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Engineers and Consultants

*Prepared for:*

# MARYLAND ENERGY ADMINISTRATION

## DRAFT REPORT

*Natural Gas Energy Efficiency Potential in Maryland*

***Prepared by:***

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## ACKNOWLEDGMENTS

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# 1.0 EXECUTIVE SUMMARY

### 1.1 10 Year Energy Efficiency Savings Potential (2012-2021)

This study estimates the technical, economic, achievable and program potential for natural gas energy efficiency savings in the State of Maryland over a 10 year period (2012 to 2021) and determines achievable potential for the years 2015 and 2020. This study did not examine potential natural gas savings due to implementation of fuel switching programs.

Energy efficiency opportunities typically are physical, long-lasting changes to buildings and equipment that result in decreased energy use while maintaining the same or improved levels of energy service. For this study, the **cost-effective** energy efficiency potential is defined as the potential over time of energy efficiency measures that are cost effective according to the Total Resource Cost (TRC) test.[1] All measures were screened for cost effectiveness at the measure level, excluding program costs such as administration and marketing. This screening at the measure level was conducted solely for the purpose of identifying individual measures to be included in the cost-effective natural gas energy efficiency potential, independent of how these measures might ultimately be bundled and included in gas company programs. This report also provides natural gas savings potential and TRC test results for three achievable potential scenarios (high, medium and low market penetration of natural gas energy efficiency measures). The TRC costs for these three scenarios do include energy efficiency measure costs as well as program costs for administration, marketing, data tracking and reporting and evaluation.

The last chapter of this report presents information on program potential, recommended programs and market approaches addressing technologies, threshold incentive levels (by market or segment), pricing strategies, trade ally involvement and communications efforts. This chapter also provides an implementation plan that addresses programs for 2015 and provides recommendations, program designs, required program budgets, incentives and expected market penetration.

GDS estimated the energy efficiency savings potential for more than 140 natural gas energy efficiency measures in the residential, commercial and industrial sectors. The types of measures for which potential energy efficiency savings are identified include:

- Energy efficient natural gas water heaters and related water heating measures such as low flow shower heads, faucet aerators, pipe insulation and heat recovery systems.
- Energy efficient natural gas boilers and furnaces and related space heating measures such as pipe insulation, boiler maintenance and control, heat recovery and ventilation control.
- Building envelope improvements including attic, wall and floor insulation, weatherization, proper air/duct sealing, and energy efficient windows.
- HVAC controls including programmable thermostats and energy management systems

[1] GDS Associates also calculated the program administrator, participant and rate impact measure tests at the measure level for information purposes only. This additional cost effectiveness information is included in an appendix.

- Energy efficient cooking including commercial griddles, ovens, fryers and steamers
- Energy eefficient clothes washers, dryers and commercial laundry systems.
- Energy efficient industrial process heating technologies

The technical, economic and achievable potential were estimated for each energy efficiency measure. Program potential has been estimated based upon a realistic budget for natural gas energy efficiency programs in Maryland. These are defined as follows:

**Technical Potential** is energy efficiency savings that would result from the complete and immediate penetration of all analyzed energy efficiency measures in applications where they are deemed to be technically feasible, from an engineering perspective.

**Economic Potential** represents that portion of the total technical potential that is cost effective in accordance with the TRC test.

**Achievable Potential** is defined as savings that would result given an expected market penetration rate of all technically feasible and cost-effective measures over the ten year study horizon. Because market penetration is highly dependent on program design and delivery, including most importantly incentive levels, GDS did not attempt to estimate specific market penetration rates for individual measures in the achievable potential scenarios. This can be done more appropriately when new programs are developed or existing programs are enhanced to target measures identified in this study. Instead this study examined three market penetration scenarios (40%, 60%, and 80%) for the calculations of achievable potential with 60% representing the medium or base case. For the 60% market penetration scenario, GDS assumed that consumers would receive a financial incentive equal to approximately 40% of the incremental cost of the natural gas efficiency measure for most technologies. Financial incentives equal to 50% and 30% of the measure incremental cost were used for the 80% and 40% market penetration scenarios, respectively. The market penetration rate is defined for this study as the percent of cost-effective, technically feasible energy efficiency measures that will be installed by customers over the 10 year (2012-2021) study horizon. The assumed values of market penetration rates are intended to capture likely outcomes of successful, well managed and well funded programs. The 80 percent market penetration scenario (the "high case" scenario) would require very aggressive funding, and a concerted, sustained campaign involving highly aggressive programs and market interventions. It should be viewed as a best estimate of the "high case" achievable cost effective potential for the natural gas measures included in this study.

The achievable potential also reflects the market driven implementation of certain measures that were modeled as non-retrofit measures. In other words, it was assumed that existing inefficient equipment will be replaced at the end of the equipment's effective useful life. For example, only half of the boilers with a 20 year useful life are assumed to be replaced over the 10 year study horizon, while all of the natural gas fryers with a 10 year useful life are assumed to be replaced. The 80 percent market penetration rate assumed in the achievable potential scenario is applied to the equipment that is expected to be replaced over the 10 year study horizon to determine the number of replaced units that will be energy efficient. For purposes of this study, retrofit measures are limited to the application of supplemental measures (such as the addition of a low-flow device to a showerhead or increased levels of insulation), and do not include the early replacement of operational equipment.

**Program Potential** is the achievable potential possible given a specific funding level and program designs. Program potential is a subset of achievable potential.

Figure 1-1 below shows a picture of how these four types of energy efficiency potential relate to each other.

**Figure 1-1: Types of DSM Potential**[2]

| | | | | |
|---|---|---|---|---|
| Not Technically Feasable | Technical Potential | | | |
| Not Technically Feasable | Not Cost Effective | Economic Potential | | |
| Not Technically Feasable | Not Cost Effective | Market & Adoption Barriers | Achievable Potential | |
| Not Technically Feasable | Not Cost Effective | Market & Adoption Barriers | Program Design, Budget, Staffing, & Time Constraints | Program Potential |

Table 1-1, later in the executive summary, provides a summary of the technical, economic and achievable potential for natural gas savings in the years 2015 and 2020.

### 1.2 Overview of Study Methodology

The general methodology used for estimating the potential for natural gas energy efficiency in the residential, commercial and industrial sectors for the years 2012-2021 included the following major steps:

1. Identify natural gas energy efficiency measures to be included in the assessment.
2. Collect and analyze the baseline and forecasted characteristics of the natural gas end use markets, including residential equipment saturations and commercial and industrial consumption, by market segment and end use.
3. Determine the characteristics of each energy efficiency measure including the saturation of the end-use or percent of applicable natural gas use to which the measure applies, its incremental or full cost, natural gas savings, associated electric and water

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

savings, the percent of homes or businesses that have already installed the measure, the effective useful life of the measure and its technical feasibility.

4. Screen each measure to determine cost effectiveness according to the Total Resource Cost (TRC) Test
5. Sort measures from most to least cost effective.
6. Estimate technical potential (immediate penetration of all measures) by integrating measure characteristics such as savings factors, base saturations and use, the remaining end uses to be replaced with the measure, and the technical feasibility.
7. Produce estimates of economic potential by removing measures from the technical potential analysis that are not cost-effective.
8. Apply achievable penetration rates and natural equipment replacement rates for market driven measures to determine a range of the achievable economic potential over the ten year study horizon.
9. Program potential was estimated based upon a program budget constraint assumption set at 1.25% of annual natural gas utility revenues.

### 1.3 Study Results

Table 1-1 below provides a summary of the 2015 and 2020 technical, economic, achievable and program potential estimates for natural gas energy efficiency in the State of Maryland for the residential, commercial and industrial sectors. Achievable potential was examined for three market penetration scenarios. Figure 1-1 provides a breakdown of the achievable potential by sector for the years 2015 and 2020 for the base case market penetration scenario (60% long-term market penetration). GDS estimates that the total achievable potential for natural gas energy efficiency savings in Maryland by 2015 is 8,625,407 MMBtu, which is approximately 4.5% of the forecasted retail natural gas sales in 2015 and by 2020 is 20,435,116 MMBtu, which represents approximately 10% of the forecasted retail natural gas sales in 2020. Based on a budget constraint on utility budgets for natural gas energy efficiency of 1.25% of annual revenues, the natural gas savings for program potential is 2.0% of annual natural gas sales in Maryland by 2020.

Table 1-2 provides information on the Total Resource Cost Test results for the base case achievable potential market penetration scenario (60% long-term market penetration). This table shows that with an aggressive portfolio of natural gas energy efficiency programs, the Total Resource Cost Test net present value savings to natural gas ratepayers is $1,818 billion. The overall Total Resource Cost Test benefit/cost ratio for this scenario is 2.14.

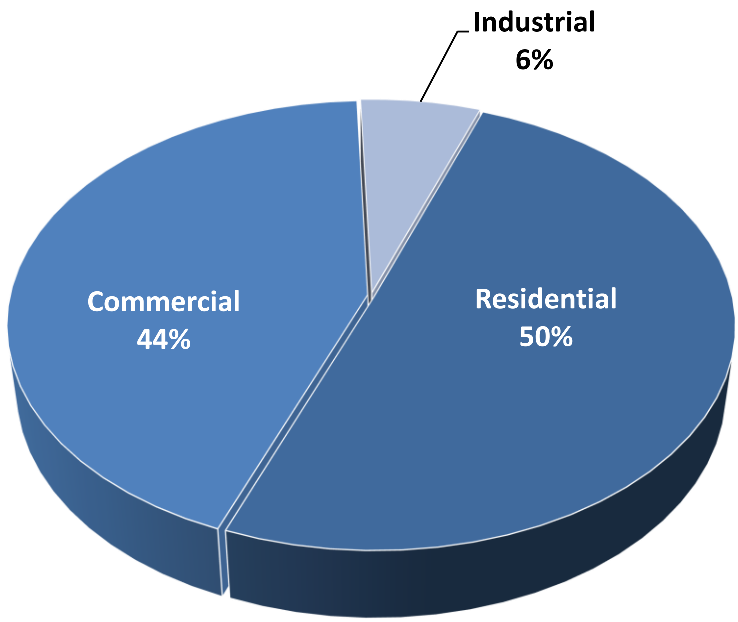
### Table 1-1: Natural Gas Energy Efficiency Potential – State of Maryland (MMBtu)

| Summary of Maryland Natural Gas Efficiency Potential | | | | |
|---|---|---|---|---|
| | Technical | Economic | Achievable 60% Market Penetration | Program Potential |
| **2015** | | | | |
| Residential | 29,819,002 | 22,381,729 | 3,948,109 | 358,892 |
| Commercial | 28,517,414 | 17,850,213 | 3,948,704 | 1,381,819 |
| Industrial | 4,008,769 | 3,619,976 | 728,595 | Included in Comm. |
| Total MMBTU Savings | 62,345,185 | 43,851,918 | 8,625,407 | 1,740,711 |
| % of 2015 Forecasted Annual Sales | 32.2% | 22.7% | 4.5% | 1.0% |
| **2020** | | | | |
| Residential | 31,552,018 | 23,709,143 | 10,300,041 | 829,458 |
| Commercial | 29,929,080 | 18,733,832 | 8,884,583 | 3,106,610 |
| Industrial | 4,042,010 | 3,649,993 | 1,250,492 | Included in Comm. |
| Total MMBTU Savings | 65,523,108 | 46,092,969 | 20,435,116 | 3,936,068 |
| % of 2020 Forecast Annual Sales | 32.6% | 22.9% | 10.2% | 2.0% |

### Table 1-2: Total Resource Cost Test Net Present Value Savings for Achievable Potential (for 60% Market Penetration Scenario)

| Market Penetration Scenario | Present Value of Total Benefits ($ in Millions) | Present Value of Total Costs ($ in Millions) | Net Present Value of Savings ($ in Millions) | Total Resource Cost Benefit/Cost Ratio |
|---|---|---|---|---|
| Residential | $2,150 | $1,082 | $1,068 | 1.99 |
| Commercial | $1,147 | $472 | $675 | 2.43 |
| Industrial | $118 | $43 | $75 | 2.78 |
| All Sectors | $3,415 | $1,597 | $1,818 | 2.14 |

**Figure 1-1: Achievable Natural Gas Energy Efficiency Potential by 2020 by Market Sector – Maryland (60% Market Penetration)**




Figures 1-2, 1-3 and 1-4 show the breakdown of achievable potential in the year 2020 by type of energy efficiency measure for the residential, commercial and industrial sectors respectively for the 60% market penetration scenario. The dominant residential measures are air sealing/duct sealing, more efficient furnaces and boilers, and efficient windows. Together they account for 59% of the residential sector achievable potential in 2020. In the commercial sector a number of different measures offer significant opportunity for savings with heating system and control measures providing 34% of the commercial sector achievable potential, followed by heat recovery and building shell measures which account for 15% and 9% of the commercial sector achievable potential respectively. Boilers offer the most opportunity for economic energy efficiency potential in the Industrial sector. Conventional boiler use efficiency measures account for 32% of the total industrial sector achievable potential.

**Figure 1-2: Residential Sector Achievable Potential in 2020 by Measure**

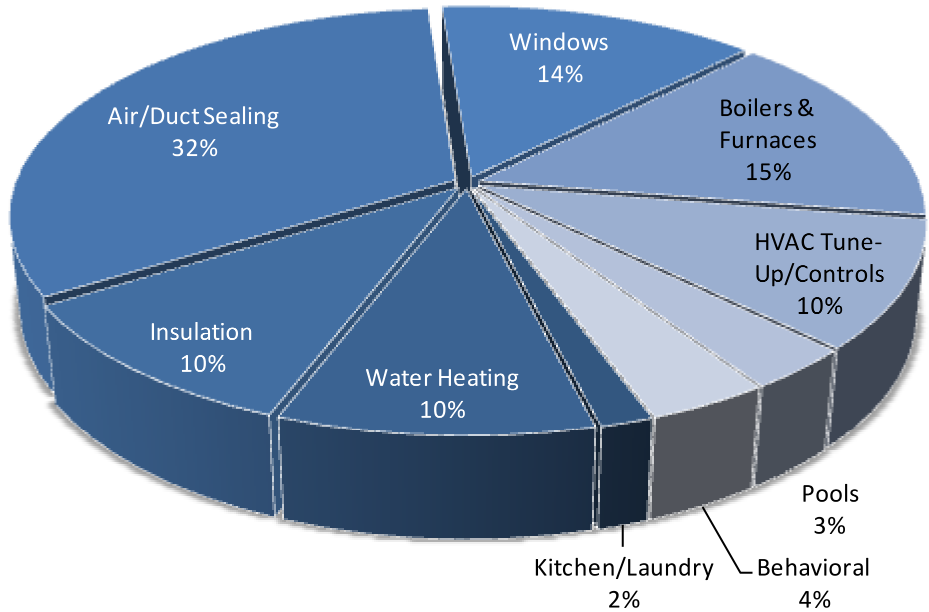



**Figure 1-3: Commercial Sector Achievable Potential in 2020 by Measure**

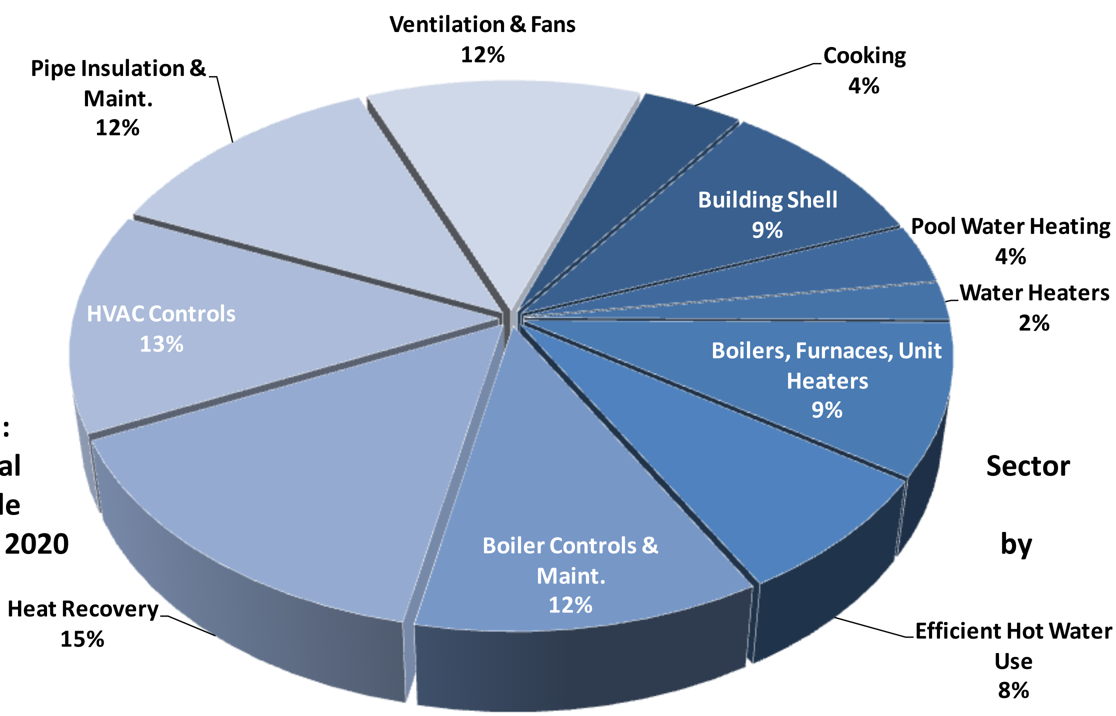
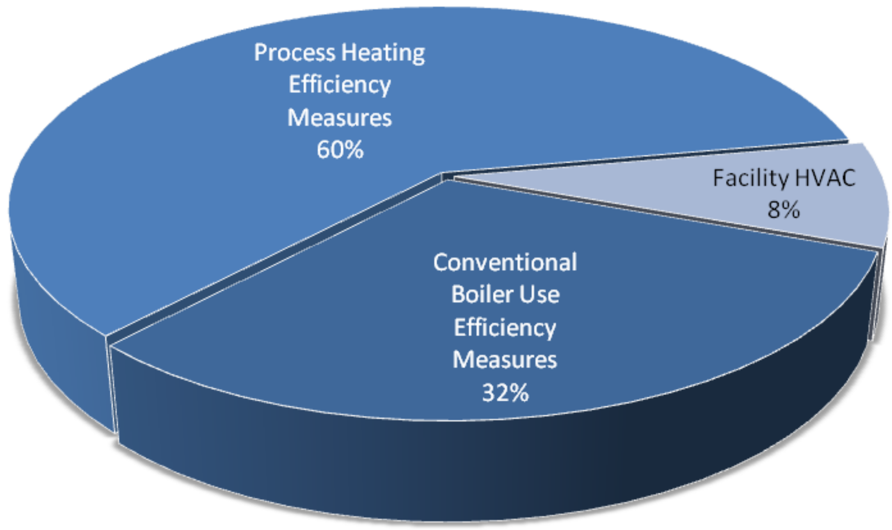



**Figure 1-3: Commercial Achievable Potential in 2020 Measure**

**Sector**

**by**

**Figure 1-4: Industrial Sector Achievable Potential in 2020 by Measure**




### 1.4 Recommended Research

During the development of the data base for this study, GDS contacted the natural gas utilities in the State and the Maryland Public Service Commission (PSC) to obtain existing natural gas demand-side information. Based upon detailed data requests and discussions with Baltimore Gas & Electric (BGE), Washington Gas, and staff at the PSC, GDS has identified several areas where detailed natural gas demand-side information that is specific to Maryland needs to be developed[3]:

- Baseline studies that report the (1) saturation of natural gas equipment, (2) the penetration of high efficiency natural gas equipment and (3) the penetration of energy efficient building practices need to be conducted for the residential, commercial and industrial sectors.
- A detailed statewide forecast of natural gas sales and customers needs to be developed, with a breakdown of forecast natural gas sales by sector, building type and end use.
- Historical data on natural gas consumption, customers and use per customer needs to be compiled and reported.
- A Natural Gas Energy Efficiency Measure Technical Reference Manual (TRM) that identifies natural gas energy efficiency measure savings, cost and life-times needs to be developed.[4]

[3] The GDS assessment of needs for further research is based on a review of data responses received from Maryland natural gas utilities as of November 1, 2011.
[4] This TRM could be developed for the State of Maryland alone or it could be developed in conjunction with other states. GDS has not estimated the cost to develop this TRM for Maryland.

