efficient technologies, is a theoretical upper bound on savings. The five-year technical potential is 13.9 million MWh on a cumulative annual basis (2,398 MW).

Economic Potential, which reflects the savings when all cost-effective measures are implemented, is 9.6 million MWh on a cumulative annual basis (1,324 MW) in 2020.

Maximum Achievable Potential is a subset of economic potential and represents the attainable savings assuming incentive levels are set at 100% of measure incremental costs and the long-term market penetration of high efficiency electric equipment reaches 85% in any given year. Maximum achievable potential is 5.5 million MWh (755 MW) in 2020, or 10.1% of 2010 residential load.

Base Achievable Potential is also a subset of economic potential and represents the SWE Team's best estimate of attainable savings potential assuming comprehensive implementation of all cost-effective measures and no restrictions on budget. The base achievable potential scenario assumes incentive levels are set at 57.5% of measure incremental costs. Base achievable is estimated at 953,810 MWh in the first year (2016). Base achievable potential savings are 3.7 million MWh (506 MW) in 2020, or 6.9% of 2010 residential load.

Table 3-1: Residential Cumulative Annual Energy (MWh) and Demand (MW) Savings Potential by Scenario by Year

	2016	2017	2018	2019	2020	2025
Cumulative Energy Savings Potential - MWh						
Technical	4,098,645	8,012,703	11,702,677	14,818,309	13,857,691	20,735,423
Economic	3,178,908	6,056,394	8,772,730	11,223,805	9,561,552	13,143,049
Maximum Achievable	1,537,529	3,071,045	4,649,025	6,197,840	5,495,310	9,486,677
Base Achievable	953,810	2,005,954	3,087,372	4,149,256	3,722,120	6,587,083
Cumulative Energy Savings Potential - % of 2010 Residential Load						
Technical	7.6%	14.8%	21.6%	27.3%	25.6%	38.3%
Economic	5.9%	11.2%	16.2%	20.7%	17.6%	24.3%
Maximum Achievable	2.8%	5.7%	8.6%	11.4%	10.1%	17.5%
Base Achievable	1.8%	3.7%	5.7%	7.7%	6.9%	12.2%
Demand Savings Potential - Summer Peak MW						
Technical	640.6	1,228.1	1,820.0	2,366.3	2,398.4	3,890.8
Economic	419.9	777.8	1,144.7	1,491.0	1,324.3	1,858.0
Maximum Achievable	202.2	392.5	602.2	816.0	755.4	1,324.3
Base Achievable	129.5	258.3	399.8	543.7	506.4	893.7

3.2 RESIDENTIAL POTENTIAL BY MARKET SEGMENT

Figure 3-2 shows the five-year cumulative annual savings potential by home type under the base achievable potential scenario. Single family detached homes account for the largest share of the statewide residential market, and accordingly, represent the housing type with the largest potential for electric energy efficiency savings. According to US Census and existing demographic data supplied by the EDCs, single family detached homes represent 59.5% of the residential housing market (weighted by population across the seven EDCs) and 72.5% of 2020 energy savings potential.[34]

[34] Housing market segmentation is discussed in the Pennsylvania Statewide Act 129 2014 Residential Baseline Study.

Figure 3-2: 2020 Residential Base Achievable Energy Savings Distribution by Housing Type

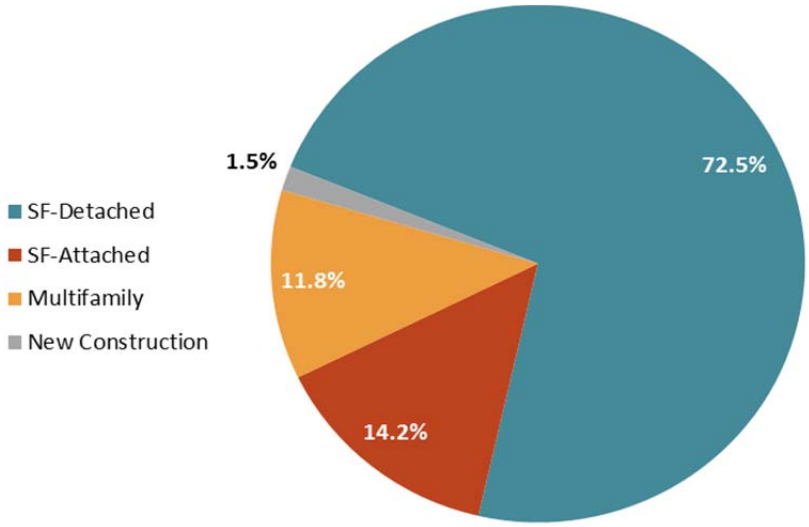


Table 3-2 details the same five-year findings and summarizes the varying savings potential under each scenario. Table 3-2 also provides the summer five-year cumulative annual demand savings potential.

Table 3-2: 2020 Residential Cumulative Annual Energy (MWh) and Demand (MW) Savings Potential by Housing Type

	Existing SF-Detached	Existing SF-Attached	Existing Multifamily	New Construction
2020 Cumulative Base Achievable Energy Savings Potential - MWh				
Technical	9,486,200	2,051,711	2,051,516	268,264
Economic	6,966,793	1,350,224	1,094,463	150,072
Max Achievable	3,999,996	778,620	633,139	83,555
Base Achievable	2,697,529	527,501	440,442	56,649
2020 Cumulative Base Achievable Energy Savings Potential - % of 2010 Residential Load				
Technical	17.5%	3.8%	3.8%	0.5%
Economic	12.9%	2.5%	2.0%	0.3%
Max Achievable	7.4%	1.4%	1.2%	0.2%
Base Achievable	5.0%	1.0%	0.8%	0.1%
2020 Demand Savings Potential - Summer Peak MW				
Technical	1,574.7	388.6	396.9	38.2
Economic	913.2	207.1	187.5	16.4
Max Achievable	520.2	118.5	107.6	9.1
Base Achievable	347.1	79.3	73.7	6.3

The SWE Team also analyzed residential energy efficiency potential between low income and non-low income consumers.[35] Low income potential includes savings stemming directly from low income-specific measures as well as additional savings attributed to low income participants in non-low income-specific programs. Low income-specific measures include those offerings where EDCs are expected to pay 100% of the measure cost to low income-qualified customers.[36] Savings attributed to the low income sector

[35] The percent of the population estimated to be low income was derived from the US Census: 2011 American Community Survey, Three-Year Estimates.

[36] The threshold for cost-effectiveness for low income specific measures was below the traditional screening level of 1.0. Low income-specific measures were retained in the economic and achievable potential if they had a TRC ratio of 0.25 or higher.

from non-low income measures do not assume any additional incentives above and beyond the standard offering.

The SWE Team developed the list of low income-specific measures included in this analysis based on the historical low income offerings of the seven EDCs and included CFL/LED lighting installation, appliance upgrades, and heating, ventilation and air conditioning (HVAC) equipment and shell improvements. The percent of savings attributed to the low income sector from non-low income measures was estimated at 15%, and was based on the average reported values in the EDCs' most recent annual reports (PY5) to the Commission.

As Table 3-3 shows, in total, the 2020 base achievable savings from low income participants is 825,104 MWh, or approximately 1.5% of 2010 residential load. Savings from non-low income participants are 2.9 million MWh, or roughly 5.3% of 2010 residential load.

Table 3-3: 2020 Residential Cumulative Annual Energy (MWh) and Demand (MW) Savings Potential Estimates by Income Type

	Non-Low Income	Low Income
2020 Cumulative Base Achievable Energy Savings Potential – MWh		
Technical	10,739,225	3,118,466
Economic	7,087,381	2,474,171
Max Achievable	4,075,805	1,419,506
Base Achievable	2,897,015	825,104
2020 Cumulative Base Achievable Energy Savings Potential - % of 2010 Residential Load		
Technical	19.8%	5.8%
Economic	13.1%	4.6%
Max Achievable	7.5%	2.6%
Base Achievable	5.3%	1.5%
2020 Demand Savings Potential – Summer Peak PW		
Technical	1,886.7	511.7
Economic	972.5	351.7
Max Achievable	554.9	200.5
Base Achievable	395.4	111.0

3.3 RESIDENTIAL POTENTIAL BY END USE

Figure 3-3 shows the residential cumulative annual energy and demand savings by end use for the base achievable scenario in 2020. Lighting represents the greatest share of the residential base achievable potential energy savings (35.6%), despite higher baseline conditions with CFLs in place of EISA-compliant halogens starting in 2020. The "Cross-Cutting" end use, consisting primarily of behavioral energy efficiency measures that provide energy consumption feedback to consumers in an effort to encourage reduced energy use, represents the third largest for potential savings due to its widespread applicability to nearly all households. Savings from the water heating, HVAC equipment, and building envelope end uses, although also substantial, are limited due to cost-effectiveness concerns and/or applicability of electric space and/or water heating across the EDCs.

Lighting also represents the greatest opportunity for demand savings in 2020 from energy efficient improvements. However, improvements to HVAC equipment and the building envelope are also opportunities for significant demand reductions.

Figure 3-3: 2020 Base Achievable Savings Potential Distribution by End Use

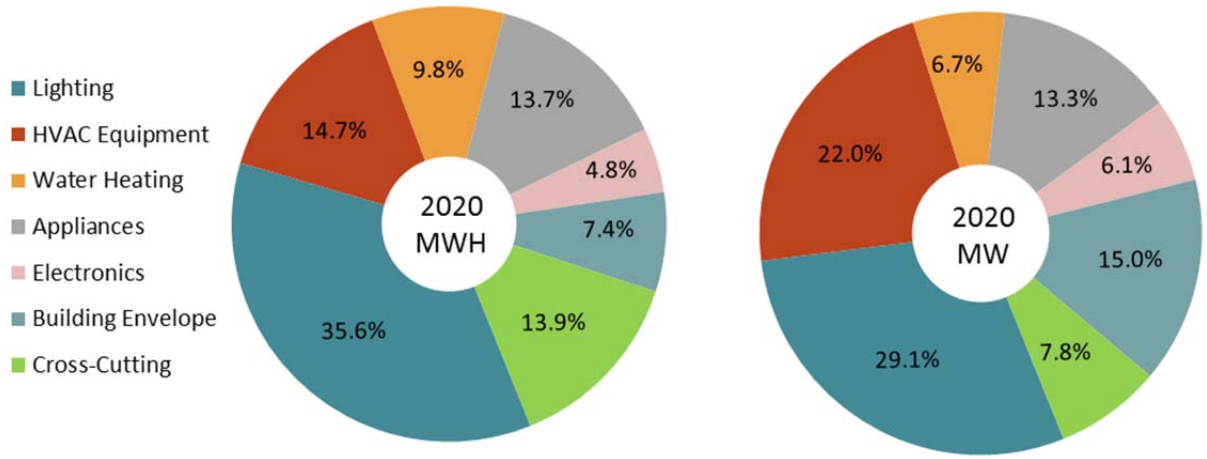


Table 3-4 provides the residential cumulative annual energy savings potential by end use for 2016 through 2020 as well as 2025. The annual look at estimated electric energy efficiency potential depicts the anticipated decrease in lighting potential from 2019 to 2020 as a result of the 2007 EISA backstop provision going into effect. However, lighting remains the end use with the greatest electric efficiency potential due to the high saturation of sockets eligible to be converted to LEDs.

