Electric and Natural Gas Energy Efficiency and Demand Response Potential for The District of Columbia

District
Department
of the
Environment

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1 EXECUTIVE SUMMARY

1.1 BACKGROUND

This draft energy efficiency potential study is an essential component of the Comprehensive Energy Comprehensive Energy Plan (CEP). The District Department of the Environment (DDOE) completed this 2013 study of energy efficiency potential in the District to assist policy makers with developing the CEP, to identify new energy efficiency initiatives for the District and to refine existing program offerings and portfolios. An energy efficiency potential study provides a roadmap for policy makers and identifies the energy efficiency measures having the greatest potential savings and the measures that are the most cost effective. In addition to technical and economic potential estimates, the development of achievable potential estimates for a range of feasible energy efficiency measures is useful for program planning and modification purposes. Unlike achievable potential estimates, technical and economic potential estimates do not include customer acceptance considerations of energy efficiency measures, which is often among the most important factors when estimating the likely customer response to new programs. For this study, the consultants (GDS Associates, Inc.) produced the following estimates of energy efficiency potential:

- Technical potential
- Economic potential
- Achievable potential

Definitions of the types of energy efficiency potential are provided below.

1. **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. It is often estimated as a "snapshot" in time assuming immediate implementation of all technologically feasible energy saving measures, with additional efficiency opportunities assumed as they arise from activities such as new construction.
2. **ECONOMIC POTENTIAL** refers to the subset of the technical potential that is economically cost-effective as compared to conventional supply-side energy resources. Both technical and economic potential are theoretical numbers that assume immediate implementation of efficiency measures, with no regard for the gradual "ramping up" process of real-life programs. In addition, they ignore market barriers to ensuring actual implementation of efficiency. Finally, they only consider the costs of efficiency measures themselves, ignoring any programmatic costs (e.g., marketing, analysis, administration) that would be necessary to capture them.
3. **ACHIEVABLE POTENTIAL –** Achievable potential is the amount of energy use that efficiency can realistically be expected to displace assuming the different market penetration scenarios. An aggressive scenario, for example, could, provide program participants with payments for the entire incremental cost of more energy efficient equipment). This is often referred to as "maximum achievable potential". Achievable potential takes into account real-world barriers to convincing end-users to adopt efficiency measures, the non-measure costs of delivering programs (for administration, marketing, tracking systems, monitoring and evaluation, etc.), and the capability of programs and administrators to ramp up program activity over time.[1]

The purpose of this energy efficiency potential study is to provide a foundation for the CEP and to determine the remaining opportunities for cost effective electricity and natural gas energy efficiency savings for the geographic region of the District of Columbia. This detailed report presents results of the

[1] These definitions are from the November 2007 National Action Plan for Energy Efficiency "Guide for Conducting Energy Efficiency Potential Studies"

technical, economic, and achievable potential for electric and natural gas efficiency measures in the District for two time periods:

- The five-year period from January 1, 2013 through December 31, 2017
- The ten-year period from January 1, 2013 through December 31, 2022

All results were developed using customized residential and non-residential, or commercial/industrial (C&I), sector-level potential assessment analytic models and District-specific cost effectiveness criteria including the most recent District-specific avoided cost projections for electricity and natural gas. To help inform these energy efficiency potential models, up-to-date energy efficiency measure data were primarily obtained from the following recent studies and reports:

1. Mid-Atlantic Technical Reference Manual 2.0, July 2011
2. District of Columbia Sustainable Efficiency Utility Technical Reference Manual
3. Northeast Energy Efficiency Partnership (NEEP) Incremental Cost Study Report, 2011
4. Appliance saturation study conducted by Pepco in 2000
5. 2009 EIA Residential Energy Consumption Survey (RECS)
6. 2007 American Housing Survey (AHS)
7. 2003 EIA Commercial Building Energy Consumption Survey (CBECS)

The above data sources provided valuable information regarding the current saturation, costs, savings and useful lives of electric and natural gas energy efficiency measures considered in this study.

The results of this study provide detailed information on energy efficiency measures that are the most cost effective and have the greatest potential electric and natural gas savings for the District of Columbia. The data used for this report were the best available at the time this analysis was developed. As building and appliance codes and energy efficiency standards change, and as energy prices fluctuate, additional opportunities for energy efficiency may occur while current practices may become outdated.

1.2 COST EFFECTIVENESS FINDINGS

The Societal Cost Test (SCT, or SC test) is the cost effectiveness screening test used in this study to determine whether a measure is cost effective. The SCT is also used by the District of Columbia Sustainable Energy Utility (DCSEU) to determine program and measure cost effectiveness. This energy efficiency and demand response potential study concludes that significant cost effective electric and natural gas energy efficiency potential remains in the District. Tables 1-1 and 1-2 show the preliminary SCT present value benefits, costs and benefit-cost ratios for the Achievable Potential scenarios examined in this study.

Table 1-1: Societal Cost Test Benefit-Cost Ratios for Achievable Potential Scenarios For 2013 to 2017 Time Period

Societal Test Benefit Cost Ratios for 2013 to 2017 Time Period			
Achievable Potential Scenarios	**SCT $ Benefits**	**SCT $ Costs**	**SCT Benefit/Cost Ratio**
Max Achievable Potential	$6,605,144,984	$1,440,446,220	4.59
Base Achievable Potential	$3,937,727,800	$609,600,088	6.46
Constrained Achievable Potential	$3,258,746,270	$476,652,583	6.84

Table 1-2: Societal Cost Test Benefit-Cost Ratios for Achievable Potential Scenarios For 2013 to 2022 Time Period

Societal Test Benefit Cost Ratios for 2013 to 2022 Time Period			
Achievable Potential Scenarios	**SCT $ Benefits**	**SCT $ Costs**	**SCT Benefit/Cost Ratio**
Max Achievable Potential	$12,670,482,719	$2,541,727,303	4.98
Base Achievable Potential	$7,745,717,753	$1,115,231,954	6.95
Constrained Achievable Potential	$6,380,955,238	$868,574,226	7.35

In addition, the consultants calculated a SCT ratio for each individual energy efficiency measure and each demand response measure considered in this study. Only measures that had a SCT ratio greater than or equal to 1.0 were retained in the economic and achievable potential savings estimates.

1.3 STUDY SCOPE

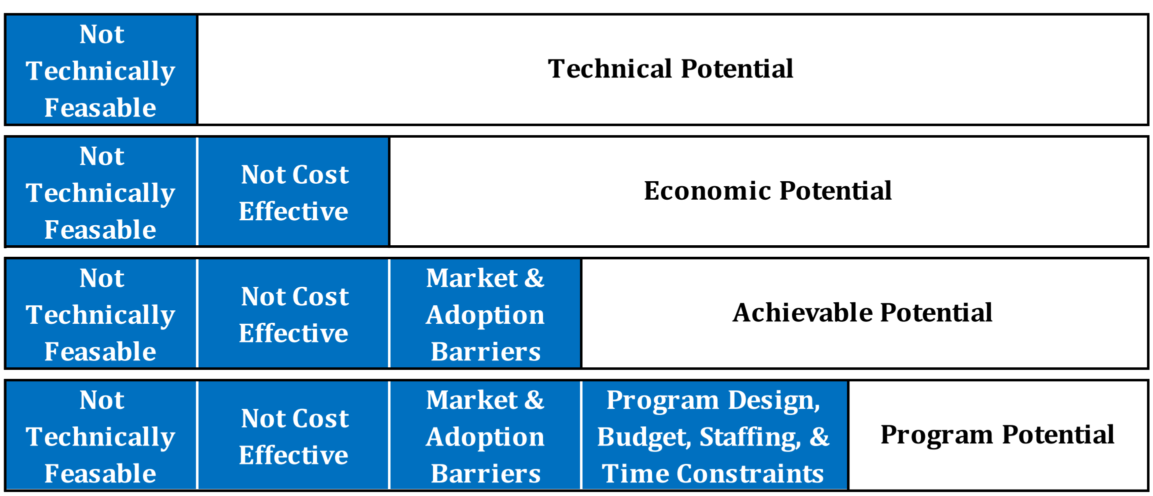
The study examines the potential to reduce electric consumption and peak demand and natural gas consumption through the implementation of energy efficiency technologies and practices in residential, commercial, and industrial facilities in the District of Columbia. This study assesses electric and natural gas energy efficiency potential in the District of Columbia over ten years, from 2013 through 2022.

The study had the following main objectives:

- Evaluate the electric and natural gas energy efficiency technical, economic and achievable potential savings in the District of Columbia;
- Calculate the Societal Cost Test ("SCT") benefit-cost ratio for the achievable potential savings scenarios.

As noted above, the scope of this study distinguishes among three types of energy efficiency potential; (1) technical, (2) economic, and (3) achievable potential. The definitions used in this study for energy efficiency potential estimates were obtained directly from a 2007 National Action Plan for Energy Efficiency (NAPEE) report. Figure 1-1 below provides a graphical representation of the relationship of the various definitions of energy efficiency potential.

Figure 1-1: Types of Energy Efficiency Potential[2]



[2] Reproduced from "Guide to Resource Planning with Energy Efficiency" November 2007. US EPA. Figure 2-1.

Limitations to the scope of study: As with any assessment of energy efficiency potential, this study necessarily builds on a large number of assumptions and data sources, including the following:

- Energy efficiency measure lives, measure savings and measure costs
- The discount rate for determining the net present value of future savings
- Projected penetration rates for energy efficiency measures
- Projections of District-specific electric and natural gas avoided costs
- Future changes to current energy efficiency codes and standards for buildings and equipment

While the consultants have sought to use the best and most current available data, there are many assumptions where there may be reasonable alternative assumptions that would yield somewhat 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 there was no attempt to place a dollar value on some difficult to quantify benefits arising from installation of some measures, such as increased comfort or increased safety, which may in turn support some personal choices to implement particular measures that may otherwise not be cost-effective or only marginally so. Instead, the consultants placed a 30% adder to the benefits of measures when performing the measure-level cost-effectiveness screening.

1.4 REPORT ORGANIZATION

The remainder of this report is organized in the following nine sections as follows:

Section 1: Executive Summary provides an overview of initial findings from the potential study and outlines the remainder of the report

Section 2: Glossary of Terms defines key terminology used in the report.

Section 3: Introduction highlights the purpose of this study and the importance of energy efficiency.

Section 4: Characterization of Washington DC Service Area provides an overview of the District and a brief discussion of the historical and forecasted electric and natural gas energy sales by sector as well as electric peak demand.

Section 5: Potential Study Methodology details the approach used to develop the estimates of technical, economic and achievable potential for electric and natural gas energy efficiency savings.

Section 6: Residential Electric and Natural Gas Energy Efficiency Potential Estimates (2013-2022) provides a breakdown of the technical, economic, and achievable potential in the residential sector.

Section 7: Non-Residential Electric and Natural Gas Energy Efficiency Potential Estimates (2013-2022) – provides a breakdown of the technical, economic, and achievable savings potential in the C&I sectors.

Section 8: Demand Response Potential Estimates

Section 9: Summary of Results presents the final discussion regarding potential for energy efficiency and demand response savings through 2023.

1.5 SUMMARY OF RESULTS

This study examined 775 energy efficiency measures in the residential, commercial and industrial sectors combined**.** 554 total measures were included in the residential sector energy efficiency potential analysis. There are 458 electric measures and 245 natural gas measures, with some of these measures savings both fuels. 221 total measures were included in the non-residential sector energy efficiency potential analysis. There are 153 electric measures and 68 gas measures. Of these 775 measures, 673 were found to be cost effective according to the SCT.

Tables 1-3 and 1-4 below show that cost effective electric energy efficiency resources can play a significantly expanded role in the District's energy resource mix over the next five and ten years. For the District overall, the maximum achievable cost effective potential for electricity savings in 2022 is 29.4% of forecast kWh sales for 2022. Tables 1-3 and 1-4 present the electric energy efficiency savings for economic potential and achievable potential for 2017 and 2022.

Table 1-3: Summary of Technical, Economic and Achievable Electric Energy Savings for 2017

Summary of Technical, Economic and Achievable Electric Energy Efficiency Savings for 2017						
	Energy		Demand			
	Energy (MWh)	% of 2017 Sales	Winter MW	% of 2017 Winter Peak	Summer MW	% of 2017 Summer Peak
ALL SECTORS COMBINED						
Technical Potential	3,544,474	28.8%	789	41.7%	668	25.6%
Economic Potential	3,413,829	27.7%	771	40.7%	643	24.7%
Max Achievable Potential	2,212,680	18.0%	486	25.7%	403	15.4%
Base Achievable Potential	1,560,081	12.7%	313	16.5%	289	11.1%
Constrained Achievable Potential	1,342,525	10.9%	244	12.9%	215	8.2%
RESIDENTIAL SECTOR						
Technical Potential	998,677	45.0%	339	71.4%	245	35.8%
Economic Potential	974,647	43.9%	339	71.5%	238	34.8%
Max Achievable Potential	478,083	21.6%	179	37.8%	115	16.8%
Base Achievable Potential	327,693	14.8%	130	27.3%	76	11.0%
Constrained Achievable Potential	258,463	11.7%	111	23.4%	64	9.3%
NON-RESIDENTIAL SECTOR						
Technical Potential	2,545,797	25.2%	451	31.8%	423	22.0%
Economic Potential	2,439,182	24.2%	432	30.4%	405	21.0%
Max Achievable Potential	1,734,597	17.2%	307	21.7%	288	15.0%
Base Achievable Potential	1,232,388	12.2%	183	12.9%	213	11.1%
Constrained Achievable Potential	1,084,062	10.7%	133	9.4%	151	7.8%

Table 1-4: Summary of Technical, Economic and Achievable Electric Energy Savings for 2022

Summary of Technical, Economic and Achievable Electric Energy Efficiency Savings for 2022						
	Energy		Demand			
	Energy (MWh)	% of 2022 Sales	Winter MW	% of 2022 Winter Peak	Summer MW	% of 2022 Summer Peak
ALL SECTORS COMBINED						
Technical Potential	5,759,943	44.7%	1,216	61.3%	1,051	38.4%
Economic Potential	5,537,521	43.0%	1,181	59.5%	1,011	36.9%
Max Achievable Potential	3,781,942	29.4%	836	42.1%	703	25.7%
Base Achievable Potential	2,715,397	21.1%	548	27.6%	511	18.6%
Constrained Achievable Potential	2,340,833	18.2%	495	25.0%	438	16.0%
RESIDENTIAL SECTOR						
Technical Potential	1,064,393	44.8%	369	72.7%	264	36.0%
Economic Potential	1,038,615	43.7%	369	72.8%	256	34.9%
Max Achievable Potential	663,229	27.9%	273	53.9%	180	24.6%
Base Achievable Potential	442,342	18.6%	202	39.8%	120	16.3%
Constrained Achievable	356,529	15.0%	177	34.9%	102	14.0%

Summary of Technical, Economic and Achievable Electric Energy Efficiency Savings for 2022						
Potential						
NON-RESIDENTIAL SECTOR						
Technical Potential	4,695,550	44.7%	848	57.4%	787	39.3%
Economic Potential	4,498,906	42.9%	812	55.0%	754	37.6%
Max Achievable Potential	3,118,713	29.7%	563	38.1%	523	26.1%
Base Achievable Potential	2,273,055	21.7%	346	23.4%	391	19.5%
Constrained Achievable Potential	1,984,304	18.9%	318	21.5%	336	16.8%

Tables 1-5 and 1-6 present the study results for natural gas savings potential. For the District overall, the maximum achievable cost effective potential for gas savings in 2022 is 24.1% of forecast MMBtu sales for 2022.

Table 1-5: Summary of Technical, Economic and Achievable Natural Gas Energy Efficiency Savings for 2017

Summary of Technical, Economic and Achievable Natural Gas Energy Efficiency Savings for 2017		
	Energy	
	Energy (MMBtu)	% of 2017 Sales
ALL SECTORS COMBINED		
Technical Potential	7,182,714	23.4%
Economic Potential	6,400,319	20.8%
Max Achievable Potential	3,845,186	12.5%
Base Achievable Potential	1,974,923	6.4%
Constrained Achievable Potential	1,645,886	5.4%
RESIDENTIAL SECTOR		
Technical Potential	3,538,697	28.5%
Economic Potential	3,125,887	25.2%
Max Achievable Potential	1,090,567	8.8%
Base Achievable Potential	660,596	5.3%
Constrained Achievable Potential	444,561	3.6%
NON-RESIDENTIAL SECTOR		
Technical Potential	3,644,017	19.9%
Economic Potential	3,274,432	17.9%
Max Achievable Potential	2,754,619	15.0%
Base Achievable Potential	1,314,327	7.2%
Constrained Achievable Potential	1,201,325	6.5%

Table 1-6: Summary of Technical, Economic and Achievable Natural Gas Energy Efficiency Savings for 2022

Summary of Technical, Economic and Achievable Natural Gas Energy Efficiency Savings for 2022		
	Energy	
	Energy (MMBtu)	% of 2022 Sales
ALL SECTORS COMBINED		
Technical Potential	10,991,828	34.5%
Economic Potential	9,817,767	30.8%
Max Achievable Potential	7,681,736	24.1%
Base Achievable Potential	3,998,724	12.5%
Constrained Achievable Potential	3,308,069	10.4%
RESIDENTIAL SECTOR		
Technical Potential	3,703,794	29.8%
Economic Potential	3,268,903	26.3%
Max Achievable Potential	2,172,498	17.5%
Base Achievable Potential	1,370,070	11.0%

Summary of Technical, Economic and Achievable Natural Gas Energy Efficiency Savings for 2022		
Constrained Achievable Potential	905,419	7.3%
NON-RESIDENTIAL SECTOR		
Technical Potential	7,288,034	37.5%
Economic Potential	6,548,864	33.7%
Max Achievable Potential	5,509,238	28.3%
Base Achievable Potential	2,628,654	13.5%
Constrained Achievable Potential	2,402,651	12.4%

The five-year and ten-year budgets and acquisition costs for the achievable potential scenarios for electric and natural gas energy efficiency savings are shown in Table 1-7 and 1-8.

Table 1-7: Achievable Potential Scenarios; Budgets and Acquisition Costs Per Unit of Energy Saved – Electric Savings

5-year and 10-year Acquisition Costs for Electric Achievable Potential				
ALL SECTORS COMBINED	**5 - Year EE Budget**	**10-Year EE Budget**	**Acquisition Cost Per First Year kWh Saved - 5 years**	**Acquisition Cost Per First Year kWh Saved - 10 years**
Max Achievable	$1,137,808,982	$2,170,714,809	$0.49	$0.51
Base Achievable	$327,791,519	$663,741,337	$0.20	$0.22
Constrained Achievable	$202,397,288	$403,523,424	$0.14	$0.15

Table 1-8: Achievable Potential Scenarios; Budgets and Acquisition Costs Per Unit of Energy Saved – Natural Gas Savings

5-year and 10-year Acquisition Costs for Gas Achievable Potential				
ALL SECTORS COMBINED	**5 - Year EE Budget**	**10-Year EE Budget**	**Acquisition Cost Per First Year MMBtu Saved - 5 years**	**Acquisition Cost Per First Year MMBtu Saved - 10 years**
Max Achievable	$686,403,906	$1,384,546,295	$164.71	$165.59
Base Achievable	$168,437,071	$346,143,666	$76.88	$76.41
Constrained Achievable	$129,319,185	$266,832,723	$69.85	$69.61

The consultants also calculated the demand response potential for the DC metro area. Tables 1-9 and 1-10 present the demand response achievable potential results. The Max Achievable potential for demand response savings is 6.4% of forecasted summer peak in 2017 and 12.5% of forecasted summer peak in 2022.

Table 1-9: Demand Response Achievable Savings Potential in 2017 – Maximum, Base and Constrained Achievable Scenarios

Summary of Achievable Demand Response Potential			
5-year	**Maximum Achievable**	**Base Achievable**	**Constrained Achievable**
Total MW Savings	167.8	86.5	40.7
% of Forecast Summer Peak	6.4%	3.3%	1.6%

Table 1-10: Demand Response Achievable Savings Potential in 2022 – Maximum, Base and Constrained Achievable Scenarios

Summary of Achievable Demand Response Potential			
10-year	**Maximum Achievable**	**Base Achievable**	**Constrained Achievable**
Total MW Savings	343.4	177.3	83.1
% of Forecast Summer Peak	12.5%	6.5%	3.0%

1.6 ENERGY EFFICIENCY POTENTIAL SAVINGS DETAIL

Note that Section 6 of this report (Residential) and Section 7 (Non-Residential) include additional detail about the electric and natural gas energy efficiency savings potential in the District by 2022. Section 8 of the report includes additional detail about the demand response savings potential.

2 GLOSSARY OF TERMS[3]

The following list defines many of the key energy efficiency terms used throughout this energy efficiency potential study.

Achievable Potential: The November 2007 National Action Plan for Energy Efficiency "Guide for Conducting Energy Efficiency Potential Studies" defines achievable potential as the amount of energy use that energy 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 convincing end-users to adopt efficiency measures, the non-measure costs of delivering programs (for administration, marketing, tracking systems, monitoring and evaluation, etc.), and the capability of programs and administrators to ramp up program activity over time.

Applicability Factor: The fraction of the applicable dwelling units or businesses that is technically feasible for conversion to the efficient 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 in a home).

Avoided Costs: For purposes of this report, electric avoided costs are defined as the generation, transmission and distribution costs that can be avoided in the future if the consumption of electricity can be reduced with energy efficiency or demand response programs. For a natural gas utility, the avoided costs include the cost of the natural gas commodity and any other natural gas infrastructure costs that can be reduced with energy efficiency programs.

Base Achievable Potential: An achievable potential scenario which assumes incentives intended to represent the current incentive levels offered by the DCSEU.

Base Case Equipment End-Use Intensity: The electricity or natural gas used per customer per year by each base-case technology in each market segment. This is the consumption of the electric or natural gas energy using equipment that the efficient technology replaces or affects. For example, if the efficient measure is a high efficiency light bulb (CFL), the base end-use intensity would be the annual kWh use per bulb per household associated with an incandescent or halogen light bulb that provides equivalent lumens to the CFL.

Base Case Factor: The fraction of the market that is applicable for the efficient technology in a given market segment. For example, for the residential electric clothes washer measure, this would be the fraction of all residential customers that have an electric clothes washer in their household.

Capital Recovery Rate (CRR): The return of invested capital expressed as an annual rate; often applied in a physical sense to wasting assets with a finite economic life.[4]

Coincidence Factor: The fraction of connected load expected to be "on" and using electricity coincident with the system peak period.

Constrained Achievable: An achievable potential scenario which assumes incentives intended to represent half of the current incentive levels offered by the DCSEU.

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[3] Potential definitions taken from National Action Plan for Energy Efficiency (2007). "Guide for Conducting Energy Efficiency Potential Studies." Prepared by Philip Mosenthal and Jeffrey Loiter, Optimal Energy, Inc.
[4] Accuval. http://www.accuval.net/insights/glossary/

Cost-Effectiveness: A measure of the relevant economic effects resulting from the implementation of an energy efficiency measure or program. If the benefits are greater than the costs, the measure is said to be cost-effective.

Cumulative Annual: Refers to the overall annual savings occurring in a given year from both new participants and annual savings continuing to result from past participation with energy efficiency measures that are still in place. Cumulative annual does not always equal the sum of all prior year incremental values as some energy efficiency measures have relatively short lives and, as a result, their savings drop off over time.

Commercial Sector: Comprised of non-manufacturing premises typically used to sell a product or provide a service, where electricity is consumed primarily for lighting, space cooling and heating, office equipment, refrigeration and other end uses. Business types are included in Section 5 – methodology.

Demand Response: Refers to demand resources involving dynamic hourly load response to market conditions, such as curtailment or load control programs.

Early Replacement: Refers to an energy efficiency measure or efficiency program that seeks to encourage the replacement of functional equipment before the end of its operating life with higher-efficiency units.

Economic Potential: The November 2007 National Action Plan for Energy Efficiency "Guide for Conducting Energy Efficiency Potential Studies" refers to the subset of the technical potential that is economically cost-effective as compared to conventional supply-side energy resources as economic potential. Both technical and economic potential are theoretical numbers that assume immediate implementation of efficiency measures, with no regard for the gradual "ramping up" process of real-life programs. In addition, they ignore market barriers to ensuring actual implementation of efficiency. Finally, they only consider the costs of efficiency measures themselves, ignoring any programmatic costs (e.g., marketing, analysis, administration) that would be necessary to capture them.

End-Use: A category of equipment or service that consumes energy (*e.g.*, lighting, refrigeration, heating, process heat, cooling).

Energy Efficiency: Using less energy to provide the same or an improved level of service to the energy consumer in an economically efficient way. Sometimes "conservation" is used as a synonym, but that term is usually taken to mean using less of a resource even if this results in a lower service level (*e.g.*, setting a thermostat lower or reducing lighting levels).

Energy Use Intensity (EUI): A unit of measurement that describes a building's energy use. EUI represents the energy consumed by a building relative to its size.[5]

Free Driver: Individuals or businesses that adopt an energy efficient product or service because of an energy efficiency program, but are difficult to identify either because they do not receive an incentive or are not aware of the program.

Free Rider: Participants in an energy efficiency program who would have adopted an energy efficiency technology or improvement in the absence of a program or financial incentive.

[5] See http://www.energystar.gov/index.cfm?fuseaction=buildingcontest.eui

Gross Savings: Gross energy (or demand) savings are the change in energy consumption or demand that results directly from program-promoted actions (e.g., installing energy-efficient lighting) taken by program participants regardless of the extent or nature of program influence on their actions.

Incentive Costs: A rebate or some form of payment used to encourage people to implement a given demand-side management (DSM) technology. The incentive is calculated as the amount of the technology costs that must be paid by the utility or program administrator for the participant test ratio to equal one and achieve the desired benefit/cost ratio to drive the market.[6]

Incremental: Savings or costs in a given year associated only with new installations of energy efficiency or demand response measures happening in that specific year.

Industrial Sector: Comprised of manufacturing premises typically used for producing and processing goods, where electricity is consumed primarily for operating motors, process cooling and heating, and space heating, ventilation, and air conditioning (HVAC). Business types are included in section 5 – methodology.

Maximum (or Max) Achievable: An achievable potential scenario which assumes incentives for program participants are equal to 100% of measure incremental costs.

Measure: Any action taken to increase energy efficiency, whether through changes in equipment, changes to a building shell, implementation of control strategies, or changes in consumer behavior. Examples are higher-efficiency central air conditioners, occupancy sensor control of lighting, and retro-commissioning. In some cases, bundles of technologies or practices may be modeled as single measures. For example, an ENERGY STAR® ™ home package may be treated as a single measure.

MMBtu: A measure of power, used in this report to refer to consumption and savings associated with natural gas consuming equipment. One British thermal unit (symbol Btu or sometimes BTU) is a traditional unit of energy equal to about 1055 joules. It is the amount of energy needed to heat one pound of water by one degree Fahrenheit. MMBtu is defined as one million BTUs.

MW: A unit of electrical output, equal to one million watts or one thousand kilowatts. It is typically used to refer to the output of a power plant.

MWh: One thousand kilowatt-hours, or one million watt-hours. One MWh is equal to the use of 1,000,000 watts of power in one hour.

Net-to-Gross Ratio: A factor representing net program savings divided by gross program savings that is applied to gross program impacts to convert them into net program load impacts

Net Savings: Net energy or demand savings refer to the portion of gross savings that is attributable to the program. This involves separating out the impacts that are a result of other influences, such as consumer self-motivation. Given the range of influences on consumers' energy consumption, attributing changes to one cause (i.e., a particular program) or another can be quite complex.

Non Incentive Cost: Costs incurred by the utility that do not include incentives paid to the customer (i.e.: program administrative costs, program marketing costs, data tracking and reporting, program evaluation, etc.)

[6] Independent Energy Producers Association http://www.iepa.com/Glossary.asp

Nonparticipant Spillover: Savings from efficiency projects implemented by those who did not directly participate in a program, but which nonetheless occurred due to the influence of the program.

Participant Cost: The cost to the participant to participate in an energy efficiency program.

Participant Spillover: Additional energy efficiency actions taken by program participants as a result of program influence, but actions that go beyond those directly subsidized or required by the program.[7]

Portfolio: Either a collection of similar programs addressing the same market, technology, or mechanisms; or the set of all programs conducted by one energy efficiency organization or utility.

Program: A mechanism for encouraging energy efficiency that may be funded by a variety of sources and pursued by a wide range of approaches (typically includes multiple energy efficiency measures).

Program Potential: The November 2007 National Action Plan for Energy Efficiency 'Guide for Conducting Energy Efficiency Potential Studies" refers to the efficiency potential possible given specific program funding levels and designs as program potential. Often, program potential studies are referred to as "achievable" in contrast to "maximum achievable." In effect, they estimate the achievable potential from a given set of programs and funding. 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.

Remaining Factor: The fraction of applicable units that have not yet been converted to the electric energy efficiency measure; that is, one minus the fraction of units that already have the energy efficiency measure installed.

Replace-on-burnout: An energy efficiency measure is not implemented until the existing technology it is replacing fails or burns out. An example would be an energy efficient water heater being purchased after the failure of the existing water heater at the end of its useful life.

Resource Acquisition Costs: The cost of energy savings associated with energy efficiency programs, generally expressed in costs per first year saved MWh ($/MWh), kWh ($/kWh), or MMBtu ($/MMBtu) in this report.

Retrofit: Refers to an efficiency measure or efficiency program that seeks to encourage the replacement of functional equipment before the end of its operating life with higher-efficiency units (also called "early retirement") or the installation of additional controls, equipment, or materials in existing facilities for purposes of reducing energy consumption (e.g., increased insulation, low flow devices, lighting occupancy controls, economizer ventilation systems).

Savings Factor: The percentage reduction in electricity consumption resulting from application of the efficient technology. The savings factor is used in the formulas to calculate energy efficiency potential.

Technical Potential: The theoretical maximum amount of energy use that could be displaced by energy efficiency, disregarding all non-engineering constraints such as cost-effectiveness and the willingness of end-users to adopt the energy efficiency measures. It is often estimated as a "snapshot" in time assuming immediate implementation of all technologically feasible energy saving measures, with additional efficiency opportunities assumed as they arise from activities such as new construction.

[7] The definitions of participant and nonparticipant spillover were obtained from the National Action Plan for Energy Efficiency Report titled "Model Energy Efficiency Program Impact Evaluation Guide", November 2007, page ES-4.

Total Resource Cost Test: The TRC measures the net benefits of the energy efficiency program for a region or service area as a whole. Costs included in the TRC are costs to purchase and install the energy efficiency measure and overhead costs of running the energy efficiency program. The benefits included are the avoided costs of energy and capacity.

Societal Cost Test: Measures the net benefits of the energy efficiency program for a region or service area as a whole. Costs included in the SCT are costs to purchase and install the energy efficiency measure and overhead costs of running the energy efficiency program. The SCT may also include non-energy costs, such as reduced customer comfort levels. The benefits included are the avoided costs of energy and capacity, plus environmental and other non-energy benefits that are not currently valued by the market.

3 INTRODUCTION

This report assesses the potential for energy efficiency programs to assist the District of Columbia in meeting future energy service needs. This section of the report provides the following information:

- Defines the term "energy efficiency",
- Describes the general benefits of energy efficiency programs
- Provides results of similar energy efficiency potential studies conducted in other states
- Describes contents of the Sections of this report.

The purpose of this energy efficiency potential study is to provide a detailed assessment of the technical, economic and achievable potential for electric and natural gas energy efficiency and demand response programs that can be used by the consultants to develop short- and long-term energy goals and strategies for accomplishing the District's energy goals within the next 10 years. The strategies that will be developed based on this potential study will align the District's Comprehensive Energy Plan (CEP) with the Sustainable DC Plan. The CEP consultants will provide a comprehensive set of energy efficiency and renewable energy goals and recommendations that will guide the District in reducing energy consumption, increasing local generation and clean power usage, ensuring energy reliability and affordability, and creating green jobs for District residents.

3.1 INTRODUCTION TO ENERGY EFFICIENCY

Efficient energy use, often referred to as energy efficiency, is using less energy to provide the same level of energy service. An example would be insulating a home or business to use less heating and cooling energy to achieve the same inside temperature. Another example would be installing fluorescent lighting in place of less efficient halogen or incandescent lights to attain the same level of illumination. Energy efficiency can be achieved through more efficient technologies and/or processes as well as through changes in individual behavior.

3.1.1 General Benefits of Energy Efficiency

There are a number of benefits that accrue to the District of Columbia due to electric and natural gas energy efficiency programs. These benefits include avoided cost savings, non-electric benefits such as water and fossil fuel savings, environmental benefits, economic stimulus, job creation, risk reduction, and energy security.

Avoided electric energy and capacity costs are based upon the costs an electric utility would incur to construct and operate new electric power plants or to purchase power from another source. These avoided costs of electricity include both fixed and variable costs that can be directly avoided through a reduction in electricity usage. The energy component includes the costs associated with the production of electricity, while the capacity component includes costs associated with the capability to deliver electric energy during peak periods. Capacity costs consist primarily of the costs associated with building peaking generation facilities. The forecasts of electric energy and capacity avoided costs and natural gas avoided costs used in this study were provided to the consultants by the DCSEU. Avoided costs for natural gas include the avoided costs of the natural gas commodity and any other savings on the natural gas distribution system for operations and maintenance expenses or natural gas infrastructure expenditures.

At the consumer level, energy efficient products often cost more than their standard efficiency counterparts, but this additional cost is balanced by lower energy consumption and lower energy bills. Over time, the money saved from energy efficient products will pay consumers back for their initial investment as well as save them money on their electric and natural gas bills. Although some energy efficient technologies are complex and expensive, such as installing new high efficiency windows or a high efficiency boiler, many are simple and inexpensive. Installing compact fluorescent lighting or low-flow water devices, for example, can be done by most individuals.