GDS recommends that the State of Maryland undertake or coordinate these research activities with the Maryland natural gas utilities in the near future in order to facilitate the design and implementation of effective natural gas energy efficiency programs in the State.[5]

[5] GDS has not estimated the cost to undertake these research activities. Developing such cost estimates was not included in the GDS scope of work for this project.

# 2.0 INTRODUCTION

MEA commissioned this study for the purpose of determining the technical, economic, achievable and program potential for natural gas energy efficiency in Maryland. This study examines the natural gas savings potential for an extensive list of energy efficiency measures that are applicable to the residential, commercial and industrial customer segments. Natural gas efficiency potential was assessed over a ten year period from 2012 through 2021. Achievable potential was then identified specifically for the years 2015 and 2020.

## 2.1 Project History

In the spring of 2011, the MEA identified the need to determine the potential for natural gas energy efficiency savings in Maryland, and to identify the types of natural gas energy efficiency programs and measures that could save the most natural gas and be the most cost effective for the State of Maryland. The need for this analysis was initially created by the Maryland Energy Efficiency Act of 2008, which requires a study of the feasibility of setting energy savings targets in 2015 and 2020 for natural gas companies. MEA contracted with GDS in June of 2011 to conduct this natural gas energy efficiency potential study for the State of Maryland. The study has the following four key objectives:

(1) Provide a natural gas study to determine the feasibility of setting energy saving targets for Natural Gas Utilities in the State of Maryland for 2015 and 2020.

(2) Provide a range of cases that suggest the market potential for high, medium and low case scenarios.

(3) Develop the information for programs or strategies that address measures, price and incentive schedules, and include the roles and ways to communicate with key market actors and stakeholders.

(4) Develop plans for the selected programs that include program designs, the expected budgets and incentives, and estimate their impact in the market.

The study began in June of 2011 and this report provides the results of the natural gas energy efficiency potential study as well as recommendations for future natural gas energy efficiency programs for Maryland.

## 2.2 Overview of this Report

As with any assessment of energy efficiency potential, this study necessarily builds on a large number of assumptions, from average measure lives, savings and costs, to the discount rate for determining the net present value of future savings. While the authors, with the assistance of the MEA, have sought to use the best available data, primary data collection (e.g. baseline studies, market characterization studies, etc.) to inform the analysis was not called for in the study scope. Furthermore, while the list of analyzed measures is extensive and represents most, if not all, commercially available natural gas energy efficiency measures and some emerging measures, no attempt was made to forecast future technologies.[6] Also, there was no attempt to place a dollar value on some difficult to quantify benefits that may result from some

[6] For this study, GDS has not examined potential natural gas savings from implementation of Smart Grid technology.

measures, such as increased comfort or reduced maintenance, which may in turn support some personal choices to implement particular measures that may otherwise not be cost-effective or only marginally so. Thus, the various potential estimates are specific to and limited by the detailed measures lists and assumptions described in this study.

The remainder of this report is organized as follows:

- Section 3 – Project Overview and Background
- Section 4 – Overall Project Methodology
- Section 5 – Residential Sector Energy Efficiency Potential
- Section 6 – Commercial Sector Energy Efficiency Potential
- Section 7 – Industrial Sector Energy Efficiency Potential
- Section 8 – Program Potential

# 3.0 PROJECT OVERVIEW AND BACKGROUND

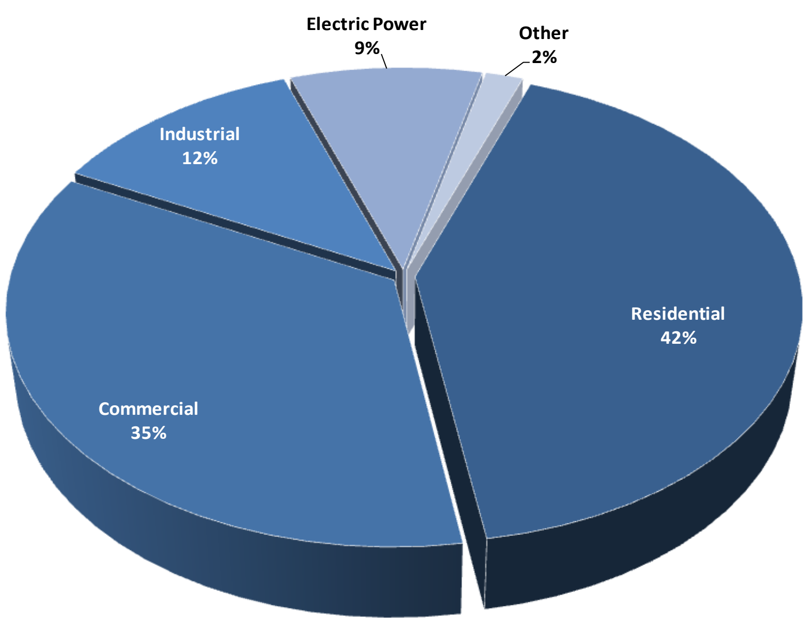
This chapter provides key background information used by GDS to determine the economic and achievable potential for natural gas energy efficiency savings in Maryland. It presents the State of Maryland data on natural gas consumption; saturation for natural gas equipment; history and forecast of natural gas customers, sales, and revenues; and breakdown of commercial and industrial natural gas sales by type of business. This data provides the foundation for determining estimates of natural gas energy efficiency potential in Maryland. It is important to have information on the current consumption levels and uses of natural gas in the State as a starting point for the energy efficiency potential study. While GDS was able to collect data on total natural gas consumption by sector, baseline information on natural gas consumption and equipment energy efficiency levels by end use was not available for Maryland.

## 3.1 Natural Gas Consumption in Maryland

### 3.1.1 Introduction

Approximately 1.14 million Maryland customers used natural gas in 2009, the most recent year where detailed natural gas consumption data for Maryland is available. In total 197,313 million cubic feet (MMcf) were consumed; that is approximately 203 trillion BTU. Figure 3-1 shows the proportion of natural gas used by various segments of the Maryland economy in 2009, the last year for which actual data is available. Deliveries to residential, commercial and industrial customers in the State account for 89% of total gas usage. Nine percent (9%) of the natural gas consumption is used by electric power plants, and two percent (2%) is for the other category.

**Figure 3-1: Breakdown of Natural Gas Usage, Maryland, 2009**




GDS has 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 GDS for this project. The remainder of this chapter describes forecasted natural gas usage for the major customer classes (residential, commercial, and industrial) and other information on natural gas usage in Maryland. The sources used to develop this characterization include:

- Natural gas appliance saturation data for Maryland;
- Natural gas equipment saturation data from the 2007 American Housing Survey and from the 2010 KEMA Maryland energy baseline study conducted for the EmPower Maryland programs;
- EIA Annual Energy Outlook Data.

This detailed market assessment of natural gas end-use saturations and use per customer is an essential component of this study. In order to estimate the potential for natural gas energy-efficiency savings, one must have a thorough understanding of its current use, and one must understand the forecast for natural gas consumption in Maryland.

### 3.1.2 Total Gas Sales Forecast

The latest available natural gas consumption forecasts[7] for the residential, commercial and industrial segments of the Maryland economy indicate that natural gas demand will increase from 180.7 trillion BTU in 2009 to 207.69 trillion BTU in 2021 (representing a compound average annual rate of growth of 1.2%). Table 3-1 shows the sales forecast for natural gas in Maryland by class of service. The market sector predicted to have the fastest growing sales is commercial, with a forecasted average annual growth rate for 2009 to 2021 of 1.4%. Table 3-2 shows the percent of market share for natural gas sales by class of service. The market share for the commercial class will increase slightly over the forecast period as that class is projected to increase at a higher rate of growth than the residential and industrial classes. Note that the residential sector is forecast to have the largest share of natural gas consumption from now until 2021.

[7] This forecast was developed by GDS in the fall of 2011 based upon an examination of historical energy use trends in Maryland and EIA's 2011 natural gas forecast for the U.S.

**Table 3-1: Forecast of Natural Gas Consumption by Class of Service, 2009-2021 (Trillion BTU)**

| Forecast of Natural Gas Consumption by Class of Service, 2009-2021 | | | | | | |
|---|---|---|---|---|---|---|
| Class of Service | 2009 | 2011 | 2015 | 2018 | 2021 | Compound Annual Growth Rate, 2009-2021 |
| Residential | 85.0 | 87.8 | 90.8 | 93.0 | 95.1 | 0.9% |
| Commercial | 71.1 | 74.9 | 79.7 | 82.3 | 84.1 | 1.4% |
| Industrial | 24.6 | 26.2 | 28.2 | 28.4 | 28.4 | 1.2% |
| Total | 180.7 | 188.9 | 198.7 | 203.6 | 207.7 | 1.2% |

**Table 3-2: Percent of Natural Gas Consumption by Class of Service, 2009-2021**

| Percent of Natural Gas Consumption by Class of Service, 2009-2021 | | | | | |
|---|---|---|---|---|---|
| Class of Service | 2009 | 2011 | 2015 | 2018 | 2021 |
| Residential | 47% | 46% | 46% | 46% | 46% |
| Commercial | 39% | 40% | 40% | 40% | 41% |
| Industrial | 14% | 14% | 14% | 14% | 14% |
| Total | 100% | 100% | 100% | 100% | 100% |

## 3.2 Residential Gas Usage

### 3.2.1 Residential Customer Forecast

As shown in Table 3-3, the number of residential natural gas customers in Maryland is projected to increase on average by 10,017 per year over the period from 2009 to 2021.[8] The compound average annual growth rate for residential natural gas customers is 1.0%. The majority of new customers added (i.e., 90%) are expected to reside in single family homes.[9]

A significant trend affecting the Maryland residential sector is the conversion from fuel oil to other fuels as a primary home-heating source. Based upon data presented in the Annual Housing Survey for the Baltimore Metropolitan Area, between 1998 and 2007 the number of oil conversions has averaged 4,455 per year. These conversions provide the opportunity to replace older inefficient heating units with new high-efficiency gas units.[10] Another key trend is the increased energy efficiency in natural gas appliances, resulting in energy savings as old inefficient heating units are replaced with new high-efficiency units. This trend is expected to continue; however, the impact will decline over time as increases in marginal appliance efficiencies reach a maximum level.

[8] This forecast is based upon the observed trend in the number of residential gas customers in the State of Maryland, 1997-2009.
[9] The distribution of customers by housing type is based on the 2010 KEMA Maryland energy baseline study.
[10] The Annual Housing Survey for Baltimore indicates that 193,300 housing units had electric heat pumps in 2007; 53% of home heated with electricity had a heat pump. Back in 1998, there were 170,300 electric heat pumps in the Baltimore Metropolitan Area; the saturation of electric heat pumps = 54%. It does appear that there were many conversions from electric heats pumps to gas space heat during 1998-2007.

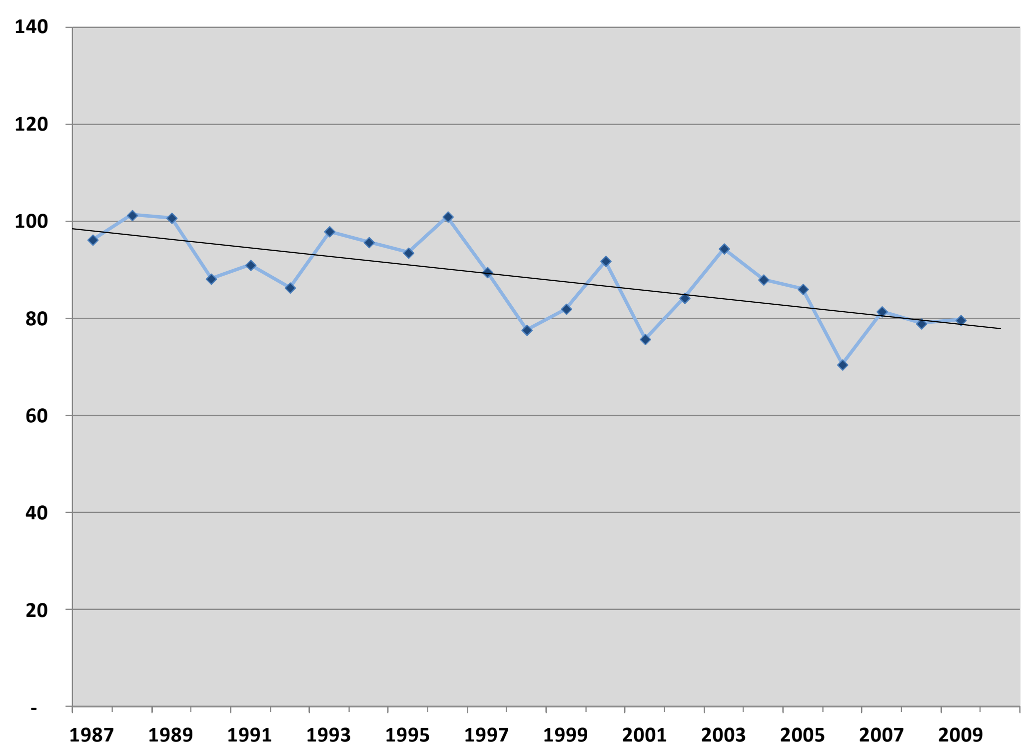
**Table 3-3: Forecast of Residential Natural Gas Customers by Housing Type, 2009-2021**

| Forecast of Residential Natural Gas Customers by Housing Type, 2009-2021 | | | | | | |
|---|---|---|---|---|---|---|
| **Housing Units** | **2009** | **2011** | **2015** | **2018** | **2021** | **Average Annual Growth** |
| Single Family, detached | 637,477 | 654,435 | 680,909 | 700,764 | 720,619 | 6,929 |
| Single Family, attached | 188,660 | 193,679 | 201,514 | 207,390 | 213,266 | 2,050 |
| Multifamily | 94,778 | 97,299 | 101,235 | 104,187 | 107,139 | 1,030 |
| Mobile Homes | 708 | 727 | 757 | 779 | 801 | 8 |
| Total | 921,624 | 946,141 | 984,415 | 1,013,120 | 1,041,825 | 10,017 |

### 3.2.2 Average Annual Natural Gas Usage per Residential Customer

Figure 3-2 provides a historical perspective on residential gas usage per customer in Maryland. Average usage per customer has been trending downward since 1987. A key factor that explains the downward trend in natural gas usage per residential customer is the increasing penetration of higher efficiency natural gas space and water heating equipment.

**Figure 3-2: Average Annual Consumption of Natural Gas per Residential Consumer (Million BTU)**




The natural gas end uses in the residential sector that have the largest use per customer—and thus offer the greatest opportunity for savings with energy-efficiency measures—are space and water heating. Table 3-4 shows data on the estimated average annual natural gas usage per residential customer by end use in Maryland. The end use with the largest use is space heating.

The one with the smallest is clothes drying. It is important to keep these statistics in mind when selecting and developing energy-efficiency programs for implementation.

**Table 3-4: Estimated Average Annual Natural Gas Usage per Residential Customer by End Use in Maryland**

| Estimated Average Annual Natural Gas Usage per Residential Customer by End Use in Maryland | | |
|---|---|---|
| **End Use** | **Average Annual Use per Customer (in Therms)** | **Data Source** |
| Space Heating | 708 | 2011 GDS analysis of single-family homes in Maryland[11] |
| Water Heating | 175 | 2011 GDS analysis of single-family homes in Maryland[12] |
| Gas Fireplace | 101.2 | American Gas Association (AGA), Residential Natural Gas Market Survey, Middle Atlantic Region, January 2011, page 78 |
| Range | 56.1 | American Gas Association (AGA), Residential Natural Gas Market Survey, Middle Atlantic Region, January 2011, page 78 |
| Clothes Dryer | 52.8 | American Gas Association (AGA), Residential Natural Gas Market Survey, Middle Atlantic Region, January 2011, page 78 |

### 3.2.3 Residential Customer Saturation Estimates by End Use

Tables 3-5 through 3-10 list the latest available information on the saturation of natural gas end uses for Maryland. The saturation data for residential end uses was obtained by GDS through a detailed analysis of the 2007 American Housing Survey data for the Baltimore Metropolitan Area and KEMA's Maryland Energy Baseline Study, Residential Sector, June 8, 2011.

**Table 3-5: Percent of Housing Units Using Piped Gas as Main Fuel for End Use**

| | Maryland Baseline Study, 2011 | Percent of Housing Units Using Piped Gas as Main Fuel for End Use 2007 American Housing Survey, Baltimore Metropolitan Region | | | | |
|---|---|---|---|---|---|---|
| **End Use** | **All Housing Units** | **All Housing Units** | **Owner Occupied** | **Renter Occupied** | **Mobile Homes** | **New Construction (last 4 years)** |
| **Space Heating** | 42.5% | 50% | 49% | 54% | 5% | 48% |
| **Cooking** | n/a | 49% | 46% | 57% | 54% | 43% |
| **Water Heating** | 46.8% | 53% | 47% | 60% | 22% | 56% |
| **Central A/C** | n/a | 5% | 5% | 6% | 0% | 5% |
| **Clothes Dryer** | 13.2% | 59% | 72% | 36% | 5% | 16% |

[11] GDS developed this estimate based upon a detailed analysis of a typical single-family home in Maryland. GDS conducted this analysis because there was no existing data source for this use per customer data.
[12] GDS developed this estimate based upon a detailed analysis of a typical single-family home in Maryland and building energy modeling analyses. GDS conducted this analysis because there was no existing data source for this use per customer data.