Table 3-4: Residential Cumulative Annual Energy (MWh) Savings Potential by End Use by Scenario

Energy (MWh)	2016	2017	2018	2019	2020	2025
Lighting						
Technical	1,449,792	3,149,477	4,720,332	6,290,309	3,703,410	3,841,113
Economic	1,430,812	3,111,570	4,663,557	6,214,674	3,637,138	3,708,909
Max Achievable	677,768	1,544,366	2,419,900	3,356,697	2,017,307	2,834,938
Base Achievable	451,236	1,024,695	1,600,553	2,213,686	1,326,647	1,828,932
HVAC Equipment						
Technical	588,858	1,176,608	1,763,250	2,348,784	2,894,675	5,400,049
Economic	282,823	565,646	848,469	1,131,292	1,375,580	2,458,856
Max Achievable	137,711	286,660	446,848	618,275	782,157	1,678,223
Base Achievable	93,946	196,991	309,136	430,379	548,234	1,212,546
Water Heating						
Technical	361,916	721,932	1,080,060	1,436,833	1,787,206	3,455,261
Economic	215,162	429,311	642,455	854,865	1,061,358	1,955,288
Max Achievable	104,204	215,870	334,929	461,468	593,119	1,298,418
Base Achievable	67,781	138,467	212,037	288,561	366,453	757,217
Appliances						
Technical	254,675	508,958	762,835	1,016,566	1,270,077	2,198,674
Economic	229,861	459,456	688,778	917,997	1,147,070	1,948,778
Max Achievable	112,048	233,215	363,475	502,910	651,484	1,356,453
Base Achievable	80,144	171,364	273,628	386,995	511,427	1,170,285
Electronics						
Technical	141,133	281,720	421,711	561,611	651,063	1,025,038
Economic	88,264	176,191	263,746	351,248	388,424	501,624
Max Achievable	43,025	89,428	139,161	192,389	224,795	372,056
Base Achievable	30,849	65,930	105,190	148,753	179,032	325,563
Building Envelope						

Energy (MWh)	2016	2017	2018	2019	2020	2025
Technical	370,611	729,135	1,075,591	1,410,619	1,735,870	3,226,918
Economic	165,528	326,734	483,617	636,178	785,710	1,486,852
Max Achievable	80,562	166,028	256,141	350,624	449,531	1,000,732
Base Achievable	52,053	105,567	160,446	216,589	274,031	577,225
Cross-Cutting/Pools*						
Technical	931,661	1,444,874	1,878,898	1,753,587	1,815,391	1,588,370
Economic	766,457	987,486	1,182,108	1,117,551	1,166,273	1,082,741
Max Achievable	382,212	535,478	688,571	715,478	776,918	945,858
Base Achievable	177,801	302,939	426,382	464,293	516,296	715,315
Total						
Technical	***4,098,645***	***8,012,703***	***11,702,677***	***14,818,309***	***13,857,691***	***20,735,423***
Economic	***3,178,908***	***6,056,394***	***8,772,730***	***11,223,805***	***9,561,552***	***13,143,049***
Max Achievable	***1,537,529***	***3,071,045***	***4,649,025***	***6,197,840***	***5,495,310***	***9,486,677***
Base Achievable	***953,810***	***2,005,954***	***3,087,372***	***4,149,256***	***3,722,120***	***6,587,083***

** Cross-cutting refers to behavioral measures. Efficient pool pumps were not cost-effective and were only included in estimates of technical potential.*

3.4 RESIDENTIAL POTENTIAL BY EDC

The SWE Team calculated electric energy efficiency potential for each EDC individually to produce a cumulative estimate of energy efficiency savings potential.

Table 3-5 provides the cumulative annual energy (MWh) savings and percentage of 2010 load. Across the EDCs, the base achievable potential ranges from 6.0% to 7.6% of 2010 residential load over a five year period. The five-year cumulative annual energy savings potential for all seven EDCs combined is estimated at 3.7 million MWh, or 6.9% of 2010 residential sector load.

Table 3-5 Residential Cumulative Annual Energy (MWh) Savings Potential by EDC by Scenario by Year

	2016	2017	2018	2019	2020	2025
Duquesne						
Technical	369,200	698,645	1,019,201	1,288,671	1,172,347	1,714,471
Economic	286,431	512,969	738,114	958,784	785,624	1,083,208
Maximum Achievable	138,419	259,973	390,680	528,197	450,355	783,124
Base Achievable	84,269	169,071	260,085	355,797	309,448	558,676
Base Achievable % of 2010 Load	***2.0%***	***4.0%***	***6.2%***	***8.5%***	***7.4%***	***13.3%***
FE: Met-Ed						
Technical	421,700	843,991	1,235,219	1,567,803	1,458,744	2,161,579
Economic	327,951	645,870	938,322	1,200,615	1,018,129	1,375,964
Maximum Achievable	158,467	327,041	496,587	662,131	584,161	995,352
Base Achievable	98,786	214,137	330,106	443,427	395,743	691,195
Base Achievable % of 2010 Load	***1.6%***	***3.5%***	***5.3%***	***7.2%***	***6.4%***	***11.1%***
FE: Penelec						
Technical	359,420	696,485	1,018,343	1,289,499	1,217,197	1,827,672
Economic	299,422	565,376	820,713	1,052,538	938,198	1,338,637
Maximum Achievable	145,083	287,199	435,641	582,135	540,268	962,486
Base Achievable	90,861	188,873	291,378	392,894	370,178	681,640
Base Achievable % of 2010 Load	***1.9%***	***3.9%***	***6.0%***	***8.0%***	***7.6%***	***14.0%***
FE: Penn Power						

	2016	2017	2018	2019	2020	2025
Technical	120,088	235,778	345,721	439,806	397,657	584,278
Economic	96,683	185,656	270,304	347,368	287,285	388,246
Maximum Achievable	46,615	93,817	142,749	191,134	164,336	280,654
Base Achievable	29,186	61,466	94,886	127,942	111,328	194,951
Base Achievable % of 2010 Load	***1.6%***	***3.3%***	***5.1%***	***6.9%***	***6.0%***	***10.6%***
FE: West Penn						
Technical	625,593	1,225,242	1,789,812	2,267,881	2,119,298	3,174,272
Economic	502,883	963,675	1,398,384	1,789,247	1,547,304	2,167,663
Maximum Achievable	243,270	488,826	741,523	988,698	889,270	1,557,092
Base Achievable	151,583	319,256	491,421	659,650	598,365	1,066,318
Base Achievable % of 2010 Load	***1.9%***	***4.0%***	***6.2%***	***8.3%***	***7.5%***	***13.4%***
PECO						
Technical	1,079,859	2,086,105	3,045,082	3,846,841	3,648,261	5,513,418
Economic	793,136	1,482,935	2,142,702	2,724,934	2,298,815	3,096,489
Maximum Achievable	383,559	752,257	1,136,291	1,506,695	1,324,290	2,247,574
Base Achievable	236,373	490,113	754,054	1,009,008	898,129	1,568,071
Base Achievable % of 2010 Load	***1.7%***	***3.5%***	***5.4%***	***7.2%***	***6.4%***	***11.2%***
PPL						
Technical	1,122,784	2,226,457	3,249,300	4,117,807	3,844,188	5,759,733
Economic	872,402	1,699,913	2,464,191	3,150,320	2,686,197	3,692,841
Maximum Achievable	422,117	861,932	1,305,554	1,738,850	1,542,630	2,660,395
Base Achievable	262,752	563,037	865,444	1,160,539	1,038,929	1,826,233
Base Achievable % of 2010 Load	***1.7%***	***3.7%***	***5.7%***	***7.7%***	***6.9%***	***12.1%***
Statewide Total						
Technical	***4,098,645***	***8,012,703***	***11,702,677***	***14,818,309***	***13,857,691***	***20,735,423***
Economic	***3,178,908***	***6,056,394***	***8,772,730***	***11,223,805***	***9,561,552***	***13,143,049***
Maximum Achievable	***1,537,529***	***3,071,045***	***4,649,025***	***6,197,840***	***5,495,310***	***9,486,677***
Base Achievable	***953,810***	***2,005,954***	***3,087,372***	***4,149,256***	***3,722,120***	***6,587,083***
Base Achievable % of 2010 Load	***1.8%***	***3.7%***	***5.7%***	***7.7%***	***6.9%***	***12.2%***

3.5 RESIDENTIAL BENEFITS AND COSTS

Table 3-6 provides the economic impacts by EDC for the residential achievable scenarios. Overall, capturing the estimated program potential would result in an NPV of nearly $2.25 billion in lifetime benefits for an investment of $1.25 billion (NPV) in the base achievable potential scenario. The Commonwealth of Pennsylvania would capture about $997 million in present value net benefits and a TRC ratio of 1.8.

Table 3-6: 2020 Residential TRC Benefit-Cost Ratios by Achievable Scenario by EDC

	NPV Costs (Million $)	NPV Benefits (Million $)	NPV Net Benefits (Million $)	TRC BC Ratio
Maximum Achievable Potential				
Duquesne	$176.5	$346.0	$169.5	2.0
FE: Met-Ed	$196.0	$376.7	$180.7	1.9
FE: Penelec	$194.2	$316.0	$121.9	1.6
FE: Penn Power	$51.4	$83.7	$32.3	1.6
FE: West Penn	$282.4	$493.9	$211.5	1.7
PECO	$474.7	$842.5	$367.8	1.8
PPL	$524.4	$918.5	$394.1	1.8

	NPV Costs (Million $)	NPV Benefits (Million $)	NPV Net Benefits (Million $)	TRC BC Ratio
Statewide	***$1,899.6***	***$3,377.4***	***$1,477.8***	***1.8***
Base Achievable Potential				
Duquesne	$117.6	$231.6	$114.0	2.0
FE: Met-Ed	$129.2	$250.7	$121.5	1.9
FE: Penelec	$129.7	$212.8	$83.1	1.6
FE: Penn Power	$33.8	$55.7	$21.8	1.6
FE: West Penn	$185.2	$327.1	$141.8	1.8
PECO	$310.3	$559.6	$249.3	1.8
PPL	$344.2	$609.6	$265.4	1.8
Statewide	***$1,250.1***	***$2,246.9***	***$996.9***	***1.8***

Table 3-7 represents the total program expenses paid by the EDCs to realize five-year achievable savings estimates under the maximum and base achievable scenarios. For the residential sector, the per first-year MWh acquisition cost is between $256/MWh in the maximum achievable scenario assuming 100% incentives for all measures, and $203/MWh in the base achievable scenario. The estimated EDC acquisition costs include both incentive costs as well as non-incentive costs to include marketing, incentive fulfillment, and EM&V.

Table 3-7: Five-Year Residential Acquisition Costs (TRC) by Achievable Scenario by EDC

EDC	2016-2020 Program Costs ($Million)	2016-2020 Program Savings (MWh)	Acquisition Costs ($/1st-YR MWh Saved)
Maximum Achievable Scenario			
Duquesne	$201.6	754,180	$267.38
FE: Met-Ed	$226.0	908,437	$248.83
FE: Penelec	$226.0	809,744	$279.10
FE: Penn Power	$62.9	260,651	$241.33
FE: West Penn	$335.1	1,366,665	$245.22
PECO	$548.7	2,141,723	$256.21
PPL	$611.5	2,394,445	$255.38
Statewide	***$2,212.0***	***8,635,846***	***$256.14***
Base Achievable Scenario			
Duquesne	$104.5	494,667	$211.20
FE: Met-Ed	$116.6	596,247	$195.56
FE: Penelec	$116.2	535,929	$216.81
FE: Penn Power	$33.0	171,152	$192.63
FE: West Penn	$174.6	893,300	$195.51
PECO	$287.4	1,400,064	$205.24
PPL	$314.8	1,565,461	$201.10
Statewide	***$1,147.1***	***5,656,819***	***$202.77***

4 Commercial Energy Efficiency Potential

This section of the report presents the commercial sector estimates of electric technical, economic, and achievable potential for the Commonwealth of Pennsylvania as well as for each EDC service area. Program potential is discussed separately in Section 6 of this report. Electric energy efficiency savings, cost estimates, and benefit-cost estimates are presented in this section.