Although the reduction in electric and natural gas costs is the primary benefit to be gained from investments in energy efficiency, the electric and natural gas utilities in the District, their consumers, and society as a whole can also benefit in other ways. Many electric efficiency measures also deliver non-energy benefits. For example, low-flow water devices and efficient clothes washers also reduce water consumption.[8] Similarly, weatherization measures that improve the building shell not only save on air conditioning costs in the summer, but also can save the customer money on space heating fuels, such as natural gas or propane. Reducing electricity consumption also reduces harmful emissions, such as SO_X, NO_X, CO_2 and particulates into the environment.[9]

Energy efficiency programs create both direct and indirect jobs. The manufacture and installation of energy efficiency products involves the manufacturing sector as well as research and development, service, and installation jobs. These are skilled positions that are not easily outsourced to other states and countries. The creation of indirect jobs is more difficult to quantify, but result from households and businesses experiencing increased discretionary income from reduced energy bills. These savings produce multiplier effects, such as increased investment in other goods and services driving job creation in other markets.

Energy efficiency reduces risks associated with fuel price volatility, unanticipated capital cost increases, environmental regulations, supply shortages, and energy security. Aggressive energy efficiency programs can help eliminate or postpone the risk associated with committing to large investments for generation facilities a decade or more before they are needed. Energy efficiency is also not subject to the same supply and transportation constraints that impact fossil fuels. Finally, energy efficiency reduces competition between states and utilities for fuels, and reduces dependence on fuels imported from other states or countries to support electricity production. Energy efficiency can help meet future demand increases and reduce dependence on out-of-state or overseas resources.

Many electric utilities recognize the benefits of reducing greenhouse gases. For example, PPL Electric's web site provides a carbon footprint calculator for customers to use. The introduction to this calculator states "If we all take a few simple steps to create less greenhouse gases, we can reduce the effects of climate change." First Energy also recognizes the importance of environmental impacts. The First Energy web site states "At FirstEnergy, we are committed to protecting the environment while delivering safe, reliable electricity to six million customers in the Midwest and Mid-Atlantic regions. Using a balanced, long-term approach, we continually look for opportunities to minimize the environmental impact of our operations."

3.2 THE WASHINGTON DC CONTEXT

3.2.1 Continuing Customer Growth

The annual kWh sales and electric system peak load for the District of Columbia is projected to increase over the next decade. From 2001 to 2011, the number of residential electric utility customers for Pepco

[8] The ENERGY STAR web site (www.energystar.gov) states that "ENERGY STAR qualified clothes washers use about 37% less energy and use over 50% less water than regular washers".

[9] The 2009 ENERGY STAR Annual Report states that "2009 was another banner year for EPA's climate protection partnerships. More than 19,500 organizations across the country have partnered with EPA and achieved outstanding results: (1) Preventing 83 million metric tons (in MMTCE2) of GHGs—equivalent to the emissions from 56 million vehicles (see Figure 4, p. 6)—and net savings to consumers and businesses of about $18 billion in 2009 alone. (2) Preventing more than 1,200 MMTCE of GHGs cumulatively and providing net savings to consumers and businesses of more than $250 billion over the lifetime of their investments." See page 2 of this Annual Report.

grew at a rate of approximately 1.7% annually.[10] The electric load forecasts for the District developed by the consultants indicate that the number of electric consumers in the District will continue to increase from 2013 through 2022 (the timeframe for this study) creating further growth in system electricity sales and peak demand. Similarly, natural gas sales are projected to increase at a rate of .9% per year from 2013 to 2022. This report assesses the potential for electric and natural gas energy efficiency programs to assist the District in meeting future electric and natural gas energy service needs.

3.2.2 Energy Efficiency Activity

Making homes and buildings more energy efficient is seen as a key strategy for addressing energy security, reducing reliance on fossil fuels from other countries, assisting consumers to lower energy bills, and addressing concerns about climate change. Faced with rapidly increasing energy prices, constraints in energy supply and demand, and energy reliability concerns, states are turning to energy efficiency as the most reliable, cost-effective, and quickest resource to deploy.[11]

3.2.3 Recent Energy Efficiency Potential Studies in the Mid-Atlantic Region

Table 3-1, below, provides the results from a review of recent energy efficiency potential studies conducted throughout the Northeast and US. It is useful to examine the results of these studies to understand if these studies are similar to this latest study for the District.

Table 3-1: Results of Recent Energy Efficiency Potential Studies in the Northeast and US

State	Study Year	Author	Study Period	# of Years	Achievable Potential
Connecticut	2009	KEMA	2009-2018	10	20.3%
New Hampshire	2009	GDS	2009-2018	10	20.5%
Rhode Island	2008	KEMA	2009-2018	10	9.0%
Vermont	2011	GDS/Cadmus	2011-2018	10	9.0%
New York	2010	Global Energy Partners	2011-2018	8	9.0%
USA	2009	McKinsey & Company	2011-2020	10	23.0%
Pennsylvania	2012	Statewide Evaluator	2013-2023	10	17.3%

A 2010 report by the American Council for an Energy Efficient Economy (ACEEE) offers information regarding the current savings and spending related to energy efficiency by state.[12] Based on self-reported data, the top states annually spend more than 2% of electric sales revenue on energy efficiency programs. The consultants also examined actual energy efficiency savings data for 2010 and 2011 from the US Energy Information Administration (EIA) on the top twenty energy efficiency electric utilities. These top twenty utilities saved over 2% of annual kWh sales in 2010 with their energy efficiency programs, and 3.8% of annual kWh sales in 2011. These percentage savings are attributable to energy efficiency measures installed in a one-year time frame and demonstrate what can be accomplished with full-scale and aggressive implementation of programs.

[10] This is the compound average annual growth rate for residential electric customers for Pepco's DC service area.

[11] The December 2008 National Action Plan for Energy Efficiency (NAPEE) "Vision for 2025: A Framework for Change" states that "the long-term aspirational goal for the Action Plan is to achieve all cost-effective energy efficiency by the year 2025. Based on studies, the efficiency resource available may be able to meet 50% or more of the expected load growth over this time frame, similar to meeting 20% of electricity consumption and 10 percent of natural gas consumption. The benefits from achieving this magnitude of energy efficiency nationally can be estimated to be more than $100 billion in lower energy bills in 2025 than would otherwise occur, over $500 billion in net savings, and substantial reductions in greenhouse gas emissions."

[12] American Council for an Energy Efficient Economy, "The 2010 State Energy Efficiency Scorecard", Report #E107, October 2010.

3.3 PURPOSE OF THIS STUDY

This study provides an analysis of the technical, economic, achievable and program potential for electric and natural gas energy efficiency resources in the District as well as demand response programs. This study has examined a full array of energy efficiency and demand response technologies and energy efficient building practices that are technically achievable.

3.4 COST-EFFECTIVENESS FINDINGS

The Societal Cost test cost-effectiveness screening as implemented by the DCSEU follows the prescribed methodology detailed in the California Standard Practice Manual (CA SPM). The California Standard Practice Manual establishes standard procedures for cost-effectiveness evaluations for utility-sponsored or public benefits programs and is generally considered to be an authoritative source for defining cost-effectiveness criteria and methodology. This manual is often referenced by many other states and utilities.

The consultants' cost effectiveness screening tool used for this study quantifies all of the societal benefits and costs included in the Societal Cost test. Quantified benefits include electric energy and capacity avoided supply costs, alternative fuel and water savings, and any specified environmental externalities, risks, or non-energy benefits. Costs include the specified measure cost (incremental or full cost, as applicable), any increase in supply costs (electric or fossil fuel), as well as operation and maintenance costs. In addition, the consultants' screening tool is capable of evaluation of cost-effectiveness based on various market replacement approaches, including replace-on-burnout, retrofit, and early retirement.

The current avoided costs incorporated in the consultants' model are based on several sources. Electric generation and capacity avoided costs are based on PEPCO's filed 2012-2014 EmPOWER Maryland Energy Efficiency Plan. T&D avoided costs were calculated based on PEPCO's July 2011 filing of the FERC formula transmission rate update and then adjusted to include assumed distribution costs. The natural gas avoided costs obtained from the DCSEU are apparently based on a forecast of natural gas avoided costs for New England and then adjusted by the historical ratio of the District's natural gas prices compared to New England gas prices.

In addition, the consultants' screening tool currently applies a 30 percent adder (10 percent each for externalities, risk, and non-energy benefits) to all quantified avoided cost benefits as specified in the DCSEU evaluation framework document.

This energy efficiency and demand response potential study concludes that there remains significant achievable cost effective potential for electric and natural gas energy efficiency and demand response measures and programs in the District. Tables 3-2, 3-3 and 3-4 show the Societal Cost test benefit-cost ratios for the Maximum Achievable, Base Achievable, and Constrained Achievable potential scenarios, for the five and ten-year implementation periods starting in 2013.

Table 3-2: Societal Cost Test Benefit-Cost Ratios for the Maximum Achievable Potential Scenario For 5-Year and 10-Year Implementation Periods

Societal Cost Test Benefit-Cost Ratios for the Maximum Achievable Potential Scenario For 5-Year and 10-Year Implementation Periods			
Achievable Potential Scenarios	**SCT $ Benefits**	**SCT $ Costs**	**SCT Benefit/Cost Ratio**
5-yr period	$6,605,144,984	$1,440,446,220	4.59
10-yr period	$12,670,482,719	$2,541,727,303	4.98

Table 3-3: Societal Cost Test Benefit-Cost Ratios for the Base Achievable Scenario For 5-Year, and 10-Year Implementation Periods

Societal Cost Test Benefit-Cost Ratios for the Base Achievable Potential Scenario For 5-Year and 10-Year Implementation Periods			
Achievable Potential Scenarios	**SCT $ Benefits**	**SCT $ Costs**	**SCT Benefit/Cost Ratio**
5-yr period	$3,937,727,800	$609,600,088	6.46
10-yr period	$7,745,717,753	$1,115,231,954	6.95

Table 3-4: Societal Cost Test Benefit-Cost Ratios for the Constrained Achievable Scenario For 5-Year and 10-Year Implementation Periods

Societal Cost Test Benefit-Cost Ratios for the Constrained Achievable Potential Scenario For 5-Year and 10-Year Implementation Periods			
Achievable Potential Scenarios	**SCT $ Benefits**	**SCT $ Costs**	**SCT Benefit/Cost Ratio**
5-yr period	$3,258,746,270	$476,652,583	6.84
10-yr period	$6,380,955,238	$868,574,226	7.35

In addition, the consultants calculated a SCT ratio for each energy efficiency measure and each demand response measure considered in this study. Only measures that had a SCT ratio greater than or equal to 1.0 were retained in the economic and achievable potential savings estimates.

4 CHARACTERIZATION OF WASHINGTON DC SERVICE AREA

Energy efficiency potential studies and other market assessment studies are valuable sources of information for planning energy efficiency programs. In order to develop estimates of electricity and natural gas savings potential, it is important to understand the extent to which electricity and natural gas is used by households and businesses in Washington D.C. This section provides a brief overview of the economic/demographic characteristics of the Washington D.C. service areas. Data are also presented for historical and forecasted energy sales and system peak demand.

4.1 WASHINGTON DC MEMBER SERVICE TERRITORIES

This section provides information on economic, demographic, geographic and appliance saturation characteristics of Washington D.C. In order to develop estimates of energy savings potential, it is important to understand how energy is used by households and businesses. Washington D.C. is an urban locale with a population of approximately 619,020 persons in 2011, and 298,902 housing units.[13] The District's population only grew 5.2% between 2000 and 2010, whereas the population in the entire US grew 9.7%.

4.1.1 Washington DC Geographic and Demographic Characteristics

Washington D.C. is the 25th largest city (in terms of population) in the US. Despite its sizeable populace, the District is small in total area (61.05 square miles) when compared to other service areas in the nation. Delivering energy efficiency services in a small service area like Washington D.C. presents different challenges than in larger jurisdictions (for example, larger geographic regions such as Alaska, California or Texas). The District is bordered by Montgomery County, Maryland to the northwest, Prince George's County, Maryland to the east, and Arlington and Alexandria, Virginia to the south and west. The Potomac River forms the District's border with Virginia and has two major tributaries. The Washington Metropolitan Area, which includes the District and surrounding suburbs, is the seventh-largest metropolitan area in the United States with an estimated 5.7 million residents in 2011[14].

As of the 2012 census, the District's population was 632,323 persons and the population density was 9,856.5 people per square mile. The District population in 2011 was spread out with 17% under the age of 18, 71.6% 18 to 65, and 11.4% who were 65 years of age or older. The median age was 33.6 years in 2010. For every 100 females in 2010 there were 89.5 males. For every 100 females age 20 and over in 2010, there were 111.4 males. The District's population in 2012 was 10.5% greater than the population in 2000.

There were 298,908 housing units in the District in 2011.[15] The housing unit density in 2011 was 4,896 units per square mile. As of 2011, there were 260,136 households in the District, of which 13.4% had children under the age of 18 living with them, 9.7% were married couples living together, 16.4% had a female householder with no husband present, and 57.7% were non-families. 44.3% of all households were made up of individuals and 20.4% had someone living alone who was 65 years of age or older. The average household size was 2.11 and the average family size was 3.01. According to the American Community Survey, 62% of D.C. residents live in multi-family homes, while single family homes account for the remaining 38% of the District's housing stock. Table 4-1 provides a detailed breakout of the

[13] The Washington D.C. population data for 2010 was obtained from US Census Bureau.
[14] "Table 1. Annual Estimates of the Population of Metropolitan and Micropolitan Statistical Areas: April 1, 2010 to July 1, 2012" (CSV). *2012 Population Estimates*. United States Census Bureau, Population Division.
[15] This figure was obtained from the United States Census Bureau, American Community Survey 1-Year Estimates, Selected Housing Characteristics.

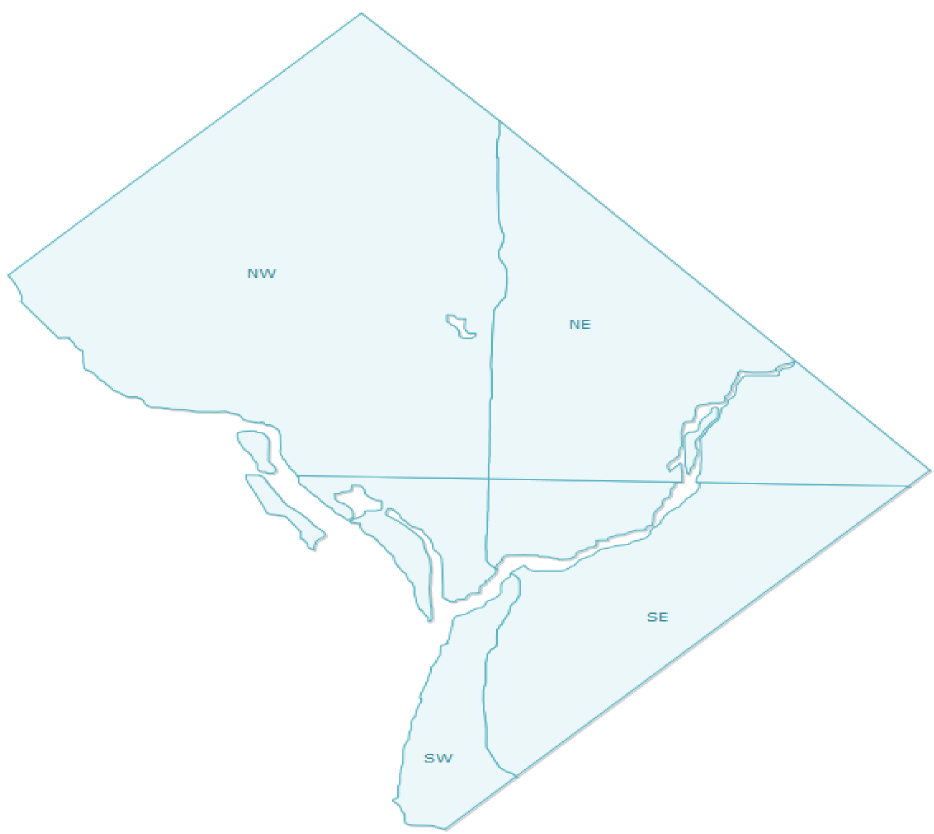
housing distribution in Washington D.C. Figure 4-1 shows a map of the geographic area covered by the District.

Table 4-1: Washington D.C. Housing Unit Characteristics[16]

Housing Type	Number of Households	Percentage
Total	**298,908**	**100.0%**
One unit, detached	36,515	12.2%
One unit, attached	78,060	26.1%
Multi-family, 2 units	8,195	2.7%
Multi-family, 3 or 4 units	20,714	6.9%
Multi-family, 5 to 9 units	17,252	5.8%
Multi-family, 10 to 19	35,031	11.7%
Multi-family, 20 or more	102,714	34.4%
Mobile home	134	0.0%
Boat, RV, van, etc.	293	0.1%

The economic/demographic data for a state or service area are important to understand when developing estimates of energy efficiency potential. For example, one needs to know how many housing units there are in a service area in order to estimate the number of appliances that are plugged into the electric grid in an area. In addition, the composition (age breakdowns, etc.) of the population is important for the development of marketing strategies for different types of energy efficiency programs.

Figure 4-1: Map of Washington D.C.



[16]This data was obtained from the United States Census Bureau, American Community Survey 1-Year Estimates, Selected Housing Characteristics. The web site link for this information is listed below:
http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk

4.1.2 Historical Electric Sales and Electrical Customers in Washington DC

Tables 4-2 and 4-3 show historical Washington D.C. data for annual GWh sales and electric customers by class of service. From 2001 to 2010, GWh sales to ultimate electric customers in Washington D.C. increased at a rate of 0.8% percent per year. From 2001 to 2011, the number of ultimate electric customers increased at a rate of 1.48% percent per year.

According to 2010 historical sales data, the residential sector accounts for approximately 90% of total customers but only 18% of total energy sales while the commercial sector accounts for merely 10% of total customers but almost 80% of all kWh sales. Not only does the commercial sector constitute the greatest portion of total kWh sales, it also consumes the most energy on a per customer basis. The average commercial facility consumes roughly 348,000 kWh annually. Comparatively, the average residential consumer uses approximately 9,300 kWh per year.

Table 4-2: Historical Washington D.C. GWh Sales to Ultimate[17] Customers by Customer Class (GWh) – 2001 to 2010[18]

Year	Residential	Commercial	Industrial	Total
2001	1,699	8,716	281	10,696
2002	1,790	8,878	282	10,950
2003	1,754	8,639	267	10,660
2004	1,834	8,994	282	11,110
2005	1,938	9,296	256	11,490
2006	1,822	9,030	240	11,092
2007	1,970	9,519	297	11,786
2008	1,897	9,290	305	11,492
2009	1,859	9,714	305	11,878
2010	2,123	9,209	230	11,562
Compound Annual Average Rate of Growth	*2.51%*	*0.61%*	*-2.20%*	*0.87%*

Table 4-3: Historical Number of Customers by Customer Class - 2001 to 2011[19]

Year	Residential	Commercial	Other	Total
2001	195,648	26,121	33	221,802
2002	198,667	26,157	33	224,857
2003	200,226	25,866	32	226,124
2004	203,536	26,391	32	229,959
2005	208,324	26,689	31	235,044
2006	211,220	26,737	31	237,988
2007	215,170	26,630	33	241,833
2008	220,113	26,679	32	246,824
2009	226,030	26,399	32	252,461
2010	229,242	26,434	33	255,709
2011	230,384	26,486	32	256,902
Compound Annual Average Rate of Growth	*1.65%*	*0.14%*	*-0.31%*	*1.48%*

[17] In the utility industry, the term "ultimate customer" refers to a household or business that buys and uses a particular product, such as electricity or natural gas, at the customer meter level of the energy distribution system and note at the wholesale level.

[18] EIA, http://www.eia.gov/state/seds/seds-data-complete.cfm?sid=dc#Consumption

[19] Provided by Pepco.

Table 4-4 shows historical system peak loads by season for Pepco's D.C. service area. Pepco's total summer peak load has fluctuated little between 2007 and 2012, translating to an overall decrease of only .01%. Conversely, Pepco has seen a much more substantial change in winter peak load. Both the residential and commercial sectors have experienced a decline in winter peak load since 2007, leading to an overall system decrease of 1.23%.

Table 4-4: Historical DC Pepco System Peak Load by Season (MW) – 2007 to 2012[20]

	SUMMER PEAK LOAD (MW)			WINTER PEAK LOAD (MW)		
Year	Residential	Commercial	Total	Residential	Commercial	Total
2007	592	1,739	2,378	435	1,371	1,864
2008	559	1,775	2,398	400	1,220	1,683
2009	558	1,605	2,229	559	1,318	1,952
2010	590	1,662	2,309	397	1,289	1,751
2011	674	1,746	2,465	485	1,278	1,839
2012	611	1,721	2,377	422	1,268	1,752
Compound Annual Average Rate of Growth	*0.62%*	*-0.22%*	*-0.01%*	*-0.61%*	*-1.56%*	*-1.23%*

4.2 FORECAST OF ENERGY SALES & PEAK DEMAND (2013-2023)[21]

The PJM load forecast for the Washington D.C. region projects that total kWh sales in the District will grow at a moderate pace over the next two decades, at a compound average annual growth rate of 0.9% a year (sales at the customer meter level of the utility grid).[22] The number of electric customers in Washington D.C. is projected to grow 1.5% per year with the greatest growth occurring in the residential sector, as depicted in Table 4-6. Summer and winter peak load for the District is projected to grow approximately 1% per year. Table 4-5 presents the GWh sales forecast for Washington D.C., and Table 4-4 presents the summer and winter peak load forecasts for Pepco's D.C. service areas. The numbers shown in Tables 4-5 and 4-6 exclude the impacts of future DSM programs for the period 2013-2023.

Table 4-5: GWh Sales Forecast for Washington D.C. (Without Future DSM Impacts)[23]

Year	Residential	Commercial	Industrial	Total
2013	2,092	9,533	252	11,877
2014	2,124	9,610	251	11,984
2015	2,155	9,687	249	12,092
2016	2,187	9,766	248	12,201
2017	2,218	9,846	247	12,310
2018	2,250	9,926	246	12,421
2019	2,281	10,007	245	12,533
2020	2,313	10,090	243	12,646
2021	2,345	10,173	243	12,760
2022	2,376	10,257	242	12,874
2023	2,408	10,341	241	12,990
Compound Annual Average Rate of Growth	*1.48%*	*0.81%*	*-0.53%*	*0.90%*

20 Provided by Pepco. Data prior to 2007 not available.

21 The electric load forecast provided in this section covers the time period from 2013 to 2023 so that policy makers will have a forecast for the year 2013 as well as ten additional years beyond 2013.

22 PJM Load Forecast Report, January 2013. http://www.pjm.com/~/media/documents/reports/2013-load-forecast-report.ashx#page=87

23 The consultants utilized a regression model to forecast GWh sales for residential, commercial and industrial sectors.

Table 4-6: Electric Customer Forecast for Washington D.C.[24]

Year	Residential	Commercial	Other	Total
2013	238,039	26,560	32	264,630
2014	241,961	26,596	32	268,589
2015	245,948	26,633	32	272,613
2016	250,000	26,670	32	276,702
2017	254,120	26,707	31	280,859
2018	258,307	26,745	31	285,083
2019	262,563	26,782	31	289,376
2020	266,890	26,819	31	293,740
2021	271,287	26,856	31	298,174
2022	275,757	26,893	31	302,682
2023	280,301	26,931	31	307,263
Compound Annual Average Rate of Growth	*1.65%*	*0.14%*	*-0.31%*	*1.50%*

Table 4-7: Pepco Peak Load Forecast for Washington D.C. (Without Future DSM Impacts)[25]

	SUMMER PEAK LOAD (MW)			WINTER PEAK LOAD (MW)		
Year	**Residential**	**Commercial**	**Total**	**Residential**	**Commercial**	**Total**
2013	646	1,863	2,509	447	1,373	1,820
2014	656	1,878	2,534	454	1,384	1,837
2015	666	1,893	2,559	460	1,395	1,855
2016	675	1,909	2,584	467	1,406	1,873
2017	685	1,924	2,609	474	1,418	1,891
2018	695	1,940	2,635	480	1,429	1,910
2019	705	1,956	2,661	487	1,441	1,928
2020	714	1,972	2,686	494	1,453	1,947
2021	724	1,988	2,712	501	1,465	1,966
2022	734	2,005	2,739	507	1,477	1,984
2023	744	2,021	2,765	514	1,489	2,003
Compound Annual Average Rate of Growth	*1.42%*	*0.82%*	*0.97%*	*1.42%*	*0.82%*	*0.97%*

4.3 NATURAL GAS USE IN WASHINGTON DC

This section provides key background information used by the consultants to determine the economic and achievable potential for natural gas energy efficiency savings in Washington D.C. It presents historical natural gas consumption data for the District as well as the consultants' forecasts of natural gas customers and sales broken down by sector. This data provides the foundation for determining estimates of natural gas energy efficiency potential in Washington D.C. It is important to have information on the current consumption levels and uses of natural gas in the District as a starting point for the energy efficiency potential study. This information is needed (1) to ensure that projections of achievable energy efficiency potential do not exceed the amount of natural gas that is consumed in the District and (2) to facilitate the matching of natural gas energy efficiency measures to applicable natural gas end uses in the District. Thus a key element of a natural gas potential study is a thorough analysis of the saturation of

[24] The consultants applied historical customer growth rates to develop the forecast of customers by class of service.
[25] The consultants analyzed Pepco's load profile to develop seasonal load factors for each sector. The load factors were then applied to the consultants' GWh forecast to develop the peak load forecast.

natural gas using equipment, the current energy efficiency levels of such equipment, and the natural gas usage characteristics of such equipment.

4.4 NATURAL GAS CONSUMPTION IN WASHINGTON DC

4.4.1 Introduction

Approximately 154,000 Washington D.C. customers used natural gas in 2011, the most recent year where detailed natural gas consumption data for Washington D.C. is available. In total, 33.0 trillion BTU were consumed. Figure 4-2 shows the proportion of natural gas used by various segments of the Washington D.C. economy in 2011, the last year for which actual data is available. Deliveries to residential and commercial customers in the District account for 89% of total gas usage.

Table 4-8: Historical Washington D.C. Trillion BTU Sales to Ultimate Customers by Customer Class (TBTU) – 2001 to 2011[26]

Year	Residential	Commercial	Other	Total
2001	12.9	16.5	0.3	29.8
2002	14.2	18.3	0.3	32.9
2003	15.2	17.1	0.6	32.8
2004	14.3	17.4	0.6	32.2
2005	13.9	17.7	0.5	32.1
2006	11.4	17.1	0.5	29.0
2007	13.4	19.3	0.3	33.0
2008	13.2	18.4	0.2	31.9
2009	13.5	18.7	1.0	33.2
2010	13.6	18.5	1.1	33.3
2011	12.4	16.9	3.7	33.0
Compound Annual Average Rate of Growth	*-0.44%*	*0.21%*	*28.17%*	*1.02%*

The number of natural gas customers grew at a modest rate of 0.55% over the past decade, with the greatest increase in customers occurring in the transportation sector. The number of transportation customers has grown 1.2% per year since 2001, compared to only a 0.6% per year rise in the number of residential customers and a corresponding 1.6% per year decrease in the number of commercial customers over the same time period. Historical trends in customer counts for each sector are presented in Table 4-9.

Figure 4-2: Breakdown of Natural Gas Consumption, Washington D.C., 2010[27]

[26] EIA, http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_SDC_a.htm
[27] Ibid.

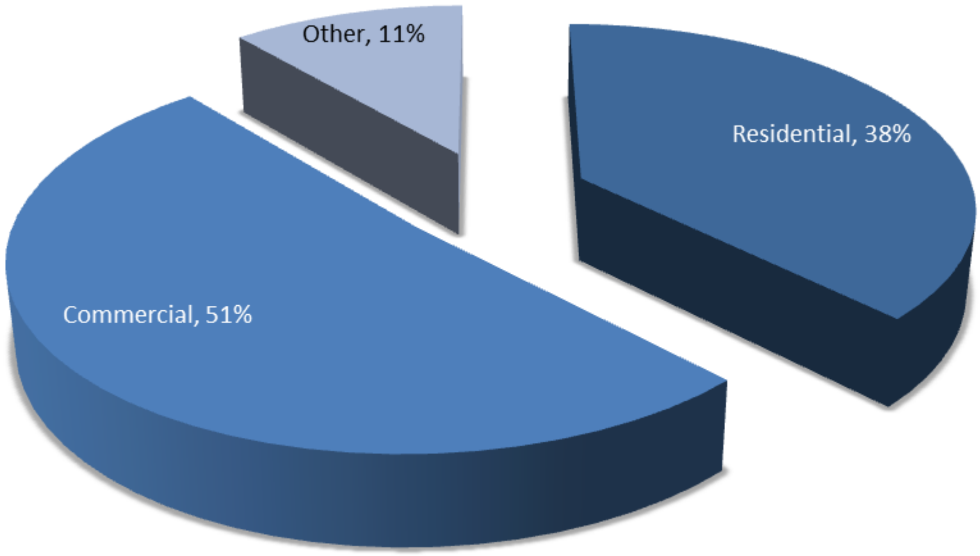


Table 4-9: Historical Number of DC Natural Gas Customers by Customer Class – 2001 to 2011[28]

Year	Residential	Commercial & Industrial	Transportation	Total
2001	120,050	9,504	15,924	145,478
2002	112,667	8,908	26,306	147,881
2003	111,555	9,277	26,587	147,419
2004	118,752	9,114	21,663	149,529
2005	124,680	9,133	15,695	149,508
2006	124,643	8,632	17,361	150,636
2007	125,527	8,452	16,804	150,783
2008	126,648	8,503	16,363	151,514
2009	126,379	8,195	17,348	151,922
2010	127,288	7,967	17,605	152,860
2011	127,669	8,076	17,897	153,642
Compound Annual Average Rate of Growth	*0.62%*	*-1.61%*	*1.17%*	*0.55%*

The table above characterized natural gas usage by residential, commercial and industrial customers based on the latest historical data available from the U.S. Energy Information Administration (EIA) and forecasts of natural gas sales and customers developed by the consultants for this project. The remainder of this section describes forecasted natural gas usage for the major customer classes (residential and commercial) and other information on natural gas usage in Washington D.C.

4.4.2 Total Gas Sales and Customer Forecast

The latest available natural gas consumption forecasts for the residential, commercial and industrial segments of the Washington D.C. region indicate that natural gas demand will increase from 33 trillion BTU in 2011 to 37 trillion BTU in 2023 (representing a compound average annual rate of growth of

[28] Provided by Washington Gas

.9%).[29] Table 4-10 shows the sales forecast for natural gas in Washington D.C. by customer class, while Table 4-11 shows the forecast of customers for the District. The consultants used the customer growth rates actually experienced over the past decade to forecast the growth in the number of natural gas customers for the next decade. The consultants plan to follow-up with Washington Gas during June of 2013 to determine if Washington Gas staff believe that a continuation in the decline of the number of commercial and industrial customers in the District is likely. This follow-up discussion is necessary to understand how natural gas sales to commercial customers can continue to increase at 1.2% per year while the number of customers continues to decline.

The sales of natural gas to the commercial sector is expected to grow at a much faster pace than the residential sector, with a forecasted average annual growth rate for 2013 to 2023 of 1.2%. Growth in residential natural gas consumption is forecasted to stagnate for the next decade with a forecasted average annual growth rate of about 0.02%.

Table 4-10: Forecast of Natural Gas Consumption by Customer Class 2013-2023 (Trillion BTU) [30]

Year	Residential	Commercial	Other	Total
2013	12.395	17.5	4.0	33.8
2014	12.397	17.7	4.0	34.1
2015	12.400	17.9	4.1	34.4
2016	12.403	18.1	4.2	34.8
2017	12.406	18.3	4.3	35.1
2018	12.409	18.6	4.4	35.4
2019	12.412	18.8	4.5	35.7
2020	12.415	19.0	4.6	36.0
2021	12.417	19.2	4.7	36.4
2022	12.420	19.5	4.8	36.7
2023	12.423	19.7	4.9	37.0
Compound Annual Average Rate of Growth	*0.02%*	*1.18%*	*2.23%*	*0.90%*

Table 4-11: Forecast of Natural Gas Customers by Customer Class, 2013-2023 (Trillion BTU)[31]

[29]During teleconferences between staff of Washington Gas and the consultants, Washington Gas stated that it does not make public its forecasts of natural gas consumption forecasts. [29] the consultants did ask Washington Gas to review the natural gas consumption forecast prepared for this study. Washington Gas staff representatives did review the forecast prepared by the consultants and had no suggested changes or comments as of May 31, 2013. Washington Gas staff did suggest that further information on future natural gas sales could be obtained in the Management Discussion section of the WGL Holdings, Inc. 2012 Corporate Financial Report, which can be located on the Washington Gas website at www.wglholdings.com under Investor Relations

[30] This forecast was developed by the consultants in the spring of 2013 based upon an examination of historical energy use trends in Washington D.C. and EIA's 2013 natural gas consumption forecast for the U.S. and the mid-Atlantic region. The electric load forecast provided in this section covers the time period from 2013 to 2023 so that policy makers will have a forecast for the year 2013 as well as ten additional years beyond 2013.

[31] The consultants applied historical customer growth rates to develop the forecast of natural gas customers by class of service.

Year	Residential	Commercial & Industrial	Transportation	Total
2013	129,250	7,817	18,320	155,387
2014	130,048	7,691	18,535	156,274
2015	130,850	7,567	18,753	157,170
2016	131,658	7,445	18,973	158,076
2017	132,471	7,324	19,196	158,991
2018	133,288	7,206	19,422	159,916
2019	134,111	7,090	19,650	160,851
2020	134,939	6,975	19,881	161,795
2021	135,772	6,863	20,114	162,749
2022	136,610	6,752	20,351	163,712
2023	137,453	6,643	20,590	164,685
Compound Annual Average Rate of Growth	*0.62%*	*-1.61%*	*1.17%*	*0.58%*

4.5 Current DDOE and DCSEU DSM Offerings

Both DDOE and the DC Sustainable Energy Utility (DCSEU) offer several energy efficiency programs for homes and businesses in the District.

4.5.1 Current DDOE Energy Efficiency Programs

DDOE offers several energy efficiency programs for both the residential and commercial sectors. These programs cover efficiency improvements for space heating, space cooling, water heating, lighting and other uses of energy. The consultants plan to add a few other DDOE programs to this section as soon as this information is received from Lance Loncke.