Based on the Maryland Energy Baseline Study, Table 3-6 shows that nearly 43% percent of residential customers use natural gas for space heating. The number of natural gas furnaces in Maryland residences outnumbers natural gas boilers by a ratio of 8 to 1. Additionally, natural gas is used for water heating in 47 percent of Maryland residential housing units.

**Table 3-6: Residential Saturation of Space Heating Equipment by Type of Household[13]**

| Residential Saturation of Space Heating Equipment by Heating Fuel Type, Single Family Units | | | | | | |
|---|---|---|---|---|---|---|
| **Primary Heating Fuel** | **Single Family Detached** | **Single Family Attached** | **Mobile Homes** | **Multi-family 2-4** | **Multi-family 5+** | **Weighted Average** |
| Natural Gas | 42.56% | 49.53% | 2.38% | 46.10% | 30.19% | 42.56% |
| **Equipment Characteristics** | | | | | | |
| Gas Furnace | 40.56% | 42.63% | 1.48% | 42.18% | 29.61% | 38.07% |
| Gas Furnace > 92% AFUE | 7.67% | 22.66% | | | | Not available |
| Gas Furnace (including gas furnaces of all efficiency levels) with programmable thermostat | 79.74% | 79.66% | 100.00% | 50.00% | 4.17% | Not available |

Table 3-6 also shows that 46% percent of residential buildings with two to four family units use natural gas for space heating. On the other hand only 30% percent of residential buildings with more than four family units use natural gas for space heating.

Table 3-7 shows historical and forecast data on the number of residential buildings in Maryland that are heated with natural gas and provides an estimate of the amount of natural gas used.

[13] The source of this data is the 2011 Maryland Energy Baseline Study prepared for the Maryland Public Service Commission by KEMA. The weighted average saturation data was not available in the Maryland Energy Baseline Study for natural gas furnaces (with AFEU >92%) or for the saturation of programmable thermostats in homes with natural gas furnaces.

**Table 3-7: Natural Gas Heated Residential Buildings in Maryland**

| Residential Gas HEAT Customers by Housing Type | | | | | |
|---|---|---|---|---|---|
| Year | Total Housing Units | Single Family (detached) | Single Family (attached) | Multifamily | Mobile Homes |
| 2009 | 829,461 | 573,729 | 169,794 | 85,300 | 638 |
| 2010 | 842,915 | 583,035 | 172,548 | 86,683 | 648 |
| 2011 | 851,527 | 588,992 | 174,311 | 87,569 | 654 |
| 2012 | 860,138 | 594,948 | 176,074 | 88,455 | 661 |
| 2013 | 868,750 | 600,905 | 177,837 | 89,340 | 668 |
| 2014 | 877,361 | 606,861 | 179,600 | 90,226 | 674 |
| 2015 | 885,973 | 612,818 | 181,363 | 91,111 | 681 |
| 2016 | 894,585 | 618,775 | 183,125 | 91,997 | 688 |
| 2017 | 903,196 | 624,731 | 184,888 | 92,883 | 694 |
| 2018 | 911,808 | 630,688 | 186,651 | 93,768 | 701 |
| 2019 | 920,420 | 636,644 | 188,414 | 94,654 | 707 |
| 2020 | 929,031 | 642,601 | 190,177 | 95,539 | 714 |
| 2021 | 937,643 | 648,557 | 191,940 | 96,425 | 721 |

## 3.3 Commercial Gas Usage

### 3.3.1 Commercial Customer Forecast

The number of commercial customers using natural gas has been trending upward for a number of years. The number of commercial customers in 2009 totaled 75,771, which represents a 10% increase from 1987. The forecast[14] calls for the number of customers to grow by about 0.8% per annum to 83,792 in 2021. Annual customer growth of 645 customers is projected.

### 3.3.2 Commercial Gas Usage by Building Type and End Use

Figure 3-3 provides a historical perspective on natural gas usage per commercial customer in Maryland. Average usage per customer has been trending upward since 1987.

[14] This forecast is based upon the observed trend in the number of commercial gas customers in the State of Maryland, 1997-2009

**Figure 3-3: Average Annual Consumption of Natural Gas per Commercial Consumer (Million BTU)**

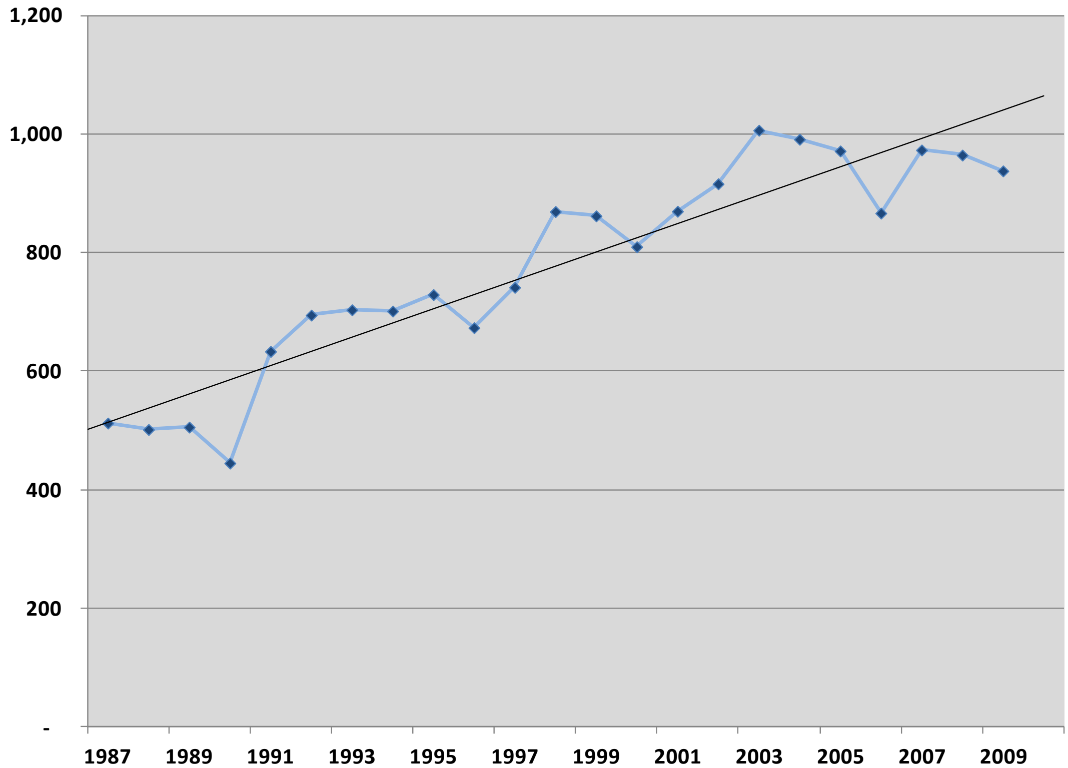



Figure 3-4 provides a breakdown of Maryland commercial sector natural gas sales for the year 2009. It is important to note that office buildings represent the largest identifiable commercial market segment in terms of annual natural gas sales, representing 23 percent of annual firm commercial gas sales.[15]

[15] The Other Retail Trade sector is quite diverse. It includes the following types of establishments: Motor vehicle and parts dealers, Furniture and home furnishings stores, Electronics and appliance stores, Building material and garden equipment and supplies dealers, Health and personal care stores, Gasoline stations, Clothing and clothing accessories stores, Sporting goods, hobby, book, and music stores, General merchandise stores, Miscellaneous store retailers and Nonstore retailers, In terms of employment, General merchandise stores accounted for 22% of the sector's total in 2009 based upon County Business Patterns data.

**Figure 3-4: Commercial Sector Gas Consumption by Building Type, 2009**

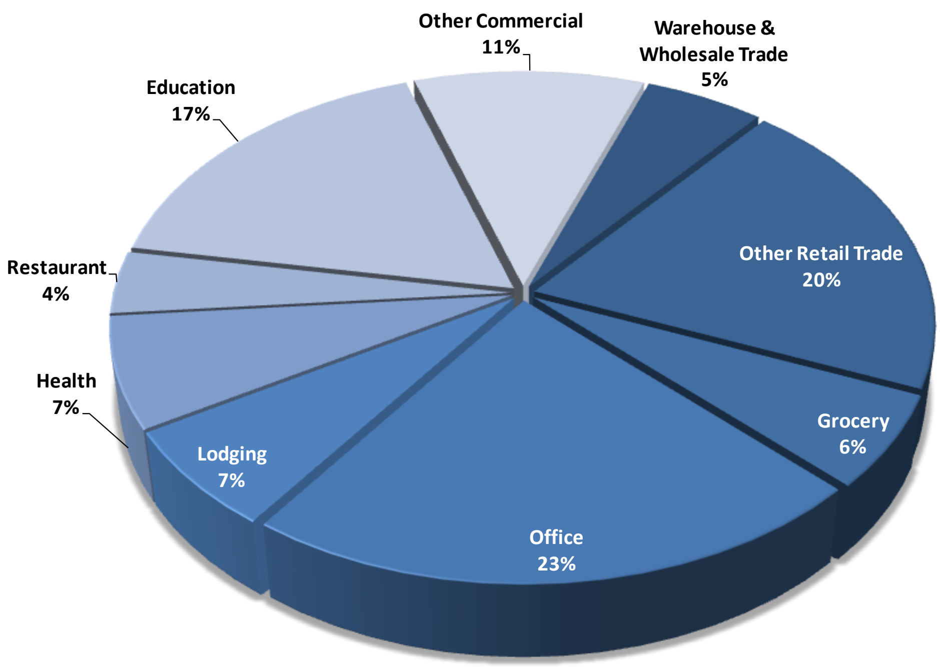



Figure 3-5 provides a breakdown of commercial sector natural gas sales by end use for the year 2009. Space heating at 50% of the total represents the primary category of natural gas usage.

**Figure 3-5: Commercial Sector Gas Consumption by End Use, 2009**

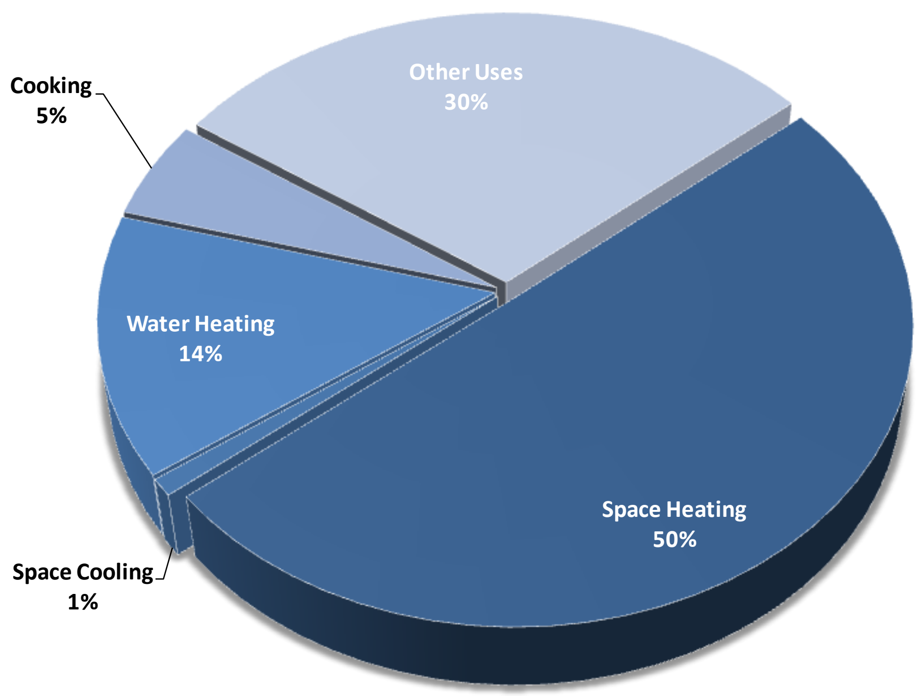


Table 3-8 highlights the saturation of natural gas end uses by commercial building type.

**Table 3-8: Natural Gas End Use by Commercial Building Type and End Use**

| Natural Gas End Uses by Commercial Building Type and End Use | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Office | Retail | Grocery | Warehouse | Education | Health | Lodging | Restaurant | Other |
| Space Heating | 86% | 71% | 69% | 84% | 77% | 56% | 30% | 27% | 85% |
| Water Heating | 5% | 7% | 5% | 3% | 14% | 30% | 58% | 28% | 4% |
| Cooking | 1% | 9% | 21% | 0% | 2% | 4% | 7% | 45% | 2% |
| Other | 9% | 13% | 5% | 13% | 7% | 9% | 6% | 1% | 8% |

## 3.4 Industrial Gas Usage

### 3.4.1 Industrial Customer Forecast

The number of industrial customers using natural gas has been trending downward for a number of years. The number of industrial customers in 2009 totaled 1,234. The forecast[16] calls for the number of customers to continue to drop by about 2.0% per annum to 964 in 2021.

### 3.4.2 Industrial Gas Usage by Segment and End Use

Figure 3-6 provides a perspective on natural gas usage by industrial customers since 2002. Average usage per customer has been essentially flat during this period of history. The GDS forecast indicates that industrial natural gas sales will increase at 1.2% per year from 2009 to 2021. Since the number of customers is decreasing at 2% per year in the forecast, this means that natural gas usage per industrial customer will be increasing. This suggests that there will be significant potential for energy efficiency programs to help address this increase in usage per customer.

[16] This forecast is based upon the observed trend in the number of industrial gas customers in the State of Maryland, 2003-2009.

**Figure 3-6: Average Annual Consumption of Natural Gas per Industrial Customer (Million BTU)**

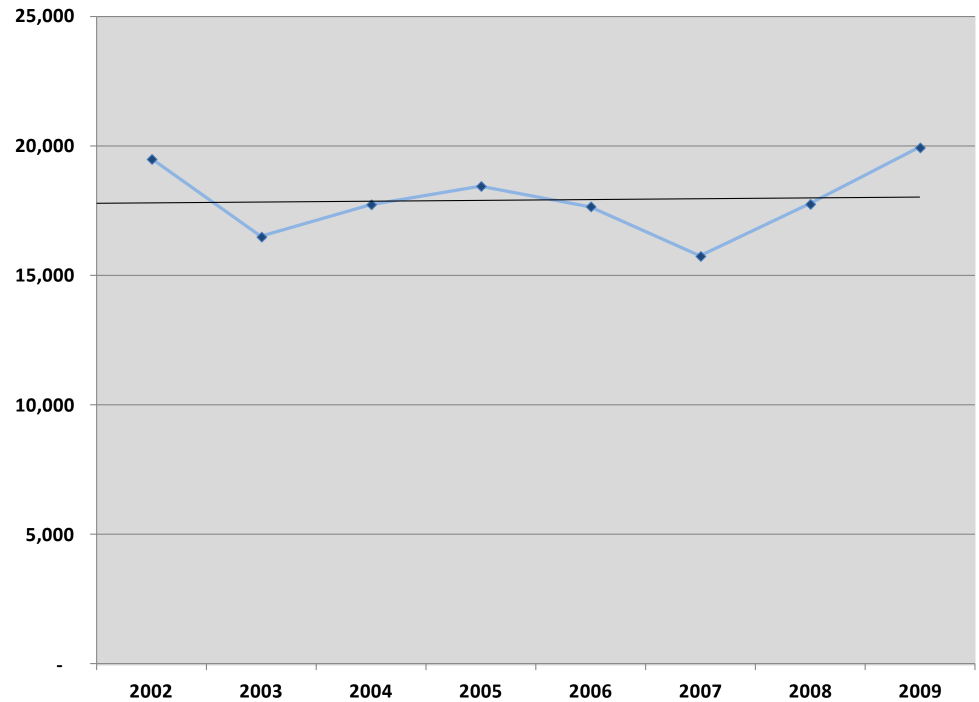



Table 3-9 provides a detailed perspective on Maryland's manufacturing sector in 2009. The output of this sector (in inflation adjusted 2005 dollars) totaled $15,685 million, or about 1.1% of the output in the U.S. The industrial sector consumed 24.6 trillion Btu of natural gas in that year. GDS estimates that the natural gas energy intensity of the Maryland manufacturing sector (i.e., 1,568 Btu/$ of GDP) is significantly less than that of the U.S. as a whole. The computer and electronic products industry represented the largest share (39 percent) of Maryland's gross domestic product (GDP) in the year 2005, followed by the chemicals industry with a 16 percent share.