4.1 SUMMARY

Figure 4-1 summarizes electric energy efficiency savings potential for the commercial sector for all seven EDCs combined across the state. The five-year cumulative energy savings potential under the base achievable scenario amount to 1,853,605 MWh and 319.2 MW, representing a possible 3.3% reduction of 2010 load in the commercial sector. Details on each of the four scenarios are discussed in more detail below.

Figure 4-1: Commercial Cumulative Annual Energy (MWh) Savings Potential by Scenario, by Year

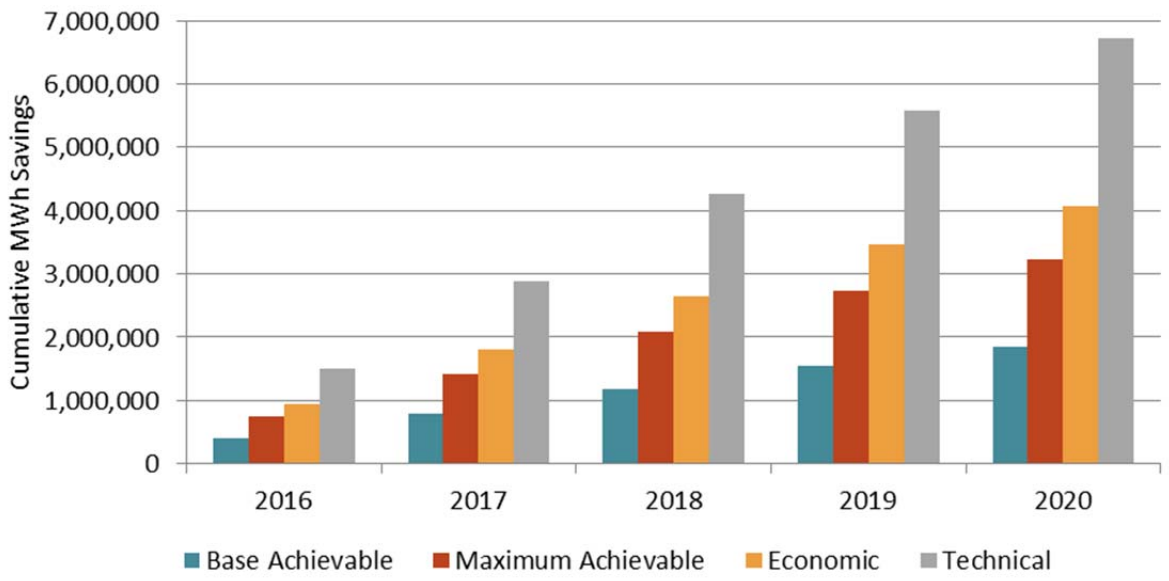


Table 4-1 presents the same estimates for electric energy efficiency savings potential for the commercial sector for all seven EDCs combined across the state by scenario. Details on the findings for each scenario are presented below.

Technical potential, which reflects the adoption of all energy efficient technologies, is a theoretical upper bound on savings. The 5-year cumulative energy efficiency technical potential is 6,716,920 MWh.

Economic Potential, which reflects the savings when all cost-effective measures are implemented, is just over 4,078,690 MWh during the same five-year period.

Maximum Achievable Potential is a subset of economic potential and represents the attainable savings assuming incentive levels are set at 100% of measure incremental costs and the long-term market penetration of high efficiency electric equipment reaches 85% of available stock in any given

year. Maximum achievable potential is 739,695 MWh in 2016. By 2020, the cumulative maximum achievable potential savings is 3,225,158 MWh, representing 5.8% of 2010 statewide commercial sales.

Base Achievable Potential is also a subset of economic potential and represents the SWE Team's best estimate of attainable savings potential assuming comprehensive implementation of all cost-effective measures and no restrictions on budget. The base achievable potential scenario assumes incentive levels are set at 35% of measure incremental costs. Base achievable potential is estimated at 408,759 MWh in 2016. By 2020, the cumulative base achievable potential savings are estimated to be 1,853,605 MWh, representing 3.3% of 2010 statewide commercial sales.

Table 4-1: Commercial Cumulative Annual Energy (MWh) and Demand (MW) Savings Potential by Scenario by Year

	2016	2017	2018	2019	2020	2025
Cumulative Energy Savings Potential - MWh						
Technical	1,510,224	2,892,043	4,258,469	5,577,160	6,716,920	11,489,398
Economic	940,525	1,802,045	2,650,569	3,467,750	4,078,690	6,805,055
Maximum Achievable	739,695	1,417,180	2,087,834	2,737,159	3,225,158	5,468,715
Base Achievable	408,759	791,076	1,173,748	1,550,571	1,853,605	3,205,776
Cumulative Energy Savings Potential - % of 2010 Commercial Load						
Technical	2.7%	5.2%	7.6%	10.0%	12.0%	20.5%
Economic	1.7%	3.2%	4.7%	6.2%	7.3%	12.2%
Maximum Achievable	1.3%	2.5%	3.7%	4.9%	5.8%	9.8%
Base Achievable	0.7%	1.4%	2.1%	2.8%	3.3%	5.7%
Demand Savings Potential - Summer Peak MW						
Technical	314.2	600.7	883.7	1,158.2	1,388.1	2,442.4
Economic	175.9	335.9	493.0	643.3	752.6	1,269.4
Maximum Achievable	138.4	264.5	389.1	509.0	596.7	1,022.3
Base Achievable	71.7	138.0	204.4	269.2	319.2	560.8

4.2 COMMERCIAL POTENTIAL BY MARKET SEGMENT

Figure 4-2 shows the five-year cumulative savings potential distribution by commercial building segment under the achievable base scenario. The office segment is the single building type with the largest share of potential savings, representing 18.9% of achievable potential in 2020. Healthcare represents the second largest opportunity for savings at 13.4% of achievable potential. The miscellaneous segment at 19.6% of achievable potential consists of various building types from movie theaters and bowling alleys to mixed-use buildings and service buildings such as gas stations, among many others.

Figure 4-2: 2020 Commercial Energy Savings Distribution by Building Type, Achievable Base

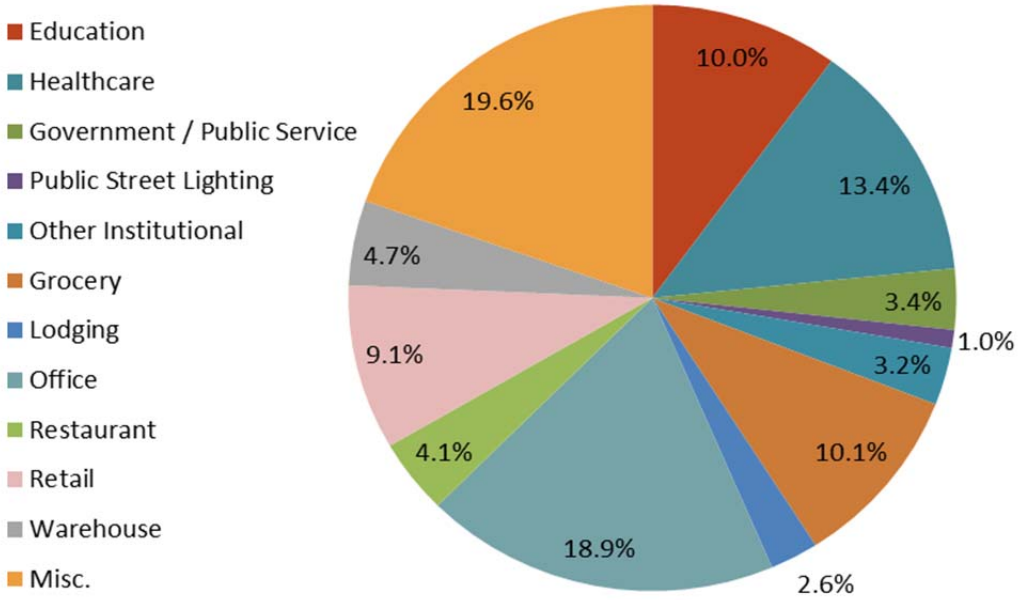


Table 4-2 details the same five-year findings, but summarizes the varying savings potential under each scenario. While the office segment shows the largest magnitude for savings potential at 350,791 MWh, the grocery segment is estimated to have the highest share of potential as a percentage of 2010 load at 5.1% (compared to 3.1% for office). The healthcare segment also shows a high percentage of potential (4.3%) compared to 2010 load, while government/public service has the lowest percentage at 2.2%.

Table 4-2: 2020 Commercial Cumulative Annual Energy (MWh) and Demand (MW) Savings Potential by Scenario by Building Type

	Education	Healthcare	Government/ Public Service	Public Street Lighting*	Other Institn'l	Grocery	Lodging	Office	Restaurant	Retail	Warehouse	Misc.
Cumulative Energy Savings Potential - MWh												
Technical	649,480	717,552	215,797	84,181	209,160	585,057	190,644	1,385,122	291,077	589,928	370,914	1,428,008
Economic	372,136	520,659	130,630	51,832	124,020	390,006	105,567	768,137	178,151	386,191	208,104	843,257
Max Achievable	300,724	404,277	102,973	40,597	98,011	327,263	84,887	607,952	143,167	298,780	162,084	654,443
Base Achievable	186,029	247,531	62,206	18,392	58,713	186,589	47,802	350,791	76,283	168,638	86,662	363,969
Cumulative Energy Savings Potential - % of 2010 Commercial Building Type Load												
Technical	9.5%	12.4%	7.7%	N/A	9.3%	16.0%	14.8%	12.4%	12.6%	10.6%	13.8%	12.4%
Economic	5.4%	9.0%	4.7%	N/A	5.5%	10.6%	8.2%	6.9%	7.7%	6.9%	7.7%	7.3%
Max Achievable	4.4%	7.0%	3.7%	N/A	4.3%	8.9%	6.6%	5.4%	6.2%	5.3%	6.0%	5.7%
Base Achievable	2.7%	4.3%	2.2%	N/A	2.6%	5.1%	3.7%	3.1%	3.3%	3.0%	3.2%	3.2%
Demand Savings Potential - Summer Peak MW												
Technical	105.3	125.4	36.0	9.6	63.2	75.1	30.1	315.9	52.7	127.1	61.8	386.0
Economic	56.3	86.6	20.3	5.9	28.5	53.7	19.1	182.0	28.6	85.7	37.5	148.4
Max Achievable	46.4	70.6	15.9	4.6	22.3	44.9	15.8	141.5	22.6	66.9	29.4	115.6
Base Achievable	25.7	36.2	9.0	2.1	12.5	24.0	8.7	77.8	12.0	35.2	15.2	60.9

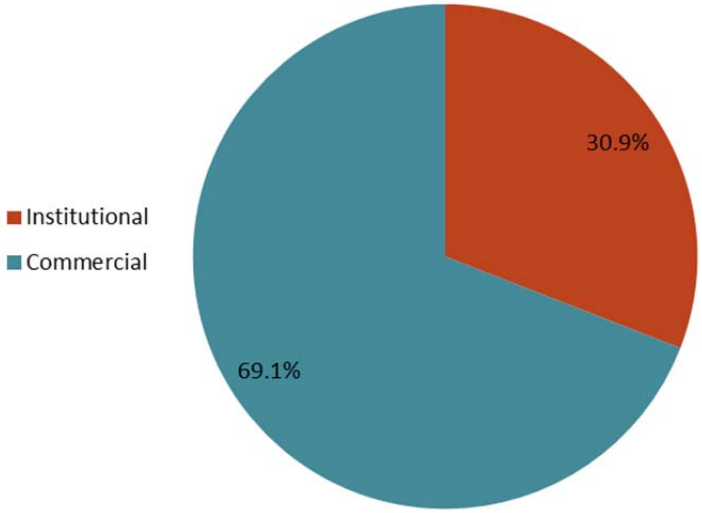
NOTES:
- 2010 energy load data not available for Public Street Lighting

Table 4-3 and Figure 4-3 show the savings potential broken out between segments that reside in the commercial sector and segments that could contribute to the GNI carve-out[37]. Under the base achievable scenario 1,280,734 MWh (69.1%) of energy savings potential resides in the commercial sector, while 521,871 MWh (30.9%) of energy savings potential is estimated to reside in the GNI sector.