DIY - Do It Yourself

DDOE recommends that residents use a certified contractor to make major energy efficiency improvements. If a consumer wishes to make some improvements on his/her own, DDOE has created a DIY Home Energy Audit section on DDOE website. This resource provides information on home energy topics including; sealing air leaks, attic insulation, heating equipment and energy-efficient appliances.

Free Home Energy Audits

DDOE's Free Home Energy Audits Program promotes energy efficiency assessments for single family homes in the District. Participants may apply to receive a free energy audit for their home if they live in a single family home or townhouse that is 4000 square feet or less; multi-family homes do not qualify for the program. Based on a home energy rating system, auditors suggest specific cost-effective, energy efficient improvements that should be done to reduce the home's operational costs and improve comfort. There are no household income restrictions for this program.

Discounts on Utility Bills

DDOE's Utility Discount Programs provide low-income District residents with discounts of up to $240 per year on electric bills to help reduce their utility costs while educating them on everyday energy efficiency and conservation practices they can employ to further cut down on their energy spending. Program participants must demonstrate financial need to qualify and must complete a short program that teaches them how to save energy in their home.

Weatherization Assistance Program (WAP)

The Weatherization Assistance Program (WAP), funded by the U.S. Department of Energy, is designed to help low-income residents reduce their energy bills by providing technical and financial assistance to make their homes more energy efficient. WAP performs energy audits for qualifying families and installs audit-recommended energy efficiency measures to help families maintain energy-efficient, safe and healthy homes. In the District, WAP is administered through selected Community Based Organizations that hire local contractors to install the energy efficiency measures recommended by the energy audit.

Small Business Energy Efficiency Program (SBEEP)

The Small Business Energy Efficiency Program (SBEEP) provides up to $7000 in financial assistance to help qualified small businesses identify and install energy efficient measures that can reduce energy consumption and overall operating costs. Local contractors are hired to supply and install audit-recommended energy efficient measures, thereby creating employment opportunities for District residents. In order to qualify for the program, business must have fewer than 15 employees and less than $1,000,000 in annual revenue.

Condominium and Cooperative Building Energy Efficiency Program (CCBEEP)

The Condominium and Cooperative Building Energy Efficiency Program (CCBEEP) provides technical and financial incentives to help resident-owners of condo/coop buildings and their associations identify and install energy efficient measures in their facilities. CCBEEP provides a comprehensive Retro-commissioning Study (RCx), financial assistance to help correct deficiencies, and follow-up performance tracking. CCBEEP specifically targets older condo/coop buildings that were built before 1978 and owners that have a demonstrated interest in improving the energy efficiency of their building(s).

Heating System Repair, Replacement, and Tune-up Program

The Heating System Repair, Replacement, and Tune-up Program performs home energy audits, tune-ups, repairs, and replacements of HVAC systems, hot-water heaters, and thermostats in low-income dwelling units. Participants in this program typically receive an assessment of their heating system as part of whole-house weatherization audit, except when heating systems are replaced or repaired on an emergency basis because there is no heat in the home or as a health and safety measure. Program eligibility is based on federal low-income guidelines.

4.5.2 Current Programs Offered by the DC Sustainable Energy Utility (DCSEU)

Listed below are descriptions of the energy efficiency programs offered by the Sustainable Energy Utility (DCSEU).

DCSEU Home Performance with ENERGY STAR Program

Home Performance with ENERGY STAR is a national program sponsored by the U.S. Department of Energy that incentivizes homeowners to identify and install energy efficiency improvements in their homes. The DCSEU is the local implementer of the Home Performance with ENERGY STAR program for the District of Columbia. DCSEU Home Performance offers a $500 incentive to District residents living in single family homes or row homes who successfully complete a minimum of $1500 worth of approved improvements. The DCSEU also offers an additional $500 incentive for homeowners who work with their contractor to complete qualifying duct sealing work on their heating/cooling system.

Low-Income Comprehensive Multifamily Program (LIMF)

The DCSEU offers financial incentives and technical assistance to affordable housing developers and property owners who work together with the DCSEU to incorporate energy-efficient systems and measures in the new development, redevelopment, or substantial rehabilitation of affordable housing in the District. To qualify for incentives, developers must demonstrate that at least 66% of their residential units per building are designated for or inhabited by households with incomes at or below 60% Area Median Income.

Low-Income Multifamily Implementation Contractor Direct Installation Program (ICDI)

The DCSEU offers no cost energy-efficient Compact Fluorescent Light (CFL) bulbs and water saving devices to owners and property managers of qualified affordable housing units. The program works in the following manner: qualifying affordable housing owners and property managers submit a request for participation to the DCSEU, upon which the DCSEU provides resident education on the equipment being installed and hires contractors to install the equipment at no cost to building owners or residents.

Business Energy Rebates Program

The DCSEU's Business Energy Rebates program provides District businesses and institutions with financial rebates for installing energy-efficient equipment. Qualifying measures include lighting, HVAC, compressed air, refrigeration, and food service and vending. Rebates are available for a maximum of 100 fixtures and/or $5,000 in rebates, per location, per fiscal year.

Commercial and Institutional Custom Program

The DCSEU Commercial and Institutional Custom Program is designed to target owners of large buildings in the District who are replacing old equipment, renovating an existing building, or beginning a new construction project. Virtually any measure or operational improvement leading to cost-effective energy savings is eligible for consideration to receive incentivized services from the program. Program services may include financial incentives, technical and design assistance, and coordinating services to assist consumers, design professionals, vendors, and contractors in overcoming the barriers to installing energy-efficient equipment.

5 POTENTIAL STUDY METHODOLOGY

This section describes the overall methodology that was utilized by the consultants to conduct the energy efficiency potential study for the District. The main objective of this energy efficiency potential study is to quantify the technical, economic and achievable potential for electric and natural gas energy efficiency in Washington D.C. This report provides estimates of the potential kWh and kW electric savings and MMBtu gas savings for each level (technical, economic and achievable potential) of energy efficiency potential. This document describes the general steps and methods that were used at each stage of the analytical process necessary to produce the various estimates of energy efficiency potential.

Energy efficiency potential studies involve a number of analytical steps to produce estimates of each type of energy efficiency potential: technical, economic, and achievable. This study utilizes benefit/cost screening tools for the residential and non-residential sectors to assess the cost effectiveness of energy efficiency measures. These cost effectiveness screening tools are Excel-based models that integrate technology-specific impacts and costs, customer characteristics, utility avoided cost forecasts and more. Excel was used as the modeling platform to provide transparency to the estimation process and allow for simple customization based on the District's unique characteristics and the availability of specific model input data. The major analytical steps and an overview of the potential savings are summarized below, and specific changes in methodology from one sector to another have been noted throughout this section.

- Measure List Development
- Measure Characterization
- Load Forecast Development and Disaggregation (for the non-residential sector)
- Potential Savings Overview
- Technical Potential
- Economic Potential
- Measure Cost-Effectiveness Screening
- Achievable Potential

5.1 MEASURE LIST DEVELOPMENT

The energy efficiency and demand response measure included in this study cover measures form the DCSEU energy efficiency programs, additional measures included in the Mid-Atlantic Technical Reference Manual (TRM), as well as other measures based on the consultants' existing knowledge and current databases of electric and natural gas end-use technologies and energy efficiency/demand response measures. The study scope 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 DSM program planners in Washington D.C. However, a small number of well documented emerging technologies were considered for each sector. Emerging technology research was focused on measures that are commercially available but may not be widely accepted at the current time. In April 2013, the consultants provided the energy efficiency measure lists for each sector to DDOE staff for review and comment. These measure lists were then reviewed, discussed and updated as necessary.

In addition, this study includes measures that could be relatively easily substituted for, or applied to, existing technologies on a retrofit or replace-on-burnout basis. Replace-on-burnout applies to equipment replacements that are made normally in the market when a piece of equipment is at the end of its useful life. A retrofit measure is eligible to be replaced at any time in the life of the equipment or building. Replace-on-burnout measures are generally characterized by incremental measure costs and savings (*e.g.* the costs and savings of a high-efficiency versus standard efficiency air conditioner); whereas retrofit measures are generally characterized by full costs and savings (e.g. the full costs and savings associated with adding ceiling insulation into an existing attic). For new construction, energy efficiency measures can be implemented when each new home or building is constructed, thus the rate of availability is a direct function of the rate of new construction.

5.1.1 Measure Characterization

A significant amount of data is needed to estimate the kWh, kW and MMBtu savings potential for individual energy efficiency and demand response measures or programs across the entire existing residential and non-residential sectors in Washington D.C. The consultants used District specific data wherever it was available and up-to-date. Considerable effort was expended to identify, review, and document all available data sources.[32] This review has allowed the development of reasonable and supportable assumptions regarding: measure lives; measure installed incremental or full costs (as appropriate); and electric and natural gas savings and saturations for each measure included in the final list of measures in this study.

Costs and savings for new construction and replace on burnout measures are calculated as the incremental difference between the code minimum equipment and the energy efficiency measure. This approach is utilized because the consumer must select an efficiency level that is at least the code minimum equipment. The incremental cost is calculated as the difference between the cost of high efficiency and standard (code compliant) equipment. However, for retrofit measures, the measure cost and savings were considered to be the "full" cost of the measure, as the baseline scenario assumes the consumer would do nothing.

Savings: Estimates of annual measure savings as a percentage of base equipment usage were developed from a variety of sources, including:

- DCSEU TRM
- Mid-Atlantic Technical Reference Manual (TRM)
- Existing deemed savings databases
- Building energy simulation software (such as the REM/Rate model) and engineering analyses
- Secondary sources such as the American Council for an Energy-Efficient Economy ("ACEEE"), Department of Energy ("DOE"), Energy Information Administration ("EIA"), ENERGY STAR, Air Conditioning Contractors of America ("ACCA") and other technical potential studies

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 measures costs were held constant over time. This general assumption is being made due to the fact that historically many measure costs (e.g., CFL bulbs, Energy Star appliances, etc.) have declined over time, while some measure costs have increased over time (e.g., fiberglass insulation). Cost estimates were obtained from the following types of data sources:

- Existing deemed savings databases
- Secondary sources such as ACEEE, ENERGY STAR, NREL, NEEP Incremental Cost Study Report, and other technical potential studies
- Retail store pricing (such as web sites of Home Depot and Lowe's) and industry experts

Measure Life: Represents the number of years that energy-using equipment is expected to operate. Useful life estimates have been obtained from the following data sources:

- Mid-Atlantic TRM
- Manufacturer data
- Savings calculators and life-cycle cost analyses

[32] The appendices and supporting databases to this report provide the data sources used by the consultants to obtain up-to-date data on energy efficiency measure costs, savings, useful lives and saturations.

- Secondary sources such as ACEEE, ENERGY STAR, and other technical potential studies
- The California Database for Energy Efficient Resources ("DEER") database
- Evaluation reports
- Other consultant research or technical reports

Baseline and Efficient Technology Saturations: In order to assess the amount of electric and natural gas energy efficiency savings and demand response savings still available, estimates of the current saturation of baseline equipment and energy efficiency measures, or for the non-residential sector the amount of energy use that is associated with a specific end use (such as HVAC) and percent of that energy use that is associated with energy efficient equipment are necessary. Up-to-date measure saturation data were primarily obtained from the following recent studies:

- 2009 EIA Residential Energy Consumption Survey (RECS)
- 2007 American Housing Survey (AHS)
- 2006 EIA Manufacturing Energy Consumption Survey (MECS)
- 2003 EIA Commercial Building Energy Consumption Survey (CBECS)
- 2000 Pepco Appliance Saturation Survey
- Maryland residential and commercial baseline studies

Further detail regarding the development of measure assumptions for energy efficiency in the residential and non-residential sectors are provided in this report in later sections. Additionally, the appendices of the report provide a comprehensive listing of all energy efficiency measure assumptions and sources.

5.2 FORECAST DISAGGREGATION

For the non-residential sector, the baseline load forecast was disaggregated by combining inputs from a Maryland commercial sector baseline study and forecasts of electric and natural gas sales for the District to obtain average consumption estimates by customer segment and end use, and summed up to the sector level. This disaggregation effort was conducted by the consultants as this level of detail was not available in the historical or forecast sales data provided by PEPCO or Washington Gas. The disaggregated forecast data provides the foundation for the development of energy efficiency potential estimates for the non-residential sector. It was not necessary to develop a disaggregated residential sales forecast because a bottom-up approach was used for the residential sector.

5.2.1 Role of Naturally Occurring Conservation

Naturally occurring conservation exists through government intervention, improved manufacturing efficiencies, building energy codes, market demand, and increased energy efficient implementation through early fore-runners, who will implement measures without explicit monetary incentives. The impacts of new Federal government mandated energy efficiency standards have already been reflected in the baseline data for equipment unit energy consumption being used for this potential study. These new government standards, such as the new standards included in the Federal government's December 2007 Energy Independence and Security Act (EISA)[33], can significantly increase naturally occurring potential through tax incentives, stimulus funding or stricter manufacturing standards. These forces cause certain sector end-use energy consumption values to improve across the baseline forecast. It is important to account for these forces as thoroughly as possible to ensure the energy efficiency potential is not double-counted, by over-stating the potential that could occur for end-uses where codes and standards are reducing baseline unit energy consumption. In addition, the consultants have reflected the impacts of new EISA lighting standards that will go into effect starting in 2012, as well as changes to other federal

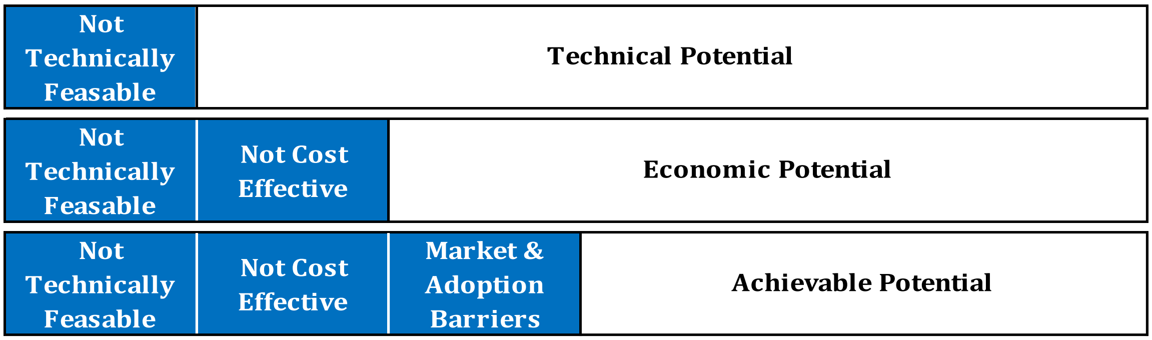
[33] PUBLIC LAW 110–140—DEC. 19, 2007. Energy Independence and Security Act of 2007

baseline standards across a variety of end uses. These adjustments reduce energy efficiency potential starting in the years these standards come into effect, and in subsequent years.

5.3 POTENTIAL SAVINGS OVERVIEW

Potential studies often distinguish between several types of energy efficiency potential: technical, economic, and achievable. 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.

Figure 5-1: Types of Energy Efficiency Potential[34]



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 percent of the technical or economic potential. Therefore, achievable potential attempts to estimate what may realistically be achieved, when it can be captured, and how much it would cost to do so. Figure 5-1 above illustrates the three most common types of energy efficiency potential.

5.4 TECHNICAL POTENTIAL

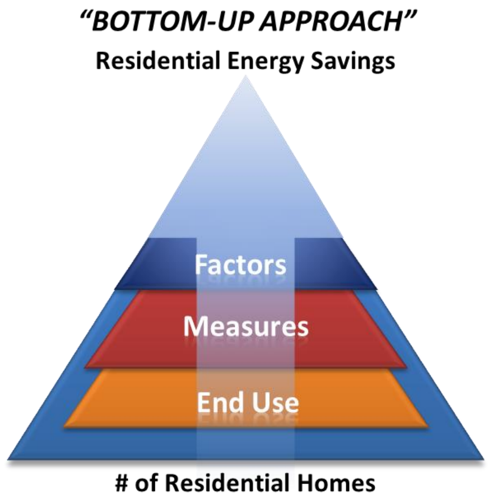
The consultants used the energy efficiency potential definitions included on page 2-4 of the November 2007 National Action Plan for Energy Efficiency (NAPEE) Guide for Conducting Energy Efficiency Potential Studies. Technical potential is the theoretical maximum amount of energy use that could be displaced by efficiency, disregarding all non-engineering constraints such as cost-effectiveness and the willingness of end-users to adopt the efficiency measures. It is often estimated as a "snapshot" in time assuming immediate implementation of all technologically feasible energy saving measures, with additional efficiency opportunities assumed as they arise from activities such as new construction.[35]

In general, this study utilizes a "bottom-up" approach in the residential sector to calculate the potential of an energy efficiency or demand response measure or set of measures as illustrated in Figure 5-2 below. A bottom-up approach was used for the residential sector due to the amount of data available for this sector from Federal government surveys and research done in nearby states. A bottom-up approach first starts with the savings and costs associated with replacing one piece of equipment with its high efficiency counterpart, and then multiplies these values by the number of measures available to be installed throughout the life of the program. The bottom-up approach is applicable in the residential sector because of better secondary data availability and greater homogeneity of the building and equipment stock to which measures are applied, compared to the non-residential sector. However, this methodology was not utilized in the non-residential sector. For the non-residential sector, a "top-down" approach was used for developing the technical potential estimates. The "top down" approach builds an energy use profile based on estimates of kWh sales by business segment and end use. Savings factors for energy efficiency measures are then applied to applicable end use energy estimates after assumptions are made

[34] Reproduced from "Guide to Resource Planning with Energy Efficiency" November 2007. US EPA. Figure 2-1.
[35] National Action Plan for Energy Efficiency, "Guide for Conducting Energy Efficiency Potential Studies", page 2-4

regarding the fraction of sales that are associated with inefficient equipment and the technical/engineering feasibility of each energy efficiency measure.

Figure 5-2: Residential Sector Savings Methodology - Bottom Up Approach



As shown in Figure 5-2, the methodology starts at the bottom based on the number of residential customers (splitting them into single-family and multi-family customers as well as existing vs. new construction). From that point, estimates of the size of the eligible market in the District are developed for each energy efficiency measure. For example, energy efficiency measures that affect electric space heating are only applicable to those homes in the District that have electric space heating.

As noted previously, to obtain up-to-date appliance and end-use saturation data, the study made extensive use of the 2007 American Housing Survey (AHS), the 2009 Residential Energy Consumption Survey (RECS), the 2000 PEPCO appliance saturation survey and the Maryland energy efficiency baseline study. The surveys collected detailed data on the current saturation of electricity and natural gas consuming equipment in the District and the energy efficiency level of HVAC equipment, appliances, and building shell characteristics. Estimates of energy efficient equipment saturations were based on several sources, including data collected from the 2009 RECS and the Maryland baseline study.

The goal of the approach is to determine how many households that a specific measure applies to (base case factor), then of that group, the fraction of households/buildings which do not have the energy efficient version of the measure being installed (remaining factor). In instances where technical reasons do not permit the installation of the efficient equipment in all eligible households an applicability factor is used to limit the potential. Alternative water heating technologies (efficient water heater tanks and/or heat pump water heaters) are then utilized to meet the remaining market potential. The last factor to be applied is the savings factor, which is the percentage savings achieved from installing the efficient measure over a standard measure.

In developing the overall potential electricity savings, the analysis accounts for the interactive effects of measures designed to impact the same end-use. For instance, if a home were to properly seal all ductwork, the overall space heating and cooling consumption in that home would decrease. As a result, the remaining potential for energy savings derived from a heating/cooling equipment upgrade would be reduced. In instances where there are two (or more) competing technologies for the same electrical (or natural gas) end use, such as heat pump water heaters, water heater efficiency measures and high-efficiency electric storage water heaters, in most cases an equal percentage of the available population is assigned to each measure using the applicability factor[36]. In the event that one of the competing measures is not found to be cost-effective, the homes/buildings assigned to that measure are transitioned over any of the remaining cost effective alternatives.

The savings estimates per base unit are determined by comparing the high-efficiency equipment to current installed equipment for existing construction retrofits or to current equipment code standards for replace-on-burnout and new construction scenarios.

5.4.1 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 below in Equation 5-1 below.

Equation 5-1: Core Equation for Residential Sector Technical Potential

Where:

- **Total Number of Households** = the number of households in the market segment (e.g. the number of households living in detached single-family buildings)
- **Base Case Equipment End-use Intensity** = annual gas consumption (MMBtu) used per customer, per year, by each base-case technology in each market segment. This is the consumption of natural gas-using equipment that efficient technology replaces or affects. This variable fully accounts for any known building characteristics in the service area, such as average square footage.
- **Saturation Share** = this variable has two parts: the first is the fraction of the end use gas energy that is applicable for the efficient technology in a given market segment. For example, for residential water heating, this would be the fraction of all residential gas customers that have gas water heating in their household; the second is the share of the end use gas energy that is applicable for the efficient technology that has not yet been converted to an efficient technology.
- **Applicability Factor** = this factor ensures that a household cannot receive two of the same type of measure. For example, if we assume there are two tiers of efficient gas furnaces, one which yields 10% savings and another which yields 20% savings, a household that needs to replace its inefficient furnace could either receive the unit which yields 10% savings or the unit which yields 20% savings, but could not receive both units. In general, the consultants apply an even distribution to the same type of measure across eligible households when applying this factor. The consultants may, in some cases, assign unbalanced applicability factors, if it believes an even distribution is inappropriate[37]. The applicability factor also captures the fraction of applicable units technically feasible for conversion to the efficient technology from an engineering perspective (e.g., it may not be possible to add wall insulation in all homes because the original construction of some homes does not allow for wall insulation to be installed without requiring major reconstruction of the house, which would be an additional cost that does not yield any energy benefits).

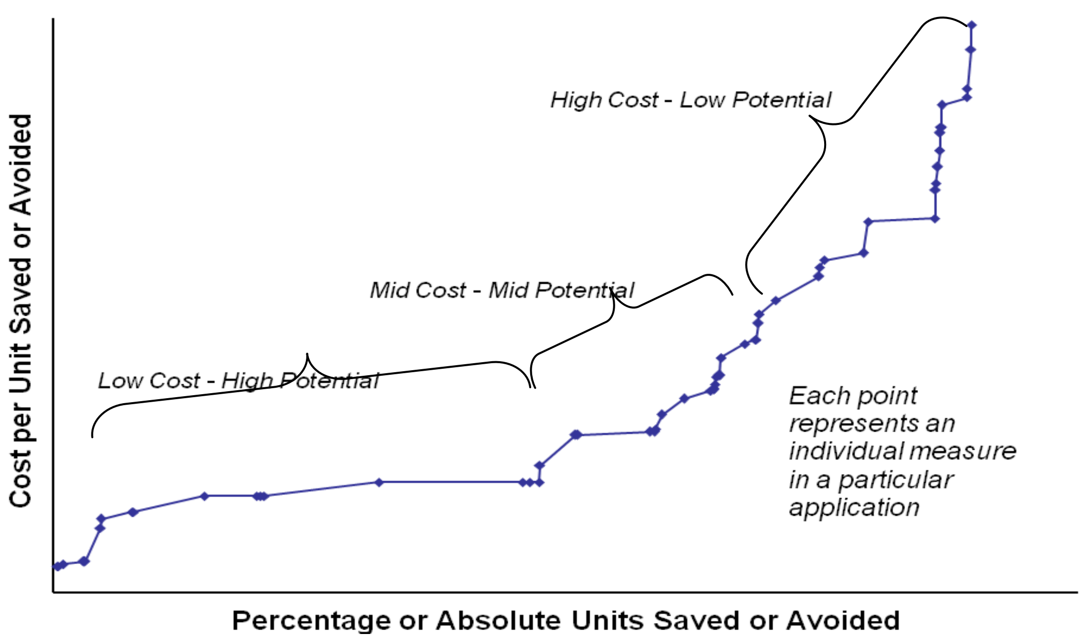
[36] The consultants used its professional judgment in some cases to assign unequal applicability factors to attempt to avoid overstating or understating the potential of the set of competing technologies.
[37] For example, if historical data indicates a technology has been able to garner a large share of the market the consultants may assign a higher applicability factor to this technology in order to properly reflect this knowledge.

- **Savings Factor** = the percentage of gas consumption reduction resulting from applications of the efficient technology. The savings factor is a general term used to illustrate the calculation of a measures technical potential. The model used fully integrated the necessary assumptions to determine the measure-level savings, given the **Base Case Equipment End-use Intensity**, and the expected savings of each technology.

Technical energy efficiency potential in the residential sector is calculated in two steps. In the first step, all measures are treated *independently*; that is, the savings of each measure are not reduced or otherwise adjusted for overlap between competing or interacting measures. By analyzing measures independently, no assumptions are made about the combinations or order in which they might be installed in customer buildings. However, the cumulative technical potential cannot be estimated by adding the savings from the individual savings estimates because some savings would be double-counted. For example, the savings from a measure that reduces heat loss from a building, such as insulation, are partially dependent on other measures that affect the efficiency of the system being used to heat the building, such as a high-efficiency furnace; the more efficient the furnace, the less energy saved from the installation of the insulation. In the second step, adjustments are made to account for such interactive effects.

Finally, the consultants have developed a supply curve to show the amount of energy efficiency savings available at different cost levels. The residential sector supply curve is included in an appendix of this report. A generic example of a supply curve is shown in Figure 5-3. As shown in the figure, a supply curve typically consists of two axes; one that captures the cost per unit of saving a resource (e.g., dollars per lifetime kWh or MMBtu saved) and another that shows the amount of savings that could be achieved at each level of cost. The curve is typically built up across individual measures that are applied to specific base-case practices or technologies by market segment. Savings measures are sorted based on a metric of cost. Total savings available at various levels of cost are calculated incrementally with respect to measures that precede them. Supply curves typically, but not always, end up reflecting diminishing returns, i.e., costs increase rapidly and savings decrease significantly at the end of the curve.

Figure 5-3: Generic Example of a Supply Curve



As noted above, the cost portion of this energy efficiency supply curve is represented in dollars per unit of lifetime energy savings. Cost are annualized (often referred to as levelized) in supply curves. For example, electric energy efficiency supply curves usually present levelized costs per kWh saved by multiplying the initial investment in an efficient technology or program by the capital recovery rate (CRR), and then dividing that amount by annual kWh savings:

Therefore,

Levelized Cost per kWh Saved = Initial Cost x CRR/Annual kWh Savings

5.4.2 Core Equation for the Non-Residential Sector

The core equation utilized in the commercial sector technical potential analysis for each individual efficiency measure is shown below in Equation 5-2. The forecast of commercial square footage information was developed by the consultants. The information used by the consultants on the total square footage by business type is available from the consultants upon request.

Equation 5-2: Core Equation for Commercial Sector Technical Potential

Where:

- **Total end-use kWh sales by industry type** = the forecasted electric sales level for a given end use (e.g., space heating) in a commercial or industrial industry type (e.g., office buildings or fabricated metals).
- **Base Case factor** = the fraction of end-use energy applicable for the efficient technology in a given industry type. For example, with fluorescent lighting, this would be the fraction of all lighting kWh in a given industry type that is associated with fluorescent fixtures.
- **Remaining factor** = the fraction of applicable kWh sales associated with equipment not yet converted to the electric energy-efficiency measure; that is, one minus the fraction of the industry type with energy-efficiency measures already installed.
- **Convertible 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 variable-frequency drives (VFDs) on all motors.
- **Savings factor** = the fraction of electric consumption reduced by application of the efficient technology.

For the non-residential sector, the development of the energy efficiency technical potential estimate begins with a disaggregated energy sales forecast over the ten year forecast horizon (2013 to 2022). The non-residential sales forecast is broken down by building type, then by electric end use. Then a savings factor is applied to end use electricity sales to determine the potential electricity savings for each end use. The commercial sector, as defined in this analysis, is comprised of the following business segments:

- Warehouse
- Retail
- Grocery
- Office
- Lodging
- Healthcare
- Restaurant

- Institutional, including education
- Other

Similar to the residential sector, technical electric energy efficiency savings potential in the non-residential sector is calculated in two steps. In the first step, all measures are treated *independently*; that is, the savings of each measure are not reduced or otherwise adjusted for overlap between competing or synergistic measures. By treating measures independently, their relative economics are analyzed without making assumptions about the order or combinations in which they might be implemented in customer buildings. However, the total technical potential across measures cannot be estimated by summing the individual measure potentials directly because some savings would be double-counted. For example, the savings from a weatherization measure, such as low-e ENERGY STAR windows, are partially dependent on other measures that affect the efficiency of the system being used to cool or heat the building, such as high-efficiency space heating equipment or high-efficiency air conditioning systems; the more efficient the space heating equipment or electric air conditioner, the less energy saved from the installation of low-e ENERGY STAR windows. Accordingly, the second step is to rank the measures based on a metric of cost-effectiveness (using the SC test) and adjust savings for interactive effects so that total savings are calculated incrementally with respect to measures that precede them.

5.5 ECONOMIC POTENTIAL

Economic potential refers to the subset of the technical potential that is economically cost-effective (based on screening with the SC test (or SCT) as compared to conventional supply-side energy resources. The consultants have calculated the SC benefit/cost ratios for this study according to the DC Sustainable Energy Utility Measurement and Verification Framework. Both technical and economic potential are theoretical numbers that assume immediate implementation of energy efficiency measures, with no regard for the gradual "ramping up" process of real-life programs. In addition, they ignore market barriers to ensuring actual implementation of energy efficiency. Finally, they only consider the costs of efficiency measures themselves, ignoring any programmatic costs (e.g., marketing, analysis, administration, program evaluation, etc.) that would be necessary to capture them.

The consultants pre-screened possible energy efficiency technologies for several reasons. Measure pre-screening removed measures that were not commercially available, were already at current code, or were not applicable to the District. Furthermore, all measures that were not found to be cost-effective based on the results of the societal cost test were excluded from the economic and achievable potential. Then allocation factors were readjusted and applied to the remaining measures that were cost effective. The societal cost test is defined in greater detail in Section 5.6 below.

5.6 DETERMINING COST-EFFECTIVENESS

The consultants utilized the DC Sustainable Energy Utility Measurement and Verification Framework to determine cost-effectiveness for energy efficiency measures in this potential study. The cost effectiveness test that was used is the Societal Cost Test (SC).

5.6.1 Societal Cost Test

The SC test aims to quantify the impact of an energy efficiency program on society as a whole, and therefore, measures the net costs and benefits of a demand-side management 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 order to determine the overall benefit to society of a measure/program, the SC test places particular emphasis on societal and environmental effects of a program typically not considered by other cost effectiveness tests. For example, the SC test aims to quantify positive program externalities such as:

- The environmental benefits of avoided transmission and distribution costs

- The environmental benefits of avoided generation costs
- The benefit of increased system reliability
- Non-energy benefits (water, waste, etc.)
- Low-income or elderly population benefits
- Benefits of fuel diversity

In general, the costs in the SC test (incremental or full cost depending on whether the measure was replaced on burnout or is an early replacement) are the program costs paid by the utility (or program administrator) and the participants. Thus all equipment costs, installation, operation and maintenance, cost of removal and administration costs, no matter who pays for them, are included in this test. According to the National Action Plan for Energy Efficiency Guide titled "Understanding Cost Effectiveness of Energy Efficiency Programs", any tax credits are considered transfer payments for the SC test, and therefore, are excluded from the analysis. For purposes of this study, administrative costs were not included for the measure cost effectiveness screening conducted to develop the estimates of economic potential. Administrative program costs are included in SC tests for achievable potential.

5.6.2 Avoided Costs

The avoided cost forecasts utilized to measure cost-effective screening and for reporting potential benefits were based on the DC Sustainable Energy Utility Measurement and Verification Framework, including energy, transmission, distribution, and capacity avoided costs. The discount rate used in the calculation of the District SC Test is the 10-year treasury rate. Avoided energy costs are time and seasonally differentiated where possible.

5.7 ACHIEVABLE POTENTIAL

Achievable potential was determined as the amount of energy and demand that can realistically be saved assuming an aggressive program marketing strategy and with three program incentive scenarios. Achievable potential takes into account barriers that hinder consumer adoption of energy efficiency measures such as financial, political and regulatory barriers, and the capability of programs and administrators to ramp up activity over time. The potential study evaluates three achievable potential scenarios:

- The Maximum Achievable potential scenario is based on incentives equal to 100% of measure incremental costs
- The Base Achievable potential scenario is based on incentive levels comparable to current DCSEU spending levels
- The Constrained Achievable potential scenario is a scaled down version the Base Achievable potential scenario in which the incentives offered are significantly lower than current DCSEU spending levels. In general, the incentives assumed in this scenario are half of those assumed in the Base Achievable potential scenario.

While many different incentive scenarios could be modeled, the number of achievable potential scenarios that could be developed was limited to three scenarios due to the available budget for this potential study. The consultants analyzed the three selected achievable potential scenarios with different anticipated penetration curves or market acceptance models for each incentive level. In each of the achievable potential scenarios, the penetration curves are based on an expected market adoption given the level of incentives associated with each scenario. For the residential sector, the consultants estimated the market adoption using the results of a survey of multifamily building property managers which ascertained the property managers' willingness to participate in hypothetical energy efficiency programs at given levels of incentives for a variety of end use measures[38]. The consultants chose to use this

[38] Massachusetts Multifamily Market Characterization and Potential Study Volume 1, May 2012. The Cadmus Group, et. al.

approach in order to use the results of actual survey data and to differentiate the anticipated market adoption across measures and end-uses, in lieu of assuming a universal market adoption rate across all measures or groups of measures, which would be based solely on professional judgment. The chosen approach provides real data in conjunction with professional judgment, which was used to verify the reasonableness of the assumed market adoption rates across the various end uses. For the non-residential sector, the consultants used a similar approach based on data collected from surveys of businesses in the state of Maine. These three penetration scenarios contain uncertainty based on consumer's actual willingness to participate in programs offered by the DCSEU.