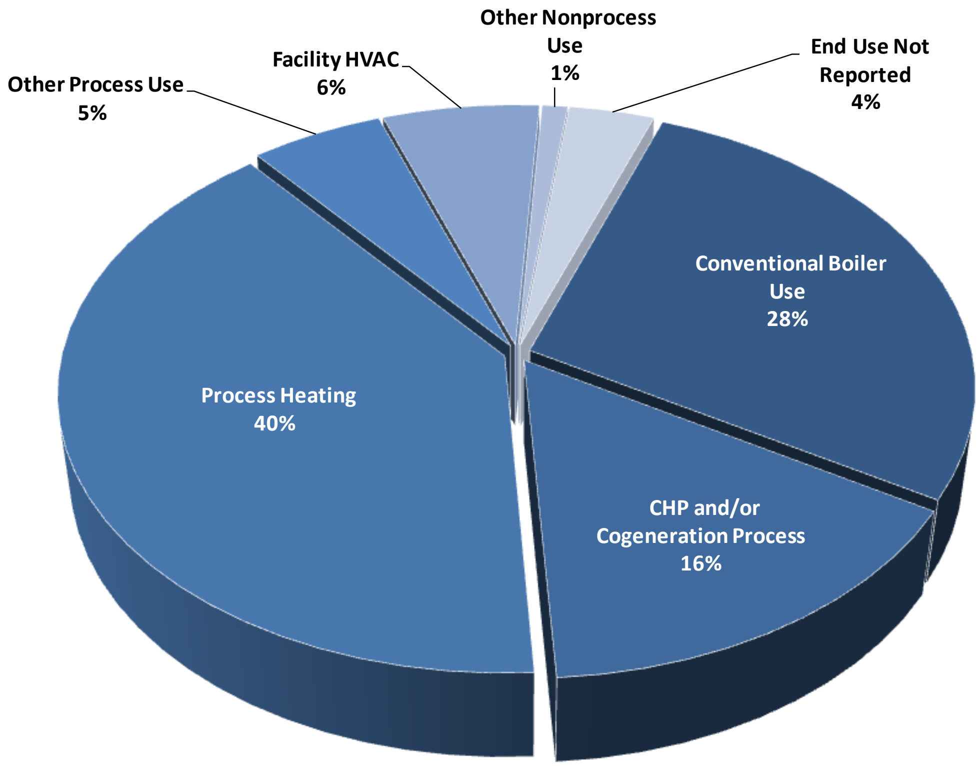
**Table 3-9: Perspective on the Industrial Sector in Maryland, 2009**[17]

| Perspective on the Industrial Sector in Maryland, 2009 | | | | |
|---|---|---|---|---|
| **NAICS** | **Industry** | **Maryland Real GDP (Mil. 2005 Dollars)** | **Maryland Natural Gas Consumption (TBtu)** | **Maryland Natural Gas Btu per Dollar of GDP** |
| 311-339 | **ALL MANUFACTURING INDUSTRIES** | **15,685** | **24.60** | **1,568** |
| 311-312 | FOOD, BEVERAGE & TOBACCO PRODUCTS | 2,485 | 4.88 | 1,965 |
| 313-314 | TEXTILE MILLS | 150 | 0.46 | 3,048 |
| 315-316 | APPAREL, LEATHER AND ALLIED PRODUCTS | 73 | 0.02 | 287 |
| 321 | WOOD PRODUCTS | 264 | 0.39 | 1,474 |
| 322 | PAPER | 234 | 1.14 | 4,852 |
| 323 | PRINTING AND RELATED SUPPORT | 647 | 0.39 | 600 |
| 324 | PETROLEUM AND COAL PRODUCTS | 196 | 0.77 | 3,941 |
| 325 | CHEMICALS | 2,550 | 9.90 | 3,882 |
| 326 | PLASTICS AND RUBBER PRODUCTS | 582 | 0.70 | 1,207 |
| 327 | NONMETALLIC MINERAL PRODUCTS | 310 | 1.99 | 6,421 |
| 331 | PRIMARY METALS | 219 | 1.55 | 7,056 |
| 332 | FABRICATED METAL PRODUCTS | 821 | 0.88 | 1,068 |
| 333 | MACHINERY | 518 | 0.21 | 406 |
| 334 | COMPUTER AND ELECTRONIC PRODUCTS | 6,062 | 0.68 | 113 |
| 335 | ELEC. EQUIP., APPLIANCES, COMPONENTS | 171 | 0.09 | 513 |
| 336 | TRANSPORTATION EQUIPMENT | 598 | 0.42 | 698 |
| 337 | FURNITURE AND RELATED PRODUCTS | 173 | 0.05 | 264 |
| 339 | MISCELLANEOUS | 473 | 0.09 | 189 |
| | **Five Largest Gas Consumers** | **5,798** | **19.45** | **3,355** |
| | Percent of Total Manufacturing | 37% | 79% | 214% |

Figure 3-7 provides a breakdown of industrial gas consumption by end use for the State of Maryland in 2009. The largest share of natural gas consumption in the industrial sector is for process heating, representing 40% of natural gas consumption.

[17] The real GDP estimates by industry for Maryland come from the Bureau of Economic Analysis, U.S. Department of Commerce. The gas consumption values are GDS estimates based upon U.S. energy intensities (i.e., BTU/$ of GDP) for each industry in 2006, advanced to 2009. Total gas consumption by industry is then scaled down because Maryland's industrial consumption as reported by the EIA is less than we'd calculate based upon U.S. intensities & Maryland GDP. This is discussed in further detail in Chapter 7.

**Figure 3-7: Breakdown of Industrial Natural Gas Consumption by End Use, Maryland, 2009**



# 4.0 OVERALL PROJECT METHODOLOGY

This section describes the overall methodology used to conduct this study and explains the general steps and methods used at each stage of the analytical process necessary to produce the various estimates of energy efficiency potential. Specific differences in methodology from one sector to another have been noted throughout the report. Information on this methodology was provided to MEA throughout the development of this report for feedback and comment.

Energy efficiency potential studies involve carrying out a number of analytical steps to produce estimates of each type of energy efficiency potential. This study utilizes the GDS Benefit/Cost Screening Tool, and other GDS developed Excel-based models that integrate technology-specific impacts and costs, customer characteristics, an updated natural gas sales forecast for Maryland, natural gas avoided cost forecasts and more. Excel was used as the modeling platform to provide transparency to the estimation process and to allow for simple customization based on Maryland's unique characteristics and the availability of specific model input data.

## 4.1 Measure List Development

Energy efficiency measure lists were based on the analysis team's existing knowledge and current databases of natural gas end-use technologies and energy efficiency measures, and were supplemented as necessary to include other technology areas of interest to MEA, the Maryland Public Service Commission, and the Maryland utilities. The study scope included measures and practices that are currently commercially available as well as emerging technologies. The commercially available measures should be of most immediate interest to energy efficiency program planners.

In addition, this study includes energy efficiency 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 natural gas furnace); whereas retrofit measures are generally characterized by full costs and savings (e.g. the full costs and savings associated with retrofitting 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.

## 4.2 Measure Characterization

A significant amount of data is needed to estimate the savings potential for individual energy efficiency measures or programs across the entire existing residential, commercial and industrial sectors. To this extent, considerable effort was expended to identify, review, and document all available data sources.[18] This review allowed development of reasonable assumptions regarding measure lives; installed incremental and full costs (where appropriate); and natural gas savings for each measure included in the final lists of measures in this study.

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

- Existing deemed savings databases
- Building energy modeling software 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® and other technical potential studies
- Program evaluations conducted by other utilities and program administrators

*Measure Costs:* Measure costs represent either incremental or full cost, and typically include the cost of installation. For purposes of this study, nominal measures costs were held constant over time. This general assumption was made due to the fact that historically many measure costs (for example, high efficiency natural gas furnaces) have declined over time, while some measure costs have increased over time (fiberglass insulation). Cost estimates were typically derived from the following sources:

- Existing deemed savings databases
- Mid-Atlantic Technical Reference Manual
- Secondary sources such as ACEEE, Energy Star®, and other technical potential studies
- Retail store/contractor pricing and industry experts
- Evaluation reports

*Measure Life*: Represents the number of years (or hours) that energy-using equipment is expected to operate. Useful life estimates were derived from:

- Manufacturer data
- Savings calculators and Life-cycle cost analyses
- Secondary sources such as ACEEE, Energy Star®, and other technical potential studies
- Mid-Atlantic Technical Reference Manual
- The California Database for Energy Efficient Resources ("DEER") database
- Evaluation reports

*Baseline and Efficient Technology Saturations*: In order to assess the amount of energy efficiency savings still available, estimates of the current saturation of baseline equipment and energy efficiency measures are necessary. Up-to-date measure saturation data were primarily obtained from the following recent studies:

- Recently completed residential baseline study completed for Maryland in 2011[19]
- 2009 EIA Residential Energy Consumption Survey

[18] The appendices to this report provide the data sources used by the GDS Team to obtain up-to-date data on measure costs, savings and useful lives.
[19] Maryland Energy Baseline Study, Residential Sector, prepared for the Maryland Public Service Commission and its sponsors in support of the EmPower Maryland Programs.

- 2006 EIA Manufacturing Energy Consumption Survey
- 2003 EIA Commercial Building Energy Consumption Survey

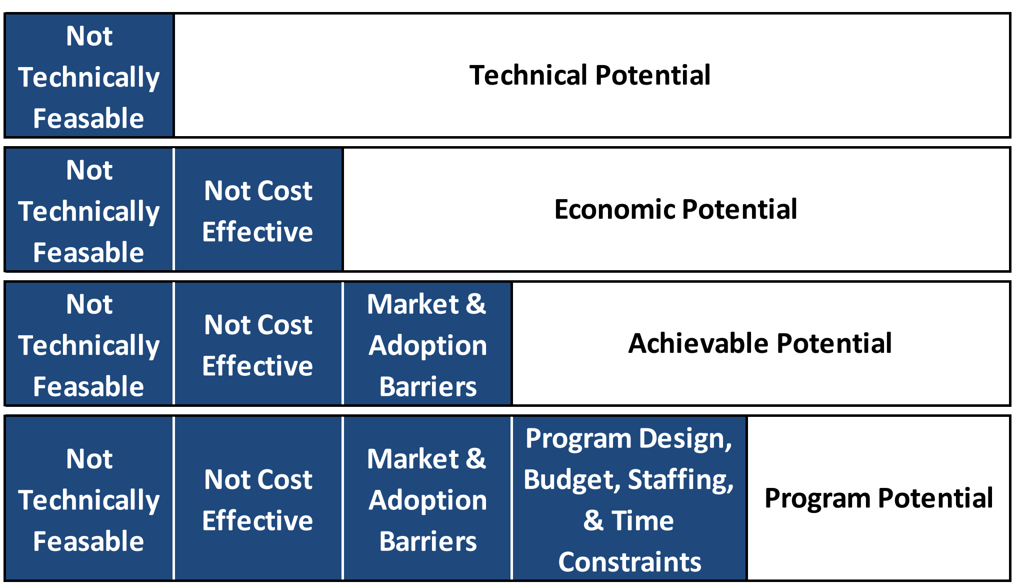
Further detail regarding the development of measure assumptions for natural gas energy efficiency measures in the residential, commercial and industrial sectors can be found in the appendices of this report. The individual sector appendices provide a comprehensive listing of all energy efficiency measure assumptions (and their data sources) used in this study.

An up-to-date and detailed statewide forecast of natural gas sales and customers was not available from the natural gas utilities in Maryland, although a 2011 residential baseline study was available for the residential natural gas sector. A forecast of the number of new residential gas customers was not available from the natural gas utilities in Maryland. For the commercial and industrial sectors, baseline studies, natural gas sales forecasts, equipment saturation data or energy efficient saturations were not available from the natural gas utilities in Maryland. The Maryland natural gas utilities were also not able to provide up-to-date information on natural gas energy efficiency measure costs, natural gas savings or useful lives for the residential, commercial and industrial sectors. GDS notes that this lack of data is commonplace with natural gas utilities in many jurisdictions. GDS was able, however, to find other suitable data from the region to use for this current study. GDS has provided detailed data sources for all of the data used in this study. GDS recommendations on further baseline research that is needed in Maryland are provided later in this report.

### 4.3 Potential Savings Overview

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

**Figure 4-1: Types of DSM Potential[20]**




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

The first two types of potential, technical and economic, provide a theoretical upper bound for energy savings. Still, even the best designed portfolio of programs is unlikely to capture 100 percent of the technical or economic potential. Therefore, achievable potential and program potential attempt to estimate what may realistically be achieved, when it can be captured, and how much it would cost to do so. Figure 4-1 illustrates the four most common types of efficiency potential.

## 4.4 Technical Potential

Technical potential is the theoretical maximum amount of energy use that could be displaced by efficiency, disregarding all non-engineering constraints such as cost-effectiveness and the willingness of end-users to adopt the efficiency measures. 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.[21]

This study used a “bottom-up” approach in the residential sector to calculate the potential of an energy efficiency measure or set of measures. A bottom-up approach first starts with the savings and costs associated with replacing one piece of equipment with its efficient 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 often preferred in the residential sector because of better data availability and greater homogeneity of the building and equipment stock to which measures are applied. However, this methodology was not able to be used in the C&I sector. For the commercial and industrial (C&I) sectors, a “top-down” approach was used for developing the technical potential estimates. This approach builds an energy use profile based on estimates of 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 regarding the fraction of sales that are associated with inefficient equipment and the technical/engineering feasibility of each energy efficiency measure.

The savings estimates per base unit were 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.

### 4.4.1 Core Equation for the Residential Sector

The core equation used in the residential sector technical potential analysis for each individual efficiency measure is shown below in Figure 4-2.

**Figure 4-2: Core Equation for the Residential Sector Technical Potential**

$$\text{Technical Potential of Efficient Measure} = \text{Total Number of Households or Buildings} \times \text{Base Case Equipment End Use Intensity [MMBTU/unit]} \times \text{Base Case Factor} \times \text{Remaining Factor} \times \text{Applicability Factor} \times \text{Savings Factor}$$

[21] National Action Plan for Energy Efficiency, “Guide for Conducting Energy Efficiency Potential Studies”, page 2-4

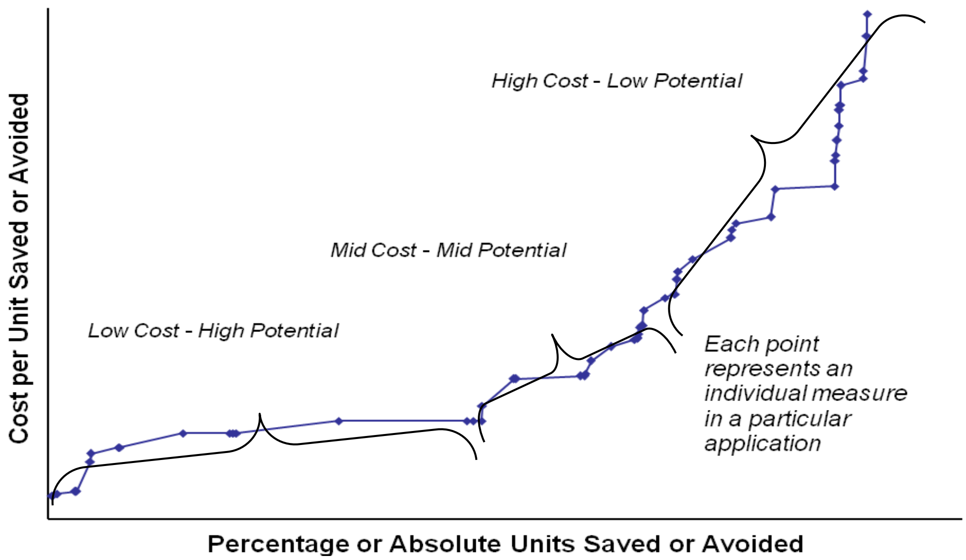
**Where:**

- Base Case Equipment End Use Intensity = the natural gas used per customer per year by each base-case technology in each market segment. This is the consumption of the natural gas energy using equipment that the efficient technology replaces or affects.
- Base Case Factor = the fraction of the end use natural 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 natural gas customers that have natural gas water heating in their household,
- Remaining Factor = the fraction of applicable dwelling units that have not yet been converted to the gas energy efficiency measure; that is, one minus the fraction of households that already have the energy-efficiency measure installed.
- Applicability Factor = the fraction of the applicable units that is technically feasible for conversion to the efficient technology from an engineering perspective (e.g., it may not be possible to replace an electric water heater with natural gas water heater if piped natural gas is not available at the home).
- Savings Factor = the percentage reduction in natural gas consumption resulting from application of the efficient technology.

Technical energy efficiency potential in the residential sector was calculated in two steps. In the first step, all measures were treated *independently*; that is, the savings of each measure were not reduced or otherwise adjusted for overlap between competing or interacting measures. By analyzing measures independently, no assumptions were 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, cumulative technical potential was estimated using an energy efficiency supply curve approach. This method eliminates the double-counting problem mentioned above. A generic example of a supply curve is shown in Figure 4-3. 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 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 were sorted on a least-cost basis and total savings 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 4-3: 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 energy savings. Cost are annualized (often referred to as levelized) in supply curves. For example, energy-efficiency supply curves usually present levelized costs per MMBTU saved by multiplying the initial investment in an efficient technology or program by the capital recovery rate (CRR):[22]

**Therefore:**

*Levelized Cost per MMBTU Saved* = Initial Cost x CRR/Annual MMBTU Savings

### 4.4.2 Core Equation for the Commercial and Industrial Sector

The core equation used in the commercial and industrial sector technical potential analysis for each individual efficiency measure is shown below in Figure 4-4.

**Figure 4-4: Core Equation for Commercial & Industrial Sector Technical Potential**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Technical Potential of Efficient Measure | = | Total End Use MMBTU Sales by Industry Type | X | Base Case Factor | X | Remaining Factor | X | Convertible Factor | X | Savings Factor |

**Where:**

- Total end use MMBTU sales (by segment) = the forecasted level of natural gas sales for a given end-use (e.g., space heating) in a commercial or industrial market segment (e.g., office buildings).
- Base Case factor = the fraction of the end use natural gas energy that is applicable for the efficient technology in a given market segment. For example, for boiler heating, this

22 The capital recovery rate (CRR) is a factor that is multiplied by the initial investment to determine a monthly or annual payment necessary to recover principal, interest and other costs over a set period of years.

would be the fraction of all space heating MMBTU in a given market segment that is associated with natural gas boilers.

- Remaining factor = the fraction of applicable MMBTU sales that are associated with equipment that has not yet been converted to the natural gas energy efficiency measure; that is, one minus the fraction of the market segment that already have the energy-efficiency measure installed.
- Applicability 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 replace an electric water heater with a high efficiency natural gas water heater if piped natural gas is not available at the home).
- Savings factor = the percentage reduction in natural gas consumption resulting from application of the efficient technology.

Similar to the residential sector, technical natural gas energy efficiency savings potential in the C&I sector was 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 were 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 furnace, the less energy saved from the installation of low-e ENERGY STAR windows.

For the residential and commercial sectors, the GDS Team addressed the new construction market as a separate market segment, with a program targeted specifically at the new construction market. In the residential new construction market segment, for example, detailed energy savings estimates for the ENERGY STAR Homes program were used as a basis for determining natural savings for this market segment in Maryland.

### 4.5 Economic Potential

Economic potential refers to the subset of the technical potential that is 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.

In practice, most technical and economic potential estimates produce similar results. Many analysts generally pre-screen possible efficiency technologies and practices based on an understanding of which measures are likely to be cost-effective and in an interest in conserving time and effort for other aspects of the analysis. All measures that were not found to be cost-effective based on the results of the Total Resource Cost Test were excluded from future analysis. The TRC Test defined in greater detail later in this section.

### 4.6 Achievable Potential

Achievable potential is the amount of energy use that can realistically be expected to save assuming a specific market penetration and funding scenarios. Achievable potential takes into account barriers that hinder consumer adoption of energy efficiency measures such as financial, political and regulatory barriers, the administrative and marketing costs associated with efficiency programs, and the capability of programs and administrators to ramp up activity over time. For this study, GDS calculated the achievable potential for the 2012 to 2021 time period for three market penetration scenarios: 40 percent, 60 percent and 80 percent.

Achievable potential can also vary with DSM program parameters, such as the magnitude of rebates or incentives offered to customers for installing DSM measures and thus, many different scenarios can be modeled.

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 two principal processes:

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

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, of 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.