Table 4-3: 2020 Commercial Cumulative Energy (MWh) and Demand (MW) Savings Potential by Scenario by Commercial Sector

	Institutional	Commercial
2020 Cumulative Base Achievable Energy Savings Potential – MWh		
Technical	1,876,170	4,840,750
Economic	1,199,277	2,879,413
Max Achievable	946,582	2,278,576
Base Achievable	572,871	1,280,734
2020 Cumulative Base Achievable Energy Savings Potential - % of 2010 Commercial Load		
Technical	10.1%	12.6%
Economic	6.5%	7.5%
Max Achievable	5.1%	6.0%
Base Achievable	3.1%	3.3%
2020 Demand Savings Potential – Summer Peak PW		
Technical	339.5	1,048.6
Economic	197.6	555.0
Max Achievable	159.9	436.8
Base Achievable	85.5	233.7

Figure 4-3: 2020 Commercial Cumulative Annual Energy Savings Distribution by Commercial Sector, Achievable Base Scenario



4.3 COMMERCIAL POTENTIAL BY END USE

Figure 4-4 summarizes the distribution of cumulative five-year savings potential by commercial end use under the base achievable scenario, while Table 4-4 details the estimated savings potential by commercial end use by scenario by year. The lighting end use (including linear fluorescents, high bay

[37] While the SWE was able to identify government and institutional buildings in the EDCs customer databases, no reliable data was available to identify nonprofit customers since nonprofits cut across multiple building types. Therefore, the SWE team used education and healthcare buildings as a proxy for nonprofit customers since many of these buildings types are occupied by nonprofits.

lighting, other interior, and exterior lighting) accounts for the largest share of potential savings by end use with 744,277 MWh by 2020, representing 40.0% of achievable potential in 2020 – despite higher baseline conditions with T8 linear fluorescent lamps in place of T12s. The SWE Team found the next largest share of energy savings potential in the refrigeration end use (18.2%), followed by HVAC (space cooling, space heating, and heat pumps) and plug loads.

Figure 4-4: 2020 Commercial Cumulative Annual Energy Savings Distribution by End Use, Achievable Base Scenario

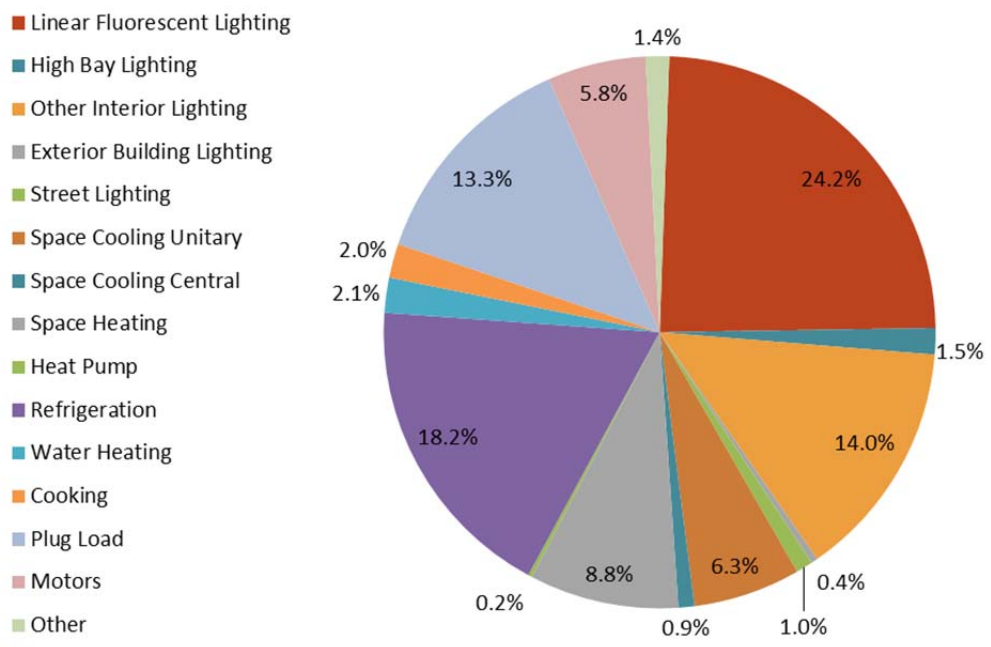


Table 4-4: Commercial Cumulative Energy (MWh) Savings Potential by Scenario by End Use by Year

	2016	2017	2018	2019	2020	2025
Lighting	Cumulative Energy Savings (MWh)					
Technical	558,732	1,061,636	1,543,960	1,986,900	2,268,053	3,585,800
Economic	442,283	841,787	1,226,004	1,576,533	1,782,231	2,742,461
Max Achievable	334,127	635,359	926,156	1,192,024	1,341,644	2,079,174
Base Achievable	176,484	339,880	499,758	649,690	744,277	1,180,329
Public Street Lighting						
Technical	18,056	34,564	51,087	67,628	84,181	167,241
Economic	11,118	21,282	31,456	41,641	51,832	102,973
Max Achievable	8,587	16,492	24,463	32,498	40,597	82,185
Base Achievable	3,806	7,349	10,959	14,640	18,392	38,348
HVAC						
Technical	421,921	808,009	1,195,059	1,583,032	1,971,399	3,500,683
Economic	160,865	308,693	456,004	602,788	748,952	1,407,795
Max Achievable	120,073	230,702	341,609	452,752	564,095	1,091,679
Base Achievable	62,315	120,811	179,936	239,730	300,164	573,979
Refrigeration						
Technical	206,288	398,768	591,748	771,636	948,825	1,823,358
Economic	147,695	284,038	420,623	557,447	692,933	1,373,916

	2016	2017	2018	2019	2020	2025
Max Achievable	124,555	239,570	355,256	471,589	587,769	1,178,799
Base Achievable	69,998	135,697	202,422	270,226	337,937	692,321
Water Heating						
Technical	21,122	40,985	60,842	80,699	100,191	196,746
Economic	15,577	30,451	45,353	60,276	74,790	147,219
Max Achievable	9,717	18,941	28,202	37,493	46,574	92,236
Base Achievable	7,831	15,405	23,022	30,680	38,096	75,633
Cooking						
Technical	31,743	60,449	88,843	116,932	144,701	279,196
Economic	19,867	37,846	55,630	73,225	90,622	174,902
Max Achievable	16,010	30,571	45,059	59,471	73,805	144,512
Base Achievable	7,799	14,986	22,217	29,499	36,828	74,336
Plug Load						
Technical	174,558	338,589	506,467	678,264	835,736	1,210,598
Economic	116,009	225,816	338,089	452,891	508,584	593,904
Max Achievable	95,189	185,273	277,866	373,029	423,176	504,539
Base Achievable	52,692	103,439	156,002	210,489	245,864	302,541
Motors						
Technical	62,515	119,492	176,348	233,082	289,666	570,714
Economic	12,485	23,862	35,207	46,518	57,791	113,537
Max Achievable	20,125	38,332	56,351	74,189	91,827	176,875
Base Achievable	22,818	43,729	64,701	85,733	106,807	212,768
Other						
Technical	15,288	29,550	44,114	58,987	74,167	155,062
Economic	14,626	28,270	42,203	56,432	70,955	148,350
Max Achievable	11,313	21,940	32,872	44,114	55,671	118,715
Base Achievable	5,016	9,779	14,732	19,884	25,240	55,521
Total						
Technical	***1,510,224***	***2,892,043***	***4,258,469***	***5,577,160***	***6,716,920***	***11,489,398***
Economic	***940,525***	***1,802,045***	***2,650,569***	***3,467,750***	***4,078,690***	***6,805,055***
Max Achievable	***739,695***	***1,417,180***	***2,087,834***	***2,737,159***	***3,225,158***	***5,468,715***
Base Achievable	***408,759***	***791,076***	***1,173,748***	***1,550,571***	***1,853,605***	***3,205,776***

4.4 COMMERCIAL POTENTIAL BY EDC

This section details the commercial energy efficiency savings potential for each of the seven EDCs included in this assessment. Table 4-5 summarizes the SWE Team's findings. The SWE Team estimates the available energy savings potential to be roughly equal between EDCs when compared on a percentage of 2010 load basis, though some variance can be noted. PPL and Penn Power showed the largest share of five-year cumulative energy savings potential under the base achievable scenario at 3.9% and 3.7% of their 2010 load, respectively. Met-Ed and PECO showed the smallest share of five-year cumulative energy savings potential under the base achievable scenario at 2.8% of its 2010 load. The five-year cumulative energy savings potential for all seven EDCs combined is estimated at 1,853,605 MWh under the base achievable scenario, representing 3.3% of 2010 commercial sector load.