For new construction, energy efficiency measures can be implemented when each new home or building is constructed, thus the rate of availability is a direct function of the rate of new construction. For existing buildings, determining the annual rate of availability of savings is more complex. Energy efficiency potential in the existing stock of buildings can be captured over time through three 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")
2) At any time in the life of the equipment or building (referred to as "retrofit")
3) When a new home or building is constructed

For the replace-on-burnout measures, existing equipment is assumed to be replaced with high-efficiency equipment at the time a consumer is shopping for a new appliance or other energy consuming equipment, 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 is 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. For new construction, savings are achieved at the time the building is completed.

6 RESIDENTIAL ELECTRIC AND NATURAL GAS ENERGY EFFICIENCY POTENTIAL ESTIMATES

This section provides electric and natural gas energy efficiency potential estimates for the residential sector in Washington D.C. which includes all residential buildings. Estimates of technical, economic and achievable potential are provided. Electric and natural gas potential are presented as separate sections, but interactive effects and measures that yield both electric and natural gas savings are fully accounted for in the analysis.

6.1 RESIDENTIAL ELECTRIC POTENTIAL

According to 2010 historical sales data, the residential sector accounts for approximately 90% of total customers and 18% of total energy sales. The average residential consumer uses approximately 9,300 kWh per year. From 2001-2011, the residential sector in DC grew at a compound rate of 2.51%. For this study, residential MWh sales are estimated to increase 1.48% annually based upon the January 2013 PJM Load Forecast Report[39]. The residential electric potential calculations are based upon these approximate consumption values and sales forecast figures over the time horizon covered by the study. The potential is calculated for the entire residential sector and includes breakdowns of the potential associated with each end use, such as water heating and appliances.

6.1.1 Energy Efficiency Measures Examined

For the residential sector, there were 458 total electric savings measures included in the potential energy savings analysis[40]. Table 6-1 provides a brief description of the types of measures included for each end use in the residential model. The list of measures was developed based on a review of the DCSEU TRM and measures found in other residential potential studies and TRMs from regions near Washington DC. Measure data includes incremental costs, electricity energy and demand savings, gas and water savings, and measure life.

Table 6-1: Measures and Programs Included in the Electric Residential Sector Analysis

End Use Type	End Use Description	Measures Included
HVAC Envelope	Building Envelope Upgrades	• Air/duct Sealing • Improved Insulation (Wall, Ceiling, and Floor) • Efficient Windows • Radiant Barrier • Low Income Weatherization Package • New Construction Package (ENERGY STAR home)
HVAC Equipment	Heating/Cooling/Ventilation Equipment	• Existing Central AC / ASHP Tune-Up • Efficient Air-Source Heat Pumps • Geothermal Heat Pumps • Ductless Minisplit Heat Pumps & ACs • Efficient Central AC Systems • Programmable Thermostats • Efficient Room Air Conditioners

[39] PJM Load Forecast Report, January 2013. http://www.pjm.com/~/media/documents/reports/2013-load-forecast-report.ashx#page=87.

[40] This total represents the number of unique energy efficiency measures and all permutations of these unique measures. For example, there are 17 permutations of the "Improved Duct Sealing" measure to account for the various housing types, heating/cooling combinations, and construction types.

End Use Type	End Use Description	Measures Included
		• Efficient Furnace Fans
Water Heating	Domestic Hot Water	• Heat Pump Water Heater • Solar Water Heater • Low Flow Showerhead/Faucet Aerator • Pipe Wrap • Tank Wrap
Lighting	Interior/Exterior Lighting	• Specialty CFLs • Standard CFLs • LED Lighting
Appliances	High-Efficiency Appliances / Retirement of Inefficient Appliances	• ENERGY STAR Clothes Washers • ENERGY STAR Refrigerator • ENERGY STAR Freezers • ENERGY STAR Dishwashers • ENERGY STAR Dehumidifiers • Secondary Refrigerator Turn-In
Electronics	High Efficiency Consumer Electronics	• Controlled Power Strips • ENERGY STAR Desktops • Efficient Laptops • Efficient Televisions • LCD Monitors
Behavioral	Consumer Response to Feedback from Utility	• Direct (Real-Time) Feedback • Indirect Feedback
Other	Efficient Pool Equipment	• Variable Speed/Two-Speed Pool Pump and Motor

6.1.2 Overview of Residential Electric Energy Efficiency Potential

This section presents estimates for electric technical, economic, and achievable potential for the residential sector. Each of the tables in the technical, economic and achievable sections present the respective potential for efficiency savings expressed as cumulative energy savings (MWh), percentage of savings by end use, and savings as a percentage of forecast sales. Data is provided on a 5-year and 10-year time horizon for Washington D.C.

This energy efficiency potential study considers the impacts of the Energy and Independence and Security Act (EISA) as an improving code standard for the residential sector. The EISA improves the baseline efficiency of several types of lighting products, including compact fluorescent lamps (CFL). Other known increases to federal minimum efficiency standards over the time period studied have also been accounted for in the analysis. These included changes to the efficiency standards of room and central air conditioners, heat pumps, electric water heaters, and appliances.

There are a variety of factors which contribute to uncertainty surrounding the savings estimates produced by this energy efficiency potential study. These factors can include the following:

- Uncertainty about economic and fuel price forecasts used as inputs to the electric and natural gas sales forecasts
- The accuracy of results generated by building energy simulation modeling software
- The lack of availability of up-to-date baseline and efficiency saturation data for the District
- Changes to codes and standards in the future which cannot be anticipated at the present time
- Unknown future funding levels for the DCSEU

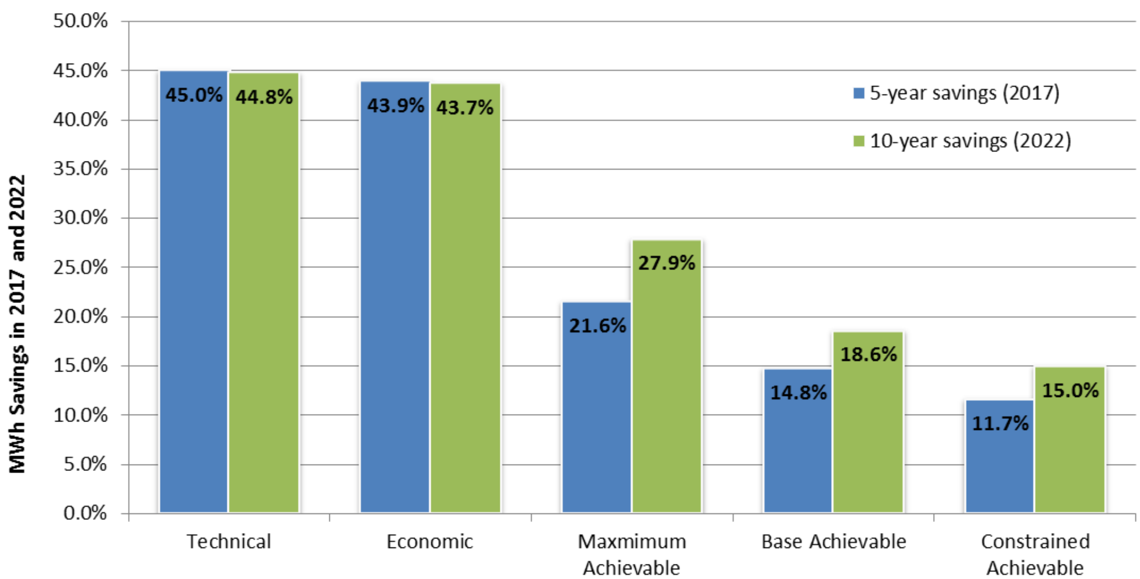
- Uncertainty regarding the future adoption of energy efficiency technologies which have minimal market share at the present time, such as LED lighting.

The consultants have addressed the areas of uncertainty as robustly as possible given the time and budget constraints of this project. For example, no sales forecast of either residential or commercial gas consumption or electric consumption was provided to the consultants by the utilities serving Washington D.C., which created a need for the consultants to develop these forecasts using the best available secondary data.

SUMMARY OF FINDINGS

Figure 6-1 illustrates the estimated savings potential for each of the scenarios included in this study.

Figure 6-1: Summary of Residential Electric Energy Efficiency Potential as a % of 2017 and 2022 Sales Forecasts



The potential estimates are expressed as cumulative 5-year and 10-year savings, as percentages of the respective 2017 and 2022 sector sales. The technical potential is 45.0% in 2017 and 44.8% in 2022. The 5-year and 10-year economic potential is 43.9% and 43.7%. The slight drop from technical potential to economic potential indicates that most measures are cost-effective. The 5-year and 10-year achievable potential savings are: 21.6% and 27.9% for the Maximum Achievable scenario; 14.8% and 18.6% for the Base Achievable scenario; and 11.7% and 15.0% for the Constrained Achievable scenario. The Maximum Achievable scenario assumes 100% incentives, the Base Achievable scenario assumes approximately 35% incentives, and the Constrained Achievable scenario assumes approximately 18% incentives[41], with a cap of 25% of incremental cost for all non-early-retirement measures.

[41] To the extent possible, the consultants used the current incentives posted on the DCSEU website for the Base Achievable scenario. The consultants identified incentive amounts for duct sealing, clothes washers, refrigerators and LED lighting measures. The consultants assumed $10/bulb incentive for LED lighting (the website indicated the rebates for LED lighting are either $5 or $10). However, for all remaining measures, the consultants assumed a 35% incentive based on limited information regarding the Home Performance program. For the Constrained Achievable scenario, in general, the consultants assumed incentives equal to half of the Base Achievable scenario. Refer to Section 6.1.3 for further discussion on the Constrained Achievable scenario incentives.

TECHNICAL POTENTIAL

Technical potential represents the quantification of savings that can be realized if all technologically available energy-efficiency measures are immediately adopted in all feasible instances, regardless of cost. Table 6-2 shows that it is technically feasible to save nearly 1 million MWh in the residential sector between 2013 to 2017, as well as approximately 1.1 million MWh during the 10 year period from 2013 to 2022 across Washington D.C., representing 45% of 5-year residential sales, and 44.8% of 10-year residential sales. Lighting represents the greatest contributor to the potential at 27% of savings, while the HVAC Envelope and HVAC Equipment end uses each contribute more than 20% of the savings. Table 6-3 shows the demand savings potential in 2017 and 2022. The five and ten year summer peak demand savings potential is 245 MW and 264 MW, respectively, which is 35.8% and 36.0% of the peak forecast. The five and ten year winter peak demand savings potential is 339 MW and 369 MW, respectively, which is 71.4% and 72.7% of the peak forecast.

Table 6-2: Residential Sector Technical Potential Energy Savings by End Use

Residential Technical Potential Savings by End Use				
	2017	% of 2017	2022	% of 2022
End Use	Energy (MWh)	Savings	Energy (MWh)	Savings
Appliances	73,743	7%	78,510	7%
Electronics	136,166	14%	154,126	14%
Lighting	271,517	27%	292,294	27%
Water Heating	57,706	6%	62,751	6%
Other	2,169	0%	2,355	0%
HVAC (Envelope)	200,060	20%	207,053	19%
HVAC (Equipment)	219,933	22%	227,465	21%
Behavioral Programs	37,384	4%	39,838	4%
Total	**998,677**	**100%**	**1,064,393**	**100%**
% of Annual Sales Forecast	*45.0%*		*44.8%*	

Table 6-3: Residential Sector Technical Potential Demand Savings

Residential Technical Potential Savings Demand Savings				
	Summer Peak Demand		Winter Peak Demand	
	2017	2022	2017	2022
Summary	MW	MW	MW	MW
Total	**245**	**264**	**339**	**369**
% of Peak	*35.8%*	*36.0%*	*71.4%*	*72.7%*

ECONOMIC POTENTIAL

Economic potential is a subset of technical potential, which only accounts for measures that are cost-effective, based on a screening using the Societal Cost Test (SCT), when calculating the savings potential. The SCT was used for this study because it is mandated by the District to be the cost-effectiveness test used when considering energy efficiency programs in Washington D.C. The test includes a 30% adder to electric and natural gas benefits. 89% of all measures that were included in the electric potential analysis passed the SCT.

Table 6-4 indicates that the economic potential is nearly 1 million MWh during the 5 year period from 2013 to 2017, and the economic potential increases to slightly more than 1 million MWh during the 10 year period from 2013 to 2022. This represents 43.9% and 43.7% of residential sales across the respective 5-year and 10-year timeframes. Similar to the technical potential scenario, lighting represents the greatest contributor to the potential at more than 25% of savings, while the HVAC Envelope and the HVAC Equipment end uses each contribute approximately 20% of the savings. Table 6-5 shows the demand savings potential in 2017 and 2022. The five and ten year summer peak demand savings potential is 245 MW and 264 MW, respectively, which is 35.8% and 36.0% of the peak forecast. The five and ten year winter peak demand savings potential is 339 MW and 369 MW, respectively, which is 71.4% and 72.7% of the peak forecast.

Table 6-4: Residential Sector Economic Potential Energy Savings by End Use

Residential Economic Potential Savings by End Use				
	2017	% of 2017	2022	% of 2022
End Use	Energy (MWh)	Savings	Energy (MWh)	Savings
Appliances	73,743	8%	78,510	8%
Electronics	137,202	14%	155,347	15%
Lighting	271,517	28%	292,294	28%
Water Heating	58,538	6%	63,658	6%
Other	2,169	0%	2,355	0%
HVAC (Envelope)	196,527	20%	203,518	20%
HVAC (Equipment)	197,568	20%	203,094	20%
Behavioral Programs	37,384	4%	39,838	4%
Total	**974,647**	**100%**	**1,038,615**	**100%**
% of Annual Sales Forecast	*43.9%*		*43.7%*	

Table 6-5: Residential Sector Economic Potential Demand Savings

Residential Economic Potential Savings Demand Savings				
	Summer Peak Demand		Winter Peak Demand	
	2017	2022	2017	2022
Summary	MW	MW	MW	MW
Total	**238**	**256**	**339**	**369**
% of Peak	*34.8%*	*34.9%*	*71.5%*	*72.8%*

6.1.3 Achievable Potential Savings in the Residential Sector

Achievable potential is an estimate of energy savings that can feasibly be achieved given market barriers and equipment replacement cycles. This study estimated achievable potential for three scenarios corresponding to varying incentive levels provided to end-use consumers. The Maximum Achievable potential scenario is based on the assumption that incentives are equal to 100% of incremental costs. The Base Achievable potential scenario is based on the assumption that incentives are equal to the current level of incentives offered by the DCSEU. Low-income measures are assumed to have 100% incentives in the Base Achievable scenario. The Constrained Achievable potential scenario is based on the assumption that incentives are equal to half of the Base Achievable scenario. Exceptions to this assumption include: low-income measures are still assumed to be eligible for 100% incentives; the incentive amount is capped at 25% of incremental cost in the Constrained Achievable scenario for all non-low-income measures.

Tables 6-6 through Table 6-11 show the estimated savings for the achievable scenarios over 5 and 10 year time horizons. The 5-year and 10-year Maximum Achievable potential savings estimates are approximately 478 thousand MWh and 663 thousand MWh. This equates to 21.6% and 27.9% of sector sales in 2017 and 2022. The respective 5-year and 10-year Base Achievable potential savings estimates are approximately 328 thousand MWh and 442 thousand MWh. This equates to 14.8% and 18.6% of sector sales in 2017 and 2022. The respective 5-year and 10-year Constrained Achievable potential savings estimates are approximately 258 thousand MWh and 357 thousand MWh. This equates to 11.7% and 15.0% of sector sales in 2017 and 2022. The ten year demand savings estimates in the Base Achievable scenario are 120 MW in the summer and 202 MW in the winter, which represents 16.3% and 39.8% of the peak demand forecast for the respective summer and winter seasons in 2022.

Table 6-6: Residential Maximum Achievable Energy Savings by End Use

Residential Maximum Achievable Potential Savings by End Use				
	2017	% of 2017	2022	% of 2022
End Use	Energy (MWh)	Savings	Energy (MWh)	Savings
Appliances	28,219	6%	53,497	8%
Electronics	98,879	21%	107,658	16%
Lighting	183,634	38%	204,830	31%
Water Heating	26,957	6%	49,915	8%
Other	921	0%	1,858	0%
HVAC (Envelope)	69,019	14%	138,645	21%
HVAC (Equipment)	39,491	8%	75,777	11%
Behavioral Programs	30,964	6%	31,050	5%
Total	**478,083**	100%	**663,229**	**100%**
% of Annual Sales Forecast	*21.6%*		*27.9%*	

Table 6-7: Residential Maximum Achievable Potential Demand Savings

Residential Maximum Achievable Potential Savings Demand Savings				
	Summer Peak Demand		Winter Peak Demand	
	2017	2022	2017	2022
Summary	MW	MW	MW	MW
Total	**115**	**180**	**179**	**273**
% of Peak	*16.8%*	*24.6%*	*37.8%*	*53.9%*

Table 6-8: Residential Base Achievable Savings Potential Energy Savings by End Use

Residential Base Achievable Potential Savings by End Use				
	2017	% of 2017	2022	% of 2022
End Use	Energy (MWh)	Savings	Energy (MWh)	Savings
Appliances	17,480	5%	32,876	7%
Electronics	58,111	18%	69,100	16%
Lighting	146,587	45%	148,654	34%
Water Heating	13,117	4%	26,841	6%
Other	390	0%	840	0%
HVAC (Envelope)	47,299	14%	96,911	22%
HVAC (Equipment)	17,333	5%	39,667	9%
Behavioral Programs	27,377	8%	27,452	6%
Total	**327,693**	**100%**	**442,342**	**100%**
% of Annual Sales Forecast	*14.8%*		*18.6%*	

Table 6-9: Residential Base Achievable Potential Demand Savings

Residential Base Achievable Potential Savings Demand Savings				
	Summer Peak Demand		Winter Peak Demand	
	2017	2022	2017	2022
Summary	MW	MW	MW	MW
Total	**76**	**120**	**130**	**202**
% of Peak	*11.0%*	*16.3%*	*27.3%*	*39.8%*

Table 6-10: Residential Constrained Achievable Savings Potential Energy Savings by End Use

Residential Constrained Achievable Potential Savings by End Use				
	2017	% of 2017	2022	% of 2022
End Use	Energy (MWh)	Savings	Energy (MWh)	Savings
Appliances	13,663	5%	24,714	7%

Residential Constrained Achievable Potential Savings by End Use				
Electronics	46,346	18%	57,121	16%
Lighting	110,630	43%	115,944	33%
Water Heating	12,361	5%	24,895	7%
Other	331	0%	701	0%
HVAC (Envelope)	34,114	13%	69,985	20%
HVAC (Equipment)	16,385	6%	36,658	10%
Behavioral Programs	24,633	10%	26,510	7%
Total	**258,463**	**100%**	**356,529**	**100%**
% of Annual Sales Forecast	*11.7%*		*15.0%*	

Table 6-11: Residential Constrained Achievable Potential Demand Savings

Residential Constrained Achievable Potential Savings Demand Savings				
	Summer Peak Demand		**Winter Peak Demand**	
	2017	**2022**	**2017**	**2022**
Summary	**MW**	**MW**	**MW**	**MW**
Total	**64**	**102**	**111**	**177**
% of Peak	*9.3%*	*14.0%*	*23.4%*	*34.9%*

Figure 6-2 shows the percentage of savings by each end use for the Base Achievable potential scenario. The lighting end use shows the largest potential for savings with 34% of total savings, followed by the HVAC Envelope end use at 22% of total savings.

Figure 6-2: Residential Sector 2022 Achievable Potential Savings for the Base Achievable Scenario, by End Use

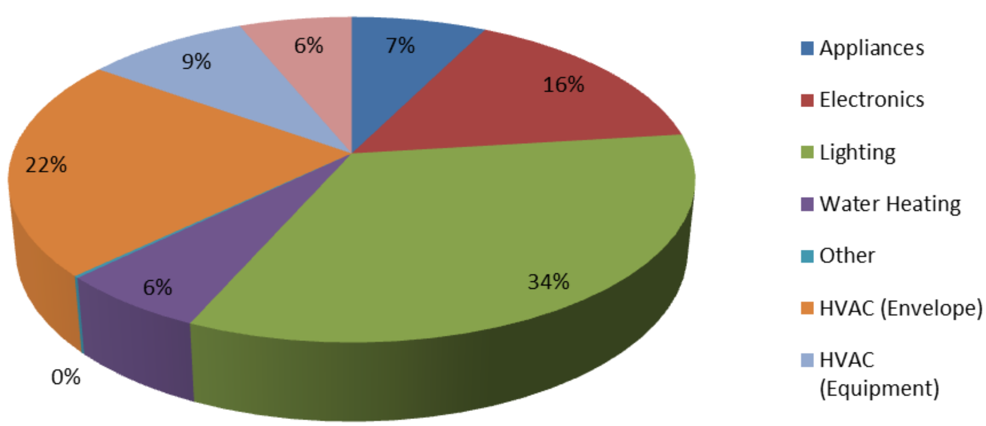


Figure 6-3 shows the breakdown of estimated savings in 2022 by housing type, low-income designation and new construction measures, for the Base Achievable potential scenario. The savings are largely coming from existing/turnover measures, meaning energy efficient equipment is installed in replacement of existing equipment that has failed. The existing single-family attached housing and existing multi-family housing types lead the way with 32% of savings each, followed by and 21% coming from existing single-family detached homes. New construction measures account for 8% of total savings and low-income measures account for 7% of total savings. The low-income measures represent only those measures which apply strictly to low-income households, and do not represent the "low-income potential" in the District. There is also low-income potential that is subsumed by the other 93% of the savings associated with the "non-low-income" measures. This report does not provide an estimate of the low-income potential.

Figure 6-3: Residential Base Achievable Savings in 2022, by Housing Type, Low-Income Designation and New Construction Measures

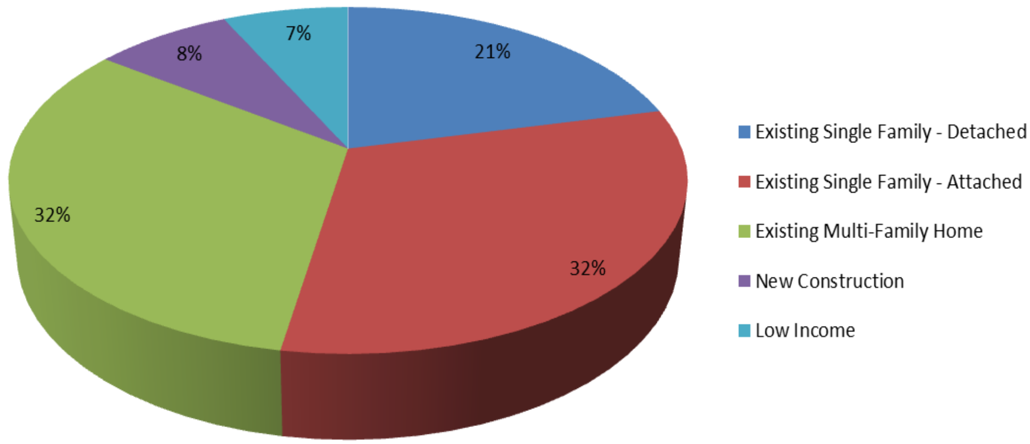


Table 6-12, Table 6-13 and Table 6-14 shows cumulative energy savings for all three achievable potential scenarios for each year across the 10-year time horizon for the study, broken out by end use.

Table 6-12: Cumulative Annual Residential Energy Savings in the Maximum Achievable Potential Scenario, by End Use for Washington D.C.

Cumulative Annual MWh Savings - Maximum Achievable by End Use										
End Use	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Appliances	5,613	11,241	16,885	22,544	28,219	33,911	39,620	45,348	49,413	53,497
Electronics	22,777	45,611	68,501	91,448	98,879	106,352	106,668	106,992	107,321	107,658
Lighting	37,842	75,750	111,119	147,079	183,634	216,241	220,848	227,571	216,469	204,830
Water Heating	5,358	10,730	16,123	21,531	26,957	31,747	36,265	40,797	45,347	49,915
Other	184	367	551	736	921	1,108	1,294	1,481	1,670	1,858
HVAC (Envelope)	13,760	27,540	41,344	55,169	69,019	82,896	96,795	110,719	124,670	138,645
HVAC (Equipment)	7,873	15,758	23,657	31,567	39,491	47,379	54,457	61,549	68,656	75,777
Behavioral Programs	22,458	26,693	30,932	30,948	30,964	30,981	30,997	31,015	31,032	31,050
Total	**115,864**	**213,690**	**309,110**	**401,022**	**478,083**	**550,614**	**586,945**	**625,472**	**644,579**	**663,229**
% of Annual Sales Forecast	*5.5%*	*10.1%*	*14.3%*	*18.3%*	*21.6%*	*24.5%*	*25.7%*	*27.0%*	*27.5%*	*27.9%*

Table 6-13: Cumulative Annual Residential Energy Savings in the Base Achievable Potential Scenario, by End Use for Washington D.C.

Cumulative Annual MWh Savings – Base Achievable by End Use										
End Use	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Appliances	3,243	6,621	10,135	13,754	17,480	21,214	24,957	28,708	30,789	32,876
Electronics	9,690	21,247	34,696	48,187	58,111	66,700	67,869	68,591	68,842	69,100
Lighting	26,172	56,418	87,023	117,080	146,587	172,859	175,142	170,951	159,507	148,654
Water Heating	1,788	4,130	7,022	10,021	13,117	15,951	18,551	21,209	23,972	26,841
Other	70	144	222	304	390	478	567	658	748	840
HVAC (Envelope)	9,214	18,555	28,014	37,597	47,299	57,090	66,965	76,920	86,899	96,911
HVAC (Equipment)	2,667	5,737	9,204	13,062	17,333	21,864	25,891	30,217	34,813	39,667
Behavioral Programs	8,683	15,918	24,207	26,314	27,377	27,391	27,406	27,420	27,437	27,452
Total	**61,528**	**128,769**	**200,524**	**266,319**	**327,693**	**383,546**	**407,348**	**424,673**	**433,008**	**442,342**
% of Annual Sales Forecast	*2.9%*	*6.1%*	*9.3%*	*12.2%*	*14.8%*	*17.0%*	*17.9%*	*18.4%*	*18.5%*	*18.6%*

Table 6-14: Cumulative Annual Residential Energy Savings in the Constrained Achievable Potential Scenario, by End Use for Washington D.C.

Cumulative Annual MWh Savings – Constrained Achievable by End Use										
End Use	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Appliances	2,581	5,245	7,995	10,800	13,663	16,532	19,407	22,288	23,499	24,714
Electronics	7,837	16,930	27,305	38,015	46,346	53,932	55,650	56,639	56,877	57,121
Lighting	17,863	40,371	64,342	87,760	110,630	130,686	135,013	132,892	124,183	115,944
Water Heating	1,722	3,941	6,669	9,476	12,361	14,987	17,369	19,797	22,304	24,895
Other	62	125	191	259	331	403	476	550	625	701
HVAC (Envelope)	6,665	13,407	20,234	27,135	34,114	41,169	48,300	55,510	62,739	69,985
HVAC (Equipment)	2,581	5,515	8,786	12,410	16,385	20,576	24,222	28,142	32,285	36,658
Behavioral Programs	8,089	14,248	21,011	22,820	24,633	25,849	26,465	26,480	26,495	26,510
Total	**47,399**	**99,781**	**156,534**	**208,676**	**258,463**	**304,134**	**326,901**	**342,297**	**349,006**	**356,529**
% of Annual Sales Forecast	*2.3%*	*4.7%*	*7.3%*	*9.5%*	*11.7%*	*13.5%*	*14.3%*	*14.8%*	*14.9%*	*15.0%*

6.1.4 Residential Savings Summary

Table 6-15 provides an end-use breakdown of the residential savings potential estimates for technical and economic potential, and each of the three achievable potential scenarios. The table indicates how the savings potential decreases systematically from the technical potential scenario to the Constrained Achievable potential scenario as additional limiting factors such as cost-effectiveness requirements and anticipated market adoption at given funding levels are introduced.

Table 6-15: Breakdown of Residential Cumulative Annual Electric Savings Potential for Technical, Economic and Achievable Potential, by End Use for Washington D.C.

End Use	Technical Potential (MWh)	Economic Potential (MWh)	Max. Achievable Potential (MWh)	Base Achievable Potential (MWh)	Constrained Achievable Scenario (MWh)
Appliances					
ENERGY STAR Refrigerators	30,067	30,067	20,365	8,948	4,188
ENERGY STAR Freezers	2,308	2,308	1,559	1,186	1,125
ENERGY STAR Clothes Washers	23,043	23,043	16,785	8,176	5,153
ENERGY STAR Dishwashers	823	823	650	570	458
ENERGY STAR Dehumidifiers	1,015	1,015	723	580	375
2nd Refrigerator Turn-In	21,253	21,253	13,416	13,416	13,416
Electronics					
Controlled Power Strips	71,548	71,548	51,040	16,708	12,376
Efficient Desktop PCs	12,699	12,699	8,919	6,371	5,878
Efficient Laptop PCs	1,941	3,162	2,015	1,728	764
Efficient Televisions	66,460	66,460	44,769	43,421	37,434
Efficient LCD Monitors	1,478	1,478	916	873	669
Lighting					
Specialty CFL Bulbs	132,244	132,244	95,390	83,364	63,670
Standard Screw-In CFL Bulbs	68,535	68,535	32,589	32,589	24,676
LED Screw-In Bulbs	46,867	46,867	44,951	3,409	1,547
Exterior Lighting	35,651	35,651	25,610	23,002	20,112
Water Heating					
Heat Pump Water Heater	21,399	32,093	25,302	6,562	5,349
Solar Water Heating	9,788	0	0	0	0
Tank Wrap	2,197	2,197	1,734	1,734	1,734
Pipe Wrap	9,017	9,017	7,115	5,599	5,387
Low Flow Showerheads	15,760	15,760	12,439	10,594	10,327
Low Flow Faucet Aerators	4,591	4,591	3,324	2,353	2,098
Other					
Efficient Pool Pump Motors	2,355	2,355	1,858	840	701
HVAC (Envelope)					
Ceiling/Attic Insulation	22,693	19,158	15,832	15,189	7,373

End Use	Technical Potential (MWh)	Economic Potential (MWh)	Max. Achievable Potential (MWh)	Base Achievable Potential (MWh)	Constrained Achievable Scenario (MWh)
Wall Insulation	32,414	32,414	26,619	25,600	14,934
Floor Insulation	4,619	4,619	3,656	1,693	1,543
Air Sealing	23,656	23,656	18,664	9,837	6,589
Duct Sealing	17,062	17,062	13,466	6,882	3,949
ENERGY STAR Windows	51,655	51,655	17,024	6,534	5,406
Radiant Barriers	9,876	9,876	7,797	988	159
Low Income Weatherization Package	37,806	37,806	29,845	29,845	29,845
New Homes Construction Package	7,274	7,274	5,743	343	189
HVAC (Equipment)					
ENERGY STAR Air Source Heat Pumps	87,537	90,139	32,856	12,700	11,453
Geothermal Heat Pumps	12,860	11,382	2,709	935	818
ENERGY STAR Central Air Conditioners	7,600	0	0	0	0
ENERGY STAR Room Air Conditioners	18,069	22,678	9,446	6,953	6,556
Tune-Up	1,948	386	243	195	183
Ductless Mini-Split Systems	51,161	33,183	14,996	8,253	7,668
Programmable Thermostats	5,859	2,895	1,549	1,027	882
Efficient Furnace Fan Motors	42,431	42,431	13,978	9,605	9,098
Behavioral Programs					
Direct Feedback (In-Home Energy Display)	16,119	16,119	12,768	11,205	10,796
Indirect Feedback (Monthly Energy Use Reports)	23,719	23,719	18,281	16,247	15,713
Total	**1,064,393**	**1,038,615**	**663,229**	**442,342**	**356,529**
% of Annual 2022 Sales Forecast	**44.8%**	**43.7%**	**27.9%**	**18.6%**	**15.0%**
Note: Measures in the above Table with "0" achievable potential are ones that did not pass the SCT Test.					

6.2 RESIDENTIAL NATURAL GAS POTENTIAL

The consultants generated natural gas consumption forecasts for the residential, commercial and institutional segments of the District economy indicate that natural gas demand will increase from 33 trillion BTU in 2011 to 37 trillion BTU in 2023 (representing a compound average annual rate of growth of .9%)[42]. The residential sector is expected to grow more slowly compared to the commercial sector and institutional sector, with a forecasted average annual growth rate for 2011 to 2023 of 0.02%. These forecasts are based on EIA Annual Energy Outlook growth rates. The residential gas potential calculations are based upon these approximate consumption values and sales forecast figures over the time horizon covered by the study. The potential is calculated for the entire residential sector and includes breakdowns of the potential associated with each end use, such as water heating and appliances.

[42] The consultants generated these forecasts because the utility did not provide a forecast of their own.

6.2.1 Energy Efficiency Measures Examined

For the residential sector, there were 251 natural gas savings measures included in the potential gas savings analysis[43]. Table 6-16 provides a brief description of the types of measures included for each end use in the residential model. The list of measures was developed based on a review of the DCSEU. TRM and measures found in other residential potential studies and TRMs from regions near Washington D.C. Measure data includes incremental costs, electricity energy and demand savings, gas and water savings, and measure life.

Table 6-16: Measures and Programs Included in the Gas Residential Sector Analysis

End Use Type	End Use Description	Measures Included
HVAC Envelope	Building Envelope Upgrades	• Air/duct Sealing • Improved Insulation (Wall, Ceiling, and Floor) • Efficient Windows • Radiant Barrier • Low Income Weatherization Package • New Construction Package (ENERGY STAR home)
HVAC Equipment	Heating/Cooling/Ventilation Equipment	• Existing Gas Furnace/Boiler Tune-up • Efficient Gas Furnaces • Efficient Gas Boilers • Programmable Thermostats
Water Heating	Domestic Hot Water	• Efficient Gas Storage Tank WH • Tankless Gas WH • Low Flow Showerhead/Faucet Aerator • Pipe Wrap • Tank Wrap
Appliances	High-Efficiency Appliances / Retirement of Inefficient Appliances	• ENERGY STAR Clothes Washers • ENERGY STAR Dishwashers
Behavioral	Consumer Response to Feedback from Utility	• Direct (Real-Time) Feedback • Indirect Feedback

6.2.2 Overview of Residential Natural Gas Energy Efficiency Potential

This section presents estimates for gas technical, economic, and achievable potential for the residential sector. Each of the tables in the technical, economic and achievable sections present the respective potential for efficiency savings expressed as cumulative energy savings (MMBtu) percentage of savings by end use, and savings as a percentage of forecast sales. Data is provided on a 5-year and 10-year time horizon for Washington D.C.