### 4.7 Determining Cost-Effectiveness

For the economic and achievable potential it is necessary to develop a method by which it can be determined that a measure or program is cost-effective. A standard methodology for energy efficiency program cost effectiveness analysis was published in California in 1983 by the California Public Utilities Commission and updated in 1987, 2001, 2002, 2007 and 2010. It was based on experience with evaluating conservation and load management programs in the late 1970's and early 1980's. This methodology examines five perspectives:

- The Total Resource Cost (TRC) Test
- The Participant Test
- The Utility Cost Test (or Program Administrator Test)

- The Rate Impact Measure (RIM) Test
- The Societal Cost Test

Table 4-1 below summarizes the major components of these five benefit/cost tests. Maryland focuses primarily on the TRC Test.

**Table 4-1: Components of Energy Efficiency Benefit/Cost Tests**

| Components of Energy Efficiency Benefit/Cost Tests | | | | | |
|---|---|---|---|---|---|
| | Participant Test | Rate Impact Test | Total Resource Cost Test | Utility Cost Test | Societal Test |
| **Benefits** | | | | | |
| Reduction in Customer's Utility Bill | X | | | | |
| Incentive Paid by Utility | X | | | | |
| Any Tax Credit Received | X | | X | | |
| Avoided Supply Costs | | X | X | X | X |
| Avoided Participant Costs | X | | X | | X |
| Participant Payment to Utility (if any) | | X | | X | |
| External Benefits | | | | | X |
| **Costs** | | | | | |
| Utility Costs | | X | X | X | X |
| Participant Costs | X | | X | | X |
| External Costs | | | | | X |
| Lost Revenues | | X | | | |

### 4.7.1 The Total Resource Cost Test

The Total Resource Cost (TRC) test measures the net costs of a demand-side management or energy efficiency program as a resource option based on the total costs of the program, including both the participants' and the utility's costs.[23]

Benefits and Costs: The TRC test represents the combination of the effects of a program on both the customers participating and those not participating in a program. In a sense, it is the summation of the benefit and cost terms in the Participant and the Ratepayer Impact Measure tests, where the revenue (bill) change and the incentive terms intuitively cancel (except for the differences in net and gross savings).

The benefits calculated in the Total Resource Cost Test include the avoided electric supply costs for the periods when there is an electric load reduction, as well as savings of other resources such as fossil fuels and water. The avoided supply costs are calculated using net program

[23]California Public Utilities Commission, California Standard Practice Manual, Economic Analysis of Demand-Side Management Programs and Projects, October 2001, page 18.

savings, which are the savings net of changes in energy use that would have happened in the absence of the program.

The costs in this test are the program costs paid by the utility and the participants plus any increase in supply costs for periods in which load is increased. Thus all equipment costs, installation, operation and maintenance, cost of removal (less salvage value), and administration costs, no matter who pays for them, are included in this test. Any tax credits are considered a reduction to costs in this test.

#### 4.7.2 The Participant Test

The Participant Test is the measure of the quantifiable benefits and costs to program participants due to participation in a program. Since many customers do not base their decision to participate in a program entirely on quantifiable variables, this test cannot be a complete measure of the benefits and costs of a program to a customer.[24] This test is designed to give an indication as to whether the program or measure is economically attractive to the customer. Benefits include the participant's retail bill savings over time, and costs include only the participant's costs.

#### 4.7.3 The Rate Impact Measure Test

The Ratepayer Impact Measure (RIM) Test measures what happens to customer bills or rates due to changes in utility revenues and operating costs caused by a program. Rates will go down if the change in revenues from the program is greater than the change in utility costs. Conversely, rates or bills will go up if revenues collected after the program is implemented are less than the total costs incurred by the utility in implementing the program. This test indicates the direction and magnitude of the expected change in customer rate levels.[25] Thus, this test evaluates an energy efficiency program from the point of view of rate levels. The RIM test is a test of fairness or equity; it is not a measure of economic efficiency.

#### 4.7.4 The Utility Cost Test

The Utility Cost Test measures the net costs of a demand-side management program as a resource option based on the costs incurred by the utility (including incentive costs) and excluding any net costs incurred by the participant. The benefits are similar to the Total Resource Cost Test benefits. Costs are defined more narrowly, and only include the utility's costs.[26] This test compares the utility's costs for an energy efficiency program to the utility's avoided costs for gas and/or electricity. This means that a measure could pass the Utility Cost Test but not be cost effective from a more comprehensive perspective that included participant costs.

### 4.8 Avoided Costs

GDS was able to obtain forecasts of natural gas avoided costs from Baltimore Gas and Electric (BG&E) Company and Washington Gas. GDS and MEA staff reviewed these forecasts of avoided costs, and decided to use the forecast obtained from Washington Gas as the source for the

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[24] Ibid., page 9.
[25] Ibid., page 17.
[26] Ibid., page 33.

forecast of avoided costs for this study. GDS then input these natural gas avoided costs into the GDS benefit/cost screening model.

Avoided cost for electric energy and demand capacity were derived from the EmPOWER Maryland Plan for 2011-2014 filed by Baltimore Gas and Electric in August 2011.[27] Avoided costs for water were developed from a survey of three Maryland water utilities' retail rates.

### 4.9 Free-Ridership versus Free-Drivers

Free riders are defined as participants in a DSM program who would have implemented the program measure or practice in the absence of the program or monetary incentive. Free drivers, on the other hand, are those who adopt a program measure or practice as an indirect result of the program, but are difficult to identify either because they do not collect an incentive or are not aware of their exposure to the program. The presence of free riders in a program tends to overstate program energy savings results (because free riders would have taken the action in the absence of the program) and complicates the evaluation of the effectiveness of DSM programs. Conversely, if one does not assess the impact of free drivers, this can result in understating a program's energy savings effectiveness. In determining whether a DSM program has had a direct impact on customer energy use, the focus should be on net savings- calculated by determining the share of free riders and free drivers and adjusting the associated savings accordingly.

Although the issue of free riders and free drivers is important, it is also one that is notoriously difficult to measure, and even more difficult to predict. Based on a review of the experiences and practices of energy efficiency program administrators and evaluators at NYSERDA, National Grid, Wisconsin Focus on Energy, the Minnesota Public Service Commission and other organizations, this analysis has adopted the approach that free riders and free drivers offset each other. The result is an assumed net to gross ratio of 1.0 for measures or programs considered in this analysis, where the energy savings that are eventually measured and verified will align exactly with the savings claimed. GDS has reviewed the result of free rider and free driver studies at such organizations and recommends this approach until programs can be fully implemented and follow-up net-to-gross research studies can be conducted to assess these issues.

### 4.10 Combined Heat & Power

The scope of work for this study did not include analysis of the potential natural gas savings for Combined Heat and Power (CHP) systems. This brief overview of the CHP market in Maryland is presented solely for the purpose of describing this technology and identifying CHP as an energy resource that warrants additional research by MEA.

CHP systems generate electricity and useful thermal energy in a single, integrated system. Heat that would normally be wasted in conventional power generation is recovered as useful energy, which avoids the losses that would otherwise be incurred from separate generation of heat and power. While the conventional, centralized method of producing usable heat and power separately has a typical combined efficiency of 45%, CHP systems can operate at levels as high

[27] Case #9154. Public Service Commission of Maryland.

as 80%. CHP is found across all sectors, but has historically been most applicable to the industrial, large commercial and institutional sectors.

The American Council for an Energy Efficient Economy (ACEEE), in a recent report[28], described the combined heat and power (CHP) market in Maryland as a growing one, with at least ten new CHP projects installed since 2000. Though Maryland has not been traditionally viewed as a hotbed for CHP activity, developers and supporters expect the Maryland market to improve in the near future. This is due in large part to the energy efficiency plans the state's utilities have recently developed in response to stated energy efficiency goals in the state's energy efficiency plan, EmPower Maryland. As the EmPower Maryland plans have matured, more of the state's utilities have decoupled their profits from their sales revenues, which could positively impact utilities' interest in the CHP market.

Since Maryland falls within the PJM Interconnection footprint, facility owners are generally eligible to participate in that regional transmission organization's demand response and forward capacity markets. These options could offer additional incentives to certain CHP projects, especially as PJM works to improve its capacity markets. Maryland does not offer other incentives for CHP, with the exception of a renewable energy production tax credit for biomass or biogas-fueled CHP.

Interconnection has been an issue in Maryland, but a new interconnection standard, effective 2009, has helped. The state's net metering laws are widely regarded as excellent for the small size bracket they serve, and have helped smaller (under 30 kW) and micro-CHP projects achieve better economic returns. However, both the interconnection standard and the net metering standard could be expanded to better serve CHP installations beyond the current size limits. These size limits present some of the biggest barriers facing larger CHP projects today.

The Marcellus natural gas shale find is expected to exert downward pressure on natural gas prices in the area, which had steadily risen for years prior to the economic downturn. Such a find could help to further encourage natural gas-fired CHP systems in the area and help potential CHP investors become comfortable making long-term plays in natural gas-dependent technology.

### 4.10.1 Installed CHP Capacity

According to the U.S. Department of Energy,[29] Maryland's installed CHP capacity is currently 766 MW or 6.5% of its total energy market. This energy is primarily generated through 14 major CHP facilities. The industrial sector accounts for 687 MW and the commercial sector accounts for the remaining 79 MW.

[28] Challenges Facing Combined Heat and Power Today: A State-by-State Assessment, Anna Chittum and Nate Kaufman, September 2011, Report Number IE111
[29] U. S. Department of Energy, Mid Atlantic Clean Energy Application Center

### 4.10.2 CHP Market Potential

While there has been a fair amount of CHP and distributed energy activity in the state to this point, there remains significant additional potential. According to the US Department of Energy, installations of CHP systems in Maryland's commercial and industrial sectors have the potential to generate 1320 to 2410 MW, representing 3-5% of DOE's 47GW long-term goal CHP goal. A major barrier to achieving this potential is what is known as the “spark spread” (the difference between the cost of electricity and the cost to produce that electrical energy on site). In the past, the spark spread has not been favorable in Maryland for CHP applications.

### 4.10.3 Opportunities for CHP in the Residential Market

Once available only to large commercial buildings, CHP systems are now being produced on a scale that is safe, practical, and affordable to homeowners. A residential CHP system uses fuel such as natural gas to produce heat and electricity simultaneously. The electricity can be used for any household device such as lights and appliances. Simultaneously, the heat produced can be used for water heating and/or space heating. About 10% of the fuel used is lost as exhaust, much like a high efficiency furnace. Micro-CHP, as residential-sized CHP systems are usually called, run on propane, natural gas, or even concentrated solar energy or biomass. The byproduct of electricity generation is waste heat. This waste heat can be used to heat a home or water for domestic use.

Micro-CHP units range in capacity from about 1 kW to 6 kW and are about the size of a major appliance. Installation may be performed initially by specialists and, after the technology matures, by an experienced plumber, electrician, or HVAC technician. Units come as grid-tied systems which connect to utility power as backup or as stand-alone systems for remote residences. One unit with a new, small capacity engine simultaneously produces 1.2 kilowatts of electric power and 11,000 Btus of heat in the form of hot water. The system is combined with a high efficiency, natural gas-fueled warm air furnace or boiler for supplemental space heating.

High initial cost for Residential CHP systems along with the previously described “spark spread,” will likely be the biggest impediment to adoption of the micro-CHP technology. However, changing electricity and natural gas rates, along with reductions in initial system costs can change the economics of CHP systems, and the technology should continue to be monitored and evaluated as a potential energy resource in Maryland.

# 5.0 RESIDENTIAL SECTOR ENERGY EFFICIENCY POTENTIAL

## 5.1 Introduction and Summary of Results

This section of the report presents the estimates of technical, economic, and achievable natural gas energy efficiency potential for the existing and new construction market segments of the residential sector in the State of Maryland. The achievable potential estimates are based primarily on a market penetration scenario that targets the installation of energy efficient equipment in 60% of the remaining eligible market by 2021. This scenario reflects the market driven implementation of certain measures that were modeled as non-retrofit measures. In other words, for these measures it was assumed that residential customers would replace existing inefficient equipment at the end of the equipment's effective useful life.

According to this analysis, there is still a large potential for natural gas efficiency savings in the residential sector. Figure and Table 5-1, below, summarize the technical, economic (based on the Total Resource Cost "TRC" test), and achievable savings potential by 2015 and 2020. If the targeted market penetration for all remaining eligible cost-effective measures can be reached over the next decade, the achievable potential for residential natural gas savings by the year 2020 is 10.3 million MMBTu, or approximately 11.1% of projected residential natural gas sales.

Market penetration scenarios targeting 40% and 80% are also included later in this section to demonstrate the impacts of lowered or increased energy efficiency measure adoption.

**Figure 5-1: Summary of Residential Natural Gas Efficiency Savings Potential by 2015 and 2020**

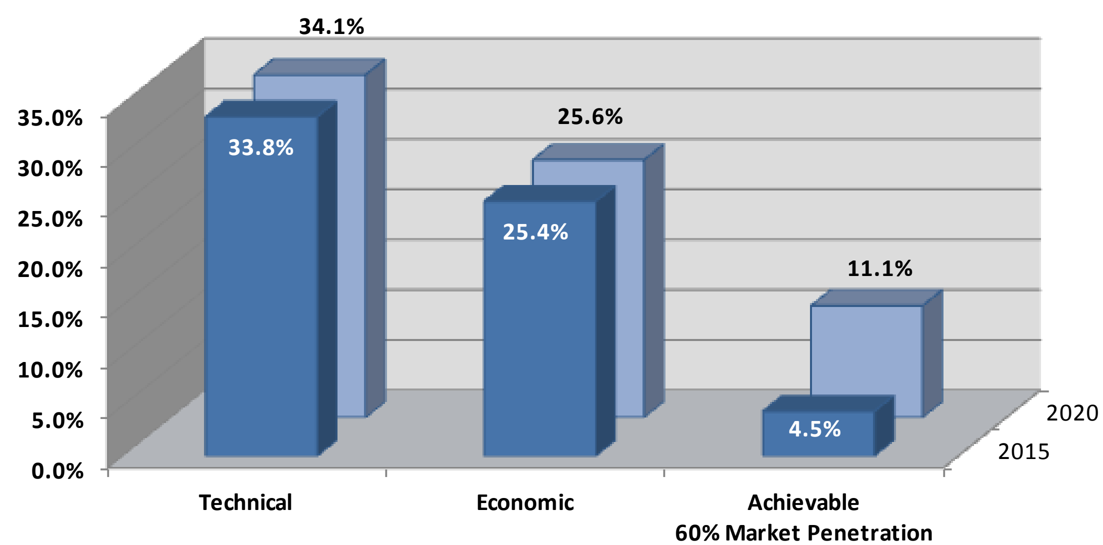


**Table 5-1: Summary of Residential Energy Efficiency Savings Potential by 2015 and 2020**

| Summary of Residential Natural Gas Efficiency Potential | | | |
|---|---|---|---|
| | Technical | Economic | Achievable 60% Market Penetration |
| **2015** | | | |
| Total MMBTU Savings | 29,819,002 | 22,381,729 | 3,948,109 |
| % of 2015 Forecast Residential Sales | 33.8% | 25.4% | 4.5% |
| **2020** | | | |
| Total MMBTU Savings | 31,552,018 | 23,709,143 | 10,300,041 |
| % of 2020 Forecast Residential Sales | 34.1% | 25.6% | 11.1% |

### 5.2 Residential Energy Efficiency Measures

Thirty-five (35) residential natural gas efficiency measures were included in the energy savings analysis for the residential sector.[30] Table 5-2 provides a brief listing of the various residential natural gas efficiency technologies considered in this analysis. The list of residential energy efficiency measures was developed by GDS based on a review of the measures and programs included in other regional natural gas program plans, measure databases, and technical potential studies. This study also includes natural gas efficiency measures suggested by MEA staff. The set of natural gas efficiency measures considered was pre-screened to only include those measures that are currently commercially available. Thus, emerging technologies, or technologies with extremely low market availability were not included in the analysis. Appendix B provides a brief discussion of each measure or program as well as the savings, useful life, cost, and equipment saturations associated with each measure.

The portfolio of measures includes only those that have some level of technical feasibility for implementation either by substituting for or being applied to existing technologies on a retrofit or market driven basis. Market driven refers to equipment replacements that are made normally in the market when a piece of equipment is at the end of its effective useful life. For purposes of this study, retrofit measures are limited to the application of supplemental measures (such as the addition of a low-flow device to a showerhead or increased levels of insulation), and do not include the early replacement of operational equipment.

30 After accounting for adjustments to different home types, housing characteristics and efficiency tiers, particularly for measures targeting the space heating and cooling end-use, the number of measures grew to approximately 132 measure permutations

**Table 5-2: List of Residential Efficiency Measures**

| List of Residential Energy Efficiency Measures | | |
|---|---|---|
| **End Use Type** | **End Use Description** | **Measures/Programs Included** |
| Water Heating | Water Heating/Kitchen/Laundry | * Clotheswashers (Tier I, II, III)<br>* Dishwashers (Tier 1, II)<br>* Efficient storage tank water heaters (Tier I, II)<br>* Tankless water heaters<br>* Solar water heating w/ gas back-up<br>* Pipe insulation<br>* Low flow faucet aerators<br>* Low flow showerheads<br>* Shower-Start technology |
| HVAC (Envelope) | Building Envelope Upgrades | * Ceiling Insulation<br>* Wall Insulation<br>* Basement Wall Insulation<br>* Rim/Band Joist Insulation<br>* Floor Insulation<br>* Air Sealing<br>* Duct Insulation<br>* Duct Sealing<br>* Energy Star Windows<br>* Energy Star New Homes Construction |
| HVAC (Equipment/Controls) | Heating Equipment/Controls | * Furnace Tune-Up<br>* Heating/Cooling system Tune-Up<br>* Programmable Thermostats<br>* High Efficiency Boilers (Tier I, II)<br>* High Efficiency Furnaces (Tier I, II, III) |
| Miscellaneous | Cooking/Pools/Whole-House | * Convection Oven Cooking<br>* Pool Covers (Vinyl, Bubble)<br>* Behavioral/Indirect Feedback Programs |

## 5.3 Characteristics of Residential Energy Efficiency Measures

GDS collected data on the energy savings, incremental costs, useful lives, and other key "per unit" characteristics for each of the residential natural gas efficiency technologies. Estimates of the size of the eligible market were also developed for each efficiency measure. For example, natural gas water heating energy efficiency measures (e.g., pipe insulation, low flow faucet aerators, low flow showerheads) are only applicable to homes that have natural gas water heating. Because there are differences in the saturation of appliances and equipment, such as natural gas water heating, for single-family and multi-family homes, GDS estimated the energy efficiency potential for these housing types separately. To obtain up-to-date appliance and end-use saturation data, GDS made extensive use of the 2011 Maryland Energy Baseline Study as well as other available regional data, such as EIA's 2009 Residential Energy Consumption Survey (RECS).