Table 4-5: Commercial Cumulative Energy (MWh) Savings Potential by EDC, by Scenario, by Year

	2016	2017	2018	2019	2020	2025
Duquesne						
Technical	170,897	325,840	479,151	626,195	744,495	1,273,533
Economic	151,638	293,327	433,667	568,265	667,353	1,106,680
Maximum Achievable	112,038	216,096	319,498	418,853	490,415	828,379
Base Achievable	55,240	107,035	158,997	209,593	247,483	431,631
Base Achievable % of 2010 Load	***0.8%***	***1.5%***	***2.2%***	***3.0%***	***3.5%***	***6.1%***
FE: Met-Ed						
Technical	71,040	135,662	199,666	262,585	319,909	577,012
Economic	50,016	95,462	140,413	184,414	220,530	384,544
Maximum Achievable	41,068	78,612	115,982	152,817	183,616	324,752
Base Achievable	24,897	48,348	71,937	95,497	116,363	206,643
Base Achievable % of 2010 Load	***0.6%***	***1.2%***	***1.7%***	***2.3%***	***2.8%***	***5.0%***
FE: Penelec						
Technical	93,973	178,546	260,902	339,128	401,377	681,676
Economic	66,182	125,723	183,766	238,590	276,440	452,923
Maximum Achievable	54,511	103,860	152,300	198,476	231,256	384,666
Base Achievable	32,093	62,026	91,819	120,844	143,630	242,786
Base Achievable % of 2010 Load	***0.8%***	***1.5%***	***2.2%***	***2.8%***	***3.4%***	***5.7%***
FE: Penn Power						
Technical	32,115	60,962	89,237	116,499	138,983	239,590
Economic	20,072	38,017	55,497	72,102	83,023	137,730
Maximum Achievable	16,334	31,027	45,434	59,232	68,567	116,153
Base Achievable	9,628	18,570	27,455	36,136	42,742	73,860
Base Achievable % of 2010 Load	***0.8%***	***1.6%***	***2.4%***	***3.1%***	***3.7%***	***6.4%***
FE: West Penn						
Technical	118,036	225,088	330,694	433,734	525,821	948,477
Economic	83,792	159,708	234,490	307,003	366,053	637,277
Maximum Achievable	69,056	132,003	194,411	255,391	305,966	541,100
Base Achievable	41,080	79,623	118,289	156,682	190,375	339,689
Base Achievable % of 2010 Load	***0.7%***	***1.4%***	***2.1%***	***2.8%***	***3.4%***	***6.1%***
PECO						
Technical	389,113	739,107	1,082,662	1,413,997	1,684,222	2,898,265
Economic	276,500	524,621	767,474	999,005	1,157,512	1,895,996
Maximum Achievable	227,757	433,432	636,102	831,053	968,751	1,612,004
Base Achievable	136,609	263,903	391,001	515,847	614,385	1,042,064
Base Achievable % of 2010 Load	***0.7%***	***1.3%***	***1.9%***	***2.5%***	***2.9%***	***5.0%***
PPL						
Technical	635,048	1,226,837	1,816,157	2,385,022	2,902,111	4,870,844
Economic	292,324	565,185	835,263	1,098,372	1,307,778	2,189,905
Maximum Achievable	218,932	422,151	624,107	821,337	976,586	1,661,662
Base Achievable	109,212	211,571	314,249	415,972	498,626	869,104
Base Achievable % of 2010 Load	***0.9%***	***1.6%***	***2.4%***	***3.2%***	***3.9%***	***6.8%***
Statewide Total						
Technical	***1,510,224***	***2,892,043***	***4,258,469***	***5,577,160***	***6,716,920***	***11,489,398***
Economic	***940,525***	***1,802,045***	***2,650,569***	***3,467,750***	***4,078,690***	***6,805,055***
Maximum Achievable	***739,695***	***1,417,180***	***2,087,834***	***2,737,159***	***3,225,158***	***5,468,715***
Base Achievable	***408,759***	***791,076***	***1,173,748***	***1,550,571***	***1,853,605***	***3,205,776***

	2016	2017	2018	2019	2020	2025
Base Achievable % of 2010 Load	*0.7%*	*1.4%*	*2.1%*	*2.8%*	*3.3%*	*5.7%*

4.5 COMMERCIAL BENEFITS AND COSTS

Table 4-6 provides the economic impacts by EDC for the commercial base achievable and maximum achievable scenarios. Overall, the SWE Team found there to be a significant amount of cost-effective energy efficiency savings potential still attainable in Pennsylvania between 2016 and 2020. The SWE Team estimates that the NPV of the cost to attain all energy efficiency savings under the base achievable scenario at $623.6 million from 2016 to 2020, while the benefits amount to almost $1.4 billion during the same time period resulting in $770 million in net benefits and a TRC ratio of 2.2.

Table 4-6: 2020 Commercial TRC Benefit-Cost Ratios by Achievable Scenario by EDC

	NPV Costs (Million $)	NPV Benefits (Million $)	NPV Net Benefits (Million $)	TRC BC Ratio
Maximum Achievable Potential				
Duquesne	$131.5	$295.6	$164.0	2.2
FE: Met-Ed	$47.5	$107.9	$60.4	2.3
FE: Penelec	$60.3	$133.0	$72.7	2.2
FE: Penn Power	$16.4	$32.8	$16.3	2.0
FE: West Penn	$77.1	$160.2	$83.2	2.1
PECO	$254.1	$582.3	$328.1	2.3
PPL	$251.7	$494.1	$242.4	2.0
Statewide	**$838.6**	**$1,805.9**	**$967.3**	**2.2**
Base Achievable Potential				
Duquesne	$86.3	$207.3	$121.1	2.4
FE: Met-Ed	$39.3	$90.2	$50.9	2.3
FE: Penelec	$47.8	$106.9	$59.0	2.2
FE: Penn Power	$13.1	$26.9	$13.8	2.1
FE: West Penn	$61.5	$131.8	$70.3	2.1
PECO	$209.6	$480.0	$270.5	2.3
PPL	$166.1	$350.5	$184.4	2.1
Statewide	**$623.6**	**$1,393.6**	**$770.0**	**2.2**

Table 4-7 summarizes the total estimated program expenses[38] that would be paid by the EDCs to realize the five-year cumulative energy savings estimates under the base achievable and maximum achievable scenarios. For the commercial sector, the per-MWh acquisition cost is between $139/MWh and $150/MWh among the EDCs under the base achievable scenario. The total estimated five-year programmatic costs for all seven EDCs is estimated at $280.7 million to achieve the 1,910,733 MWh of commercial sector savings under the base achievable scenario, resulting in a statewide average acquisition cost of $147/MWh.

[38] Program costs include administrative costs and incentive costs incurred by EDCs to obtain the sum of the five-year annual incremental savings.

Table 4-7: Five-Year Commercial Acquisition Costs (TRC) by Achievable Scenario by EDC

EDC	2016-2020 Program Costs ($Million)	2016-2020 Program Savings (MWh)	Acquisition Costs ($/1st-YR MWh Saved)
Maximum Achievable Scenario			
Duquesne	$141.1	511,658	$275.8
FE: Met-Ed	$50.6	188,615	$268.4
FE: Penelec	$64.7	241,692	$267.6
FE: Penn Power	$17.6	71,938	$244.9
FE: West Penn	$82.3	314,758	$261.4
PECO	$272.6	1,011,799	$269.4
PPL	$269.2	1,010,479	$266.4
Statewide	***$898.1***	***3,350,940***	***$268.0***
Base Achievable Scenario			
Duquesne	$38.5	256,958	$149.7
FE: Met-Ed	$17.5	118,692	$147.4
FE: Penelec	$21.7	148,405	$146.2
FE: Penn Power	$6.1	44,288	$138.8
FE: West Penn	$27.9	194,475	$143.5
PECO	$94.1	634,108	$148.3
PPL	$74.9	513,806	$145.8
Statewide	***$280.7***	***1,910,733***	***$146.9***

5 Industrial Energy Efficiency Potential

This section of the report presents the industrial sector estimates of electric technical, economic, and achievable potential for the Commonwealth of Pennsylvania, as well as for each EDC service area. Program potential is discussed separately in Section 6 of this report. Electric energy efficiency savings, cost estimates, and benefit-cost estimates are presented in this section.

5.1 SUMMARY

Figure 5-1 summarizes electric energy efficiency savings potential for the industrial sector for all seven EDCs combined across the state. The five-year cumulative energy savings potential under the base achievable scenario amount to 1,173,082 MWh and 151.4 MW, representing a possible 3.2% reduction of 2010 load in the industrial sector. Details on each of the four scenarios are discussed in more detail below.

Figure 5-1: Industrial Energy (MWh) and Demand (MW) Savings Potential by Scenario by Year

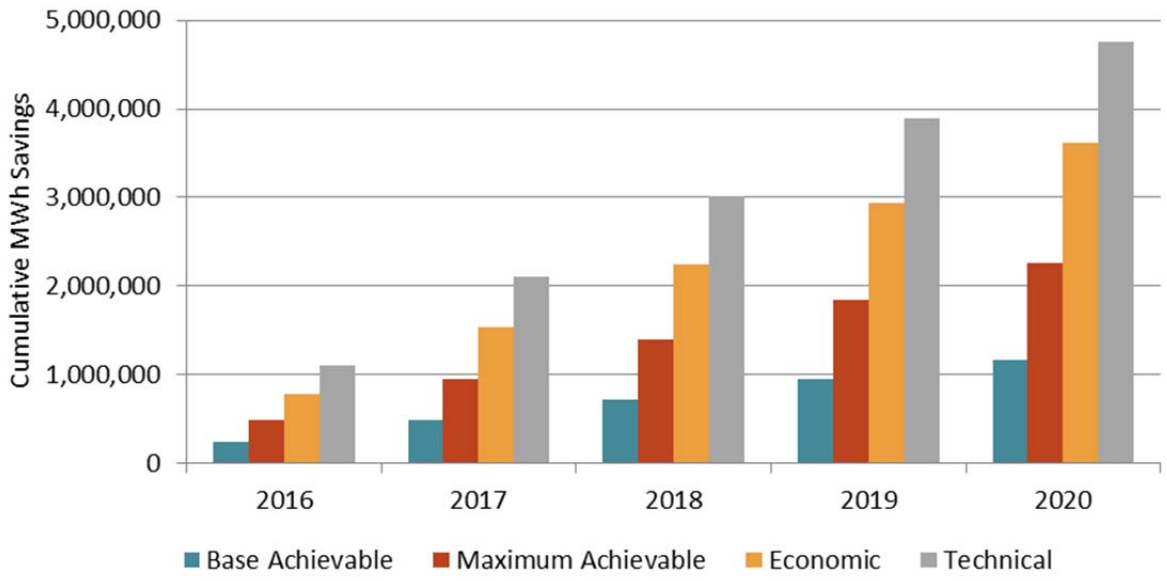


Table 5-1 presents the same estimates for electric energy efficiency savings potential for the commercial sector for all seven EDCs combined across the state by scenario. Details on the findings for each scenario are presented below.

Technical potential, which reflects the adoption of all energy efficient technologies, is a theoretical upper bound on savings. The five-year technical potential is 4,762,249 MWh (708.3 MW).

Economic Potential, which reflects the savings when all cost-effective measures are implemented, is 3,613,522 MWh during that same five-year period.

Maximum Achievable Potential is a subset of economic potential and represents the attainable savings assuming incentive levels are set at 100% of measure incremental costs and the long-term market penetration of high efficiency electric equipment reaches 85% of available stock in any given

year. Maximum achievable potential is 483,986 MWh in 2016. By 2020, the cumulative maximum achievable potential savings is 2,262,661 MWh, representing 6.2% of 2010 statewide industrial sales.

Base Achievable Potential is also a subset of economic potential and represents the SWE team's best estimate of attainable savings potential assuming comprehensive implementation of all cost-effective measures and no restrictions on budget. The base achievable potential scenario assumes incentive levels are set at 35% of measure incremental costs. Base achievable potential is estimated at 248,169 MWh in 2016. By 2020, the cumulative base achievable potential savings are estimated to be 1,173,082 MWh, representing 3.2% of 2010 statewide industrial sales.

Table 5-1: Industrial Cumulative Annual Energy (MWh) and Demand (MW) Savings Potential by Scenario by Year

	2016	2017	2018	2019	2020	2025
Cumulative Energy Savings Potential - MWh						
Technical	1,098,216	2,111,876	3,012,499	3,899,434	4,762,249	8,965,507
Economic	775,959	1,528,644	2,239,016	2,936,690	3,613,522	6,996,830
Maximum Achievable	483,986	950,293	1,396,380	1,837,463	2,262,661	4,401,700
Base Achievable	248,169	488,254	719,423	949,338	1,173,082	2,319,030
Cumulative Energy Savings Potential - % of 2010 Industrial Load						
Technical	3.0%	5.8%	8.3%	10.7%	13.0%	24.6%
Economic	2.1%	4.2%	6.1%	8.0%	9.9%	19.2%
Maximum Achievable	1.3%	2.6%	3.8%	5.0%	6.2%	12.1%
Base Achievable	0.7%	1.3%	2.0%	2.6%	3.2%	6.4%
Demand Savings Potential – Summer Peak MW						
Technical	170.2	317.1	448.8	578.2	708.3	1,353.6
Economic	106.1	209.7	307.5	403.1	499.3	982.3
Maximum Achievable	62.7	123.6	181.7	238.8	296.4	588.0
Base Achievable	31.8	62.7	92.4	121.7	151.4	303.8

5.2 INDUSTRIAL POTENTIAL BY MARKET SEGMENT

Figure 5-2 shows the five-year cumulative savings potential distribution by industrial building segment under the achievable base scenario. The Manufacturing (Mfg): Other segment accounts for the largest share of potential savings, representing 33.2% of achievable potential in 2020. This segment includes the manufacturing of automobiles, aircraft, furniture, and other miscellaneous materials. Mfg: Metals represents the second largest opportunity for savings at 15.2% of achievable potential.