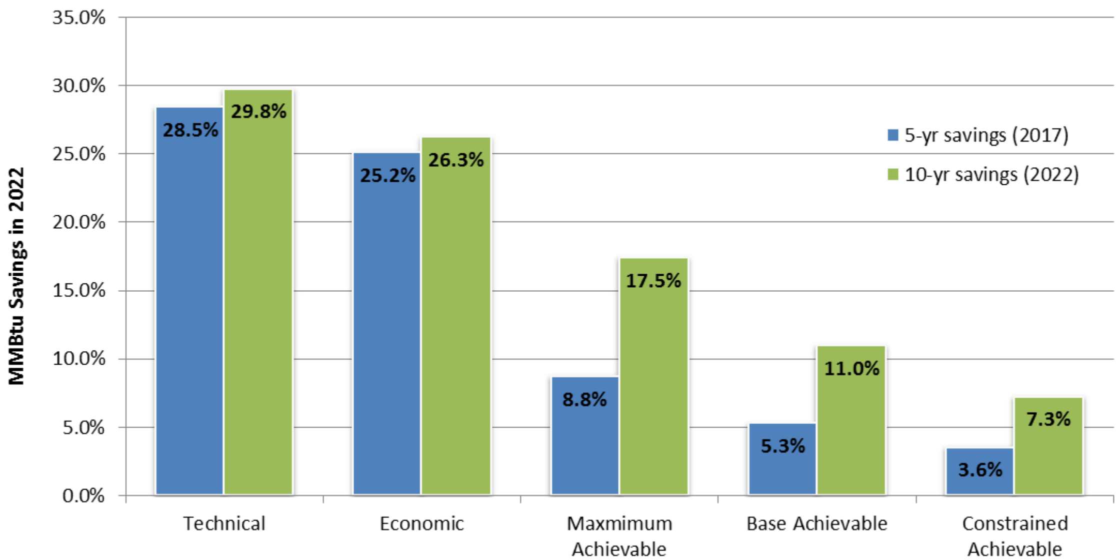
This energy efficiency potential study considers the impacts of the Energy and Independence and Security Act (EISA) as an improving code standard for the residential sector. The EISA improves the baseline efficiency of several types of lighting products, including compact fluorescent lamps (CFL). Other known increases to federal minimum efficiency standards over the time period studied have also been accounted for in the analysis. These included changes to the efficiency standards of room and central air conditioners, heat pumps, electric water heaters, and appliances.

[43] This total represents the number of unique energy efficiency measures and all permutations of these unique measures. For example, there are 6 permutations of the "Programmable Thermostat" measure to account for the various housing types, heating/cooling combinations, and construction types.

SUMMARY OF FINDINGS

Figure 6-4 illustrates the estimated savings potential for each of the scenarios included in this study.

Figure 6-4: Summary of Residential Energy Efficiency Potential as a % of 2017 and 2022 Sales Forecasts



The potential estimates are expressed as cumulative 5-year and 10-year savings, as percentages of the respective 2017 and 2022 sector sales. The technical potential is 28.5% in 2017 and 29.8% in 2022. The 5-year and 10-year economic potential is 25.2% and 26.3%. The slight drop from technical potential to economic potential indicates that most measures are cost-effective based on the SCT measure-level screening. The 5-year and 10-year achievable potential savings are: 8.8% and 17.5% for the Maximum Achievable scenario; 5.3% and 11.0% for the Base Achievable scenario; and 3.6% and 7.3% for the Constrained Achievable scenario. The Maximum Achievable scenario assumes 100% incentives, the Base Achievable scenario assumes approximately 35% incentives, and the Constrained Achievable scenario assumes approximately 18% incentives[44], with a cap of 25% of incremental cost for all non-early-retirement measures.

TECHNICAL POTENTIAL

Technical potential represents the quantification of savings that can be realized if all technologically available energy-efficiency measures are immediately adopted in all feasible instances, regardless of cost. Table 6-17 shows that it is technically feasible to save about 3.5 million MMBtu in the residential sector between 2013 and 2017 and approximately 3.7 million MMBtu during the 10 year period from 2013 to 2022 across Washington D.C., representing more than 28% of 5-year residential sales, and nearly 30% of 10-year residential sales. The HVAC Envelope end use represents the greatest contributor to the potential at 59% of 10-yr savings, while the Water Heating end use contributes 27% of the 10-yr savings, and the HVAC Equipment end use contributes 16% of the 10-yr savings. The lighting end use yields an 8% gain in consumption. While there is significant potential for electric savings in the lighting end use,

[44] To the extent possible, the consultants used the current incentives posted on the DCSEU website for the Base Achievable scenario. the consultants identified incentive amounts for duct sealing, clothes washers, refrigerators and LED lighting measures. The consultants assumed $10/bulb incentive for LED lighting (the website indicated the rebates for LED lighting are either $5 or $10. However, for all remaining measures, the consultants assumed a 35% incentive based on limited information regarding the Home Performance program. For the Constrained Achievable scenario, in general, the consultants assumed incentives equal to half of the Base Achievable scenario. Refer to Section 6.1.3 for further discussion on the Constrained Achievable scenario incentives.

this potential would produce a negative impact on natural gas potential, due to increased heating requirements associated with efficiency lighting.[45]

Table 6-17: Residential Sector Technical Potential MMBtu Savings by End Use

Residential Technical Potential Savings by End Use				
End Use	2017 Savings (MMBtu)	% of 2017 Savings	2022 Savings (MMBtu)	% of 2022 Savings
Appliances	72,459	2%	79,140	2%
Electronics	0	0%	0	0%
Lighting	-289,578	-8%	-312,039	-8%
Water Heating	931,490	26%	995,522	27%
Other	0	0%	0	0%
HVAC (Envelope)	2,106,656	60%	2,186,048	59%
HVAC (Equipment)	564,598	16%	592,000	16%
Behavioral Programs	153,073	4%	163,124	4%
Total	**3,538,697**	**100%**	**3,703,794**	**100%**
% of Annual Sales Forecast	*28.5%*		*29.8%*	

ECONOMIC POTENTIAL

Economic potential is a subset of technical potential, which only accounts for measures that are cost-effective, based on a screening using the Societal Cost Test (SCT), when calculating the savings potential. The SCT was used for this study because it is mandated by the District to be the cost-effectiveness test used when considering energy efficiency programs in Washington DC. The test includes a 30% adder to electric and natural gas benefits. 87% of all measures that were included in the gas potential analysis passed the SCT.

Table 6-18 indicates that the economic potential is more than 3 million MMBtu during the 5 year period from 2013 to 2017, and the economic potential increases to nearly 3.3 million MMBtu during the 10 year period from 2013 to 2022. This represents 25.2% and 26.3% of residential sales across the respective 5-year and 10-year timeframes. Similar to the technical potential scenario, the HVAC Envelope end use represents the greatest contributor to the potential at 64% of the 10-yr savings, while the Water Heating end use contributes 24% of the 10-yr savings, and the HVAC Equipment end use contributes 14% of the 10-yr savings.

Table 6-18: Statewide Residential Sector Economic Potential MMBtu Savings by End Use

Residential Economic Potential Savings by End Use				
End Use	2017 Savings (MMBtu)	% of 2017 Savings	2022 Savings (MMBtu)	% of 2022 Savings
Appliances	72,459	2%	79,140	2%
Electronics	0	0%	0	0%
Lighting	-289,578	-9%	-312,039	-10%
Water Heating	734,792	24%	785,710	24%
Other	0	0%	0	0%
HVAC (Envelope)	2,017,113	65%	2,096,492	64%
HVAC (Equipment)	438,029	14%	456,476	14%
Behavioral Programs	153,073	5%	163,124	5%
Total	**3,125,887**	**100%**	**3,268,903**	**100%**
% of Annual Sales Forecast	*25.2%*		*26.3%*	

45 High efficiency lighting reduces the amount of waste heat that is released during hours of lighting operation. The reduction in waste heat places a greater burden on heating equipment (electric and gas) to meet the winter heating load requirements.

6.2.3 Achievable Potential Savings in the Residential Sector

Achievable potential is an estimate of energy savings that can feasibly be achieved given market barriers and equipment replacement cycles. This study estimated achievable potential for three scenarios corresponding to varying incentive levels provided to end-use consumers. The Maximum Achievable potential scenario is based on the assumption that incentives are equal to 100% of incremental costs. The Base Achievable potential scenario is based on the assumption that incentives are equal to the current level of incentives offered by the DCSEU[46]. Low-income measures are assumed to have 100% incentives in the Base Achievable scenario. The Constrained Achievable potential scenario is based on the assumption that incentives are equal to half of the Base Achievable scenario. Exceptions to this assumption include: low-income measures are still assumed to be eligible for 100% incentives; the incentive amount is capped at 25% of incremental cost in the Constrained Achievable scenario for all non-low-income measures.

Tables 6-19 and Table 6-20 show the estimated savings for the achievable scenarios over 5 and 10 year time horizons. The 5-year and 10-year Maximum achievable potential savings estimates are approximately 1.1 million MMBtu and 2.2 million MMBtu. This equates to 8.8% and 17.5% of sector sales in 2017 and 2022. The respective 5-year and 10-year Base Achievable potential savings estimates are approximately 660 thousand MMBtu and 1.4 million MMBtu. This equates to 5.3% and 11.0% of sector sales in 2017 and 2022. The respective 5-year and 10-year Constrained Achievable potential savings estimates are approximately 440 thousand MMBtu and 900 thousand MMBtu. This equates to 3.6% and 7.3% of sector sales in 2017 and 2022.

Table 6-19: Residential Achievable Savings Potential in 2017 – Maximum, Base and Constrained Achievable Scenarios

Summary of Achievable Gas Efficiency Potential						
	Maximum Achievable		Base Achievable		Constrained Achievable	
End Use	**Energy Savings (MMBtu)**	**% of Total**	**Energy Savings (MMBtu)**	**% of Total**	**Energy Savings (MMBtu)**	**% of Total**
Appliances	28,612	3%	13,039	2%	6,897	2%
Electronics	0	0%	0	0%	0	0%
Lighting	-192,195	-18%	-154,823	-23%	-113,904	-26%
Water Heating	277,808	25%	96,866	15%	81,134	18%
Other	0	0%	0	0%	0	0%
HVAC (Envelope)	743,080	68%	541,402	82%	325,290	73%
HVAC (Equipment)	106,474	10%	51,793	8%	44,029	10%
Behavioral Programs	126,788	12%	112,318	17%	101,114	23%
Total	**1,090,567**	**100%**	**660,596**	**100%**	**444,561**	**100%**
% of Annual Sales Forecast	*8.8%*		*5.3%*		*3.6%*	

[46] To the extent possible, the consultants used the current incentives posted on the DCSEU website for the Base Achievable scenario. The consultants identified incentive amounts for duct sealing, clothes washers, refrigerators and LED lighting measures. The consultants assumed $10/bulb incentive for LED lighting (the website indicated the rebates for LED lighting are either $5 or $10). However, for all remaining measures, the consultants assumed a 35% incentive based on limited information regarding the Home Performance program. For the Constrained Achievable scenario, in general, the consultants assumed incentives equal to half of the Base Achievable scenario. Refer to Section 6.1.3 for further discussion on the Constrained Achievable scenario incentives.

Table 6-20: Residential Achievable Savings Potential in 2022 – Maximum, Base and Constrained Achievable Scenarios

Summary of Achievable Gas Efficiency Potential						
	Maximum Achievable		Base Achievable		Constrained Achievable	
End Use	Energy Savings (MMBtu)	% of Total	Energy Savings (MMBtu)	% of Total	Energy Savings (MMBtu)	% of Total
Appliances	57,803	3%	27,616	2%	14,808	2%
Electronics	0	0%	0	0%	0	0%
Lighting	-217,904	-10%	-152,774	-11%	-116,517	-13%
Water Heating	524,781	24%	188,672	14%	158,352	17%
Other	0	0%	0	0%	0	0%
HVAC (Envelope)	1,492,986	69%	1,099,417	80%	661,455	73%
HVAC (Equipment)	187,694	9%	94,510	7%	78,498	9%
Behavioral Programs	127,139	6%	112,628	8%	108,823	12%
Total	**2,172,498**	**100%**	**1,370,070**	**100%**	**905,419**	**100%**
% of Annual Sales Forecast	*17.5%*		*11.0%*		*7.3%*	

Figure 6-5 shows the estimated 10-year cumulative efficiency savings for the Base Achievable potential scenario, broken out by end use across the entire residential sector. The HVAC Envelope end use shows the largest potential for savings by a wide margin at nearly 1.1 million MMBtu, or 80% of total savings.

Figure 6-5: Residential Sector 2022 Achievable Potential Savings for the Base Achievable Scenario, by End Use

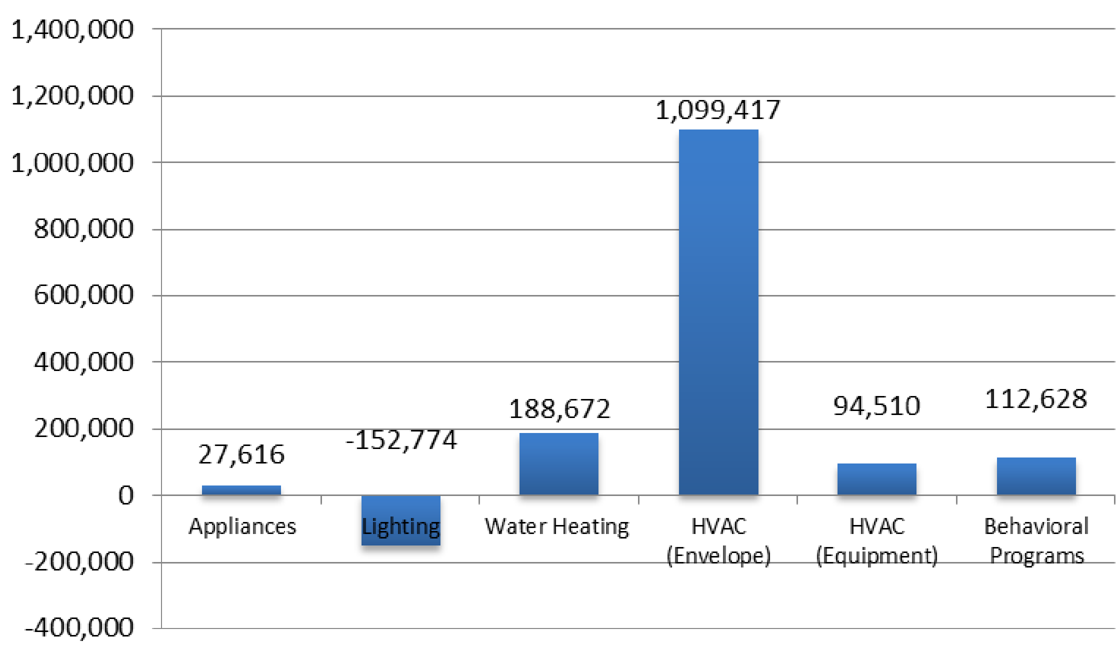


Figure 6-6 shows the breakdown of estimated savings in 2022 by housing type, low-income designation and new construction measures, for the Base Achievable potential scenario. The savings are largely coming from existing/turnover measures, meaning energy efficient equipment is installed in replacement of existing equipment that has failed. The existing single-family attached housing type leads the way with 39% of savings, followed by 26% of savings coming from existing single-family detached homes, and 13% coming from existing multi-family homes. New construction measures account for 2% of total savings and low-income measures account for 20% of total savings. The low-income measures represent only those measures which apply strictly to low-income households, and do not represent the "low-income potential" in the District. There is also low-income potential subsumed by the other 80% of the savings associated with the "non-low-income" measures. This report does not provide an estimate of the low-income potential.

Figure 6-6: Residential Base Achievable Savings in 2022, by Housing Type, Low-Income Designation and New Construction Measures

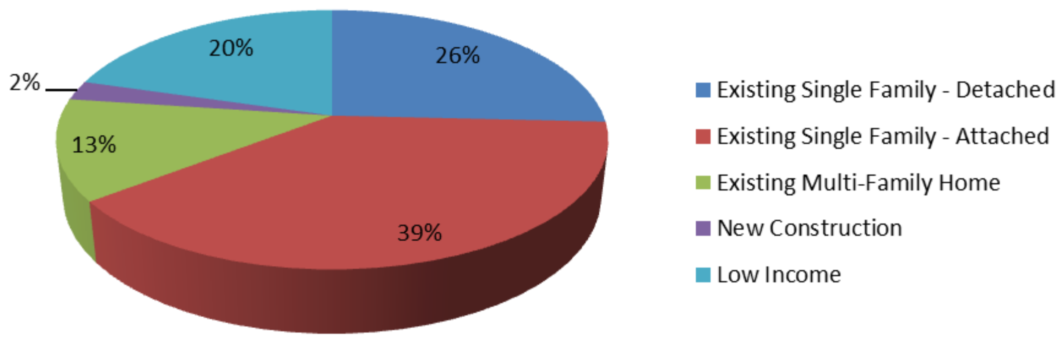


Table 6-21, Table 6-22 and Table 6-23 shows cumulative energy savings for all three achievable potential scenarios for each year across the 10-year time horizon for the study, broken out by end use.

Table 6-21: Cumulative Annual Residential Energy Savings in the Maximum Achievable Potential Scenario, by End Use for Washington D.C.

Cumulative Annual MMBtu Savings – Maximum Achievable by End Use										
End Use	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Appliances	5,681	11,381	17,103	22,848	28,612	34,405	40,220	46,062	51,922	57,803
Electronics	0	0	0	0	0	0	0	0	0	0
Lighting	-39,767	-79,605	-116,423	-153,952	-192,195	-231,791	-237,343	-245,466	-231,916	-217,711
Water Heating	55,238	110,632	166,185	221,910	277,808	326,857	376,076	425,471	475,040	524,781
Other	0	0	0	0	0	0	0	0	0	0
HVAC (Envelope)	148,094	296,456	445,062	593,935	743,080	892,490	1,042,169	1,192,146	1,342,411	1,492,986
HVAC (Equipment)	21,225	42,487	63,784	85,111	106,474	122,587	138,795	155,053	171,348	187,694
Behavioral Programs	91,958	109,298	126,655	126,722	126,788	126,856	126,922	126,994	127,066	127,139
Total	**282,429**	**490,650**	**702,365**	**896,573**	**1,090,567**	**1,271,404**	**1,486,839**	**1,700,260**	**1,935,871**	**2,172,692**
% of Annual Sales Forecast	*2.3%*	*4.0%*	*5.7%*	*7.2%*	*8.8%*	*10.2%*	*12.0%*	*13.7%*	*15.6%*	*17.5%*

Table 6-22: Cumulative Annual Residential Energy Savings in the Base Achievable Potential Scenario, by End Use for Washington D.C.

Cumulative Annual MMBtu Savings – Base Achievable by End Use										
End Use	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Appliances	2,326	4,794	7,405	10,153	13,039	15,933	18,839	21,754	24,681	27,616
Electronics	0	0	0	0	0	0	0	0	0	0
Lighting	-29,220	-61,879	-93,536	-124,517	-154,823	-183,707	-184,928	-179,786	-165,825	-152,580
Water Heating	14,476	32,202	53,231	74,779	96,866	115,440	133,898	152,251	170,511	188,672
Other	0	0	0	0	0	0	0	0	0	0
HVAC (Envelope)	106,684	214,325	322,663	431,686	541,402	652,007	763,199	874,999	986,969	1,099,417
HVAC (Equipment)	9,087	18,816	29,106	40,143	51,793	59,911	68,272	76,825	85,582	94,510
Behavioral Programs	35,600	65,289	99,305	107,956	112,318	112,376	112,437	112,497	112,564	112,628
Total	**138,952**	**273,545**	**418,174**	**540,200**	**660,596**	**771,959**	**911,718**	**1,058,541**	**1,214,482**	**1,370,263**
% of Annual Sales Forecast	*1.1%*	*2.2%*	*3.4%*	*4.4%*	*5.3%*	*6.2%*	*7.3%*	*8.5%*	*9.8%*	*11.0%*

Table 6-23: Cumulative Annual Residential Energy Savings in the Constrained Achievable Potential Scenario, by End Use for Washington D.C.

Cumulative Annual MMBtu Savings – Constrained Achievable by End Use										
End Use	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Appliances	1,197	2,490	3,873	5,339	6,897	8,462	10,036	11,621	13,212	14,808
Electronics	0	0	0	0	0	0	0	0	0	0
Lighting	-19,359	-43,082	-67,365	-90,970	-113,904	-135,700	-139,645	-137,024	-126,394	-116,334
Water Heating	12,429	27,462	45,104	63,000	81,134	96,806	112,325	127,696	143,041	158,352
Other	0	0	0	0	0	0	0	0	0	0
HVAC (Envelope)	63,977	128,414	193,590	259,213	325,290	391,768	458,650	525,953	593,660	661,455
HVAC (Equipment)	7,736	16,054	24,810	34,135	44,029	50,579	57,266	64,197	71,312	78,498
Behavioral Programs	33,172	58,462	86,233	93,665	101,114	106,110	108,640	108,700	108,761	108,823
Total	**99,153**	**189,800**	**286,245**	**364,381**	**444,561**	**518,024**	**607,271**	**701,141**	**803,592**	**905,601**
% of Annual Sales Forecast	*0.8%*	*1.5%*	*2.3%*	*2.9%*	*3.6%*	*4.2%*	*4.9%*	*5.6%*	*6.5%*	*7.3%*

6.2.4 Residential Savings Summary

Table 6-24 provides an end-use breakdown of the residential natural gas savings potential estimates for technical and economic potential, and each of the three achievable potential scenarios. The table indicates how the savings potential decreases systematically from the technical potential scenario to the Constrained Achievable potential scenario as additional limiting factors such as cost-effectiveness requirements and anticipated market adoption at given funding levels are introduced.

Table 6-24: Breakdown of Residential Cumulative Annual Gas Savings Potential for Technical, Economic and Achievable Potential, by End Use for Washington D.C.

End Use	Technical Potential (MMBtu)	Economic Potential (MMBtu)	Max. Achievable Potential (MMBtu)	Base Achievable Potential (MMBtu)	Constrained Achievable Scenario (MMBtu)
Appliances					
ENERGY STAR Clothes Washers	76,905	76,905	56,038	26,086	13,639
ENERGY STAR Dishwashers	2,236	2,236	1,766	1,530	1,169
Lighting					
Specialty CFL Bulbs	(160,788)	(160,788)	(115,979)	(101,358)	(77,413)
Standard Screw-In CFL Bulbs	(83,329)	(83,329)	(39,624)	(39,624)	(30,002)
LED Screw-In Bulbs	(56,983)	(56,983)	(54,654)	(4,145)	(1,881)
Common Area Lighting	(10,939)	(10,939)	(7,648)	(7,648)	(7,221)
Exterior Lighting	0	0	0	0	0
Water Heating					
Heat Pump Water Heater	(36,194)	(54,283)	(42,794)	(11,102)	(9,051)
Solar Water Heating	216,714	0	0	0	0
Gas Water Heater	546,020	571,012	358,466	54,919	37,547
Tank Wrap	0	0	0	0	0
Pipe Wrap	63,431	63,431	50,064	30,620	27,510
Low Flow Showerheads	156,378	156,378	123,418	93,980	88,826
Low Flow Faucet Aerators	49,172	49,172	35,628	20,255	13,520
HVAC (Envelope)					
Ceiling/Attic Insulation	323,661	234,105	189,364	178,422	60,831
Wall Insulation	508,727	508,727	410,645	394,351	187,570
Floor Insulation	101,382	101,382	80,032	27,737	22,304
Air Sealing	328,365	328,365	258,298	132,534	51,384
Duct Sealing	97,144	97,144	76,660	38,473	20,857
ENERGY STAR Windows	373,397	373,397	121,621	42,945	36,103
Radiant Barriers	10,958	10,958	8,648	1,096	163

End Use	Technical Potential (MMBtu)	Economic Potential (MMBtu)	Max. Achievable Potential (MMBtu)	Base Achievable Potential (MMBtu)	Constrained Achievable Scenario (MMBtu)
Low Income Weatherization Package	356,815	356,815	280,164	280,164	280,164
New Homes Construction Package	85,599	85,599	67,553	3,694	2,078
HVAC (Equipment)					
Tune-Up	49,969	41,595	26,508	23,975	21,915
Programmable Thermostats	44,432	35,000	18,710	11,636	8,783
Efficient Furnaces	354,164	295,271	112,102	45,532	38,571
Efficient Boiler	143,434	84,610	30,373	13,367	9,229
Behavioral Programs					
Direct Feedback (In-Home Energy Display)	66,004	66,004	52,282	45,977	44,327
Indirect Feedback (Monthly Energy Use Reports)	97,120	97,120	74,856	66,651	64,496
Total	**3,703,794**	**3,268,903**	**2,172,498**	**1,370,070**	**905,419**
% of Annual 2022 Sales Forecast	**29.8%**	**26.3%**	**17.5%**	**11.0%**	**7.3%**
Note: Measures in the above Table with "0" achievable potential are ones that did not pass the SCT Test.					

6.3 ACHIEVABLE POTENTIAL BENEFITS & COSTS

The societal cost test (SCT) measures the net benefits of the energy efficiency program for a region or service area as a whole. Costs included in the SCT are costs to purchase and install the energy efficiency measure and overhead costs of running the energy efficiency program. The benefits included are the avoided costs of energy and capacity, as well as a 30% benefits adder to account for externalities such as improved health and reduced environmental degradation. Tables 6-25 and 6-26 below provide the present value of benefits and costs of the Societal Cost Test for the 5-year and 10-year periods for all three achievable potential scenarios.

Table 6-25: 5-Year SCT Ratios for Achievable Potential Scenarios – Residential Sector Only

5-year	SCT Benefits	SCT Costs	SCT Ratio
Maximum Achievable	$1,205,331,346	$309,119,646	3.90
Base Achievable	$770,900,691	$173,244,109	4.45
Constrained Achievable	$565,905,304	$139,995,197	4.04

Table 6-26: 10-Year SCT Ratios for Achievable Potential Scenarios– Residential Sector Only

10-year	SCT Benefits	SCT Costs	SCT Ratio
Maximum Achievable	$2,445,641,800	$559,704,042	4.37
Base Achievable	$1,613,767,915	$327,224,535	4.93
Constrained Achievable	$1,192,219,514	$266,337,151	4.48

7 NON-RESIDENTIAL ELECTRIC AND NATURAL GAS ENERGY EFFICIENCY POTENTIAL ESTIMATES

This section provides electric and natural gas energy efficiency potential estimates for the non-residential sector in Washington D.C. which includes all commercial and institutional buildings. Estimates of technical, economic and achievable potential are first presented for the entire non-residential sector and then an estimate of institutional sector savings potential is presented. Separate sections are listed below for electric and natural gas.

7.1 NON-RESIDENTIAL ELECTRIC

According to 2010 historical sales data, the residential sector accounts for approximately 90% of total customers but only 18% of total energy sales while the commercial sector accounts for only 10% of total customers but almost 80% of all kWh sales. Not only does the commercial sector constitute the greatest portion of total annual kWh sales, it also consumes the most energy on a per customer basis. The average commercial facility consumes roughly 348,000 kWh annually. Comparatively, the average residential consumer uses approximately 9,300 kWh per year. From 2001-2010, the commercial section in the District grew at a compound rate of 0.61%. For this study, commercial MWh is estimated to increase 0.81% annually based upon the January 2013 Load Forecast Report.[47]

7.1.1 Electric Energy Efficiency Measures Examined

For the non-residential sector, there were 129 unique energy efficiency measures included in the energy savings potential analysis. Table 7-1 provides a brief description of the types of measures included for each end use in the non-residential sector. The list of measures was developed based on a review of the DCSEU TRM and measures found in other non-residential potential studies. For each measure, the analysis considered incremental costs, energy and demand savings, and useful measure life.

Table 7-1: Types of Measures Included in the Non-Residential Sector Analysis

End Use Type	End Use Description	Measures Included
Compressed Air	Compressor Equipment	• Air-Entraining Air Nozzles • Low Pressure Drop-Filters • Receiver Capacity Addition • Efficient Air Compressors • Automatic Drains • Cycling Dryers
Computers & Office Equipment	Equipment Improvements	• High Efficient Office Equipment
Cooking	Cooking Equipment Improvements	• Efficient Cooking Equipment • Demand Ventilation Control
Lighting	Lighting Improvements	• Efficient Lighting Equipment • Fixture Retrofits • Ballast Replacement • Premium Efficiency T8 and T5 • High Bay Lighting Equipment • LED Fixtures • CFL Retrofits

[47] PJM Load Forecast Report, January 2013. http://www.pjm.com/~/media/documents/reports/2013-load-forecast-report.ashx#page=87.

End Use Type	End Use Description	Measures Included
		• Lighting Controls • Efficient Design for New Construction
Pools		• Solar Water Heating • Heat Pump Heaters and Controls • Efficient Equipment
Refrigeration	Refrigeration Improvements	• Anti-Sweat Heat Controls • Refrigerated Case Covers • Upgrades Motors and Controls • High Efficiency Equipment • Variable Frequency Drives on Motors • Efficient Lighting • Vending Misers • Compressors • Heat Recovery • Economizers
Space Cooling	Cooling System Upgrades	• Cooling Equipment Upgrades • Improved Controls • Building Shell Upgrades • Economizers • Re-Commissioning • Duct Sealing
Space Heating	Heating System Improvements	• Building Envelope Improvements • Thermostat Upgrades • Heating Equipment Upgrades • Duct Sealing
Transformers	Transformer Equipment	• Efficient Transformers
Ventilation	Ventilation Equipment	• Variable Speed Drive Controls • Dual Enthalpy Economizer • Demand-Controlled Ventilation • Electronically-Commutated Permanent • Magnet Motors (ECPMs • Improved Duct Sealing • High Volume Low Speed Fans
Water Heating	Water Heating Improvements	• High Efficiency Equipment • Low Flow Equipment • Heat Recovery Units • Solar Water Heaters

7.1.2 Technical and Economic Potential Electric Savings

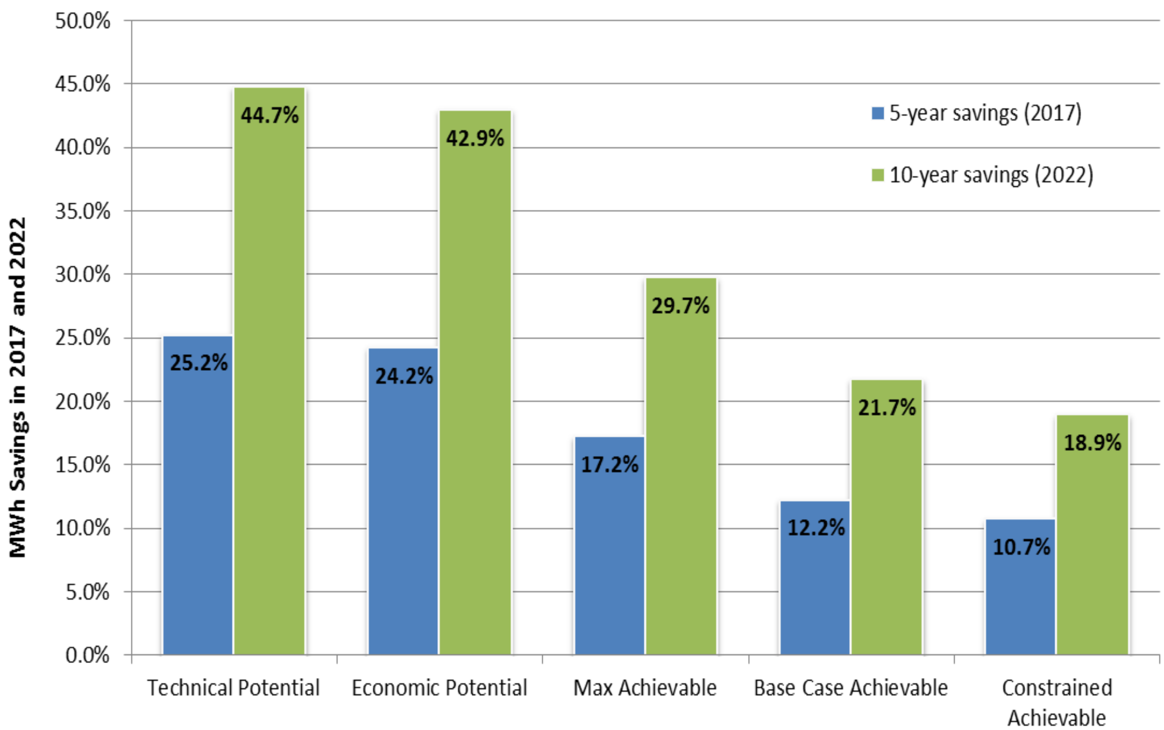
This section presents estimates for electric technical, economic, and achievable savings potential for the non-residential sector (commercial and institutional combined). Each of the tables in the technical, economic and achievable sections present the respective potential for efficiency savings expressed as cumulative savings (MWh) and percentage of sales. Data is provided for a 5 and 10-year horizon for Washington D.C.

This energy efficiency potential study considers the impacts of the Energy and Independence and Security Act (EISA) as an improving code standard for the non-residential sector. EISA improves the baseline efficiency of compact fluorescent lamps (CFL), general service fluorescent lamps (GSFL), high intensity discharge (HID) lamps and ballasts and motors, all applicable in the non-residential sector.

SUMMARY OF FINDINGS

Figure 7-1 illustrates the estimated savings potential in Washington D.C. for each of the scenarios included in this study.