As shown in Table 3-3 in Section 3 of this report, the number of residential natural gas customers in Maryland is projected to increase by about 10,000 per year over the period from

2009 to 2021.[31] The compound average annual growth rate is 1.0%. The majority of new customers added (i.e., 90%) are expected to reside in single family homes.[32]

The estimate of the percentage of homes that already have energy efficient measures installed (remaining factor) is also based largely on available data from the 2011 Maryland Energy Baseline Data as well as the data reported in EIA's 2009 Residential Energy Consumption survey. Due to a lack of detailed state-specific data regarding the percentage of homes currently equipped with energy efficient natural gas equipment, GDS also relied on other existing regional or national studies on energy efficiency potential to inform assumptions related to the stock of equipment that is already energy efficiency. For new construction, GDS assumed all new homes could benefit from the installation of high efficiency natural gas equipment.

### 5.4 Residential Measure Cost Effectiveness

GDS screened individual residential natural gas efficiency measures to determine their cost effectiveness in accordance with the Total Resource Cost test. Benefits and costs were calculated by incorporating the various measure assumptions (natural gas savings, costs, and useful life) into the GDS cost-effectiveness screening tool. Any programmatic costs (e.g., marketing, analysis, and administration) were ignored in the measure-level cost effectiveness analysis in order to screen whether energy efficient technologies were cost-effective on their own merit prior to any assistance or marketing endeavors from utilities or other organizations.

Table 5-3 below presents the cost effectiveness screening results for each residential measure by type of home (single-family/multi-family). Those measures that did not pass the TRC test (benefit/cost ratio of less than 1.0) were not included in the estimates of economic and achievable potential.

**Table 5-3: Residential Natural Gas Efficiency Measure Screening Results**

| Residential Natural Gas Measure Level TRC Screening Results | | | |
|---|---|---|---|
| **Measure Name** | **Existing vs. New Construction** | **TRC Ratio (Single Family)** | **TRC Ratio (Multi-Family)** |
| **Water Heating End Use** | | | |
| Low Flow Showerheads | EX | 11.65 | 13.52 |
| Clothes Washer Energy Star/CEE Tier 1 (NG-WH/E-Dryer) | EX | 6.12 | 6.12 |
| Pipe Wrap - gas water heater | EX | 4.89 | 4.89 |
| Clothes Washer Energy Star/CEE Tier 1 (NG-WH/Dryer) | EX | 4.67 | 4.67 |
| Low Flow Faucet Aerators | EX | 4.55 | 5.76 |
| Clothes Washer CEE Tier 2 (NG-WH/E-Dryer) | EX | 3.04 | 3.04 |

31 This forecast is based upon the observed trend in the number of residential gas customers in the State of Maryland, 1997-2009.
32 The distribution of customers by housing type is based on the 2010 KEMA Maryland energy baseline study.

| Residential Natural Gas Measure Level TRC Screening Results | | | |
|---|---|---|---|
| **Measure Name** | **Existing vs. New Construction** | **TRC Ratio (Single Family)** | **TRC Ratio (Multi-Family)** |
| Clothes Washer CEE Tier 2 (NG-WH/Dryer) | EX | 2.40 | 2.40 |
| Clothes Washer CEE Tier3 (NG-WH/E-Dryer) | EX | 1.86 | 1.86 |
| Dishwasher CEE Tier 1 | EX | 1.65 | 1.65 |
| Shower Start | EX | 1.47 | 1.71 |
| Clothes Washer CEE Tier3 (NG-WH/Dryer) | EX | 1.47 | 1.47 |
| High Efficiency Gas Water Heater (CEE Tier1) | EX | 1.08 | 0.91 |
| Tankless Gas Water Heater | EX | 0.65 | 0.54 |
| Solar Domestic Hot Water | EX | 0.59 | n/a |
| Dishwasher CEE Tier 2 | EX | 0.55 | 0.55 |
| Super-Efficiency Gas Water Heater (CEE Tier 2) | EX | 0.39 | 0.33 |
| Clothes Washer Energy Star/CEE Tier 1 (NG-WH/E-Dryer) | NC | 6.12 | 6.12 |
| Clothes Washer Energy Star/CEE Tier 1 (NG-WH/Dryer) | NC | 4.67 | 4.67 |
| Clothes Washer CEE Tier 2 (NG-WH/E-Dryer) | NC | 3.04 | 3.04 |
| Clothes Washer CEE Tier 2 (NG-WH/Dryer) | NC | 2.40 | 2.40 |
| Clothes Washer CEE Tier3 (NG-WH/E-Dryer) | NC | 1.86 | 1.86 |
| Dishwasher CEE Tier 1 | NC | 1.65 | 1.65 |
| Clothes Washer CEE Tier3 (NG-WH/Dryer) | NC | 1.47 | 1.47 |
| High Efficiency Gas Water Heater (CEE Tier1) | NC | 1.08 | 0.91 |
| Tankless Gas Water Heater | NC | 0.65 | 0.54 |
| Solar Domestic Hot Water | NC | 0.59 | n/a |
| Dishwasher CEE Tier 2 | NC | 0.55 | 0.55 |
| Super-Efficiency Gas Water Heater (CEE Tier 2) | NC | 0.39 | 0.33 |
| **HVAC (Envelope)** | | | |
| Efficient Windows (DblPane to ES Windows) | EX | 7.19 | 6.85 |
| Duct Sealing (20% to 6%) | EX | 4.27 | 3.86 |
| Duct Insulation | EX | 1.55 | n/a |
| Efficient Windows (Single to ES Windows) | EX | 1.45 | 0.82 |
| Air Sealing (12ACH to 7ACH) | EX | 1.36 | 0.72 |

| Residential Natural Gas Measure Level TRC Screening Results | | | |
|---|---|---|---|
| **Measure Name** | **Existing vs. New Construction** | **TRC Ratio (Single Family)** | **TRC Ratio (Multi-Family)** |
| Ceiling Insulation (R11-R49) | EX | 1.08 | 1.05 |
| Rim/Band Joist Insulation (R0 to R16) | EX | 1.05 | n/a |
| Ceiling Insulation (R19-R49) | EX | 0.94 | 0.90 |
| Floor Insulation (R0 to R19) | EX | 0.68 | n/a |
| Wall Insulation (R6-R13) | EX | 0.40 | 0.14 |
| Basement Wall Insulation (R7-R13) | EX | 0.28 | n/a |
| Floor Insulation (R11 to R19) | EX | 0.20 | n/a |
| Efficient Windows (DblPane to ES Windows) | NC | 4.96 | 6.18 |
| Ceiling Insulation (R19-R49) | NC | 3.19 | 2.37 |
| Duct Sealing (12% to 6%) | NC | 2.03 | 1.67 |
| Energy Star New Homes Construction | NC | 1.67 | 1.36 |
| Air Sealing (7ACH to 5ACH) | NC | 1.21 | 0.50 |
| Wall Insulation (R13-R21) | NC | 0.71 | 0.14 |
| Basement Wall Insulation (R13-R19) | NC | 0.54 | n/a |
| Rim/Band Joist Insulation (R13 to R21) | NC | 0.35 | n/a |
| **HVAC (Equipment/Controls)** | | | |
| O&M Tune-up - furnace only | EX | 3.47 | 0.91 |
| Programmable Thermostat | EX | 2.57 | 0.09 |
| O&M Tune-up | EX | 2.38 | 1.48 |
| Furnace- Tier 3 (80 AFUE to 94 AFUE) | EX | 1.05 | 0.30 |
| Furnace- Tier 2 (80 AFUE to 92 AFUE) | EX | 1.02 | 0.29 |
| Furnace- Tier 1 (80 AFUE to 90 AFUE) | EX | 0.98 | 0.28 |
| Boiler- Tier 1 (80 AFUE to 85 AFUE) | EX | 0.57 | 0.26 |
| Boiler- Tier 2 (80 AFUE to 90 AFUE) | EX | 0.35 | 0.12 |
| Furnace- Tier 3 (80 AFUE to 94 AFUE) | NC | 1.13 | 0.23 |
| Furnace- Tier 2 (80 AFUE to 92 AFUE) | NC | 1.10 | 0.23 |
| Furnace- Tier 1 (80 AFUE to 90 AFUE) | NC | 1.06 | 0.22 |
| **Miscellaneous** | | | |
| Indirect Feedback (Behavioral) | EX | 4.88 | 2.26 |

| Residential Natural Gas Measure Level TRC Screening Results | | | |
|---|---|---|---|
| **Measure Name** | **Existing vs. New Construction** | **TRC Ratio (Single Family)** | **TRC Ratio (Multi-Family)** |
| Pool Covers ( Vinyl) | EX | 3.89 | 3.89 |
| Pool Covers ( Bubble) | EX | 3.07 | 3.07 |
| Gas Convection Oven | EX | 0.47 | 0.39 |

* Single Family HVAC (Envelope) TRC Ratios represent an average of homes with conditioned basements and homes without conditioned basements. Additional breakout for these measures can be found in the residential appendices.

Nineteen single-family and twenty-five multi-family natural gas energy efficiency measures were not cost effective.

### 5.5 Residential Technical and Economic Savings Potential

In the calculation of a measure's cost-effectiveness, all measures are treated *independently*; that is, the measure savings is 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 residential buildings. This approach evaluates energy-efficient technologies on their own merit, and does not unfairly exclude one measure in favor of another.

However, the cumulative savings potential cannot be estimated by adding the savings from each individual savings estimate 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. For this study it is assumed that measures with the highest TRC benefit-cost ratio would typically be installed first, followed by the measures with the next highest TRC ratio. Additionally, retrofit opportunities, because they can occur at any time, were given priority over those measures considered as replace-on-burnout options.

In instances where there were two (or more) competing technologies for the same natural gas end use, such as high efficiency storage water heating, tank-less water heating, and solar water heating equipment, GDS assigned a percent of the available population to each measure. In the event that one of the competing measures was not found to be cost-effective, the homes assigned to that measure were transitioned over to the cost-effective alternative (if any).

Technical potential represents the savings that could be captured if 100 percent of inefficient natural gas equipment were replaced instantaneously (where they are deemed to be technically feasible). As shown in Table 5-4, total technical potential savings in the Maryland residential sector are 31.5 million MMBTu, or 34.1% of forecast residential MMBTu sales in 2020.

**Table 5-4: Residential Natural Gas Technical Potential Savings by End Use**

| Residential Natural Gas Technical Potential Savings by End Use | | |
|---|---|---|
| **End Use** | **2015 MMBTU** | **2020 MMBTU** |
| Water Heating | 4,938,652 | 5,319,958 |
| HVAC (Envelope) | 16,813,535 | 17,986,404 |
| HVAC (Equipment/ Controls) | 5,808,221 | 5,987,062 |
| Miscellaneous | 2,258,594 | 2,258,594 |
| **Total** | **29,819,002** | **31,552,018** |
| *% of Annual Sales Forecast* | *33.8%* | *34.1%* |

As shown in Table 5-5, the residential economic energy efficiency potential is 23.7 million MMBTu in 2020. The economic potential assumes 100% of all cost-effective measures eligible for installation are installed, but excludes measures previously included in the technical potential that did not pass the TRC benefit/cost screening test. As a result, the economic potential is typically lower than the technical potential estimates. However, in the case of the HVAC (Equipment) end-use, the economic potential estimates are slightly higher than the technical potential. This anomaly is an artifact of fewer measures included in the HVAC (Envelope) category and a corresponding smaller interactive adjustment to the HVAC (Equipment) measures. In other words, because fewer efficient measures are installed to improve the building envelope, there are greater opportunities for savings by the HVAC equipment.

**Table 5-5: Residential Natural Gas Economic Potential Savings by End Use**

| Residential Natural Gas Economic Potential Savings by End Use | | |
|---|---|---|
| **End Use** | **2015 MMBTU** | **2020 MMBTU** |
| Water Heating | 2,595,637 | 2,762,686 |
| HVAC (Envelope) | 11,659,463 | 12,621,407 |
| HVAC (Equipment/ Controls) | 6,636,365 | 6,834,787 |
| Miscellaneous | 1,490,264 | 1,490,264 |
| **Total** | **22,381,729** | **23,709,143** |
| *% of Annual Sales Forecast* | *25.4%* | *25.6%* |

### 5.6 Base Case Achievable Potential Results (60% Market Penetration)

The achievable potential is a subset of the economic potential and is limited by various market and adoption barriers. Because this analysis has adopted a replace-on-burnout approach for replacing standard efficiency equipment with high efficiency technologies, each year the eligible market is limited to those measures that are expected to reach the end of their useful life and be targeted for replacement. For example, if a measure has a 20 year useful life, only half of the existing units would be expected to burnout during the 10 year timeframe, and only 1/20 would be eligible for replacement annually.

In the residential base case scenario, the natural gas achievable potential represents the attainable savings if the market penetration of the selected measures ramps up to replace 60% of the eligible market turning over each year by 2015. The targeted market penetration is not fully realized until the fourth year of the analysis, and is ramping up from 2012-2014. From 2015-2021, the base case assumes that 60% of the annual eligible market will be transformed with energy efficient alternatives. Although this methodology simplifies what an adoption curve might look like in practice, it succeeds in providing a concise method for estimating achievable savings potential over a specific period of time.

Table 5-6 provides the achievable potential in the 60% market penetration base case scenario by measure type. As participation ramps up to 60% of the remaining eligible annual market turnover, the achievable potential for natural gas efficiency savings in 2015 is estimated at 3,948,109 MMBTUs or 4.5% of residential natural gas sales in 2015. As program participation continues, the achievable potential savings increases to 10,300,041 MMBTUs in 2020, or 11.1% of 2020 residential sales.

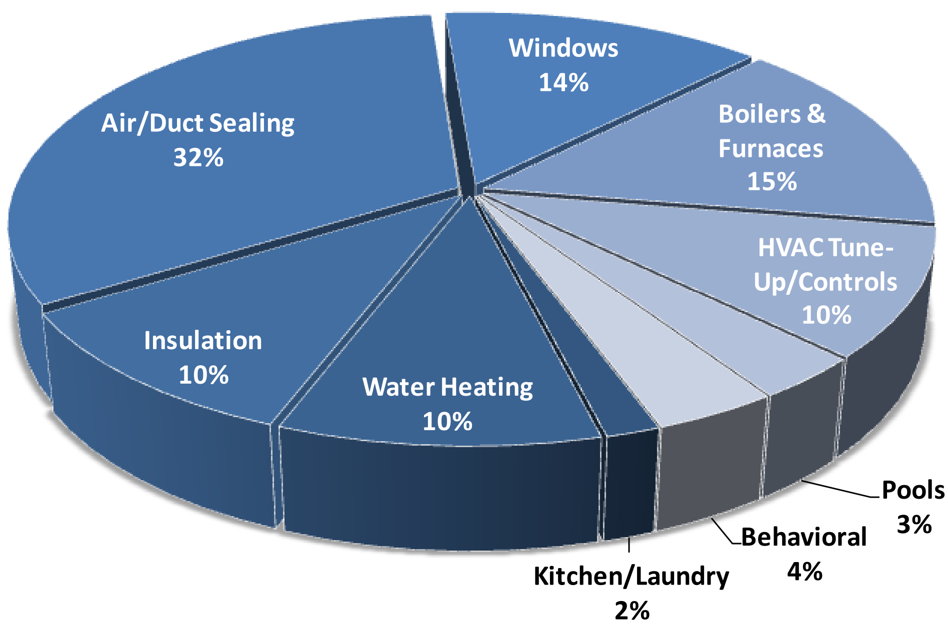
**Table 5-6: Residential Natural Gas Achievable Savings Potential by Measure Type (60% Market Penetration)**

| Residential Natural Gas Achievable MMBTu Savings Potential (60% Market Penetration) by Measure Type (MMBTU) | | |
|---|---|---|
| **Measure Name** | **Achievable Potential 2015** | **Achievable Potential 2020** |
| **Water Heating End Use** | | |
| High Efficiency Gas Water Heater | 205,542 | 535,711 |
| Pipe Wrap - gas water heater | 69,816 | 182,421 |
| Shower Start | 54,819 | 143,234 |
| Low Flow Showerheads | 39,927 | 104,325 |
| ClothesWashers CEE Tier 3 | 19,198 | 49,975 |
| ClothesWashers CEE Tier 2 | 17,210 | 44,798 |
| ClothesWashers CEE Tier 1 | 15,472 | 40,275 |
| Low Flow Faucet Aerators | 12,958 | 33,859 |
| Dishwasher CEE Tier 1 | 12,902 | 33,611 |
| Dishwasher CEE Tier 2 | 0 | 0 |
| Solar Domestic Hot Water | 0 | 0 |
| Super-Efficiency Gas Water Heater (CEE Tier 2) | 0 | 0 |
| Tankless Gas Water Heater | 0 | 0 |

| Residential Natural Gas Achievable MMBTu Savings Potential (60% Market Penetration) by Measure Type (MMBTU) | | |
|---|---|---|
| **Measure Name** | **Achievable Potential 2015** | **Achievable Potential 2020** |
| **HVAC (Envelope)** | | |
| Air Sealing | 661,425 | 1,726,755 |
| Duct Sealing | 574,690 | 1,500,540 |
| Efficient Windows | 537,686 | 1,403,630 |
| Ceiling Insulation | 249,470 | 649,540 |
| Energy Star New Homes | 102,819 | 263,497 |
| Rim/Band Joist Insulation | 90,726 | 237,054 |
| Duct Insulation | 19,033 | 49,733 |
| Basement Wall Insulation | 0 | 0 |
| Floor Insulation | 0 | 0 |
| Wall Insulation | 0 | 0 |
| **HVAC (Equipment/Controls)** | | |
| Efficient Furnace (Tier 3) | 312,603 | 815,757 |
| Efficient Furnace (Tier 2) | 272,641 | 711,468 |
| O&M Tune-Up | 175,286 | 458,013 |
| O&M Tune-up - furnace only | 164,105 | 428,798 |
| Programmable Thermostat | 47,899 | 125,155 |
| Efficient Furnace (Tier 1) | 14,690 | 37,650 |
| Efficient Boiler (Tier 1) | 0 | 0 |
| Efficient Boiler (Tier 2) | 0 | 0 |
| **Miscellaneous** | | |
| Indirect Feedback (Behavioral) | 148,232 | 387,317 |
| Pool Covers ( Bubble) | 64,481 | 168,465 |
| Pool Covers ( Vinyl) | 64,481 | 168,465 |
| Gas Convection Oven | 0 | 0 |
| ***TOTAL ACHIEVABLE (60% Market Penetration) POTENTIAL:*** | ***3,948,109*** | ***10,300,041*** |
| Note: Measures in the above Table with "0" achievable potential are ones that did not pass the TRC Test. | | |

Figure 5-2 provides a detailed breakdown of the natural gas end-use savings as a percent of the total achievable potential for the 60% market penetration scenario. The major opportunities for natural gas energy efficiency resources are improvements to the residential building shell, such as improved insulation, air and duct sealing, and high efficiency windows. Combined these efficiency improvements make up 56% of the total achievable potential in 2020. An additional 25% stems from high efficiency natural gas furnace and water heating equipment installations, and 10% of the estimated achievable potential is represented through existing HVAC tune-ups and programmable thermostats.