Figure 5-2: 2020 Industrial Base Achievable Cumulative Annual Energy Savings Distribution by Industry Type

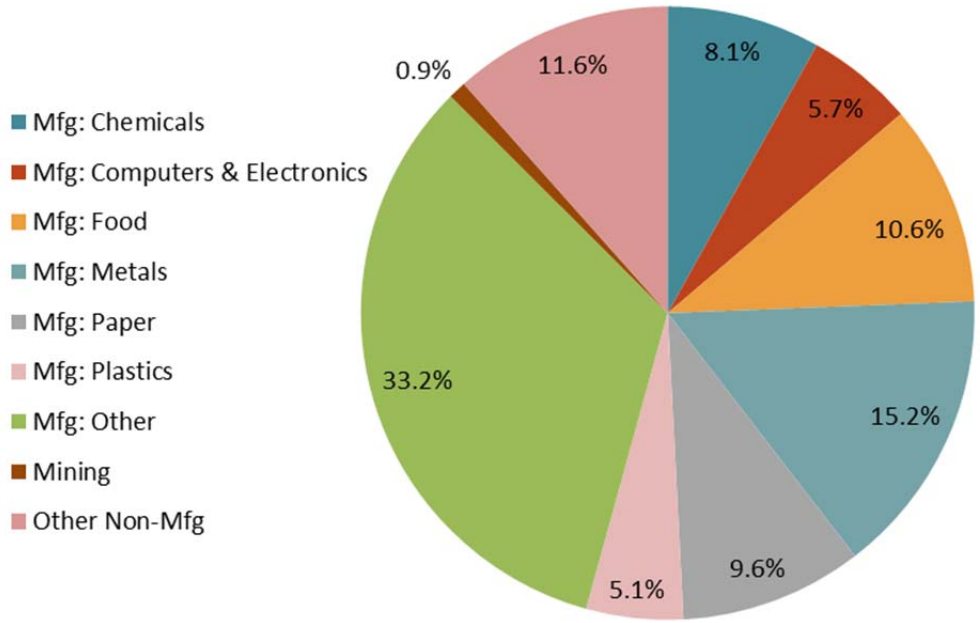


Table 5-2 details the same five-year findings, but summarizes the varying savings potential under each scenario. Mfg: Other has the largest magnitude for savings potential at 389,529 MWh, and also has the highest share of potential as a percentage of 2010 load at 19.1%. The Mfg: Other segment is comprised of several, smaller miscellaneous manufacturing industry types in Pennsylvania. Some of the industries types included in this bundled industrial segment include apparel, machinery, textile, transportation equipment, printing, furniture and stone/clay/concrete manufacturing facilities, to name a few. Mfg: Food has the next highest share of potential as a percentage of 2010 load at 4.0%.

Table 5-2: Industrial Cumulative Energy (MWh) & Demand (MW) Savings Potential by Scenario, by Industry Type

	Manufacturing								
Energy (MWh)	Chemicals	Computers & Electronics	Food	Metals	Paper	Plastics	Other	Mining	Other Non-Mfg.
Cumulative Energy Savings Potential - MWh									
Technical	337,073	366,393	468,556	768,882	353,486	228,392	1,557,455	54,373	627,638
Economic	275,774	230,860	380,263	581,861	294,591	180,638	1,200,707	25,953	442,874
Base Achievable	182,175	131,808	239,770	348,237	203,352	116,363	759,065	17,752	264,139
Max Achievable	94,836	66,525	124,687	177,796	113,084	59,928	389,529	10,986	135,712
Cumulative Energy Savings Potential - % of 2010 Industrial Load									
Technical	8.9%	18.1%	15.1%	10.1%	3.7%	9.8%	76.5%	2.7%	15%
Economic	7.2%	11.4%	12.2%	7.6%	3.1%	7.8%	59.0%	1.3%	11%
Base Achievable	4.8%	6.5%	7.7%	4.6%	2.1%	5.0%	37.3%	0.9%	6%
Max Achievable	2.5%	3.3%	4.0%	2.3%	1.2%	2.6%	19.1%	0.5%	3%
Demand Savings Potential – Summer Peak MW									
Technical	49.5	61.1	73.5	107.3	46.1	33.4	230.2	9.6	97.7
Economic	38.5	34.2	58.3	78.8	37.2	25.1	161.1	4.6	61.5
Base Achievable	24.7	18.5	35.4	45.3	25.2	15.4	95.2	2.6	34.1
Max Achievable	12.7	9.2	18.1	22.8	13.9	7.8	48.1	1.6	17.2

5.3 INDUSTRIAL POTENTIAL BY END USE

Figure 5-3 summarizes the distribution of cumulative five-year savings potential by industrial end use under the base achievable scenario, while Table 5-3 details the estimated savings potential by industry end use by scenario by year. The Motors end use accounts for the largest share of the potential savings by end use with 449,568 MWh by 2020, representing 38.3% of achievable potential in 2020. The SWE Team found the next largest share of energy savings potential in the HVAC end use (19.5%), followed by Process (18.7%).

Figure 5-3: Industrial 2020 Cumulative Annual Base Achievable Energy (MWh) Savings Potential by End Use

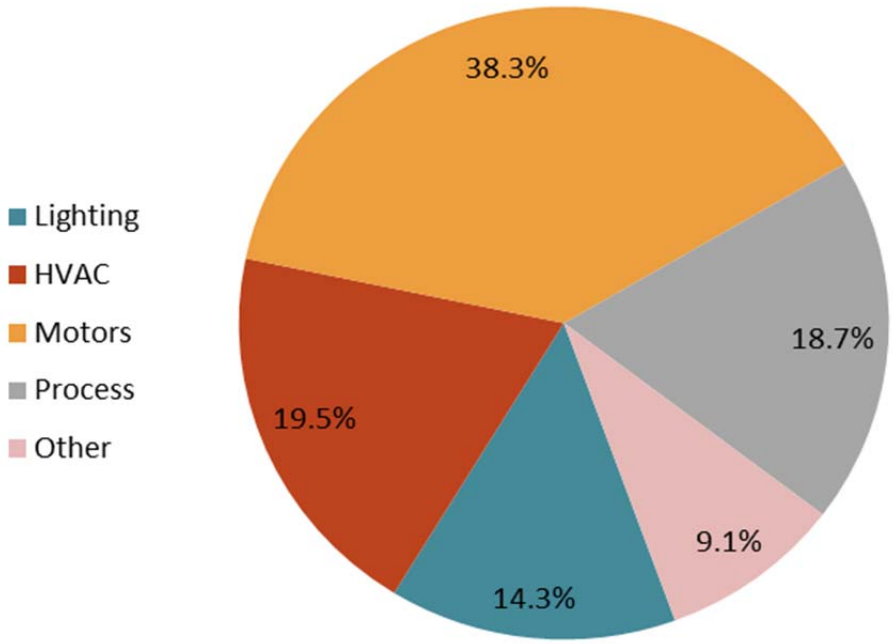


Table 5-3: 2020 Industrial Cumulative Annual Energy (MWh) Savings Potential by Scenario, by End Use

Energy (MWh)	2016	2017	2018	2019	2020	2025
Lighting						
Technical	125,581	242,751	360,056	477,563	569,649	940,393
Economic	83,592	160,751	237,984	315,342	370,206	627,436
Max Achievable	69,580	134,130	199,070	264,442	312,068	539,777
Base Achievable	36,390	70,508	105,195	140,480	167,758	304,184
HVAC						
Technical	329,540	600,042	871,961	1,144,590	1,417,165	2,743,267
Economic	177,395	351,529	526,014	700,938	876,272	1,754,229
Max Achievable	92,712	183,560	274,624	365,951	457,523	915,595
Base Achievable	46,334	91,792	137,403	183,191	229,149	460,004
Motors						
Technical	295,021	577,468	828,559	1,080,137	1,332,462	2,601,470
Economic	262,773	515,161	736,940	959,148	1,182,056	2,303,692
Max Achievable	182,792	357,142	516,627	677,117	838,726	1,662,588
Base Achievable	96,440	188,918	274,597	361,457	449,568	909,656
Process						
Technical	260,951	520,313	698,924	862,083	1,025,611	1,849,168

Energy (MWh)	2016	2017	2018	2019	2020	2025
Economic	165,630	330,977	486,493	627,959	769,729	1,484,115
Max Achievable	94,814	188,779	277,988	360,307	442,998	862,685
Base Achievable	46,713	93,207	137,477	178,437	219,747	432,219
Other						
Technical	87,124	171,302	252,998	335,061	417,363	831,208
Economic	86,569	170,226	251,586	333,303	415,260	827,357
Max Achievable	44,087	86,682	128,071	169,646	211,345	421,055
Base Achievable	22,292	43,828	64,752	85,773	106,861	212,967
Total						
Technical	***1,098,216***	***2,111,876***	***3,012,499***	***3,899,434***	***4,762,249***	***8,965,507***
Economic	***775,959***	***1,528,644***	***2,239,016***	***2,936,690***	***3,613,522***	***6,996,830***
Max Achievable	***483,986***	***950,293***	***1,396,380***	***1,837,463***	***2,262,661***	***4,401,700***
Base Achievable	***248,169***	***488,254***	***719,423***	***949,338***	***1,173,082***	***2,319,030***

5.4 INDUSTRIAL POTENTIAL BY EDC

This section details the industrial energy efficiency savings potential for each of the seven EDCs included in this study. Table 5-4 summarizes the SWE Team's findings. The SWE Team estimates the available energy savings potential to be roughly equal between EDCs when compared on a percentage of 2010 load basis, though some variance can be noted. PECO shows the largest share of five-year cumulative energy savings potential under the base achievable scenario at 5.5% of its 2010 load. Penn Power showed the smallest share of five-year cumulative energy savings potential under the base achievable scenario at 2.3% of its 2010 load. The five-year cumulative energy savings potential for all seven EDCs combined is estimated at 1,173,082 MWh under the base achievable scenario, representing 3.2% of 2010 industrial sector load.