Figure 7-1: Summary of Non-Residential Energy Efficiency Potential as a % of Sales Forecasts



Expressed as the cumulative 5-year savings, the theoretical technical savings potential is 25% of forecasted 2017 non-residential sales. 5-year economic potential scenario savings is 24.2% and the Max Achievable potential (100% incentive levels) is 17.2% of sector sales. The Base Achievable and Constrained Achievable scenarios 5-year potential are 12.2% and 10.7% of sales respectively. The 10-year savings technical potential is 44.7% of sector sales. Economic potential is 42.9% of sales; Max Achievable potential is 29.7%, while Base Achievable potential scenario is estimated to be 21.7% based on an incentive level of 50 percent. Constrained Achievable potential is 18.9% of sector sales based on an incentive level of 50 percent with a 25% of incremental cost cap.

Table 7-2 shows the savings from the Institutional sector as a percentage of total non-residential sales for the three scenarios that were modeled. The 5-yr technical potential for the Institutional sector is 5.5%, and the 10-yr technical potential is 9.8%.

Table 7-2: Institutional Savings as a Percentage of Non-Residential Sales

Institutional Electric Savings				
	5 yr. Inst. Savings (MWh)	5 yr % of Sales	10 yr. Inst. Savings (MWh)	10 yr % of Sales
Technical	556,639	5.5%	1,026,683	9.8%

Institutional Electric Savings				
Economic	533,294	5.3%	983,624	9.4%
Max Achievable	370,395	3.7%	683,168	6.5%
Base Case Achievable	267,613	2.7%	493,595	4.7%
Constrained Achievable	232,745	2.3%	429,281	4.1%
Non-Res Sales	10,092,409		10,498,148	

TECHNICAL POTENTIAL

Technical potential represents the quantification of savings that can be realized if energy-efficiency measures passing the qualitative screening are applied in all feasible instances, regardless of cost. Table 7-3 shows that it is technically feasible to more than 2.5 million MWh in the non-residential sector between 2013 to 2017, and approximately 4.7 million MWh during the 10 year period from 2013 to 2022 across Washington D.C., representing 25% of 5-year non-residential sales, and 44% of 10-year non-residential sales. Lighting represents the majority of the potential at 41% of 10-yr savings, while water heating, cooking and other represent the smallest shares, each with less than 1 percent of 10-yr savings. Table 7-4 shows the demand savings potential in 2017 and 2022. The five and ten year summer peak demand savings potential is 423 MW and 787 MW, respectively, which is 22.0% and 39.3% of the peak forecast. The five and ten year winter peak demand savings potential is 451 MW and 848 MW, respectively, which is 31.8% and 57.4% of the peak forecast.

Table 7-3: Non-Residential Sector Technical Potential Savings By End Use

Non-Residential Technical Potential Savings by End Use				
End Use	**2017 Energy Savings (MWh)**	**% of 2017 Total**	**2022 Energy Savings (MWh)**	**% of 2022 Total**
Lighting	944,290	37%	1,917,912	41%
Ventilation	310,334	12%	1,098,849	23%
Refrigeration	54,388	2%	56,832	1%
Space Cooling	689,436	27%	865,906	18%
Office Equipment	131,468	5%	124,390	3%
Space Heating	357,713	14%	412,561	9%
Water Heating	0	0%	140,924	3%
Process	41,896	2%	39,289	1%
Other	10,155	0%	24,201	1%
Cooking	6,116	0%	14,685	0%
Total	**2,545,797**	**100%**	**4,695,550**	**100%**
% of Annual Sales Forecast	*25.2%*		*44.7%*	

Table 7-4: Non-Residential Sector Technical Potential Demand Savings

Non-Residential Technical Potential Savings Demand Savings				
	Summer Peak Demand		**Winter Peak Demand**	
	2017	**2022**	**2017**	**2022**
Summary	**MW**	**MW**	**MW**	**MW**
Total	**423**	**787**	**451**	**848**
% of Peak	*22.0%*	*39.3%*	*31.8%*	*57.4%*

ECONOMIC POTENTIAL

Economic potential is a subset of technical potential, which only accounts for measures that are cost-effective, based on a screening using the Societal Cost Test (SCT), when calculating the savings potential. The SCT was used for this study because it is mandated by the District to be the cost-effectiveness test used when considering energy efficiency programs in Washington D.C. The test includes a 30% adder to electric and natural gas benefits.

Table 7-5 shows that it is economically feasible to save slightly less than 2.5 million MWh during the 5-year period from 2013 to 2017 and to save just under 4.5 million MWh during the 10-year period from 2013 to 2022, representing 24.2% and 42.5% of non-residential sales respectively. Lighting, space cooling and space heating make up a majority of the savings. Table 7-6 shows the demand savings potential in 2017 and 2022. The five and ten year summer peak demand savings potential is 405 MW and 754 MW, respectively, which is 21.0% and 37.6% of the peak forecast. The five and ten year winter peak demand savings potential is 432 MW and 812 MW, respectively, which is 30.4% and 55.0% of the peak forecast

Table 7-5: Non-Residential Sector Economic Potential Savings By End Use

Non-Residential Economic Potential Savings by End Use				
End Use	2017 Energy Savings (MWh)	% of 2017 Total	2022 Energy Savings (MWh)	% of 2022 Total
Lighting	904,745	37%	1,817,196	40%
Ventilation	297,337	12%	1,096,520	24%
Refrigeration	52,110	2%	55,913	1%
Space Cooling	660,563	27%	809,855	18%
Office Equipment	125,963	5%	120,085	3%
Space Heating	342,733	14%	383,387	9%
Water Heating	0	0%	139,876	3%
Process	40,142	2%	39,289	1%
Other	9,730	0%	24,201	1%
Cooking	5,860	0%	12,583	0%
Total	**2,439,182**	**100%**	**4,498,906**	**100%**
% of Annual Sales Forecast	*24.2%*		*42.9%*	

Table 7-6: Non-Residential Sector Economic Potential Demand Savings

Non-Residential Economic Potential Savings Demand Savings				
	Summer Peak Demand		Winter Peak Demand	
	2017	2022	2017	2022
Summary	MW	MW	MW	MW
Total	**405**	**754**	**432**	**812**
% of Peak	*21.0%*	*37.6%*	*30.4%*	*55.0%*

7.1.3 Achievable Potential Savings in the Non-Residential Sector

Achievable potential is an estimate of energy savings that can feasibly be achieved given market barriers and equipment replacement cycles. This study estimated achievable potential for three scenarios corresponding to varying incentive levels provided to end-use consumers. The Maximum Achievable potential scenario is based on the assumption that incentives are equal to 100% of incremental costs. The Base Achievable potential scenario is based on the assumption that incentives are equal to the current level of incentives offered by the DCSEU. The Constrained Achievable potential scenario is based on the assumption that incentives are equal to half of the Base Achievable scenario. An exception to this assumption is an assumed incentive cap of 25% of incremental cost in the Constrained Achievable scenario.

Table 7-7 and Table 7-8 show the estimated savings for the achievable scenarios over 5 and 10 year horizons. Under the Max Achievable scenario it is feasible to save 1.7 million MWh during the 5 year period from 2013 to 2017 across the region, representing 17.2% of sector sales. Base Case achievable scenario can save 1.2 MWh at 12.2% of sector sales. Under the Constrained Achievable scenario it is feasible to save just over 1.0 million MWh based on the lower incentive level. The 10-year savings for achievable potential scenario is 29.5%, 21.5% and 18.8% of sector sales for each of the achievable scenarios respectively. The ten year demand savings estimates in the Base Achievable scenario are 391 MW in the summer and 346 MW in the winter, which represents 19.5% and 23.4% of the peak demand forecast for the respective summer and winter seasons in 2022.

Table 7-7: Non-Residential Maximum Achievable Energy Savings by End Use

Non-Residential Maximum Achievable Potential Savings by End Use				
	2017	% of 2017	2022	% of 2022
End Use	Energy (MWh)	Savings	Energy (MWh)	Savings
Lighting	629,511	36%	1,248,152	40%
Ventilation	430,194	25%	766,334	25%
Refrigeration	33,108	2%	51,791	2%
Space Cooling	374,517	22%	605,489	19%
Office Equipment	65,883	4%	110,493	4%
Space Heating	101,861	6%	167,042	5%
Water Heating	64,983	4%	108,750	3%
Process	21,752	1%	36,226	1%
Other	7,898	0%	14,657	0%
Cooking	4,890	0%	9,781	0%
Total	1,734,597	100%	3,118,713	100%
% of Annual Sales Forecast	*17.2%*		*29.7%*	

Table 7-8: Non-Residential Maximum Achievable Demand Savings

Non-Residential Maximum Achievable Potential Savings Demand Savings				
	Summer Peak Demand		Winter Peak Demand	
	2017	2022	2017	2022
Summary	MW	MW	MW	MW
Total	288	523	307	563
% of Peak	*15.0%*	*26.1%*	*21.7%*	*38.1%*

Table 7-9: Non-Residential Base Achievable Energy Savings by End Use

Non-Residential Base Achievable Potential Savings by End Use				
	2017	% of 2017	2022	% of 2022
End Use	Energy (MWh)	Savings	Energy (MWh)	Savings
Lighting	457,119	37%	912,529	40%

Non-Residential Base Achievable Potential Savings by End Use				
Ventilation	361,744	29%	659,351	29%
Refrigeration	26,329	2%	41,502	2%
Space Cooling	252,681	21%	428,065	19%
Office Equipment	63,642	5%	106,165	5%
Space Heating	9,846	1%	17,870	1%
Water Heating	32,869	3%	59,426	3%
Process	20,281	2%	33,287	1%
Other	4,916	0%	8,940	0%
Cooking	2,961	0%	5,922	0%
Total	1,232,388	100%	2,273,055	100%
% of Annual Sales Forecast	*12.2%*		*21.7%*	

Table 7-10: Non-Residential Base Achievable Demand Savings

Non-Residential Base Achievable Potential Savings Demand Savings				
	Summer Peak Demand		**Winter Peak Demand**	
	2017	**2022**	**2017**	**2022**
Summary	**MW**	**MW**	**MW**	**MW**
Total	**213**	**391**	**183**	**346**
% of Peak	*11.1%*	*19.5%*	*12.9%*	*23.4%*

Table 7-11: Non-Residential Constrained Achievable Energy Savings by End Use

Non-Residential Constrained Achievable Potential Savings by End Use				
	2017	**% of 2017**	**2022**	**% of 2022**
End Use	**Energy (MWh)**	**Savings**	**Energy (MWh)**	**Savings**
Lighting	353,506	33%	706,175	36%
Ventilation	341,101	31%	623,637	31%
Refrigeration	25,848	2%	40,709	2%
Space Cooling	252,438	23%	426,413	21%
Office Equipment	56,119	5%	91,170	5%
Space Heating	193	0%	276	0%
Water Heating	29,904	3%	53,856	3%
Process	18,661	2%	30,080	2%
Other	3,676	0%	6,755	0%
Cooking	2,617	0%	5,233	0%
Total	1,084,062	100%	1,984,304	100%
% of Annual Sales Forecast	*10.7%*		*18.9%*	

Table 7-12: Non-Residential Constrained Achievable Demand Savings

Non-Residential Constrained Achievable Potential Savings Demand Savings				
	Summer Peak Demand		**Winter Peak Demand**	
	2017	**2022**	**2017**	**2022**
Summary	**MW**	**MW**	**MW**	**MW**
Total	**151**	**336**	**133**	**318**
% of Peak	*7.8%*	*16.8%*	*9.4%*	*21.5%*

Figure 7-2 shows the estimated 10-year cumulative efficiency savings potential broken out by end use across the entire non-residential sector. The lighting end use shows the largest potential for savings by a wide margin at just over 0.9 million MWh, or 40% of total savings, in the Base Achievable scenario.

Figure 7-2: Non-Residential Sector 2022 Base Case Achievable Potential Savings for by End Use

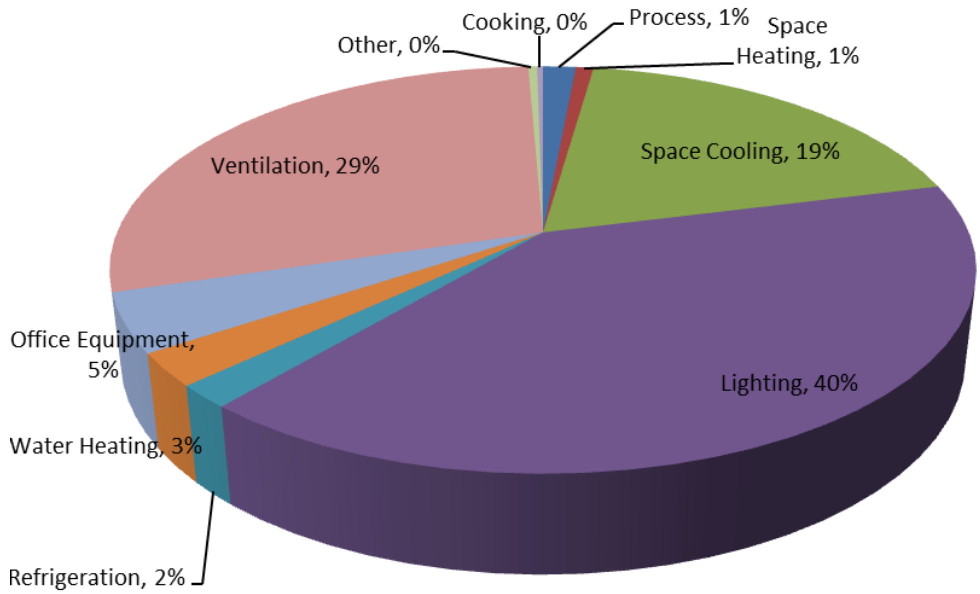


Figure 7-3 shows the breakdown of estimated savings in 2022 by vintage for the Base Achievable scenario. The vast majority of savings come from existing/turnover measures, meaning energy efficient equipment is installed in replacement of existing equipment that has failed, with less than 4% of savings potential coming from new construction. The institutional savings represent all District and US Government building and their respective contributions to each building types. The building types shown in this figure are Non-Institutional Office properties.

Figure 7-3: Non-Residential Base Case Savings in 2022 by Vintage

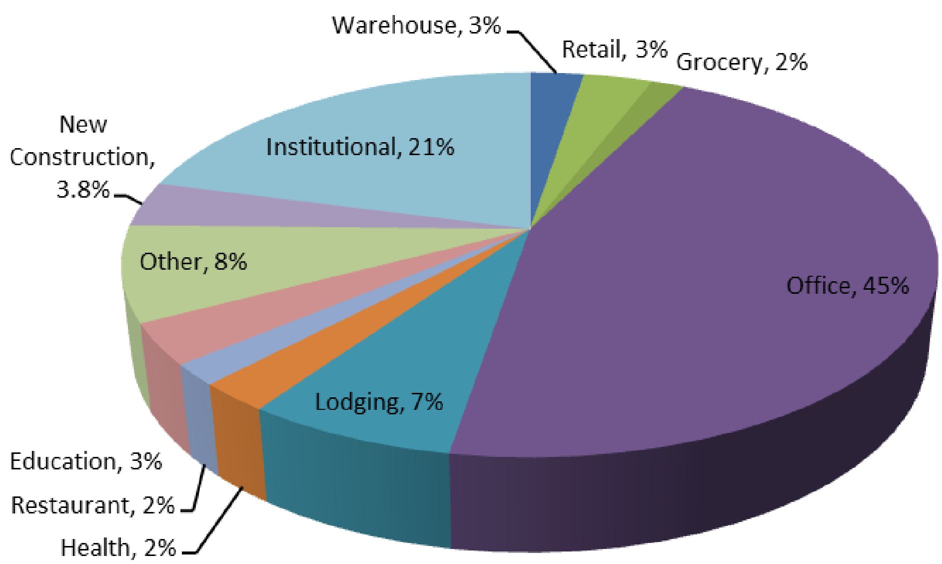


Table 7-13, Table 7-14 and Table 7-15 show cumulative energy savings for all achievable scenarios for each year across the 10-year horizon for the study, broken out by end use.

Table 7-13: Cumulative Annual Non-Residential Energy Savings in Max Achievable Potential Scenario by End Use for Washington D.C.

Cumulative Annual MWh Savings – Maximum Achievable by End Use										
End Use	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Lighting	123,457	249,630	377,163	504,695	629,511	754,326	877,782	1,001,239	1,124,696	1,248,152
Ventilation	64,876	153,267	253,414	353,561	430,194	506,828	571,704	636,581	701,457	766,334
Refrigeration	3,376	10,358	19,143	27,929	33,108	38,287	41,663	45,039	48,415	51,791
Space Cooling	42,606	121,098	217,533	313,968	374,517	435,066	477,671	520,277	562,883	605,489
Office Equipment	8,390	22,099	38,466	54,834	65,883	76,933	85,323	93,713	102,103	110,493
Space Heating	12,119	33,408	59,283	85,157	101,861	118,565	130,685	142,804	154,923	167,042
Water Heating	8,223	21,750	37,929	54,108	64,983	75,858	84,081	92,304	100,527	108,750
Process	2,713	7,245	12,687	18,129	21,752	25,375	28,088	30,801	33,513	36,226
Other	1,323	2,931	4,682	6,433	7,898	9,364	10,687	12,011	13,334	14,657
Cooking	978	1,956	2,934	3,912	4,890	5,868	6,847	7,825	8,803	9,781
Total	**268,061**	**623,743**	**1,023,234**	**1,422,726**	**1,734,597**	**2,046,469**	**2,314,530**	**2,582,591**	**2,850,652**	**3,118,713**
% of Annual Sales Forecast	***2.7%***	***6.3%***	***10.3%***	***14.2%***	***17.2%***	***20.1%***	***22.6%***	***25.0%***	***27.4%***	***29.7%***

Table 7-14: Cumulative Annual Non-Residential Energy Savings in Base Achievable Potential Scenario by End Use for Washington D.C.

Cumulative Annual MWh Savings – Base Achievable by End Use										
End Use	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Lighting	91,039	182,506	274,186	365,866	457,119	548,372	639,411	730,450	821,489	912,529
Ventilation	57,918	131,870	213,840	295,809	361,744	427,679	485,597	543,515	601,433	659,351
Refrigeration	2,756	8,300	15,239	22,178	26,329	30,479	33,234	35,990	38,746	41,502
Space Cooling	33,144	85,613	147,744	209,874	252,681	295,487	328,632	361,776	394,921	428,065
Office Equipment	7,977	21,233	37,129	53,026	63,642	74,259	82,235	90,212	98,188	106,165
Space Heating	1,559	3,574	5,817	8,059	9,846	11,633	13,192	14,752	16,311	17,870
Water Heating	5,154	11,885	19,406	26,927	32,869	38,812	43,965	49,119	54,273	59,426
Process	2,419	6,657	11,805	16,953	20,281	23,610	26,029	28,448	30,867	33,287

Cumulative Annual MWh Savings – Base Achievable by End Use										
Other	783	1,788	2,905	4,022	4,916	5,810	6,592	7,375	8,158	8,940
Cooking	592	1,184	1,776	2,369	2,961	3,553	4,145	4,737	5,329	5,922
Total	**203,341**	**454,611**	**729,847**	**1,005,082**	**1,232,388**	**1,459,693**	**1,663,034**	**1,866,374**	**2,069,715**	**2,273,055**
% of Annual Sales Forecast	***2.1%***	***4.6%***	***7.3%***	***10.0%***	***12.2%***	***14.4%***	***16.2%***	***18.1%***	***19.9%***	***21.7%***

Table 7-15: Cumulative Annual Non-Residential Energy Savings in Constrained Achievable Potential Scenario by End Use for Washington D.C.

Cumulative Annual MWh Savings – Constrained Achievable by End Use										
End Use	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Lighting	70,513	141,235	212,062	282,888	353,506	424,123	494,636	565,149	635,662	706,175
Ventilation	55,043	124,727	201,732	278,737	341,101	403,464	458,507	513,550	568,594	623,637
Refrigeration	2,697	8,142	14,960	21,777	25,848	29,919	32,617	35,314	38,012	40,709
Space Cooling	32,833	85,283	147,540	209,797	252,438	295,079	327,913	360,746	393,579	426,413
Office Equipment	6,484	18,234	32,618	47,002	56,119	65,236	71,719	78,203	84,687	91,170
Space Heating	14	55	111	166	193	221	235	249	263	276
Water Heating	4,642	10,771	17,645	24,518	29,904	35,290	39,931	44,573	49,214	53,856
Process	2,103	6,016	10,835	15,653	18,661	21,669	23,772	25,875	27,977	30,080
Other	601	1,351	2,176	3,000	3,676	4,351	4,952	5,553	6,154	6,755
Cooking	523	1,047	1,570	2,093	2,617	3,140	3,663	4,187	4,710	5,233
Total	**175,453**	**396,861**	**641,246**	**885,631**	**1,084,062**	**1,282,492**	**1,457,945**	**1,633,398**	**1,808,851**	**1,984,304**
% of Annual Sales Forecast	***1.8%***	***4.0%***	***6.5%***	***8.8%***	***10.7%***	***12.6%***	***14.2%***	***15.8%***	***17.4%***	***18.9%***

7.1.4 Non-Residential Savings Summary

Table 7-16 below shows the Electric potential breakdown by measure for technical, economic and all three achievable scenarios.

Table 7-16 Electric Potential by End-Use and Measure

End Use	Technical Potential (MWh)	Economic Potential (MWh)	Max. Achievable (MWh)	Base Achievable (MWh)	Constrained Achievable (MWh)
Building Envelope					
Energy Efficient Windows	239,961	239,961	69,341	67,475	66,685
Roof Insulation to R-18	28,106	0	0	0	0
Ceiling insulation to R32	25,685	0	0	0	0
Wall Insulation to R12	19,439	0	0	0	0
Below Grade Insulation to R6	11,996	0	0	0	0
Integrated Building Design	44,803	44,803	14,099	8,131	4,937
Compressed Air					
Air-Entraining Air Nozzles	18,937	18,937	17,665	17,665	17,582
Automatic Drains	11,707	11,707	10,678	10,503	7,978
Efficient Air Compressors	3,278	3,278	2,990	2,899	2,460
Cycling Dryers	2,832	2,832	2,580	0	0
Receiver Capacity Addition	1,955	1,955	1,783	1,693	1,578
Low Pressure Drop-Filters	580	580	530	526	524
Cooking					
Energy Star HE Steamer	4,930	4,930	3,749	3,631	3,564
Energy Star HE Holding Cabinet	4,045	4,045	3,076	609	34
Demand Ventilation Control	1,682	0	0	0	0
HE Combination Oven	1,384	1,384	1,263	0	0
Energy Star High Efficiency Griddle	1,299	1,299	988	988	981
Energy Star HE Fryer	670	670	509	499	461
Induction Cooktops	419	0	0	0	0
Energy Star Electric convection oven	256	256	194	194	193
HVAC Controls					
EMS install	176,189	176,189	165,167	5,766	5,271
Programmable Thermostats	107,353	107,353	99,496	98,830	98,732
EMS Optimization	11,702	11,702	10,941	0	0
Hotel Guest Room Occupancy Control System	909	909	570	353	222
Lighting					
LED Screw In	293,970	293,970	185,003	181,166	169,558
LED Wallpack	160,493	160,493	101,002	88,264	56,206
Low Glare Recessed T5/HP T8 (replacing	124,527	124,527	77,346	160	160

End Use	Technical Potential (MWh)	Economic Potential (MWh)	Max. Achievable (MWh)	Base Achievable (MWh)	Constrained Achievable (MWh)
T12)					
New Fluorescent Fixtures T5/HP T8 reduced wattage (replacing T8)	110,448	110,448	67,397	59,554	18,965
CFL Screw-in	106,636	106,636	100,590	100,279	99,862
Low Glare Recessed T5/HP T8 Reduced Wattage (replacing T8)	98,262	98,262	59,961	24	11
High Efficiency Fluorescent Fixture (HP T8 Troffer Replacing T12)	91,139	91,139	56,608	56,121	55,794
LED Outdoor Area Fixture	87,245	87,245	54,905	49,462	35,310
Fluorescent Fixture with Reflectors	83,445	83,445	60,470	46,830	5,010
Lamp & Ballast Retrofit (HPT8 Reduced Wattage Replacing Standard T8)	68,797	68,797	48,440	13,731	6
High Efficiency Fluorescent Fixture (HP T8 Reduced Wattage Replacing T8)	65,387	65,387	39,900	39,433	38,816
Lamp & Ballast Retrofit (HPT8 Replacing T12)	61,820	61,820	38,398	37,563	27,425
New Fluorescent Fixtures T5/HP T8 (replacing T12)	55,000	55,000	34,162	71	71
LED Pin Based Lamp	47,043	47,043	29,605	29,243	28,047
High Intensity Fluorescent Fixture (replacing HID)	40,993	40,993	29,704	7,067	4,907
LED Exit Sign	25,368	25,368	15,735	9,699	855
LED Downlight	24,760	24,760	15,582	15,582	11,432
CFL Fixture	10,576	10,576	6,651	6,600	6,229
LED Parking Garage Fixture	9,321	9,321	5,866	5,799	3,693
Induction Fluorescent 23W	2,544	2,544	2,386	1,916	1,261
Halogen Infra-Red Bulb	1,178	1,178	1,105	1,093	1,081
Integrated Ballast MH 25W	850	850	798	788	765
Cold Cathode Downlight	597	597	490	462	390
Ceramic Metal Halide	565	565	353	274	136
Metal Halide Track	565	565	530	230	16
HID Fixture Upgrade - Pulse Start Metal Halide	0	0	0	0	0
Pendant Mounted Indirect Fluorescent Fixtures	115	0	0	0	0
LED Traffic / Pedestrian Signals	0	0	0	0	0
Daylight Dimming	100,601	0	0	0	0
Remote Mounted Occupancy Sensor	60,417	60,417	56,924	53,611	50,653
Switch Mounted Occupancy Sensor	60,417	60,417	56,924	51,896	43,613
Controls for H.I.F.	45,673	45,673	42,904	20,474	13,079
Controls for HID (Hi/Lo)	18,352	18,352	17,239	3,062	1,093
15% More Efficient Design - New Construction	16,871	16,871	10,538	10,313	10,199

End Use	Technical Potential (MWh)	Economic Potential (MWh)	Max. Achievable (MWh)	Base Achievable (MWh)	Constrained Achievable (MWh)
30% More Efficient Design - New Construction	33,974	33,974	21,230	20,780	20,552
Daylight Dimming - New Construction	9,963	9,963	9,403	980	980
Space Cooling					
Centrifugal Chiller, 0.51 kW/ton, 300 tons	57,767	57,767	21,179	20,232	19,316
Centrifugal Chiller, 0.51 kW/ton, 500 tons	57,767	57,767	21,179	20,232	19,316
Chiller Tune Up/Diagnostics - 300 ton	22,209	22,209	19,726	19,375	19,322
Chiller Tune Up/Diagnostics - 500 ton	22,209	22,209	19,726	19,377	19,326
Centrifugal Chiller, Optimal Design, 0.4 kW/ton, 500 tons	7,549	7,549	2,768	2,644	2,524
Improved Duct Sealing	106,162	106,162	49,001	48,408	48,296
High Efficiency AC - Unitary & Split Systems (CEE Tier 2)	86,664	86,664	53,885	53,331	53,265
High Efficiency AC - Unitary & Split Systems (CEE Tier 1)	65,562	65,562	40,217	39,773	39,729
Ductless (mini split)	58,729	58,729	55,081	54,172	53,508
HVAC Advanced Tune-Up	27,986	27,986	24,857	24,142	22,842
PTAC	1,686	1,686	1,048	709	470
Hotel Guest Room Occupancy Control System	1,525	1,525	957	949	948
Ventilation					
Dual Enthalpy Economizer - from Fixed Damper	340,593	340,593	228,386	210,445	199,898
Dual Enthalpy Economizer - from Dry Bulb	247,704	247,704	166,099	164,178	161,894
Demand-Controlled Ventilation	113,627	113,627	69,787	61,783	55,454
Variable Speed Drive Control, 40 HP	85,345	85,345	79,993	74,738	73,074
Variable Speed Drive Control, 5 HP	85,345	85,345	79,993	26,043	17,969
Variable Speed Drive Control, 15 HP	80,181	80,181	75,152	59,563	55,369
Improved Duct Sealing	27,727	27,727	12,798	9,303	6,986
Electronically-Commutated Permanent Magnet Motors (ECPMs)	9,836	9,836	5,125	4,889	4,697
High Volume Low Speed Fans	2,329	0	0	0	0
Space Heating					
Hydronic Heat Pump	96,045	96,045	59,059	9,776	0
Ductless (mini split)	85,754	85,754	80,428	276	276
High Efficiency Heat Pump	20,876	20,876	12,806	394	0
Pools					
Energy Efficient Pool Pump with controls	5,249	5,249	4,858	4,082	3,000
Heat Pump Pool Heater	2,496	2,496	2,310	1,695	963
Solar Pool Heating	573	573	540	533	529
High efficiency spas/hot tubs	245	245	230	3	1

End Use	Technical Potential (MWh)	Economic Potential (MWh)	Max. Achievable (MWh)	Base Achievable (MWh)	Constrained Achievable (MWh)
Water Heating					
Heat Pump Water Heater	67,487	67,487	45,362	41,241	37,166
Solar Water Heating System	39,413	39,413	37,094	2,195	2,195
Drain water Heat Recovery Water Heater	5,993	5,993	2,811	10	10
Faucet Aerators	5,880	5,880	5,222	5,131	5,127
Low Flow Pre-Rinse Spray Nozzle (included in 2006 Federal Standards) (Electric HW)	5,162	5,162	4,818	4,789	4,785
Commercial Clothes washers - Water Heating Savings	3,672	3,672	3,312	0	0
Ozone Commercial laundry System	2,592	2,592	2,230	1,405	656
High Efficiency Electric Water Heater	2,251	2,251	1,271	696	115
Hot Water Circulation Pump Time-Clock	1,662	1,662	1,507	1,487	1,484
Commercial Dishwasher (Under Counter Hi-Temp, Electric DHW)	1,529	1,529	1,412	1,389	1,375
Booster Water Heater	1,413	1,413	1,331	100	100
Point of Use Water Heating	1,048	0	0	0	0
Hot Water (DHW) Pipe Insulation	542	542	502	298	158
Commercial Clothes washers - Non-Water Heating Savings	507	507	457	0	0
Commercial Dishwasher (Single Tank Conveyor Hi-Temp, - Electric DHW)	494	494	213	211	210
Low-Flow Showerheads	383	383	340	332	331
Refrigeration					
H.E. Evaporative Fan Motors	17,109	17,109	16,092	15,928	15,829
Vending Miser for Soft Drink Vending Machines	7,558	7,558	6,995	6,909	6,891
Zero-Energy Doors	4,138	4,138	3,907	3,818	3,768
ECM case fan motors	4,109	4,109	3,849	3,674	3,506
LED Lighting in Refrigeration	3,721	3,721	3,513	383	383
Evaporator Fan Motor Controls	3,042	3,042	2,872	313	313
Discus and Scroll Compressors	2,346	2,346	1,668	51	0
Refrigeration Heat Recovery	2,249	2,249	2,108	109	109
Door Heater Controls	2,214	2,214	2,063	2,038	2,036
Floating Head Pressure Control	1,899	1,899	1,793	1,589	1,288
Commercial Reach-In Freezer - Tier 2	1,809	1,809	1,681	1,676	1,664
Commercial Reach-In Cooler - Tier 2	1,472	1,472	1,367	1,352	1,318
Refrigeration Heat Recovery	1,403	1,403	1,325	144	144
Commercial Ice-makers	1,287	1,287	1,191	1,191	1,166
Commercial Reach-In Freezer - Tier 1	1,140	1,140	1,060	1,060	1,050
Refrigeration Economizer	919	0	0	0	0

End Use	Technical Potential (MWh)	Economic Potential (MWh)	Max. Achievable (MWh)	Base Achievable (MWh)	Constrained Achievable (MWh)
Commercial Reach-In Cooler - Tier 1	850	850	790	790	771
Refrigerated Case Covers	667	667	625	620	620
Efficient low-temp compressor	303	303	217	0	0
Refrigeration Heat Recovery	0	0	0	0	0
Transformers					
Energy Efficient Transformers - CEE Tier 1	9,429	9,429	2,964	266	266
Energy Efficient Transformers - CEE Tier 2	2,440	2,440	767	69	69
Computers & Office Equipment					
Energy Star office equipment including computers, monitors, copiers, multi-function machines.	62,286	62,286	57,309	53,365	38,570
Energy Efficient "Smart" Power Strip for PC/Monitor/Printer	57,799	57,799	53,184	52,799	52,668
EZ Save Monitor Power Management Software	4,305	0	0	0	0
Energy Star Compliant Single Door Refrigerator	3,261	3,261	2,532	2,292	1,927
Total	**4,695,550**	**4,498,906**	**3,118,713**	**2,273,055**	**1,984,415**
% of Annual Sales Forecast	**44.7%**	**42.9%**	**29.7%**	**21.7%**	**18.9%**
Note: Measures in the above Table with "0" achievable potential are ones that did not pass the SCT Test.					

7.2 NON-RESIDENTIAL NATURAL GAS POTENTIAL

The consultants' natural gas consumption forecasts for the residential, commercial and institutional segments of the District economy indicate that natural gas demand will increase from 33 trillion BTU in 2011 to 37 trillion BTU in 2023 (representing a compound average annual rate of growth of .9%). The commercial sector is expected to grow at a much faster pace than the residential sector, with a forecasted average annual growth rate for 2013 to 2023 of 1.18%.

7.2.1 Energy Efficiency Measures Examined

Table 7-17 provides a brief description of the types of measures included for each end use in the commercial model. The list of measures was developed based on a review of the DCSEU TRM and measures found in other non-residential potential studies. Measure data includes incremental costs, energy and demand savings, and measure life with persistence discounting.