**Figure 5-2: 2020 Achievable Economic Potential (MMBtu)**




For the achievable potential, the 60% market penetration scenario assumes that consumers would receive a financial incentive equal to approximately 40% of the incremental cost of the natural gas efficiency measure for most technologies. In addition, an overall non-incentive or administrative cost was assigned to each measure in order to run the achievable cost-effectiveness tests. Non-incentive costs were estimated at 20% of the total utility budget. Non-incentive costs include marketing, education, program delivery, fulfillment, program tracking, reporting, and evaluation.

The overall benefit/cost screening results for the residential sector 60% market penetration scenario are shown below in Table 5-7. The net present value costs (in $2012) for the period 2012 to 2021 include $470 million dollars of utility costs (for incentive payments to participants as well as the associated costs for program marketing, labor, and monitoring) and $564 million in participant costs associated with the purchase and installation of efficient natural gas technologies. The net present value benefits of $2,150 million dollars represent the lifetime benefits of all measures installed during the same time period.

**Table 5-7: Overall Residential Sector Cost Effectiveness Screening Results ($ in Millions)**

| Residential Sector Cost Effectiveness Screening Results - 60% Market Penetration Scenario | | | | | |
|---|---|---|---|---|---|
| Benefit Cost Test | Present Value of Total Benefits ($2012) | Present Value of Utility Costs ($2012) | Present Value of Participant Costs ($2012) | Present Value of Total Costs ($2012) | Benefit/Cost Ratio |
| TRC Test | $2,150 | $518 | $564 | $1,082 | 1.99 |

Although the base case achievable potential estimates would require a substantial investment in energy efficiency from the State of Maryland, its natural gas utilities and their consumers (a total of $1,035 million for utility and participant costs combined), the resulting energy and demand savings would result in a net present value savings (benefits minus costs) of nearly $1,115 million dollars (in $2012).

## 5.7 Residential Market Penetration Scenarios

In addition to the 60% market penetration scenario reported above, this report also includes a low and high case market penetration scenario. The low case scenario achieves approximately 40% market penetration by 2021; the high case achieves 80% market penetration. As noted earlier, the 60% market penetration assumed financial incentives equal to 40% of the measure incremental cost. The high up-front cost of energy efficient technologies is an important adoption barrier and altering incentive levels is likely to have an impact on the achievable market potential. The low and high case scenarios illustrate the impacts of changing the incentive level. Financial incentives equal to 50% and 30% of the measure incremental cost were used for the 80% and 40% market penetration scenarios, respectively.

Additionally, program administrative costs were lowered from 20% (60% market penetration scenario) to 15% of the total DSM budget for the high market penetration scenario. Increased penetration in natural gas efficiency programs will result in some economies of scale for program administration. Similarly, program administrative costs were increased to 25% of the total DSM budget for the low market penetration scenario.

Figure 5-3 graphically illustrates the low and high case achievable savings by year and compares it to the equivalent base case scenario savings. Table 5-8 shows that the achievable potential savings by 2020 range from a low of 7.5% in the 40% market penetration scenario to a high of 14.6% in the 80% market penetration scenario.

**Figure 5-3: Achievable Potential Savings (MMBtu) Results for all Market Penetration Scenarios**

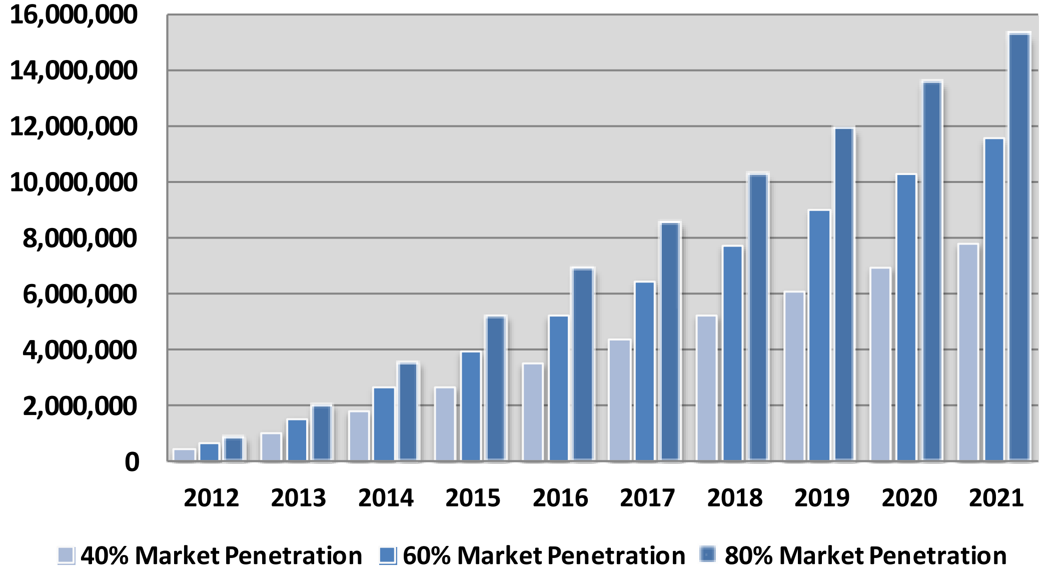



Table 5-8 also presents the total benefits and costs for the TRC Test in the 40%, 60%, and 80% market penetration scenarios. The net present value benefits (benefits minus costs) range from approximately $756 million in the 40% market penetration scenario to $1,476 million in the 80% market penetration scenario.

**Table 5-8: Benefit/Cost Ratios for all Market Penetration Scenarios Using the TRC Test**

| Residential Benefit/Cost Ratios for all Market Penetration Scenarios Using the TRC Test | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Market Penetration Scenario** | **MMBTu Savings 2015** | **% of 2015 Forecast** | **MMBTu Savings 2020** | **% of 2020 Forecast** | **Present Value of Total Benefits ($2012)** | **Present Value of Total Costs ($2012)** | **Benefit/ Cost Ratio** |
| 40% Market Penetration | 2,665,691 | 3.0% | 6,954,603 | 7.5% | $1,445,600,533 | $718,821,785 | 2.01 |
| 60% Market Penetration | 3,948,109 | 4.5% | 10,300,041 | 11.1% | $2,149,529,687 | $1,081,971,654 | 1.99 |
| 80% Market Penetration | 5,196,489 | 5.9% | 13,557,142 | 14.6% | $2,840,814,960 | $1,429,347,393 | 1.99 |

Finally, annual MMBTU savings and estimated annual program costs are detailed in Tables 5-9 through 5-14. Annual savings are presented at both incremental annual (savings based on new measures installed in that year) and cumulative annual (savings based new measures installed in that year as well as any prior year measures installed still producing savings).

Annual program cost tables include the assumed incentive costs as well as any non-incentive cost associated with administering and evaluating the programs. Annual costs to program participants are not included in these tables. For each market penetration scenario, the annual program cost tables also include an estimated number of full-time equivalent employees that would be required to help achieve the estimated participation goals and natural gas savings. These full-time equivalent employee estimates are based on the assumption that 85% of non-incentive costs are for labor, with the remaining 15% set aside for material costs. Additionally, the assumed average salary for the employees was set at $70,000 (with an additional 40% in overhead) in 2012 and escalated at 2% annually from 2013-2021.

**Table 5-9: Incremental Annual & Cumulative Annual Achievable Potential Savings – 80% Market Penetration Scenario**

| Incremental Annual MMBTU Savings - Achievable 80% | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **End-Use** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Water Heating End Use | 97,659 | 134,471 | 172,888 | 203,888 | 208,604 | 216,105 | 231,366 | 237,197 | 242,469 | 256,615 |
| HVAC (Envelope) | 488,610 | 671,037 | 862,777 | 958,645 | 958,645 | 958,645 | 958,645 | 958,645 | 958,645 | 958,645 |
| HVAC (Equipment/Controls) | 203,157 | 281,517 | 361,938 | 402,154 | 402,154 | 402,154 | 471,296 | 498,955 | 526,615 | 540,443 |
| Miscellaneous | 59,589 | 83,435 | 153,015 | 183,264 | 247,297 | 274,758 | 352,647 | 385,656 | 455,236 | 485,485 |
| **Total** | **849,015** | **1,170,460** | **1,550,618** | **1,747,950** | **1,816,700** | **1,851,662** | **2,013,953** | **2,080,453** | **2,182,966** | **2,241,188** |
| *% of Annual Forecast Sales* | *1.0%* | *1.3%* | *1.8%* | *2.0%* | *2.0%* | *2.1%* | *2.2%* | *2.3%* | *2.4%* | *2.4%* |
| **Cumulative Annual MMBTU Savings - Achievable 80%** | | | | | | | | | | |
| **End-Use** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Water Heating End Use | 97,659 | 232,130 | 405,018 | 597,117 | 789,217 | 981,316 | 1,173,416 | 1,365,515 | 1,557,614 | 1,749,714 |
| HVAC (Envelope) | 488,610 | 1,159,647 | 2,022,423 | 2,981,068 | 3,939,713 | 4,898,358 | 5,857,003 | 6,815,648 | 7,774,293 | 8,732,938 |
| HVAC (Equipment/Controls) | 203,157 | 484,674 | 846,612 | 1,248,766 | 1,650,919 | 2,053,073 | 2,455,227 | 2,857,381 | 3,259,535 | 3,661,689 |
| Miscellaneous | 59,589 | 143,024 | 250,306 | 369,538 | 488,770 | 608,003 | 727,235 | 846,467 | 965,699 | 1,084,932 |
| **Total** | **849,015** | **2,019,474** | **3,524,359** | **5,196,489** | **6,868,620** | **8,540,750** | **10,212,881** | **11,885,012** | **13,557,142** | **15,229,273** |
| *% of Annual Forecast Sales* | *1.0%* | *2.3%* | *4.0%* | *5.9%* | *7.7%* | *9.5%* | *11.3%* | *13.0%* | *14.8%* | *16.5%* |

**Table 5-10: Annual Incentive and Administrative Budgets – 80% Market Penetration Scenario**

| Annual Incentives by End-Use (80% Market Penetration) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **End-Use** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Water Heating End Use | $5,852,605 | $7,968,632 | $10,245,237 | $11,687,733 | $11,809,354 | $11,992,545 | $12,381,973 | $12,528,242 | $12,662,134 | $13,026,913 |
| HVAC (Envelope) | $30,752,165 | $42,215,856 | $54,279,052 | $60,310,379 | $60,310,379 | $60,310,379 | $60,310,379 | $60,310,379 | $60,310,379 | $60,310,379 |
| HVAC (Equipment/Controls) | $12,541,089 | $17,300,391 | $22,241,947 | $24,713,552 | $24,713,552 | $24,713,552 | $26,063,352 | $26,603,302 | $27,143,302 | $27,413,252 |
| Miscellaneous | $302,028 | $422,890 | $755,305 | $900,503 | $1,196,693 | $1,323,690 | $1,710,355 | $1,873,578 | $2,205,993 | $2,351,190 |
| **Total** | **$49,447,886** | **$67,907,768** | **$87,521,541** | **$97,612,166** | **$98,029,977** | **$98,340,166** | **$100,466,058** | **$101,315,500** | **$102,321,807** | **$103,101,734** |
| **Annual Utility Budgets(80% Market Penetration)** | | | | | | | | | | |
| **Budget Category** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Incentive Budget | $49,447,886 | $67,907,768 | $87,521,541 | $97,612,166 | $98,029,977 | $98,340,166 | $100,466,058 | $101,315,500 | $102,321,807 | $103,101,734 |
| Program Marketing/Education | $4,017,641 | $5,656,137 | $7,473,901 | $8,547,218 | $8,802,913 | $9,057,435 | $9,492,101 | $9,820,905 | $10,177,529 | $10,524,629 |
| Program Delivery | $5,562,887 | $7,831,574 | $10,348,478 | $11,834,609 | $12,188,649 | $12,541,064 | $13,142,909 | $13,598,176 | $14,091,964 | $14,572,563 |
| Program Tracking & Reporting | $1,545,246 | $2,175,437 | $2,874,577 | $3,287,392 | $3,385,736 | $3,483,629 | $3,650,808 | $3,777,271 | $3,914,434 | $4,047,934 |
| Program Verification & Evaluation | $1,236,197 | $1,740,350 | $2,299,662 | $2,629,913 | $2,708,589 | $2,786,903 | $2,920,646 | $3,021,817 | $3,131,547 | $3,238,347 |
| **Total** | **$61,809,858** | **$85,311,266** | **$110,518,159** | **$123,911,298** | **$125,115,864** | **$126,209,196** | **$129,672,522** | **$131,533,668** | **$133,637,282** | **$135,485,207** |
| *Estimated # of FTE's* | *82.6* | *113.9* | *147.4* | *165.2* | *166.7* | *168.2* | *173.0* | *175.6* | *178.7* | *181.4* |

**Table 5-11: Incremental Annual & Cumulative Annual Achievable Potential Savings – 60% Market Penetration Scenario**

| Incremental Annual MMBTU Savings - Achievable 60% | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **End-Use** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Water Heating End Use | 73,246 | 100,853 | 129,671 | 152,914 | 156,451 | 162,078 | 173,524 | 177,897 | 181,851 | 192,461 |
| HVAC (Envelope) | 366,466 | 503,280 | 647,122 | 718,980 | 718,980 | 718,980 | 718,980 | 718,980 | 718,980 | 718,980 |
| HVAC (Equipment/Controls) | 160,630 | 222,542 | 286,129 | 317,923 | 317,923 | 317,923 | 372,662 | 394,559 | 416,455 | 427,407 |
| Miscellaneous | 44,704 | 62,577 | 114,807 | 137,435 | 185,485 | 206,049 | 264,497 | 289,215 | 341,446 | 364,073 |
| **Total** | **645,047** | **889,252** | **1,177,730** | **1,327,252** | **1,378,839** | **1,405,030** | **1,529,663** | **1,580,650** | **1,658,732** | **1,702,921** |
| *% of Annual Forecast Sales* | *0.7%* | *1.0%* | *1.3%* | *1.5%* | *1.5%* | *1.6%* | *1.7%* | *1.7%* | *1.8%* | *1.8%* |
| **Cumulative Annual MMBTU Savings - Achievable 60%** | | | | | | | | | | |
| **End-Use** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Water Heating End Use | 73,246 | 174,100 | 303,771 | 447,843 | 591,916 | 735,989 | 880,062 | 1,024,135 | 1,168,208 | 1,312,281 |
| HVAC (Envelope) | 366,466 | 869,746 | 1,516,868 | 2,235,848 | 2,954,828 | 3,673,807 | 4,392,787 | 5,111,767 | 5,830,747 | 6,549,727 |
| HVAC (Equipment/Controls) | 160,630 | 383,173 | 669,301 | 987,224 | 1,305,148 | 1,623,071 | 1,940,994 | 2,258,917 | 2,576,840 | 2,894,763 |
| Miscellaneous | 44,704 | 107,281 | 187,783 | 277,193 | 366,604 | 456,015 | 545,425 | 634,836 | 724,247 | 813,657 |
| **Total** | **645,047** | **1,534,299** | **2,677,723** | **3,948,109** | **5,218,496** | **6,488,882** | **7,759,268** | **9,029,655** | **10,300,041** | **11,570,427** |
| *% of Annual Forecast Sales* | *0.7%* | *1.8%* | *3.1%* | *4.5%* | *5.9%* | *7.2%* | *8.6%* | *9.9%* | *11.2%* | *12.5%* |

**Table 5-12: Annual Incentive and Administrative Budgets – 60% Market Penetration Scenario**

| Annual Incentives by End-Use (60% Market Penetration) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **End-Use** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Water Heating End Use | $3,511,776 | $4,781,082 | $6,147,366 | $7,012,618 | $7,085,580 | $7,195,516 | $7,429,169 | $7,516,919 | $7,597,275 | $7,816,137 |
| HVAC (Envelope) | $18,451,997 | $25,329,526 | $32,570,012 | $36,186,349 | $36,186,349 | $36,186,349 | $36,186,349 | $36,186,349 | $36,186,349 | $36,186,349 |
| HVAC (Equipment/Controls) | $7,524,517 | $10,380,231 | $13,346,189 | $14,829,027 | $14,829,027 | $14,829,027 | $15,638,907 | $15,962,867 | $16,286,827 | $16,448,867 |
| Miscellaneous | $181,262 | $253,734 | $453,342 | $540,250 | $718,018 | $794,146 | $1,026,234 | $1,124,062 | $1,323,670 | $1,410,578 |
| **Total** | **$29,669,551** | **$40,744,573** | **$52,516,910** | **$58,568,244** | **$58,818,974** | **$59,005,037** | **$60,280,659** | **$60,790,197** | **$61,394,121** | **$61,861,931** |
| **Annual Utility Budgets(60% Market Penetration)** | | | | | | | | | | |
| **Budget Category** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Incentive Budget | $29,669,551 | $40,744,573 | $52,516,910 | $58,568,244 | $58,818,974 | $59,005,037 | $60,280,659 | $60,790,197 | $61,394,121 | $61,861,931 |
| Program Marketing/Education | $3,164,752 | $4,462,761 | $5,907,673 | $6,767,743 | $6,983,082 | $7,198,690 | $7,559,042 | $7,836,816 | $8,138,539 | $8,434,444 |
| Program Delivery | $4,549,331 | $6,415,219 | $8,492,280 | $9,728,630 | $10,038,180 | $10,348,117 | $10,866,123 | $11,265,423 | $11,699,149 | $12,124,513 |
| Program Tracking & Reporting | $1,186,782 | $1,673,535 | $2,215,377 | $2,537,904 | $2,618,656 | $2,699,509 | $2,834,641 | $2,938,806 | $3,051,952 | $3,162,917 |
| Program Verification & Evaluation | $988,985 | $1,394,613 | $1,846,148 | $2,114,920 | $2,182,213 | $2,249,591 | $2,362,201 | $2,449,005 | $2,543,293 | $2,635,764 |
| **Total** | **$39,559,402** | **$54,690,702** | **$70,978,389** | **$79,717,440** | **$80,641,105** | **$81,500,945** | **$83,902,666** | **$85,280,246** | **$86,827,054** | **$88,219,569** |
| *Estimated # of FTE's* | *66.4* | *91.7* | *118.9* | *133.4* | *135.0* | *136.4* | *140.5* | *143.0* | *145.8* | *148.4* |