Table 5-4: Industrial Cumulative Annual Energy (MWh) Savings Potential by EDC, by Scenario, by Year

	2016	2017	2018	2019	2020	2025
Duquesne						
Technical	82,907	157,522	226,768	295,878	362,665	685,654
Economic	56,056	109,857	162,863	215,733	267,287	526,232
Maximum Achievable	35,190	68,768	102,042	135,354	167,688	331,388
Base Achievable	17,886	35,037	52,129	69,335	86,194	173,065
Base Achievable % of 2010 Load	***0.6%***	***1.2%***	***1.9%***	***2.5%***	***3.1%***	***6.1%***
FE: Met-Ed						
Technical	143,489	275,562	396,300	514,591	629,604	1,182,422
Economic	99,653	196,410	290,163	381,543	469,714	904,257
Maximum Achievable	62,298	122,412	181,186	238,959	294,277	568,536
Base Achievable	31,653	62,339	92,515	122,353	151,196	296,845
Base Achievable % of 2010 Load	***0.7%***	***1.4%***	***2.0%***	***2.7%***	***3.3%***	***6.5%***
FE: Penelec						
Technical	155,790	299,617	429,147	557,064	681,467	1,284,260
Economic	112,491	221,252	326,204	429,790	529,875	1,026,226
Maximum Achievable	70,124	137,493	203,095	268,176	330,581	641,814
Base Achievable	36,265	71,226	105,464	139,606	172,651	340,146
Base Achievable % of 2010 Load	***0.7%***	***1.4%***	***2.0%***	***2.7%***	***3.3%***	***6.5%***
FE: Penn Power						
Technical	42,920	82,724	116,300	149,434	181,558	337,320
Economic	28,751	56,558	83,326	109,750	135,573	264,763

	2016	2017	2018	2019	2020	2025
Maximum Achievable	17,264	33,842	49,926	65,869	81,366	159,334
Base Achievable	8,666	17,025	25,176	33,295	41,250	81,921
Base Achievable % of 2010 Load	***0.5%***	***1.0%***	***1.4%***	***1.9%***	***2.3%***	***4.6%***
FE: West Penn						
Technical	184,221	355,954	505,543	653,793	797,965	1,501,337
Economic	123,596	244,228	360,729	476,449	589,777	1,159,463
Maximum Achievable	75,582	148,828	220,157	291,258	360,588	711,362
Base Achievable	38,947	76,813	113,894	151,038	187,555	375,173
Base Achievable % of 2010 Load	***0.5%***	***1.0%***	***1.5%***	***2.0%***	***2.5%***	***5.0%***
PECO						
Technical	231,117	443,637	623,732	800,934	973,139	1,808,703
Economic	169,583	334,037	475,097	613,333	746,745	1,409,530
Maximum Achievable	105,156	206,425	295,981	384,378	469,087	892,553
Base Achievable	53,961	106,129	152,675	198,899	243,643	471,571
Base Achievable % of 2010 Load	***1.2%***	***2.4%***	***3.5%***	***4.5%***	***5.5%***	***10.7%***
PPL						
Technical	257,773	496,861	714,708	927,741	1,135,852	2,165,810
Economic	185,830	366,303	540,634	710,092	874,551	1,706,359
Maximum Achievable	118,373	232,525	343,993	453,468	559,074	1,096,711
Base Achievable	60,790	119,684	177,572	234,811	290,593	580,309
Base Achievable % of 2010 Load	***0.6%***	***1.2%***	***1.7%***	***2.3%***	***2.8%***	***5.7%***
Statewide Total						
Technical	**1,098,216**	**2,111,876**	**3,012,499**	**3,899,434**	**4,762,249**	**8,965,507**
Economic	**775,959**	**1,528,644**	**2,239,016**	**2,936,690**	**3,613,522**	**6,996,830**
Maximum Achievable	**483,986**	**950,293**	**1,396,380**	**1,837,463**	**2,262,661**	**4,401,700**
Base Achievable	**248,169**	**488,254**	**719,423**	**949,338**	**1,173,082**	**2,319,030**
Base Achievable % of 2010 Load	***0.7%***	***1.3%***	***2.0%***	***2.6%***	***3.2%***	***6.4%***

5.5 INDUSTRIAL BENEFITS AND COSTS

Table 5-5 provides the economic impacts by EDC for the industrial base achievable and maximum achievable scenarios. Overall, the SWE Team found there to be a significant amount of cost-effective energy efficiency savings potential still attainable in Pennsylvania between 2016 and 2020. The SWE Team estimates that the NPV of the cost to attain all energy efficiency savings under the base achievable scenario at $359.6 million from 2016 to 2020, while the benefits amount to over $545 million during the same time period resulting in more than $185 million in net benefits and a TRC ratio of 1.5.

Table 5-5: 2020 Industrial TRC Benefit-Cost Ratios by Achievable Scenario by EDC

	NPV Costs (Million $)	NPV Benefits (Million $)	NPV Net Benefits (Million $)	TRC BC Ratio
Maximum Achievable Potential				
Duquesne	$49.9	$85.0	$35.1	1.7
FE: Met-Ed	$89.0	$143.1	$54.1	1.6
FE: Penelec	$96.5	$152.6	$56.1	1.6
FE: Penn Power	$22.9	$31.9	$9.0	1.4
FE: West Penn	$102.5	$157.1	$54.6	1.5
PECO	$143.8	$224.2	$80.3	1.6
PPL	$169.9	$257.8	$87.9	1.5
Statewide	**$674.5**	**$1,051.8**	**$377.3**	**1.6**

	NPV Costs (Million $)	NPV Benefits (Million $)	NPV Net Benefits (Million $)	TRC BC Ratio
Base Achievable Potential				
Duquesne	$26.7	$43.8	$17.1	1.6
FE: Met-Ed	$46.9	$73.5	$26.6	1.6
FE: Penelec	$51.9	$79.6	$27.7	1.5
FE: Penn Power	$11.8	$16.2	$4.4	1.4
FE: West Penn	$55.0	$81.7	$26.7	1.5
PECO	$76.6	$116.3	$39.7	1.5
PPL	$90.7	$134.1	$43.4	1.5
Statewide	**$359.6**	**$545.2**	**$185.6**	**1.5**

Table 5-6 summarizes the total estimated program expenses that would be paid by the EDCs to realize the five-year cumulative energy savings estimates under the base achievable and maximum achievable scenarios. For the industrial sector, the per-MWh acquisition cost is between $148/MWh and $159/MWh among the EDCs under the base achievable scenario. The total estimated five-year programmatic costs for all seven EDCs is estimated at $188.2 million to achieve 1,214,609 MWh of industrial sector savings under the base achievable scenario, resulting in a statewide average acquisition cost of $155/MWh.

Table 5-6: Five-Year Industrial Acquisition Costs (TRC) by Achievable Scenario by EDC

EDC	2016-2020 Program Costs (Million $)	2016-2020 Program Savings (MWh)	Acquisition Costs ($/1st-YR MWh Saved)
Maximum Achievable Scenario			
Duquesne	$39.8	169,398	$235.0
FE: Met-Ed	$71.2	301,964	$235.7
FE: Penelec	$76.2	337,636	$225.8
FE: Penn Power	$17.8	83,356	$213.9
FE: West Penn	$80.0	368,218	$217.3
PECO	$113.3	507,951	$223.0
PPL	$135.8	576,821	$235.5
Statewide	***$534.2***	***2,345,342***	***$227.8***
Base Achievable Scenario			
Duquesne	$13.8	87,049	$158.7
FE: Met-Ed	$24.4	155,053	$157.4
FE: Penelec	$27.2	176,188	$154.5
FE: Penn Power	$6.3	42,250	$148.2
FE: West Penn	$29.0	191,385	$151.6
PECO	$40.3	263,156	$153.0
PPL	$47.2	299,528	$157.5
Statewide	***$188.2***	***1,214,609***	***$154.9***

6 Portfolio-Level Results and Energy Efficiency Program Potential Estimates

This section presents the total[39] technical, economic, and achievable potential and then presents the estimates of electric program potential for the Commonwealth of Pennsylvania as well as each EDC service area for 2016 through 2020. Program potential is an estimate of energy savings that can be achieved through programs within a specific planning constraint. This study estimates program potential for a scenario where annual program spending is capped at 2% of 2006 EDC revenues.

Program potential is only determined for the first five years of the study horizon, as the purpose of this analysis is to inform decision making on the next Phase of PA Act 129, expected to be the period from June 1, 2016 through May 31, 2020.

6.1 TOTAL TECHNICAL AND ECONOMIC POTENTIAL

Table 6-1 summarizes the total cumulative annual technical and economic potential. Total cumulative annual technical potential across all customer classes and EDCs is 25.3 million MWh after five years and 41.2 million MWh after 10 years. These numbers are equivalent to 17.3% and 28.1% of the baseline load, respectively. After excluding measures that were not cost-effective based on the TRC, potential decreases to 11.8% of the baseline load after five years, and 18.4% of the baseline load after 10 years.

Table 6-1: Total Cumulative Annual Technical and Economic Energy (MWh) Potential across all EDCs

	2016	2017	2018	2019	2020	2025
Cumulative Savings Potential - MWh						
Technical	6,707,085	13,016,622	18,973,644	24,294,903	25,336,859	41,190,328
Economic	4,895,392	9,387,083	13,662,316	17,628,245	17,253,764	26,944,933
Cumulative Savings Potential - % of 2010 Load						
Technical	4.6%	8.9%	12.9%	16.6%	17.3%	28.1%
Economic	3.3%	6.4%	9.3%	12.0%	11.8%	18.4%

6.2 TOTAL ACHIEVABLE POTENTIAL

Table 6-2 shows the cumulative annual and incremental annual achievable savings potential. Incremental annual savings could achieve roughly 1.2% to 2.0% of 2010 load in the base achievable and maximum achievable scenarios, respectively. On a cumulative annual basis, the base achievable potential is 4.6% of the baseline load in 2020 and maximum achievable potential is 7.5% of baseline load in 2020. Without a spending cap, the EDC costs to acquire base achievable potential would range from $300 million to $360 million annually. In the maximum achievable scenario, assuming incentives equal to 100% of the measure cost, EDC costs would range from $582 million to $642 million annually.

Table 6-2: Total Cumulative Annual Achievable Energy (MWh) Potential across all EDCs

	2016	2017	2018	2019	2020	2025
Cumulative Savings Potential - MWh						
Maximum Achievable	2,761,211	5,438,518	8,133,238	10,772,462	10,983,129	19,357,092
Base Achievable	1,610,739	3,285,284	4,980,543	6,649,165	6,748,807	12,111,889
Cumulative Savings Potential - % of 2010 Load						

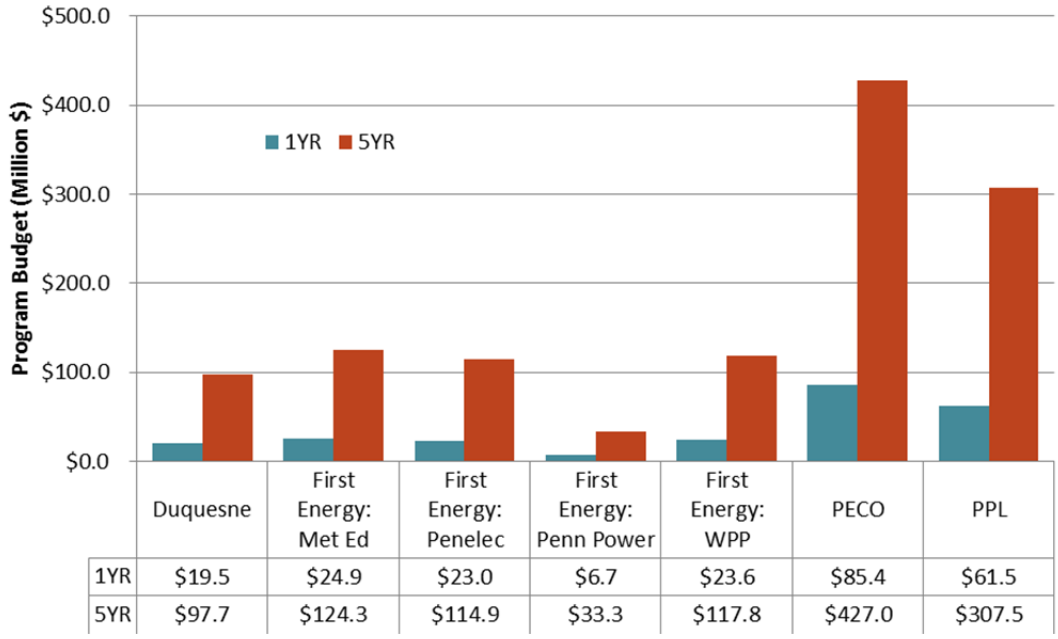
[39] Total potential represents the sum of residential and nonresidential potential.