Table 7-17: Measures and Programs Included in the Non-Residential Sector Analysis

End Use Type	End Use Description	Measures/Programs Included
Building Envelope	Building Insulation & Air Sealing	• Improved Wall and Roof/Ceiling Insulation • Air Sealing • Integrated Building Design • Envelope Only (30% > code) • Energy Efficient Windows (with triple glazing and low emissivity)
Cooking	Cooking - Broiling/Frying/Steaming	• High Efficiency Gas Broilers, Fryers and

End Use Type	End Use Description	Measures/Programs Included
		Steamers
	Cooking - Ovens & Ranges	• High Efficiency Gas Rack, Convection, Combination and Conveyer Ovens and Power Burner Range
HVAC Controls	Building Systems Management	• Retrocommissioning • Commissioning • EMS Install
	Cross-Cutting HVAC Controls	• Programmable Thermostat • Zoning • EMS Optimization
Space & Water Heating	High Efficiency Boiler, Furnaces & Unit Heaters	• High Efficiency Furnaces, Steam Boilers, Hot Water Boilers, Infrared Heaters and Gas Unit Heaters
Space Heating	Boiler Controls & Maintenance	• Boiler Reset and O_2 Trim Controls • Circulation Pump Time Clocks • Boiler Tune-Up
	Heat Recovery	• Heat Recovery from Air to Air • Boiler Blowdown Heat Exchanger (steam) • Stack Heat Exchanger • Heat Recovery Water Heater • Graywater Heat Exchanger/GFX
	Hot Water/Steam Pipe Insulation & Maintenance	• Boiler and Water Heater Pipe Insulation • Steam Trap Replacement
	Ventilation & Fans	• Destratification Fans • Demand Controlled Ventilation and Exhaust Hood Makeup Air
Water Heating	Efficient Hot Water Use	• Faucet Aerator • Ozone Commercial Laundry System (Gas HW) • Wastewater • Filtration/Reclamation • Low flow Shower Head • High Efficiency Clothes Washer • Low Flow Pre-Rinse Spray Nozzle
	High Efficiency Water Heaters	• High Efficiency Stand Alone • Indirect • On-Demand Tankless • Combination Water Heaters
	Pool Water Heating	• Pool Cover • High Efficient Gas • Solar Pool Heater

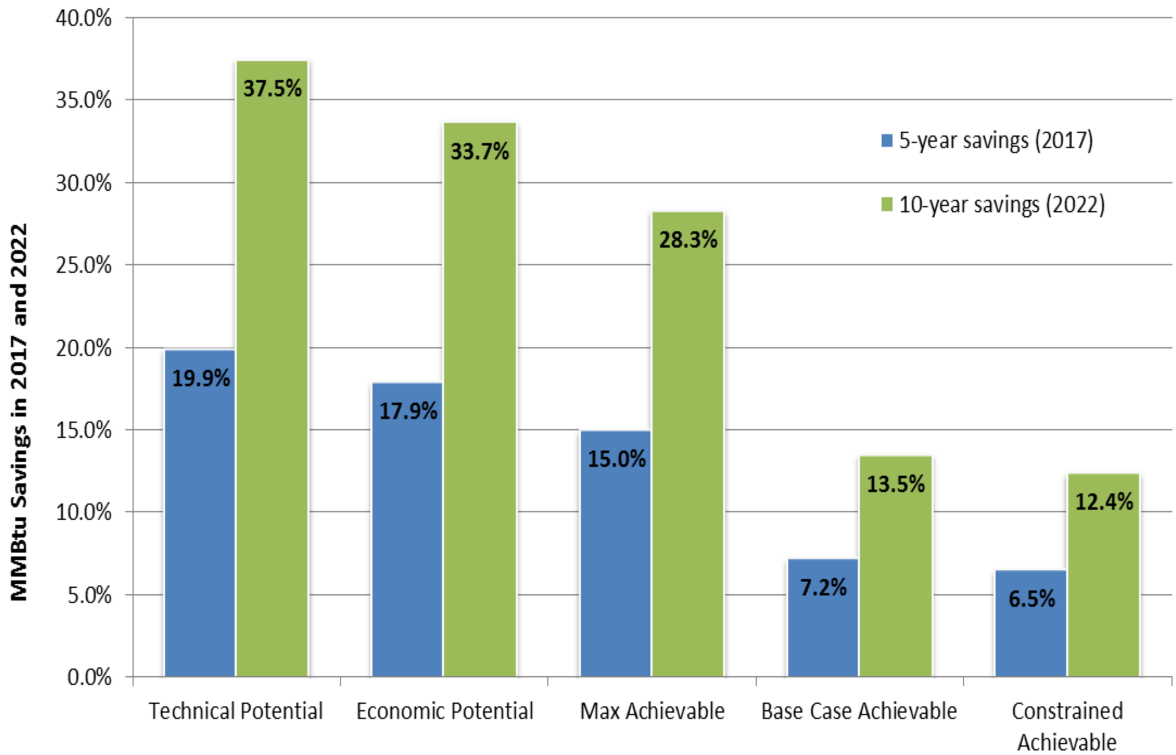
7.2.2 Technical and Economic Potential Natural Gas Savings

This section presents estimates for natural gas technical, economic, and achievable potential for the non-residential sector (commercial and institutional combined). Each of the tables in the technical, economic and achievable sections present the respective potential for efficiency savings expressed as cumulative savings (MMBtu) and percentage of sales. Data is provided for a 5 and 10-year horizon for Washington D.C.

SUMMARY OF FINDINGS

Figure 7-4 illustrates the estimated savings potential for each of all the scenarios included in this study.

Figure 7-4: Summary of Non-Residential Energy Efficiency Potential as a % Sales Forecasts



Expressed as the cumulative 5-year savings, the theoretical technical savings potential is 19.9% of forecasted 2017 non-residential sales. 5-year economic potential scenario savings is 17.9% and the Max Achievable potential (100% incentive levels) is 15.0% of sector sales. The Base Achievable and Constrained Achievable scenarios 5-year potential are 7.2% and 6.5% of sales respectively. The 10-year savings technical potential is 37.5% of sector sales. Economic potential is 33.7% of sales, Max Achievable potential is 28.3%, while Base Achievable potential is estimated to be 13.5% based on an incentive level of 50 percent. Constrained Achievable is 12.4% of sector sales based on an incentive level of 50 percent with a 25% of incremental cost cap.

Table 7-18 shows the savings from the Institutional sector as a percentage of total non-residential sales for the three scenarios that were modeled. The 5-yr technical potential for the Institutional sector is 5.1%, and the 10-yr technical potential is 9.7%.

Table 7-18: Institutional Savings as a Percentage of Non-Residential Sales

Institutional Savings				
	5-yr Savings (MMBtu)	% of Sales	10-yr Savings (MMBtu)	% of Sales
Technical	939,603	5.1%	1,879,207	9.7%
Economic	838,774	4.6%	1,677,548	8.6%
Max Achievable	702,354	3.8%	1,404,708	7.2%
Base Case Achievable	320,024	1.7%	640,048	3.3%
Constrained Achievable	289,560	1.6%	579,119	3.0%

Institutional Savings		
Non-Res Sales	18,341,033	19,451,555

TECHNICAL POTENTIAL

Technical potential represents the quantification of savings that can be realized if energy-efficiency measures passing the qualitative screening are applied in all feasible instances, regardless of cost. Table 7-19 shows that it is technically feasible to save more than 3.6 million MMBtu in the non-residential sector between 2013 to 2017 and approximately 7.3 million MMBtu during the 10 year period from 2013 to 2022 across Washington D.C., representing just fewer than 20% of 5-year non-residential sales, and 37.5% of 10-year non-residential sales. Space heating represents the majority of the potential at 45% of 10-yr savings, while cooking and space & water heating represent the smallest share each with less than 2 percent of 10-yr savings.

Table 7-19: Non-Residential Sector Technical Potential MMBtu Savings By End Use

Non-Residential Technical Potential Savings by End Use				
End Use	**2017 Energy Savings (MMBtu)**	**% of 2017 Total**	**2022 Energy Savings (MMBtu)**	**% of 2022 Total**
Space Heating	1,631,062	45%	3,262,123	45%
Building Envelope	712,444	20%	1,424,888	20%
Water Heating	596,650	16%	1,193,300	16%
HVAC Controls	566,992	16%	1,133,985	16%
Space & Water Heating	73,985	2%	147,971	2%
Cooking	62,884	2%	125,768	2%
Total	3,644,017	100%	7,288,034	100%
Percent of Annual Sales Forecast	19.9%		37.5%	

ECONOMIC POTENTIAL

Economic potential is a subset of technical potential, which only accounts for measures that are cost-effective, based on cost effectiveness screening using the Societal Cost Test (SCT). The SCT was used for this study because it is mandated by the District to be the cost-effectiveness test used when considering energy efficiency programs in Washington D.C.[48] The test includes a 30% adder to electric and natural gas benefits.

Table 7-20 shows that it is economically feasible to save nearly 3.3 million MMBtu during the 5 year period from 2013 to 2017, and more than 6.5 million MMBtu during the 10 year period from 2013 to 2022, representing 17.9% and 33.7% of non-residential sales respectively. Space heating again makes up a majority of the savings.

Table 7-20: Non-Residential Sector Economic Potential MMBtu Savings By End Use

Non-Residential Economic Potential Savings by End Use

[48] The September 2012 "Evaluation Framework" for the District of Columbia Sustainable Efficiency Utility states on page 5-2 that the Societal Cost Test is the test to be used for the cost effectiveness screening of all DC SEU energy efficiency programs.

Non-Residential Economic Potential Savings by End Use				
End Use	2017 Energy Savings (MMBtu)	% of 2017 Total	2022 Energy Savings (MMBtu)	% of 2022 Total
Space Heating	1,584,395	48%	3,168,790	48%
Building Envelope	668,611	20%	1,337,222	20%
Water Heating	564,458	17%	1,128,916	17%
HVAC Controls	320,099	10%	640,197	10%
Space & Water Heating	73,985	2%	147,971	2%
Cooking	62,884	2%	125,768	2%
Total	3,274,432	100%	6,548,864	100%
Percent of Annual Sales Forecast	17.9%		33.7%	

7.2.3 Achievable Potential Savings in the Non-Residential Sector

Achievable potential is an estimate of energy savings that can feasibly be achieved given market barriers and equipment replacement cycles. This study estimated achievable potential for three scenarios corresponding to varying incentive levels provided to end-use consumers. The Maximum Achievable potential scenario is based on the assumption that incentives are equal to 100% of incremental costs. The Base Achievable potential scenario is based on the assumption that incentives are equal to the current level of incentives offered by the DCSEU. The Constrained Achievable potential scenario is based on the assumption that incentives are equal to half of the Base Achievable scenario. An exception to this assumption is an assumed incentive cap of 25% of incremental cost in the Constrained Achievable scenario.

Table 7-21 and Table 7-22 show the estimated savings for the achievable scenarios over 5 and 10 year horizons. Under the Max Achievable scenario it is feasible to save nearly 2.8 million MMBtu during the 5 year period from 2013 to 2017 across the region, representing 15.0% of sector sales. Base Achievable scenario can save more than 1.3 MMBtu at 7.2% of sector sales. Under the Constrained Achievable scenario it is feasible to save 1.2 million MMBtu based on the lower incentive level. The 10-year savings for the three achievable potential scenarios is 28.3%, 13.5% and 12.4% of sector sales for each of the Max, Base and Constrained Achievable scenarios, respectively.

Table 7-21: Non-Residential Achievable Savings Potential in 2017

Summary of Achievable Gas Efficiency Potential						
	Maximum Achievable		Base Achievable		Constrained Achievable	
End Use	Energy Savings (MMBtu)	% of Total	Energy Savings (MMBtu)	% of Total	Energy Savings (MMBtu)	% of Total
Space Heating	1,451,860	53%	734,575	56%	670,318	56%
Building Envelope	610,917	22%	93,852	7%	72,173	6%
Water Heating	515,246	19%	313,868	24%	289,269	24%
HVAC Controls	115,620	4%	114,345	9%	113,720	9%
Space & Water Heating	11,503	0%	8,214	1%	6,611	1%
Cooking	49,474	2%	49,474	4%	49,234	4%
Total	2,754,619	100%	1,314,327	100%	1,201,325	100%
Percent of Annual Sales Forecast	15.0%		7.2%		6.5%	

Table 7-22: Non-Residential Achievable Savings Potential in 2022

Summary of Achievable Gas Efficiency Potential						
	Maximum Achievable		Base Achievable		Constrained Achievable	
End Use	**Energy Savings (MMBtu)**	**% of Total**	**Energy Savings (MMBtu)**	**% of Total**	**Energy Savings (MMBtu)**	**% of Total**
Space Heating	2,903,721	53%	1,469,150	56%	1,340,635	56%
Building Envelope	1,221,833	22%	187,704	7%	144,346	6%
Water Heating	1,030,492	19%	627,735	24%	578,538	24%
HVAC Controls	231,239	4%	228,689	9%	227,440	9%
Space & Water Heating	23,005	0%	16,428	1%	13,223	1%
Cooking	98,948	2%	98,948	4%	98,469	4%
Total	5,509,238	100%	2,628,654	100%	2,402,651	100%
Percent of Annual Sales Forecast	*28.3%*		*13.5%*		*12.4%*	

Figure 7-5 shows the estimated 10-year cumulative efficiency savings potential broken out by end use across the entire non-residential sector. The Space Heating end use shows the largest potential for savings by a wide margin at just under 15.2 million MMBtu, or 56% of total savings, in the Base Achievable scenario.

Figure 7-5: Non-Residential Sector 2022 Base Case Achievable Potential Savings for by End Use

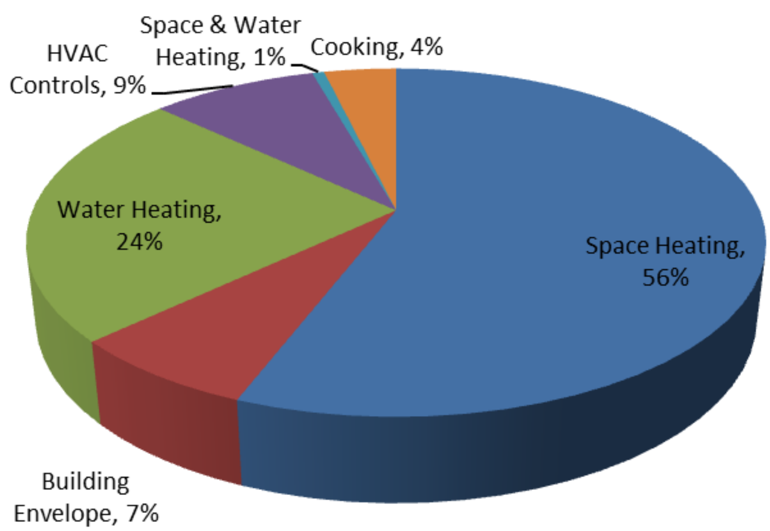
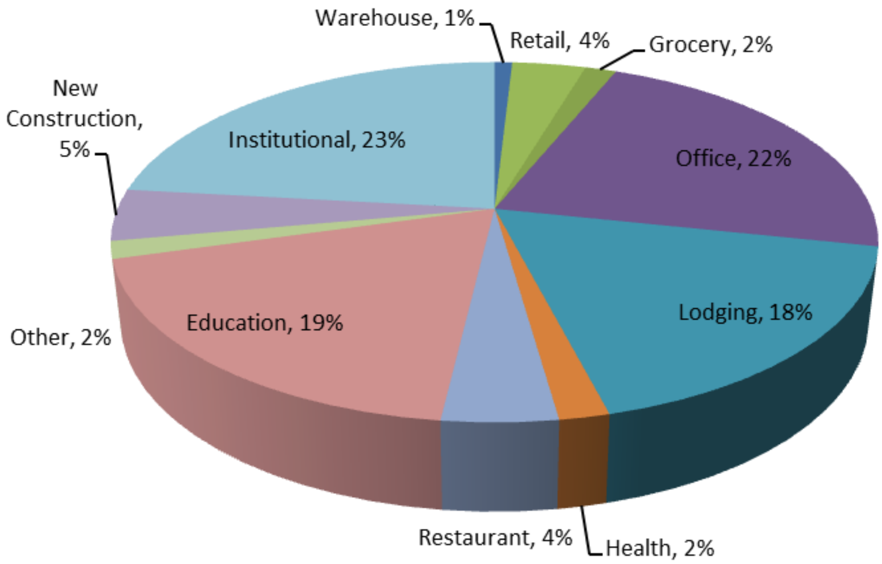


Figure 7-6 shows the breakdown of estimated savings in 2022 by vintage for the Base Achievable scenario. The vast majority of savings come from existing/turnover measures, meaning energy efficient equipment is installed in replacement of existing equipment that has failed, with less than 5% of savings potential coming from new construction.

Figure 7-6: Non-Residential Base Case Achievable Savings in 2022 by Vintage



Tables 7-23, Table 7-24 and Table 7-25 show cumulative energy savings for all achievable scenarios for each year across the 10-year horizon for the study, broken out by end use.

Table 7-23: Cumulative Annual Non-Residential Energy Savings in Max Achievable Potential Scenario by End Use for Washington D.C.

Cumulative Annual MMBtu Savings – Maximum Achievable by End Use										
End Use	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Space Heating	290,372	580,744	871,116	1,161,488	1,451,860	1,742,233	2,032,605	2,322,977	2,613,349	2,903,721
Building Envelope	122,183	244,367	366,550	488,733	610,917	733,100	855,283	977,467	1,099,650	1,221,833
Water Heating	103,049	206,098	309,147	412,197	515,246	618,295	721,344	824,393	927,442	1,030,492
HVAC Controls	23,124	46,248	69,372	92,496	115,620	138,743	161,867	184,991	208,115	231,239
Space & Water Heating	2,301	4,601	6,902	9,202	11,503	13,803	16,104	18,404	20,705	23,005
Cooking	9,895	19,790	29,684	39,579	49,474	59,369	69,263	79,158	89,053	98,948
Total	**550,924**	**1,101,848**	**1,652,771**	**2,203,695**	**2,754,619**	**3,305,543**	**3,856,467**	**4,407,390**	**4,958,314**	**5,509,238**
% of Annual Sales Forecast	***3.1%***	***6.2%***	***9.2%***	***12.2%***	***15.0%***	***17.8%***	***20.5%***	***23.2%***	***25.8%***	***28.3%***

Table 7-24: Cumulative Annual Non-Residential Energy Savings in Base Achievable Potential Scenario by End Use for Washington D.C.

Cumulative Annual MMBtu Savings – Base Achievable by End Use										
End Use	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Space Heating	146,915	293,830	440,745	587,660	734,575	881,490	1,028,405	1,175,320	1,322,235	1,469,150
Building Envelope	18,770	37,541	56,311	75,082	93,852	112,622	131,393	150,163	168,933	187,704
Water Heating	62,774	125,547	188,321	251,094	313,868	376,641	439,415	502,188	564,962	627,735
HVAC Controls	22,869	45,738	68,607	91,476	114,345	137,214	160,082	182,951	205,820	228,689
Space & Water Heating	1,643	3,286	4,928	6,571	8,214	9,857	11,500	13,143	14,785	16,428
Cooking	9,895	19,790	29,684	39,579	49,474	59,369	69,263	79,158	89,053	98,948
Total	**262,865**	**525,732**	**788,596**	**1,051,462**	**1,314,328**	**1,577,193**	**1,840,058**	**2,102,923**	**2,365,788**	**2,628,654**
% of Annual Sales Forecast	***1.5%***	***3.0%***	***4.4%***	***5.8%***	***7.2%***	***8.5%***	***9.8%***	***11.1%***	***12.3%***	***13.5%***

Table 7-25: Cumulative Annual Non-Residential Energy Savings in Constrained Achievable Potential Scenario by End Use for Washington D.C.

Cumulative Annual MMBtu Savings – Constrained Achievable by End Use										
End Use	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Space Heating	134,064	268,127	402,191	536,254	670,318	804,381	938,445	1,072,508	1,206,572	1,340,635
Building Envelope	14,435	28,869	43,304	57,738	72,173	86,608	101,042	115,477	129,911	144,346
Water Heating	57,854	115,708	173,561	231,415	289,269	347,123	404,976	462,830	520,684	578,538
HVAC Controls	22,744	45,488	68,232	90,976	113,720	136,464	159,208	181,952	204,696	227,440
Space & Water Heating	1,322	2,645	3,967	5,289	6,611	7,934	9,256	10,578	11,900	13,223
Cooking	9,847	19,694	29,541	39,387	49,234	59,081	68,928	78,775	88,622	98,469
Total	**240,265**	**480,531**	**720,796**	**961,059**	**1,201,325**	**1,441,591**	**1,681,855**	**1,922,120**	**2,162,385**	**2,402,651**
% of Annual Sales Forecast	***1.4%***	***2.7%***	***4.0%***	***5.3%***	***6.5%***	***7.8%***	***9.0%***	***10.1%***	***11.2%***	***12.4%***

7.2.4 Non-Residential Savings Summary

Table 7-26 below show the Natural Gas potential breakdown by measure for technical, economic and all three achievable scenarios.

Table 7-26: Natural Gas Potential by End-Use and Measure

End Use	Technical Potential (MMBtu)	Economic Potential (MMBtu)	Max. Achievable (MMBtu)	Base Achievable (MMBtu)	Constrained Achievable (MMBtu)
Building Envelope					
Improved Wall Insulation (to R12)	365,755	365,755	345,309	37,636	37,636
Air Sealing	346,559	346,559	327,186	62,694	38,174
Improved Roof/Ceiling Insulation (to R32)	243,798	243,798	230,169	25,087	25,087
Triple Glazing Low Emissivity Windows	228,682	228,682	107,949	11,766	11,766
Integrated Building Design, Envelope Only (30% > code)	152,429	152,429	35,977	4,233	3,921
Double Glazing Low Emissivity Windows	56,322	0	0	0	0
Improved Below-Grade Insulation (to R6)	31,343	0	0	0	0
Cooking					
Energy Star Steam Cooker	56,998	56,998	44,843	44,843	44,550
Energy Star Fryer	46,225	46,225	36,367	36,367	36,276
Energy Star Griddle	12,303	12,303	9,680	9,680	9,616
Energy Star Oven	10,242	10,242	8,058	8,058	8,027
HVAC Controls					
Programmable Thermostat	244,931	244,931	231,239	228,689	227,440
Zoning	209,648	209,648	197,929	30,388	23,376
Retrocommissioning	159,631	159,631	150,707	30,753	17,570
EMS Optimization	25,988	25,988	24,535	15,535	10,191
EMS install	486,785	0	0	0	0
Commissioning	7,003	0	0	0	0
Space Heating					
Demand Controlled Ventilation	411,370	411,370	388,375	49,481	45,775
Heat Recovery from Air to Air	378,920	378,920	357,738	38,991	38,991
Repair/Replace malfunctioning steam traps	321,667	321,667	303,686	301,207	301,148
High Efficiency Furnace (<=300,000 Btu/h) (AFUE>=92%)	310,972	310,972	163,105	163,105	155,640
Boiler Reset Controls	294,040	294,040	277,603	141,408	97,611
Boiler blowdown heat exchanger (steam)	203,388	203,388	192,019	70,563	45,395

End Use	Technical Potential (MMBtu)	Economic Potential (MMBtu)	Max. Achievable (MMBtu)	Base Achievable (MMBtu)	Constrained Achievable (MMBtu)
Stack Heat Exchanger (Condensing Economizer)	182,135	182,135	171,954	169,388	168,446
High Efficiency Steam Boiler (<=300,000 Btu/h) (AFUE >=82%)	155,222	155,222	58,618	19,874	12,501
Boiler O2 Trim Controls	114,288	114,288	107,899	11,760	11,760
Boiler Heating Pipe Insulation	112,770	112,770	106,466	96,598	91,699
Destratification Fans (HVLS)	98,044	98,044	92,563	10,089	10,089
Exhaust Hood Makeup Air	98,214	98,214	92,724	79,476	73,325
Boiler Tune-Up	94,768	94,768	89,470	88,692	88,616
Stack Heat Exchanger (Standard Economizer)	73,636	73,636	69,520	66,982	65,688
Infrared Heater (low intensity - two stage)	72,770	72,770	40,413	38,534	37,564
High Efficiency Steam Boiler (>300,000 Btu/h) (Th.Eff.>=80%)	72,061	72,061	27,213	12,643	8,851
High Efficiency Hot Water Boiler (<=300,000 Btu/h) (AFUE =85%-90%)	46,244	46,244	21,830	6,418	3,926
Boiler Parallel Positioning	38,170	38,170	36,036	3,928	3,928
Insulate steam lines/condensate tank	33,524	33,524	31,650	30,962	30,647
Condensing Boiler (<=300,000 Btu/h) (AFUE>90%)	30,776	30,776	16,142	4,759	2,912
Condensing Boiler (>300,000 Btu/h) (Th.eff.=>90%)	9,864	9,864	5,174	4,614	4,341
Gas Unit Heater - Condensing (AFUE =93%)	9,656	9,656	4,240	702	502
High Efficiency Hot Water Boiler (>300,000 Btu/h) (Th.eff.=85%-90%)	6,291	6,291	2,376	2,217	2,136
Exhaust Hood - Demand Ventilation	33,121	0	0	0	0
Insulate and Seal Ducts (New Aerosl Duct Sealing)	60,212	0	0	0	0
Water Heating					
Solar pool heater	146,715	146,715	138,514	58,701	30,096
Ozone Commercial Laundry System (Gas HW)	143,208	143,208	135,203	132,832	131,035
Low flow shower head (1.5 GPM)	121,783	121,783	114,976	113,215	111,997
Wastewater, Filtration/Reclamation	114,747	114,747	108,333	11,808	11,808
Graywater Heat Exchanger/GFX	95,930	95,930	90,568	16,566	10,567
Pool Cover	95,190	95,190	89,869	89,266	89,214
Circulation Pump Time Clocks	81,079	81,079	76,546	73,033	69,802
Condensing Stand Alone Commercial Water Heater (.96 TE/.8 TE) (Baseline >75000 btu)	65,920	65,920	47,873	5,586	5,218
Heat Recovery Water Heater	62,131	62,131	58,658	57,077	55,683
High Efficiency Clothes Washer	57,528	57,528	49,375	5,381	5,381

End Use	Technical Potential (MMBtu)	Economic Potential (MMBtu)	Max. Achievable (MMBtu)	Base Achievable (MMBtu)	Constrained Achievable (MMBtu)
High Efficiency (95%) Gas Pool Water Heater	47,711	47,711	45,044	5,586	4,909
Indirect Water Heater - Combined appliance efficiency rating (CAE)>=85% (EF=.82/.59 EF Baseline)	33,680	33,680	21,198	19,245	14,820
Faucet aerator	31,809	31,809	30,031	29,835	29,827
Pipe wrap	12,564	12,564	11,862	2,865	1,445
Low Flow Pre-Rinse Spray Nozzle (1.25 gpm)	6,414	6,414	6,056	6,043	6,040
On-Demand, Tankless Water Heater (>=.95 EF) (<=200,000 Btu/h)	5,141	5,141	2,427	264	264
On-Demand, Tankless Water Heater (.82 EF/.59 EF Baseline) (<=200,000 BTU/h)	3,768	3,768	1,778	194	194
High Efficiency Stand Alone Commercial Water Heater (0.67 EF/.59 EF) (Baseline <=75000 Btu)	1,901	1,901	1,381	151	151
On-Demand, Tankless Water Heater (.85 TE/.8 TE Baseline) (>200,000 BTU)	1,696	1,696	801	87	87
Solar Water Heating w/gas auxiliary tank (SEF=1.5)	64,384	0	0	0	0
Space & Water Heating					
Combination Water Heater/Boiler (Condensing)(0.9 EF, 0.9 AFUE)	126,648	126,648	59,784	32,189	19,246
Combination Water Heater/Furnace (.86 EF, .90 AFUE)	13,569	13,569	8,540	8,405	8,309
Combination Water Heater/Boiler (Non-Condensing) (0.86 EF, 85 AFUE)	7,754	7,754	3,660	2,206	1,435
Combination Water Heater/Boiler (Non-Condensing) (0.86 EF, 85 AFUE) Retrofit	0	0	0	0	0
Total	**7,288,034**	**6,548,864**	**5,509,238**	**2,628,654**	**2,402,651**
% of Annual Sales Forecast	**37.5%**	**33.7%**	**28.3%**	**13.5%**	**12.4%**
Note: Measures in the above Table with "0" achievable potential are ones that did not pass the SCT Test.					

7.3 ACHIEVABLE POTENTIAL BENEFITS & COSTS

The societal cost test (SCT) measures the net benefits of the energy efficiency program for a region or service area as a whole. Costs included in the SCT are costs to purchase and install the energy efficiency measure and overhead costs of running the energy efficiency program. The benefits included are the avoided costs of energy and capacity, as well as a 30% benefits adder to account for externalities such as improved health and reduced environmental degradation. Tables 7-27 and 7-28 below provide the present value of benefits and costs of the Societal Cost Test for the 5-year and 10-year periods for all three achievable potential scenarios.

Table 7-27: 5-Year SCT Ratios for Achievable Potential Scenarios – Non-Residential Sector Only

5-year	SCT Benefits	SCT Costs	SCT Ratio
Maximum Achievable	$4,957,853,585	$1,048,067,967	4.73
Base Achievable	$2,939,805,946	$404,323,886	7.27
Constrained Achievable	$2,586,039,443	$325,273,962	7.95

Table 7-28: 10-Year SCT Ratios for Achievable Potential Scenarios– Non-Residential Sector Only

10-year	SCT Benefits	SCT Costs	SCT Ratio
Maximum Achievable	$9,330,507,338	$1,821,566,529	5.12
Base Achievable	$5,672,286,113	$726,248,449	7.81
Constrained Achievable	$4,973,192,834	$580,031,118	8.57

8 DEMAND RESPONSE POTENTIAL ESTIMATES

This section provides electric demand response potential estimates for the residential and commercial sectors in Washington D.C. Estimates of technical, economic and achievable potential are provided. As shown in Section 4, summer peak demand is projected to reach 2,739 MW by 2022, growing at an average rate of 1% per year. Demand response programs have the potential to target reductions in the summer peak demand, as described more fully in this section.

8.1 INTRODUCTION TO DEMAND RESPONSE

In an August 2006 report by staff to the Federal Energy Regulatory Commission ("FERC"), a definition of "demand response" was adopted by the Commission. This definition was used by the U.S. Department of Energy ("DOE") in its February 2006 report to Congress:

> *Changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized.*[49]

In the same August 2006 report, it was noted that demand response is an active response to prices or incentive payments. The changes in electricity use are designed to be short-term in nature, centered on critical hours when demand or market prices are high, or when reserve margins are low. This is contrasted to energy efficiency programs that are focused on longer-term responses or reduction in consumption through the investment in energy efficient equipment or change in behavior.

There are generally two major types of demand response programs: incentive-based programs and time-based programs. Incentive-based programs generally involve the utility paying an incentive to a retail customer to reduce peak demand or allow for direct control of end use appliances. Such programs include direct load control, interruptible programs, demand buy-back, and emergency demand response. Time-based programs include a suite of rate alternatives known as dynamic pricing. These programs have rates that incentivize customers to reduce loads during certain times of the day and year (critical peaking hours). Time-based programs include time-of-use, critical peak pricing, and real time pricing rates.

8.2 GENERAL BENEFITS OF DEMAND RESPONSE

Customer responses under demand response programs can either reduce or shift consumption during high cost periods. While all of the programs evaluated within this project result in reducing the load requirements of the system during certain peak periods, there are two distinct load impacts that can result.

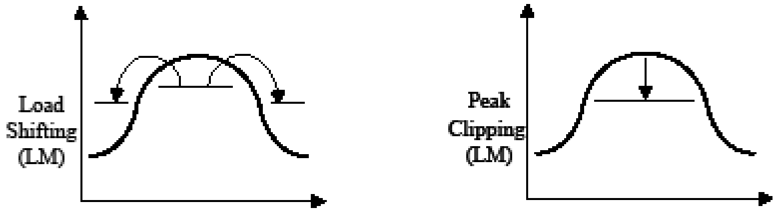
> "Load Shifting" – Projects that move energy consumption from one time to another (usually during a single day).

> "Peak Clipping" – Projects that reduce energy demand at certain critical times, with no recovery of the energy at a later time.

Demand response can provide the benefit of serving as a substitute for peaking generation resources. In addition, it can reduce the need for expansion in distribution investment. Demand response also has the potential to reduce energy supply costs and, in general, electricity price volatility. Finally, demand response can also serve as supplemental (non-spinning) operating reserves.

[49] U.S. Department of Energy, Benefits of Demand Response in Electricity Markets and Recommendations for Achieving Them: A Report to the United States Congress Pursuant to Section 1252 of the Energy Policy Act of 2005, February 2006 (February 2006 DOE EPAct Report).

Figure 8-1: Load Shifting and Peak Clipping Programs



8.3 DEMAND RESPONSE MEASURES EXAMINED

Ten residential and six commercial demand response measures were evaluated in the potential study. These represent several of the more typical demand response programs administered by utilities in the United States and include a mix of incentive-based and time-based programs. The list below gives a brief description of each measure examined in the potential study.