	2016	2017	2018	2019	2020	2025
Maximum Achievable	1.9%	3.7%	5.5%	7.3%	7.5%	13.2%
Base Achievable	1.1%	2.2%	3.4%	4.5%	4.6%	8.3%
Incremental Savings Potential - MWh						
Maximum Achievable	2,761,211	2,866,823	2,989,121	3,104,271	2,610,702	2,574,169
Base Achievable	1,610,739	1,725,249	1,836,917	1,943,976	1,665,279	1,794,256
Incremental Savings Potential - % of 2010 Load						
Maximum Achievable	1.9%	2.0%	2.0%	2.1%	1.8%	1.8%
Base Achievable	1.1%	1.2%	1.3%	1.3%	1.1%	1.2%
Annual EDC Program Costs – Million $						
Maximum Achievable	$581.8	$601.9	$619.9	$638.5	$607.0	$642.6
Base Achievable	$302.1	$316.2	$329.3	$342.6	$325.7	$361.6

6.3 TOTAL PROGRAM POTENTIAL

As noted above, program potential estimation considered an annual spending ceiling that limits the annual program spending to 2% of 2006 annual revenue. This program spending constraint is the same as currently implemented within Phase II of Act 129. The ceiling was determined for each EDC and is summed to the state level, as each EDC has a unique rate and customer structure. The 2006 spending for each EDC was obtained from the PA PUC. Figure 6-1 summarizes the annual spending ceiling and the spending ceiling for a five-year implementation phase for each EDC.

Figure 6-1 One-Year and Five-Year Program Potential Budgets



Estimation of program potential for Phase III of Act 129 (estimated to be a five-year cycle) utilizes both residential and nonresidential potential savings. Because the base achievable potential scenario is based on historical incentive levels in Phase I and Phase II, the SWE Team utilized this achievable scenario as a foundational piece in the determination of program potential. In calculating expected program costs, incentive and non-incentive, the SWE Team utilized economic and performance metrics from the Phase I and Phase II implementation of EDC programs, as described in Section 2.3, "Phase I/II EDC Performance Benchmarking," of this report.

The first step in the program potential calculation is to compile the sum of the incremental annual five-year (2016-2020) residential and nonresidential sector estimates for energy efficiency savings potential and the associated costs in the base achievable potential scenario. The next step in the program potential calculation compares the sum of the residential and nonresidential program costs to the five-year budgets ceilings at the EDC and state levels. The final step to calculate program potential is to scale the respective EDC base achievable potential energy savings to the five-year spending ceiling value while holding the acquisition cost constant. Using this scaling approach, the SWE Team found that the total five-year program potential for energy efficiency savings to be 6.6 million MWh, representing 4.5% of the 2010 baseline load.

The five-year program potential energy savings and budget values are found in Table 6-3 for each EDC and the Commonwealth of Pennsylvania.

Table 6-3: Five-Year Program Potential Savings and Budget by EDC

	Portfolio Spending Ceiling (Million $)	Program Acquisition Costs ($/1st-YR MWh Saved)	2016-2020 Potential Savings (MWh)	% of 2010 Forecast
2016-2020 – Five-Year Program Potential				
Duquesne	$97.7	$186.9	522,837	3.7%
FE: Met-Ed	$124.3	$182.2	682,474	4.6%
FE: Penelec	$114.9	$191.9	598,704	4.2%
FE: Penn Power	$33.3	$176.1	189,107	4.0%
FE: West Penn	$117.8	$181.0	650,760	3.1%
PECO	$427.0	$184.7	2,311,387	5.9%
PPL	$307.5	$183.7	1,674,191	4.4%
Statewide	***$1,222.5***	***$184.4***	***6,629,460***	***4.5%***

6.4 PROGRAM POTENTIAL BENEFITS AND COSTS

Table 6-4 provides the economic impacts for the program potential scenario. Overall, the SWE Team found that the costs incurred to acquire the estimated energy efficiency savings in the program potential scenario would have an NPV of $1.7 billion. The lifetime benefits those energy savings would provide are estimated to equal more than $3 billion, providing more than $1.49 billion in net benefits for the Commonwealth of Pennsylvania.

Table 6-4: Five-Year Program Potential Benefit-Cost Results and TRC Ratios

	NPV Costs (Million $)	NPV Benefits (Million $)	Net NPV Benefits (Million $)	TRC BC Ratio
2016-2020 – Five-Year Program Potential				
Duquesne	$143.7	$300.9	$157.2	2.1
FE: Met-Ed	$168.9	$325.0	$156.1	1.9
FE: Penelec	$159.7	$277.8	$118.1	1.7
FE: Penn Power	$43.0	$72.5	$29.4	1.7
FE: West Penn	$153.5	$275.0	$121.5	1.8
PECO	$600.1	$1,162.9	$562.8	1.9
PPL	$423.0	$770.1	$347.1	1.8
Statewide	**$1,692.0**	**$3,184.2**	**$1,492.3**	**1.9**

7 Conclusions & Recommendations

The final section of this report provides a brief summary of the overall potential findings and general conclusions and recommendations stemming from the SWE Team analysis.

7.1 SUMMARY

In summary, the remaining potential for cost-effective electric energy efficiency in the service areas of the seven EDCs bound under Act 129 is significant. The statewide estimated electricity savings attainable under the program potential scenario for the five-year time period (2016-2020) amount to 6,629,460 MWh (a 4.5% reduction in the projected 2010 baseline MWh sales) based on the sum of first-year savings over the five-year period. These values are based on an estimated weighted average portfolio acquisition cost among all EDCs of $184/MWh saved.

The NPV costs to acquire the savings over the five-year period are equal to $1.7 billion, yet yield NPV benefits during the same timeframe in excess of $3 billion resulting in net benefits of $1.49 billion and a TRC ratio of 1.9. The results of this study demonstrate that cost-effective electric energy efficiency resources can play an important role in Pennsylvania's energy resource mix during the next five years.

7.2 FINAL OBSERVATIONS

This energy efficiency potential study was designed as an update to the 2012 potential study and is intended to assess the remaining cost-effective electric energy efficiency potential in Pennsylvania over the possible implementation of Phase III of Act 129 (2016-2020). There are several important facts about the data and assumptions used in this electric energy efficiency potential study, including:

- The forecasts of program potential are based on many assumptions, including EDC-forecasted sales, avoided costs, measure costs and expected savings, the SWE Team's experience and industry knowledge, among others. A significant change to these assumptions can affect the applicability of the SWE Team's estimates (e.g., due to a large change in economic conditions).
- As discussed in Section 6, the SWE Team utilized a "scaling" approach to scale the base achievable savings potential to program potential given the estimated acquisition cost of obtaining the mix of measures adopted within the base achievable scenario. Given the budget ceiling for each EDC under Act 129, actual achieved savings could be higher or lower depending on the actual mix of "expensive" measures vs. "cheap" measures offered by EDCs in their DSM programs.
- Currently, Phase II of Act 129 has specific targets for two "set-asides" sectors: residential low income and government, nonprofit and institutional (GNI). This analysis considers the market opportunity for these "set-aside" sectors based on specific residential and commercial segments, but does not directly recommend whether targets should be established for the set-asides in Phase III or what those targets should be.
- The SWE Team estimated savings from the low income sub-sector in this analysis based on historical program offerings and experience as well as current market conditions. Any significant increases to these offerings might impact overall potential, likely with the effect of reducing program potential. For instance, residential low income programs often utilize 100% incremental measure cost incentives. Higher budgets for either set-aside program would have the consequence of reducing the overall budget for the broader portfolio, leading to reduced program potential savings.
- The scenarios examined in this study (base achievable and maximum achievable) are intended to align with the aggressiveness of program delivery, generally aligned with program spending

levels and the associated average incentive rates. The SWE Team used the EDCs' historical incentive rates coupled with other regional trends to inform the aggressiveness of the market adoption for the base achievable scenario in this study. Findings from the willingness-to-pay research collected during the baseline studies were used to inform the achievable scenarios.

- This study includes a comprehensive list of energy efficiency measures for the residential, commercial, and industrial sectors. For example, consumer electronics are treated as a comprehensive end use in the residential sector in this analysis. The SWE Team included all of the energy efficiency measures in the 2015 Pennsylvania Technical Reference manual in this study.
- The SWE Team closely examined and included the anticipated impacts of the federal lighting standards (EISA and EPAct) in its measure research (among other code impacts). While these higher baselines eroded a large share of eligible energy savings claimed by EDCs during Phase I and Phase II of Act 129, the SWE Team still found a reasonable share of remaining potential in the lighting end use for Phase III.
- All equipment measures were assumed to be eligible to revert back to the code baseline when they reached the end of their useful life. This assumption allows for savings to be collected regardless of the prior equipment's efficiency. The 2012 potential study omitted already efficient equipment from future potential which resulted in fewer eligible measures and lower potential for savings.
- Administrative costs were not included when screening measures for cost-effectiveness, but where included in program acquisition costs and the calculation of the TRC cost effectiveness test.
- While measure costs are assumed to hold constant for cost-effective screening, the SWE Team did apply an inflation rate to both incremental measure costs and administrative costs when estimating program delivery and TRC costs over the five-year period.
- The SWE team found that the vast majority of space cooling equipment measures (e.g., unitary air conditioners) are no longer cost-effective in Pennsylvania under the TRC cost effectiveness test. While the SWE Team did not conduct a full investigation into this finding, we believe the reduction in the effective full load hours (EFLH) in the 2015 TRM played a significant role. This finding reduced savings in the space cooling end use and resulted in an overall lower acquisition cost than what might have otherwise occurred had space cooling equipment been cost-effective (as was the case in the 2012 study).
- This study considered the latest available forecasts of electric avoided costs provided by the seven EDCs. Future updates to EDC avoided costs could result in a different cost-effective measure mix and alternate estimates of electric energy efficiency potential.

It is clear that electric energy efficiency programs could save residents and business owners of Pennsylvania a substantial amount of electricity by 2020, despite the savings achieved to-date by the EDCs and increasing equipment efficiency standards. The SWE Team estimates that the attainable statewide program potential electricity savings, based on the sum of first-year savings for the five-year period (2016-2020), amounts to 6,629,460 MWh (a 4.5% reduction in the projected 2010 baseline MWh sales). The SWE Team further finds that DSM programs offered by the EDCs will continue to be cost-effective in a possible Phase III with an estimated TRC ratio of 1.9. The electric energy efficiency potential estimates and the TRC savings provided in this report are based on the latest load forecasts and avoided cost forecasts provided by the EDCs. Over time, additional technologies are likely to become available in the market that may serve to increase the potential for energy and demand savings and warrant additional attention. Finally, actual energy and demand savings will depend upon the level and degree of Pennsylvania residences and business participation in the energy efficiency programs offered by the EDCs.