- Residential Measures
  - *Air Conditioning Control – 50% Cycling* – a control switch is placed on the AC unit, giving the utility the ability to control the AC. The compressor is cycled off for 50% of the hour.
  - *Air Conditioning Control – 75% Cycling* – similar to the 50% cycling case, but the compressor is turned off for 45 minutes out of each hour of a control event.
  - *Standard Water Heater Control* – a control switch on an electric water heater allows the utility to turn off the heating element during control periods. This measure assumes a standard 40-50 gallon tank water heater.
  - *Large Capacity Water Heater Control* – similar to the standard water heater control, this is a direct control program. This measure is for larger tank sizes, in excess of 60 gallons.
  - *Pool Pump Control* – the utility installs a direct control switch of swimming pool pumps. Typically, pool pumps are associated with in-ground pools. The pump can be shut off during critical event hours and allowed to run during off-peak hours to assure proper circulation of chemicals.
  - *Smart Thermostat* – This is a direct control program in which a programmable thermostat can also be controlled by the utility, allowing the utility to remotely adjust the temperature set point of the thermostat.
  - *TOU without enabling technology* – this is a simple time-of-use rate with two parts, an on-peak and off-peak rate.
  - *TOU with enabling technology* – the same TOU rate is considered as above, however, the customer is also provided with technology that better enables them to respond to price signals. A display unit is installed in the home that provides price and usage information to the customer.
  - *CPP without enabling technology* – a critical peak pricing rate is a three part rate. There are on-peak and off-peak energy charges much like a TOU rate. However, during a select few critical peaking days and hours, the price is much higher to encourage reduction of loads during peaking conditions. The price can be as high as $1.00 per kWh for such critical hours.
  - *CPP with enabling technology* – The same CPP rate as described above, but with enabling technology provided to the customer to better enable load reductions

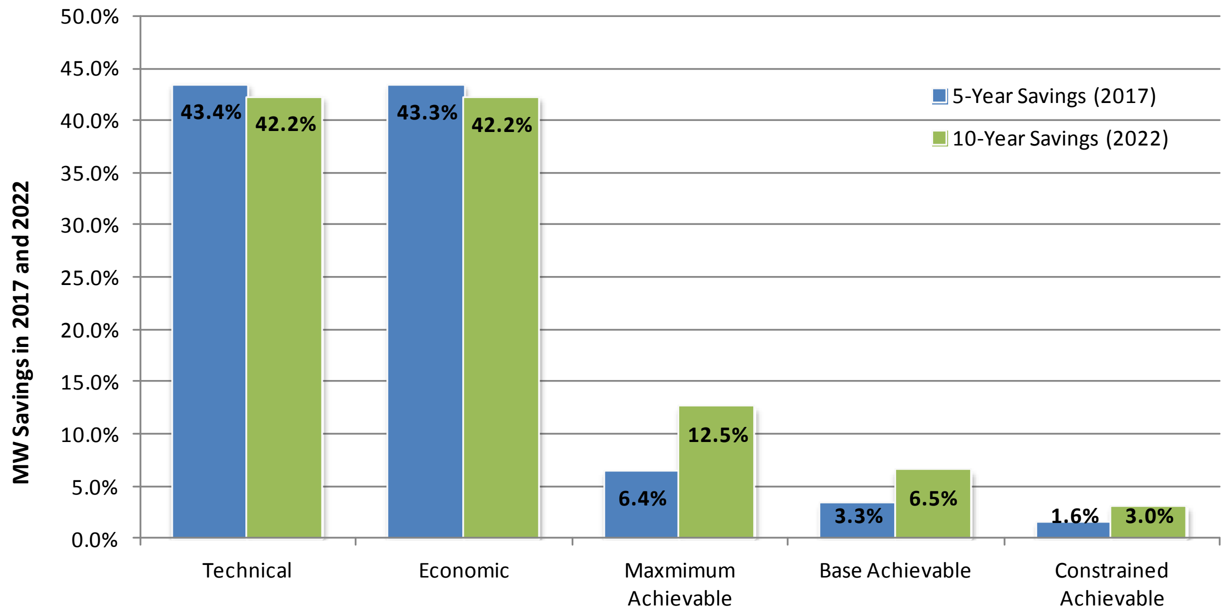
- Commercial Measures
  - *Control of AC* – much like the residential program, this program represents utility control over commercial air conditioning units.
  - *Control of lights – small* – This program involves the utility having direct control of some proportion of the lightings in commercial buildings. The small classification is for smaller applications such as small offices, smaller retail stores, or restaurants.
  - *Control of lights – large* – this is the same program as the small light control measure, but is targeted at larger buildings, such as hospitals, warehouses, or large office or retail spaces.
  - *CPP rate* – critical peak pricing for commercial buildings
  - *RTP rate* – a real time pricing rate provides a different price for power in every hour of the day. Typically, prices are provided to the customer every day for the next-days' prices.
  - *Interruptible* – this is a rate-based program in which a price incentive is offered to customers who are able to reduce their loads when control events are called.

Given that all avoided cost benefits are accrued for reductions in the summer peak demand, programs which target winter demands were excluded from the study. Examples of winter programs include dual fuel heat pumps and electric thermal storage heating. Furthermore, some programs can be considered energy efficiency and demand response programs, such as commercial Energy Management Systems (EMS). In such cases, the program is modeled as part of the energy efficiency potential.

8.4 DEMAND RESPONSE SAVINGS SUMMARY

This section presents estimates for electric technical, economic, and achievable potential for demand response. Each of the tables in the technical, economic and achievable sections present the respective potential for demand savings expressed as cumulative summer peak demand savings (MW), percentage of savings by end use, and savings as a percentage of forecast summer peak demand. Data is provided on a 5-year and 10-year time horizon for Washington D.C. As with the energy efficiency potential estimates, the demand response estimates are subject to uncertainty due to several factors.

Figure 8-2: Summary of Demand Response Potential as a % of 2017 and 2022 Summer Peak Demand Forecasts



The potential estimates are expressed as cumulative 5-year and 10-year savings, as percentages of the respective 2017 and 2022 summer peak demand. The technical potential is 43.4% in 2017 and 42.2% in 2022. The 5-year and 10-year economic potential is 43.3% and 42.2%. The slight drop from technical potential to economic potential indicates that most measures are cost-effective. The 5-year and 10-year achievable potential savings are: 6.4% and 12.5% for the Maximum Achievable scenario; 3.3% and 6.5% for the Base Achievable scenario; and 1.6% and 3.0% for the Constrained Achievable scenario. As described earlier, the achievable scenarios are varied based on the incentive level for each measure.

TECHNICAL POTENTIAL

Technical potential represents the quantification of savings that can be realized if all technologically available demand response measures are immediately adopted in all feasible instances, regardless of cost. Table 8-1 shows that it is technically feasible to save more than 1,100 MW in the residential and commercial sectors between 2013 to 2017, and more than 1,150 MW during the 10 year period from 2013 to 2022 across Washington D.C., representing 43% of the 5-year summer peak demand of 2,609 MW, and 42% of 10-year peak of 2,739 MW. A much greater potential exists in the commercial sector relative to the residential sector.

Table 8-1: Technical Potential MW Savings by Sector

Technical Potential Savings by End Use				
Sector	2017 Demand (MW)	% of 2017 Savings	2022 Demand (MW)	% of 2022 Savings
Residential	171.0	15%	188.8	16%
Commercial & Industrial	960.6	85%	967.2	84%
Total	**1,131.6**	**100%**	**1,155.9**	**100%**
% of Annual Summer Demand Forecast	*43.4%*		*42.2%*	

In the residential sector, the greatest potential lies with AC control. Other measures that provide significant technical potential include water heater control, CPP rates, and control of pool pumps. In the commercial sector, direct control of lighting has the greatest technical potential with dynamic pricing options following close behind.

Table 8-2: Residential Technical Potential MW Savings by Measure

Residential Technical Potential Savings by End Use				
	2017	% of 2017	2022	% of 2022
Sector	Demand (MW)	Savings	Demand (MW)	Savings
AC Control	79.6	47%	90.3	48%
WH Control	35.0	20%	36.6	19%
Pool Pump Control	20.1	12%	20.7	11%
Smart Thermostat	8.6	5%	9.8	5%
TOU Rate	1.3	1%	1.4	1%
CPP Rate	26.4	15%	30.0	16%
Total	171.0	100%	188.8	100%
% of Annual Summer Demand Forecast	*6.6%*		*6.9%*	

Table 8-3: Commercial Technical Potential MW Savings by Measure

Commercial Technical Potential Savings by End Use				
	2017	% of 2017	2022	% of 2022
Sector	Demand (MW)	Savings	Demand (MW)	Savings
AC Control	90.6	9%	90.6	9%
Lighting Control	359.8	37%	362.9	37%
CPP Rate	159.4	17%	160.6	17%
RTP Rate	53.1	6%	53.5	6%
Interruptible Rate	297.6	31%	299.7	31%
Total	960.6	100%	967.2	100%
% of Annual Summer Demand Forecast	*36.8%*		*35.3%*	

ECONOMIC POTENTIAL

Economic potential is a subset of technical potential, which only accounts for measures that are cost-effective, based on a screening using the Societal Cost Test (SCT), when calculating the savings potential. The SCT was used for this study because it is mandated by the District to be the cost-effectiveness test used when considering energy efficiency programs in Washington D.C. The test includes a 30% adder to electric and natural gas benefits. The only demand response program to not pass the SCT was the residential TOU rate. Therefore, the economic potential is not very different from the technical potential.

Table 8-4: Economic Potential MW Savings by Sector

Economic Potential Savings by End Use				
	2017	% of 2017	2022	% of 2022
Sector	Demand (MW)	Savings	Demand (MW)	Savings
Residential	169.7	15%	187.3	16%
Nonresidential	960.6	85%	967.2	84%
Total	1,130.3	100%	1,154.5	100%
% of Annual Summer Demand Forecast	*43.3%*		*42.2%*	

Table 8-5: Residential Economic Potential MW Savings by Measure

Residential Economic Potential Savings by End Use				
Sector	2017 Demand (MW)	% of 2017 Savings	2022 Demand (MW)	% of 2022 Savings
AC Control	79.6	47%	90.3	48%
WH Control	35.0	20%	36.6	20%
Pool Pump Control	20.1	12%	20.7	11%
Smart Thermostat	8.6	5%	9.8	5%
CPP Rate	26.4	16%	30.0	16%
Total	**169.7**	**100%**	**187.3**	**100%**
% of Annual Summer Demand Forecast	*6.5%*		*6.8%*	

Table 8-6: Commercial Economic Potential MW Savings by Measure

Commercial Economic Potential Savings by End Use				
Sector	2017 Demand (MW)	% of 2017 Savings	2022 Demand (MW)	% of 2022 Savings
AC Control	90.6	9%	90.6	9%
Lighting Control	359.8	37%	362.9	37%
CPP Rate	159.4	17%	160.6	17%
RTP Rate	53.1	6%	53.5	6%
Interruptible Rate	297.6	31%	299.7	31%
Total	**960.6**	**100%**	**967.2**	**100%**
% of Annual Summer Demand Forecast	*36.8%*		*35.3%*	

ACHIEVABLE POTENTIAL

Achievable potential is an estimate of demand savings that can feasibly be achieved given market barriers and equipment replacement cycles. This study estimated achievable potential for three scenarios corresponding to varying incentive levels provided to end-use consumers. Since participants have no real costs for demand response, the Maximum Achievable potential scenario is based on aggressive incentive levels, rather than 100% of incremental costs as they are in the energy efficiency analyses. The Base Achievable potential scenario is based on the assumption that incentives are equal to the current level of incentives offered by PEPCO (where available). The Constrained Achievable potential scenario is based on the assumption that incentives are equal to half of the Base Achievable scenario.

Tables 8-7 and through 8-12 show the estimated savings for the achievable scenarios over 5 and 10 year time horizons. The 5-year and 10-year Maximum Achievable potential savings estimates are approximately 167.8 MW and 343.4 MW, respectively. This equates to 6.4% and 12.5% of summer peak demand in 2017 and 2022. The respective 5-year and 10-year Base Achievable potential savings estimates are approximately 86.5 MW and 177.3 MW. This equates to 3.3% and 6.5% of summer peak in 2017 and 2022. The respective 5-year and 10-year Constrained Achievable potential savings estimates are approximately 40.7 MW and 83.1 MW. This equates to 1.6% and 3.0% of sector sales in 2017 and 2022.

Table 8-7: Demand Response Achievable Savings Potential in 2017 – Maximum, Base and Constrained Achievable Scenarios

Summary of Achievable Demand Response Potential

Summary of Achievable Demand Response Potential						
5-year	Maximum Achievable	% of Savings	Base Achievable	% of Savings	Constrained Achievable	% of Savings
Residential	57.8	34.4%	31.1	36.0%	14.5	35.5%
Commercial	110.0	65.5%	55.5	64.1%	26.2	64.5%
Total MW Savings	167.8	100.0%	86.5	100.0%	40.7	100.0%
% of Forecast Summer Peak	6.4%		3.3%		1.6%	

Table 8-8: Residential Achievable Potential MW Savings by Measure in 2017 – Maximum, Base and Constrained Achievable Scenarios

Residential Achievable Potential Savings by End Use						
	2017					
End-Use	Maximum Achievable	% of Savings	Base Achievable	% of Savings	Constrained Achievable	% of Savings
AC Control	33.6	58.2%	18.49	59.5%	8.41	58.2%
WH Control	3.4	6.0%	1.89	6.1%	0.86	6.0%
Pool Pump Control	2.1	3.6%	1.13	3.6%	0.51	3.5%
Smart Thermostat	4.9	8.5%	2.70	8.7%	1.23	8.5%
CPP Rate	13.8	23.8%	6.89	22.2%	3.44	23.8%
Residential Sub-Total	**57.8**	**100.0%**	**31.1**	**100.0%**	**14.5**	**100.0%**
% of Annual Summer Demand Forecast	2.2%		1.2%		0.6%	

Table 8-9: Commercial Achievable Potential MW Savings by Measure in 2017 – Maximum, Base and Constrained Achievable Scenarios

Commercial Achievable Potential Savings by End Use						
	2017					
End-Use	Maximum Achievable	% of Savings	Base Achievable	% of Savings	Constrained Achievable	% of Savings
AC Control	9.1	8.2%	5.0	9.0%	2.3	8.6%
Lighting Control	9.0	8.2%	4.5	8.1%	1.8	6.8%
CPP Rate	70.7	64.3%	35.4	63.8%	17.7	67.3%
RTP Rate	2.7	2.4%	1.3	2.4%	0.8	3.0%
Interruptible Rate	18.6	16.9%	9.3	16.8%	3.7	14.2%
Commercial Sub-Total	**110.0**	**100.0%**	**55.5**	**100.0%**	**26.2**	**100.0%**
% of Annual Summer Demand Forecast	4.2%		2.1%		1.0%	

Table 8-10: Demand Response Achievable Savings Potential in 2022 – Maximum, Base and Constrained Achievable Scenarios

Summary of Achievable Demand Response Potential						
5-year	Maximum Achievable	% of Savings	Base Achievable	% of Savings	Constrained Achievable	% of Savings
Residential	122.9	35.8%	66.1	37.3%	30.7	37.0%
Commercial	220.5	64.2%	111.2	62.7%	52.4	63.0%
Total MW Savings	343.4	100.0%	177.3	100.0%	83.1	100.0%
% of Forecast Summer Peak	12.5%		6.5%		3.0%	

Table 8-11: Residential Achievable Potential MW Savings by Measure in 2022 – Maximum, Base and Constrained Achievable Scenarios

Residential Achievable Potential Savings by End Use						
	2022					
End-Use	**Maximum Achievable**	**% of Savings**	**Base Achievable**	**% of Savings**	**Constrained Achievable**	**% of Savings**
AC Control	71.8	58.4%	39.5	59.7%	17.95	58.4%
WH Control	7.0	5.7%	3.87	5.9%	1.76	5.7%
Pool Pump Control	4.2	3.4%	2.29	3.5%	1.04	3.4%
Smart Thermostat	10.5	8.5%	5.76	8.7%	2.62	8.5%
CPP Rate	29.4	24.0%	14.7	22.3%	7.36	24.0%
Residential Sub-Total	**122.9**	**100.0%**	**66.1**	**100.0%**	**30.7**	**100.0%**
% of Annual Summer Demand Forecast	4.5%		2.4%		1.1%	

Table 8-12: Commercial Achievable Potential MW Savings by Measure in 2022 – Maximum, Base and Constrained Achievable Scenarios

Commercial Achievable Potential Savings by End Use						
	2022					
End-Use	**Maximum Achievable**	**% of Savings**	**Base Achievable**	**% of Savings**	**Constrained Achievable**	**% of Savings**
AC Control	18.1	8.2%	10.0	9.0%	4.5	8.7%
Lighting Control	18.0	8.2%	9.0	8.1%	3.6	6.9%
CPP Rate	141.9	64.3%	70.9	63.8%	35.5	67.7%
RTP Rate	5.3	2.4%	2.7	2.4%	1.3	2.5%
Interruptible Rate	37.2	16.9%	18.6	16.7%	7.4	14.2%
Commercial Sub-Total	**220.5**	**100.0%**	**111.2**	**100.0%**	**52.4**	**100.0%**
% of Annual Summer Demand Forecast	8.0%		4.1%		1.9%	

Figure 8-3 shows the percentage of savings by each measure for the Base Achievable potential scenario in the residential sector. Direct control of air conditioners has the greatest residential potential, followed by CPP rates. Water heater control provides a greater winter than summer benefit, so the proportion of water heater control potential in the summer is lower. Pool pumps provide a good per-unit kW reduction, but the market share of pools limits the potential of the program.

Figure 8-3: Residential Sector 2022 Achievable Potential Savings for the Base Achievable Scenario, by Measure

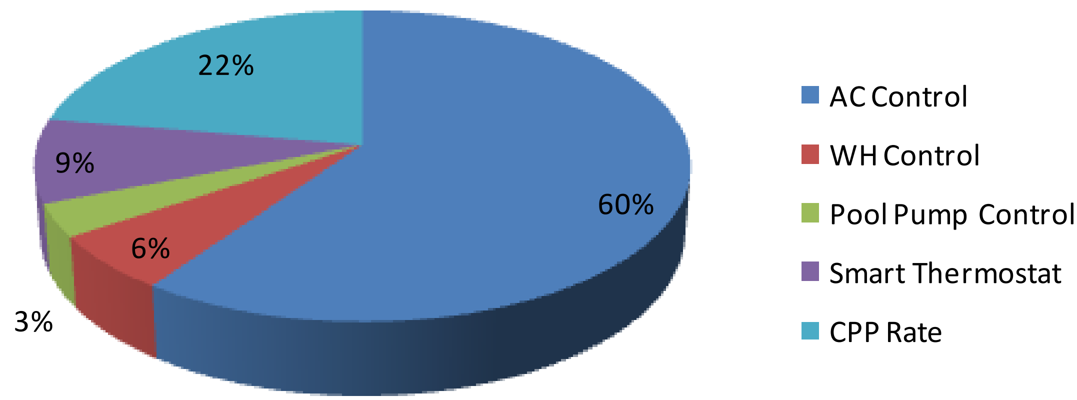


Figure 8-4 shows the breakdown of estimated savings in 2022 by measure in the commercial sector. The dynamic pricing programs offer the greatest potential in the commercial sector. CPP and interruptible rates provide incentives for nonresidential customers to alter their operations or otherwise respond to the price incentives. They can require little investment from the utility, depending on how strong the price incentive is.

Figure 8-4: Commercial Sector 2022 Achievable Potential Savings for the Base Achievable Scenario, by Measure

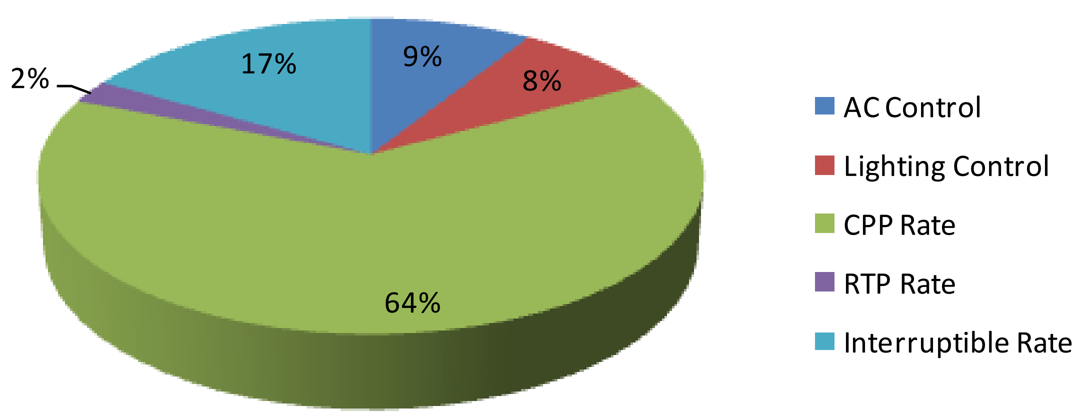


Table 8-13, Table 8-14 and Table 8-15 shows cumulative demand savings for all three achievable potential scenarios for each year across the 10-year time horizon for the study, broken out by end use.

Table 8-13: Cumulative Annual Demand Response Savings in the Maximum Achievable Potential Scenario, by Measure for Washington D.C.

Cumulative Annual MW Savings - Maximum Achievable by End Use										
End Use	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Res AC	6.38	12.93	19.65	26.54	33.61	40.87	48.31	55.94	63.77	71.80
Res WH	0.68	1.36	2.05	2.74	3.44	4.15	4.86	5.58	6.30	7.03
Res Pool Pumps	0.41	0.82	1.23	1.64	2.06	2.47	2.89	3.31	3.74	4.16
Res TSTAT	0.93	1.89	2.87	3.87	4.90	5.96	7.05	8.16	9.30	10.47
Res CPP	2.62	5.30	8.06	10.88	13.78	16.76	19.81	22.94	26.15	29.44
Com AC	1.81	3.62	5.43	7.24	9.06	10.87	12.68	14.49	16.30	18.11
Com Lights	1.79	3.58	5.38	7.17	8.97	10.77	12.58	14.39	16.19	18.01
Com CPP	14.10	28.22	42.35	56.52	70.69	84.88	99.10	113.33	127.58	141.85
Com RTP	0.53	1.06	1.59	2.13	2.66	3.19	3.72	4.25	4.78	5.31
Com Interruptible	3.72	7.44	11.16	14.88	18.60	22.32	26.04	29.76	33.48	37.20
Total	32.97	66.21	99.76	133.62	167.77	202.24	237.03	272.14	307.59	343.39
% of Annual Peak Forecast	1.3%	2.6%	3.9%	5.2%	6.4%	7.7%	8.9%	10.1%	11.3%	12.5%

Table 8-14: Cumulative Annual Demand Response Savings in the Base Achievable Potential Scenario, by Measure for Washington D.C.

Cumulative Annual MW Savings - Base Achievable by End Use										
End Use	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Res AC	3.51	7.11	10.81	14.60	18.49	22.48	26.57	30.77	35.07	39.49
Res WH	0.37	0.75	1.13	1.51	1.89	2.28	2.67	3.07	3.47	3.87
Res Pool Pumps	0.22	0.45	0.68	0.90	1.13	1.36	1.59	1.82	2.06	2.29
Res TSTAT	0.51	1.04	1.58	2.13	2.70	3.28	3.88	4.49	5.12	5.76
Res CPP	1.31	2.65	4.03	5.44	6.89	8.38	9.91	11.47	13.08	14.72
Com AC	1.00	1.99	2.99	3.98	4.98	5.98	6.97	7.97	8.97	9.96
Com Lights	0.89	1.79	2.69	3.59	4.49	5.39	6.29	7.19	8.10	9.00
Com CPP	7.05	14.11	21.17	28.26	35.35	42.44	49.55	56.66	63.79	70.93
Com RTP	0.27	0.53	0.80	1.06	1.33	1.59	1.86	2.13	2.39	2.66
Com Interruptible	1.86	3.72	5.58	7.44	9.30	11.16	13.02	14.88	16.74	18.60
Total	17.00	34.14	51.44	68.92	86.54	104.34	122.31	140.45	158.77	177.28
% of Annual Peak Forecast	0.7%	1.3%	2.0%	2.7%	3.3%	4.0%	4.6%	5.2%	5.9%	6.5%

Table 8-15: Cumulative Annual Demand Response Savings in the Constrained Achievable Potential Scenario, by Measure for Washington D.C.

Cumulative Annual MW Savings - Constrained Achievable by End Use										
End Use	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Res AC	1.60	3.23	4.91	6.64	8.41	10.22	12.08	13.99	15.94	17.95
Res WH	0.17	0.34	0.51	0.69	0.86	1.04	1.22	1.39	1.58	1.76
Res Pool Pumps	0.10	0.20	0.31	0.41	0.51	0.62	0.72	0.83	0.93	1.04
Res TSTAT	0.23	0.47	0.72	0.97	1.23	1.49	1.76	2.04	2.33	2.62
Res CPP	0.65	1.32	2.01	2.72	3.44	4.19	4.95	5.73	6.54	7.36
Com AC	0.45	0.91	1.36	1.81	2.26	2.72	3.17	3.62	4.08	4.53
Com Lights	0.36	0.72	1.08	1.43	1.79	2.15	2.52	2.88	3.24	3.60
Com CPP	3.53	7.05	10.59	14.13	17.67	21.22	24.77	28.33	31.89	35.46

Com RTP	0.27	0.27	0.53	0.53	0.80	0.80	1.06	1.06	1.33	1.33
Com Interruptible	0.74	1.49	2.23	2.98	3.72	4.46	5.21	5.95	6.70	7.44
Total	8.10	16.00	24.25	32.30	40.70	48.91	57.46	65.83	74.55	83.09
% of Annual Peak Forecast	0.3%	0.6%	0.9%	1.3%	1.6%	1.9%	2.2%	2.5%	2.7%	3.0%

8.5 ACHIEVABLE POTENTIAL BENEFITS & COSTS

The societal cost test (SCT) measures the net benefits of the energy efficiency program for a region or service area as a whole. Costs included in the SCT are costs to purchase and install the demand response measure and overhead costs of running the demand response program. The benefits included are the avoided costs of energy and capacity, as well as a 30% benefits adder to account for externalities such as improved health and reduced environmental degradation. Tables 8-16 and 8-17 below provide the present value of benefits and costs of the Societal Cost Test for the 5-year and 10-year periods for all three achievable potential scenarios.

Table 8-16: 5-Year SCT Ratios for Achievable Potential Scenarios – Demand Response Only

5-year	SCT Benefits	SCT Costs	SCT Ratio
Maximum Achievable	$441,960,053	$83,258,607	5.31
Base Achievable	$227,021,163	$32,032,093	7.09
Constrained Achievable	$106,801,523	$11,383,424	9.38

Table 8-17: 10-Year SCT Ratios for Achievable Potential Scenarios– Demand Response Only

10-year	SCT Benefits	SCT Costs	SCT Ratio
Maximum Achievable	$894,333,581	$160,456,732	5.57
Base Achievable	$459,663,725	$61,758,970	7.44
Constrained Achievable	$215,542,890	$22,205,957	9.71

9 SUMMARY OF RESULTS

This final section of the report provides a brief recap of the savings estimates of technical, economic and achievable potential, and also provides some recommendations for policy makers and planners to consider when utilizing the results of this study for the development of future program plans and policy measures.

9.1 TECHNICAL, ECONOMIC AND ACHIEVABLE SAVINGS POTENTIAL

Tables 9-1 through 9-4 provide a summary of the technical, economic, and achievable energy efficiency potential over the 5 and 10 year planning horizons. These energy efficiency savings potential results show that significant electric energy and demand and natural gas savings potential remains in the District. The tables also show the savings as a percentage of the respective sales forecasts for 2017 and 2022. The Base Achievable estimates include 13% electric savings and 7% natural gas savings by 2017. The Base Achievable estimates include 21% electric savings and 13% natural gas savings by 2022. Tables 9-5 and 9-6 provide a summary of the technical, economic, and achievable demand response potential over the 5 and 10 year planning horizons.

Table 9-1: Summary of Technical, Economic and Achievable Electric Energy Savings for 2017

Summary of Technical, Economic and Achievable Electric Energy Efficiency Savings for 2017						
	Energy		Demand			
	Energy (MWh)	% of 2017 Sales	Winter MW	% of 2017 Winter Peak	Summer MW	% of 2017 Summer Peak
ALL SECTORS COMBINED						
Technical Potential	3,544,474	28.8%	789	41.7%	668	25.6%
Economic Potential	3,413,829	27.7%	771	40.7%	643	24.7%
Max Achievable Potential	2,212,680	18.0%	486	25.7%	403	15.4%
Base Achievable Potential	1,560,081	12.7%	313	16.5%	289	11.1%
Constrained Achievable Potential	1,342,525	10.9%	244	12.9%	215	8.2%

Table 9-2: Summary of Technical, Economic and Achievable Electric Energy Savings for 2022

Summary of Technical, Economic and Achievable Electric Energy Efficiency Savings for 2022						
	Energy		Demand			
	Energy (MWh)	% of 2022 Sales	Winter MW	% of 2022 Winter Peak	Summer MW	% of 2022 Summer Peak
ALL SECTORS COMBINED						
Technical Potential	5,759,943	44.7%	1,216	61.3%	1,051	38.4%
Economic Potential	5,537,521	43.0%	1,181	59.5%	1,011	36.9%
Max Achievable Potential	3,781,942	29.4%	836	42.1%	703	25.7%
Base Achievable Potential	2,715,397	21.1%	548	27.6%	511	18.6%
Constrained Achievable Potential	2,340,833	18.2%	495	25.0%	438	16.0%

Table 9-3: Summary of Technical, Economic and Achievable Natural Gas Energy Efficiency Savings for 2017

Summary of Technical, Economic and Achievable Natural Gas Energy Efficiency Savings for 2017		
	Energy	
	Energy (MMBtu)	% of 2017 Sales
ALL SECTORS COMBINED		
Technical Potential	7,182,714	23.4%
Economic Potential	6,400,319	20.8%
Max Achievable Potential	3,845,186	12.5%
Base Achievable Potential	1,974,923	6.4%
Constrained Achievable Potential	1,645,886	5.4%

Table 9-4: Summary of Technical, Economic and Achievable Natural Gas Energy Efficiency Savings for 2022

Summary of Technical, Economic and Achievable Natural Gas Energy Efficiency Savings for 2022		
	Energy	
	Energy (MMBtu)	% of 2022 Sales
ALL SECTORS COMBINED		
Technical Potential	10,991,828	34.5%
Economic Potential	9,817,767	30.8%
Max Achievable Potential	7,681,736	24.1%
Base Achievable Potential	3,998,724	12.5%
Constrained Achievable Potential	3,308,069	10.4%

Table 9-5: Summary of Technical, Economic and Achievable Demand Response Savings for 2017

Summary of Technical, Economic and Achievable Natural Gas Demand Response Savings for 2017		
	Demand (MW)	% of 2017 Sales
ALL SECTORS COMBINED		
Technical Potential	1,131.6	43.4%
Economic Potential	1,130.3	43.3%
Max Achievable Potential	167.8	6.4%
Base Achievable Potential	86.5	3.3%
Constrained Achievable Potential	40.7	1.6%

Table 9-6: Summary of Technical, Economic and Achievable Demand Response Savings for 2022

Summary of Technical, Economic and Achievable Demand Response Savings for 2022		
	Demand (MW)	% of 2022 Sales
ALL SECTORS COMBINED		
Technical Potential	1,155.9	42.2%
Economic Potential	1,154.5	42.2%
Max Achievable Potential	343.4	12.5%
Base Achievable Potential	177.3	6.5%
Constrained Achievable Potential	83.1	3.0%

9.2 RECOMMENDATIONS

Finally, the consultants offer a few recommendations for how to best utilize the results of this report for planning purposes. While the sector level and overall savings provide a useful vantage point in terms of the potential impact of energy efficiency in the District, it is also useful to point out some of the measures which may yield the most significant energy efficiency gains over the next 5 and 10 years. Tables 9-7 through 9-10 list the Top 10 energy efficiency measures for the following categories: residential electric measures, residential gas measures, non-residential electric measures, and non-residential gas measures. In the residential sector, the analysis indicates significant potential remains in the lighting sector, with LED Screw-In Bulbs and Specialty CFL Bulbs taking 2 of the top 3 spots, and Controlled Power Strips rounding out the Top 3. The increase in plug load electric use across the U.S. means efficient electronics products are becoming increasingly viable options for capturing energy efficiency gains. Wall insulation and Gas Water Heaters make up 2 of the Top 3 among residential gas measures. The cold winters of the District combined with the aging infrastructure of District homes means weatherization measures can still yield significant gains in the District. Among non-residential electric measures, LED Screw-In bulbs again make the top 3, as do two separate dual enthalpy economizer measures. Among non-residential gas measures, Demand Controlled Ventilation, Heat Recovery from Air to Air, and Improved Wall Insulation make the top 3, with several other weatherization measures rounding out the Top 10.

Table 9-7: Top 10 Residential Electric Savings Measures

10-Year	Max. Achievable Potential (MWh)
Specialty CFL Bulbs	95,390
Controlled Power Strips	51,040
LED Screw-In Bulbs	44,951
Efficient Televisions	44,769
ENERGY STAR Air Source Heat Pumps	32,856
Standard Screw-In CFL Bulbs	32,589
Low Income Weatherization Package	29,845
Wall Insulation	26,619
Exterior Lighting	25,610
Heat Pump Water Heater	25,302

Table 9-8: Top 10 Residential Gas Savings Measures

10-Year	Max. Achievable Potential (MMBtu)
Wall Insulation	410,645
Gas Water Heater	358,466
Low Income Weatherization Package	280,164
Air Sealing	258,298
Ceiling/Attic Insulation	189,364
Low Flow Showerheads	123,418
ENERGY STAR Windows	121,621
Efficient Furnaces	112,102
Floor Insulation	80,032
Duct Sealing	76,660

Table 9-9: Top 10 Non-Residential Electric Savings Measures

10-Year	Max. Achievable Potential (MWh)
Dual Enthalpy Economizer - from Fixed Damper	228,386
LED Screw In	185,003
Dual Enthalpy Economizer - from Dry	166,099

10-Year	Max. Achievable Potential (MWh)
Bulb	
EMS install	165,167
LED Wallpack	101,002
CFL Screw-in	100,590
Programmable Thermostats	99,496
Ductless (mini split)	80,428
Variable Speed Drive Control, 40 HP	79,993
Variable Speed Drive Control, 5 HP	79,993

Table 9-10: Top 10 Non-Residential Gas Savings Measures

10-Year	Max. Achievable Potential (MMBtu)
Demand Controlled Ventilation	388,375
Heat Recovery from Air to Air	357,738
Improved Wall Insulation (to R12)	345,309
Air Sealing	327,186
Repair/Replace malfunctioning steam traps	303,686
Boiler Reset Controls	277,603
Programmable Thermostat	231,239
Improved Roof/Ceiling Insulation (to R32)	230,169
Zoning	197,929
Boiler blowdown heat exchanger (steam)	192,019

the consultants recommend that the reader of this report use the overall results in order to understand the energy efficiency potential that remains to be captured Washington D.C. and to understand the measures that have the most savings potential and are the most cost effective. Utilizing the report in this way will best inform policy makers and planners in order to equip them with the best information possible to help the District to continue capturing the available energy efficiency gains as efficiently and cost effectively as possible.