### Table 5-13: Incremental Annual & Cumulative Annual Achievable Potential Savings – 40% Market Penetration Scenario

| Incremental Annual MMBTU Savings - Achievable 40% | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **End-Use** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Water Heating End Use | 48,833 | 67,233 | 86,444 | 101,942 | 104,300 | 108,051 | 115,681 | 118,596 | 121,233 | 128,305 |
| HVAC (Envelope) | 244,285 | 335,515 | 431,366 | 479,336 | 479,336 | 479,336 | 479,336 | 479,336 | 479,336 | 479,336 |
| HVAC (Equipment/Controls) | 112,593 | 155,954 | 200,530 | 222,809 | 222,809 | 222,809 | 261,224 | 276,595 | 291,958 | 299,638 |
| Miscellaneous | 29,822 | 41,718 | 76,495 | 91,605 | 123,622 | 137,339 | 176,297 | 192,774 | 227,551 | 242,661 |
| **Total** | **435,533** | **600,420** | **794,837** | **895,693** | **930,067** | **947,535** | **1,032,538** | **1,067,300** | **1,120,078** | **1,149,940** |
| *% of Annual Forecast Sales* | *0.5%* | *0.7%* | *0.9%* | *1.0%* | *1.0%* | *1.1%* | *1.1%* | *1.2%* | *1.2%* | *1.2%* |
| **Cumulative Annual MMBTU Savings - Achievable 40%** | | | | | | | | | | |
| **End-Use** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Water Heating End Use | 48,833 | 116,067 | 202,511 | 298,559 | 394,608 | 490,656 | 586,705 | 682,753 | 778,802 | 874,850 |
| HVAC (Envelope) | 244,285 | 579,800 | 1,011,167 | 1,490,503 | 1,969,839 | 2,449,174 | 2,928,510 | 3,407,846 | 3,887,182 | 4,366,518 |
| HVAC (Equipment/Controls) | 112,593 | 268,547 | 469,077 | 691,886 | 914,695 | 1,137,504 | 1,360,313 | 1,583,122 | 1,805,931 | 2,028,741 |
| Miscellaneous | 29,822 | 71,540 | 125,154 | 184,743 | 244,332 | 303,921 | 363,510 | 423,099 | 482,688 | 542,277 |
| **Total** | **435,533** | **1,035,953** | **1,807,909** | **2,665,691** | **3,523,474** | **4,381,256** | **5,239,039** | **6,096,821** | **6,954,603** | **7,812,386** |
| *% of Annual Forecast Sales* | *0.5%* | *1.2%* | *2.1%* | *3.0%* | *4.0%* | *4.9%* | *5.8%* | *6.7%* | *7.6%* | *8.4%* |

**Table 5-14: Annual Incentive and Administrative Budgets – 40% Market Penetration Scenario**

| Annual Incentives by End-Use (40% Market Penetration) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **End-Use** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Water Heating End Use | $1,756,117 | $2,390,647 | $3,073,762 | $3,506,133 | $3,542,602 | $3,597,576 | $3,714,396 | $3,758,260 | $3,798,445 | $3,907,871 |
| HVAC (Envelope) | $9,225,018 | $12,664,991 | $16,282,666 | $18,093,662 | $18,093,662 | $18,093,662 | $18,093,662 | $18,093,662 | $18,093,662 | $18,093,662 |
| HVAC (Equipment/Controls) | $3,762,103 | $5,189,403 | $6,673,105 | $7,414,581 | $7,414,581 | $7,414,581 | $7,819,521 | $7,981,551 | $8,143,491 | $8,224,461 |
| Miscellaneous | $90,686 | $126,867 | $226,544 | $270,074 | $358,935 | $397,005 | $513,062 | $561,947 | $661,623 | $705,153 |
| **Total** | **$14,833,923** | **$20,371,907** | **$26,256,076** | **$29,284,449** | **$29,409,780** | **$29,502,824** | **$30,140,640** | **$30,395,419** | **$30,697,221** | **$30,931,146** |

| Annual Utility Budgets(40% Market Penetration) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Budget Category** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Incentive Budget | $14,833,923 | $20,371,907 | $26,256,076 | $29,284,449 | $29,409,780 | $29,502,824 | $30,140,640 | $30,395,419 | $30,697,221 | $30,931,146 |
| Program Marketing/Education | $2,013,175 | $2,844,435 | $3,772,603 | $4,331,194 | $4,478,560 | $4,627,086 | $4,869,898 | $5,060,929 | $5,268,811 | $5,474,485 |
| Program Delivery | $2,966,785 | $4,191,799 | $5,559,625 | $6,382,812 | $6,599,983 | $6,818,863 | $7,176,692 | $7,458,212 | $7,764,563 | $8,067,663 |
| Program Tracking & Reporting | $741,696 | $1,047,950 | $1,389,906 | $1,595,703 | $1,649,996 | $1,704,716 | $1,794,173 | $1,864,553 | $1,941,141 | $2,016,916 |
| Program Verification & Evaluation | $635,740 | $898,243 | $1,191,348 | $1,367,745 | $1,414,282 | $1,461,185 | $1,537,863 | $1,598,188 | $1,663,835 | $1,728,785 |
| **Total** | **$21,191,318** | **$29,354,333** | **$38,169,558** | **$42,961,903** | **$43,552,600** | **$44,114,673** | **$45,519,266** | **$46,377,301** | **$47,335,571** | **$48,218,995** |
| *Estimated # of FTE's* | *42.8* | *59.2* | *76.9* | *86.5* | *87.7* | *88.9* | *91.8* | *93.6* | *95.7* | *97.6* |

# 6.0 COMMERCIAL SECTOR ENERGY EFFICIENCY POTENTIAL

## 6.1 Introduction and Summary of Results

This section of the report provides the estimates of technical, economic and achievable potential for natural gas energy efficiency measures for the commercial sector in Maryland. The commercial sector as defined in this analysis is based on the natural gas sales data for the following business segments:

- Warehouse
- Retail
- Grocery
- Office
- Lodging
- Health
- Restaurant
- Education
- Other

Commercial efficiency potential estimates can be developed using either a top-down or a bottom-up approach, depending on data availability. The bottom up approach requires detailed equipment saturation data, which is not available for the commercial market in Maryland. Therefore a top-down approach was used. This approach builds an energy use profile based on estimates of 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 regarding the fraction of sales that are associated with inefficient equipment and the technical/engineering feasibility of each energy efficiency measure.

According to this analysis, there is still a large potential for natural gas efficiency savings in this sector. Table 6-1 and Figure 6-1, below summarize the technical, economic (based on the TRC test), and the achievable savings potential, based upon a 60% market penetration, for 2015 and 2020. This scenario also reflects the market driven implementation of certain measures that were modeled as non-retrofit measures. In other words, for these measures it was assumed that commercial customers would replace existing inefficient equipment at the end of the equipment's effective useful life.

As can be seen, the majority of the commercial technical potential is economic and that economic potential represents close to one-fourth of total 2020 commercial sales. The amount of this economic potential that can be achieved by 2020 is approximately 11% of 2020 commercial sales assuming a market penetration rate of 60% over the next ten years.

**Figure 6-1: Summary of Commercial Natural Gas Efficiency Potential in 2015 and 2020**

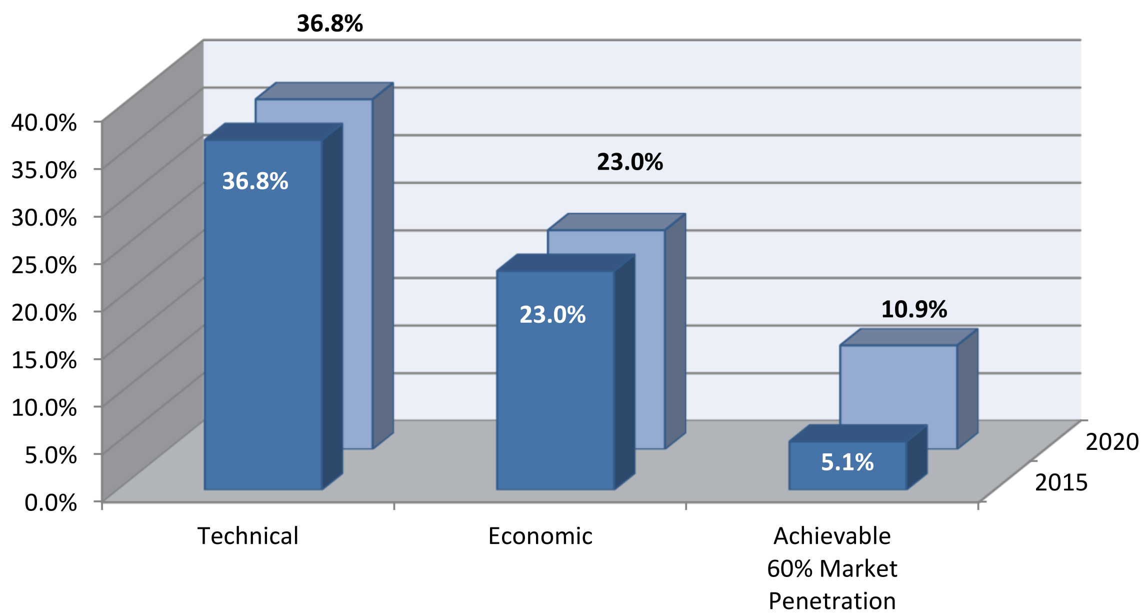



**Table 6-1: Summary of Commercial Natural Gas Efficiency Potential in 2015 and 2020**

| Summary of Commercial Natural Gas Efficiency Potential | | | |
|---|---|---|---|
| | Technical | Economic | Achievable 60% Market Penetration |
| **2015** | | | |
| Total MMBTU Savings | 28,517,414 | 17,850,213 | 3,948,704 |
| % of 2015 Forecast Residential Sales | 36.8% | 23.0% | 5.1% |
| **2020** | | | |
| Total MMBTU Savings | 29,929,080 | 18,733,832 | 8,884,583 |
| % of 2020 Forecast Residential Sales | 36.8% | 23.0% | 10.9% |

## 6.2 Commercial Energy Efficiency Measures

The list of commercial energy efficiency measures was developed by GDS based on a review of measures included in other studies conducted by GDS and research of the latest gas technologies and efficiency standards. Only measures that are commercially available were considered.

A total of 71 commercial natural gas energy efficiency measures were included in the energy efficiency potential analysis. These measures, which impact water heating, space heating, building envelope and cooking end uses, are shown below in Table 6-2.

**Table 6-2: List of Commercial Efficiency Measures**

| List of Commercial Energy Efficiency Measures | | |
|---|---|---|
| **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 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 O2 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 and Combination Water Heaters |
| | Pool Water Heating | Pool Cover, High Efficient Gas and Solar Pool Heater |

Measures have been grouped in these categories for presentation purposes only and are not intended to represent program groupings in existing or future MEA programs.

### 6.3 Characteristics of Commercial Energy Efficiency Measures

GDS collected data and developed estimates of measure savings, cost and effective useful life for each of the commercial natural gas energy efficiency measures. Savings factors for each measure, which represent the percent savings in annual energy use resulting from implementation of the measure, were then applied to the applicable end-use energy. So, for example, water heating measure savings factors were applied to the estimated water heating end-use energy that is associated with equipment that has not yet been converted to the energy efficiency measure and is technically feasible for conversion.

Table 6-3 in the next section shows the savings factors, measure cost and effective useful life for each commercial measure. Measures cost are defined as either full or incremental. Incremental costs should be used when measures are replaced on burn-out, i.e., at the end of the measure's effective useful life. Replace on burn-out measures are generally characterized by incremental measure costs and savings (e.g., the incremental costs and savings of a high-efficiency versus a standard efficiency boiler). In contrast, full cost driven measures are retrofit measures that are generally characterized by full costs and savings (e.g., the full costs and savings associated with retrofitting ceiling insulation into an existing attic).

### 6.4 Commercial Measure Cost Effectiveness

In the calculation of a measure's cost-effectiveness, 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. This approach evaluates energy-efficient technologies on their own merit, and does not unfairly exclude one measure in favor of another. GDS screened individual commercial sector natural gas energy efficiency measures to determine their cost effectiveness in accordance with TRC test. Table 6-3 below shows the screening results for each measure. Those measures that did not pass the TRC test (benefit/cost ratio of less than 1.0) were not included in the estimate of economic and achievable economic potential.

**Table 6-3: Measure Characteristics and Cost-Effectiveness Screening Results**

| Commercial Natural Gas Measure Level TRC Screening Results | | | | | |
|---|---|---|---|---|---|
| **Measure Name** | **Savings Factor** | **Measure Cost** | **Cost Type: 1=Full 2=Incr.** | **Useful Life** | **TRC B/C Ratio** |
| **Water Heating End Use** | | | | | |
| Faucet aerator | 32% | $6 | 1 | 10 | 89.47 |
| Low Flow Pre-Rinse Spray Nozzle (1.25 gpm) | 19% | $50 | 1 | 5 | 29.43 |
| Low flow shower head (1.5 GPM) | 40% | $77 | 1 | 10 | 12.05 |
| Pool Cover | 63% | $1,170 | 1 | 6 | 10.22 |
| Ozone Commercial Laundry System (Gas HW) | 55% | $26,000 | 1 | 15 | 7.21 |
| High Efficiency Clothes Washer | 31% | $258 | 2 | 11 | 6.01 |
| Heat Recovery Water Heater | 50% | $4,800 | 1 | 15 | 5.24 |
| Wastewater, Filtration/Reclamation | 50% | $150,000 | 1 | 20 | 3.31 |
| Circulation Pump Time Clocks | 5% | $132 | 1 | 10 | 3.18 |

| Commercial Natural Gas Measure Level TRC Screening Results | | | | | |
|---|---|---|---|---|---|
| **Measure Name** | **Savings Factor** | **Measure Cost** | **Cost Type: 1=Full 2=Incr.** | **Useful Life** | **TRC B/C Ratio** |
| Indirect Water Heater - Combined appliance efficiency rating (CAE)>=85% (EF=.82/.59 EF Baseline) | 28% | $1,175 | 2 | 15 | 2.51 |
| Solar pool heater | 100% | $5,500 | 1 | 20 | 2.13 |
| Graywater Heat Exchanger/GFX | 40% | $3,364 | 1 | 20 | 1.58 |
| Pipe wrap | 2% | $156 | 1 | 13 | 1.25 |
| On-Demand, Tankless Water Heater (.85 TE/.8 TE Baseline) (>200,000 BTU) | 13% | $1,522 | 2 | 20 | 1.06 |
| Condensing Stand Alone Commercial Water Heater (.96 TE/.8 TE) (Baseline >75000 btu) | 23% | $2,340 | 2 | 13 | 0.93 |
| High Efficiency (95%) Gas Pool Water Heater | 16% | $1,300 | 2 | 10 | 0.86 |
| On-Demand, Tankless Water Heater (>=.95 EF) (<=200,000 Btu/h) | 38% | $1,373 | 2 | 20 | 0.83 |
| On-Demand, Tankless Water Heater (.82 EF/.59 EF Baseline) (<=200,000 BTU/h) | 28% | $1,198 | 2 | 20 | 0.71 |
| High Efficiency Stand Alone Commercial Water Heater (0.67 EF/.59 EF) (Baseline <=75000 Btu) | 12% | $415 | 2 | 13 | 0.63 |
| Solar Water Heating w/gas auxiliary tank (SEF=1.5) | 61% | $26,400 | 1 | 20 | 0.31 |
| **Space & Water Heating** | | | | | |
| Combination Water Heater/Furnace (.86 EF, .90 AFUE) | 15% | $360 | 2 | 15 | 3.24 |
| Combination Water Heater/Boiler (Non-Condensing) (0.86 EF, 85 AFUE) | 9% | $2,160 | 1 | 15 | 1.24 |
| Combination Water Heater/Boiler (Condensing)(0.9 EF, 0.9 AFUE) | 14% | $1,093 | 2 | 20 | 1.15 |
| **Building Envelope** | | | | | |
| Integrated Building Design, Envelope Only (30% > code) | 30% | $83,113 | 2 | 40 | 1.76 |
| Air Sealing | 13% | $4,200 | 1 | 20 | 1.63 |
| Improved Roof/Ceiling Insulation (to R32) | 4% | $4,289 | 1 | 30 | 0.69 |
| Improved Wall Insulation (to R12) | 7% | $7,833 | 1 | 30 | 0.57 |
| Triple Glazing Low Emissivity Windows | 10% | $12,615 | 2 | 20 | 0.39 |
| Double Glazing Low Emissivity Windows | 5% | $7,624 | 2 | 20 | 0.35 |
| Improved Below-Grade Insulation (to R6) | 1% | $2,271 | 1 | 30 | 0.21 |
| **HVAC Controls** | | | | | |
| Programmable Thermostat | 19% | $92 | 0 | 0 | 5.92 |
| Zoning | 5% | $1,500 | 1 | 7 | 1.25 |

| Commercial Natural Gas Measure Level TRC Screening Results | | | | | |
|---|---|---|---|---|---|
| **Measure Name** | **Savings Factor** | **Measure Cost** | **Cost Type: 1=Full 2=Incr.** | **Useful Life** | **TRC B/C Ratio** |
| EMS Optimization | 5% | $2,608 | 1 | 15 | 1.07 |
| Retrocommissioning | 10% | $3,082 | 1 | 7 | 0.73 |
| EMS install | 20% | $72,438 | 1 | 5 | 0.37 |
| Commissioning | 7% | $15,936 | 1 | 10 | 0.26 |
| **Cooking** | | | | | |
| Energy Star Fryer | 31% | $50 | 2 | 12 | 82.75 |
| Energy Star Steam Cooker | 53% | $420 | 2 | 12 | 54.28 |
| Energy Star Oven | 29% | $50 | 2 | 12 | 50.14 |
| Energy Star Griddle | 12% | $60 | 2 | 12 | 20.35 |
| **Space Heating** | | | | | |
| Stack Heat Exchanger (Condensing Economizer) | 10% | $2,120 | 1 | 20 | 9.73 |
| Stack Heat Exchanger (Standard Economizer) | 5% | $1,500 | 1 | 20 | 6.88 |
| Insulate steam lines/condensate tank | 2% | $1,302 | 1 | 15 | 6.74 |
| Repair/Replace malfunctioning steam traps | 10% | $236 | 1 | 5 | 6.61 |
| High Efficiency Hot Water Boiler (>300,000 Btu/h) (Th.eff.=85%-90%) | 10% | $5,181 | 2 | 25 | 6.51 |
| Exhaust Hood Makeup Air | 57% | $5,900 | 1 | 20 | 6.26 |
| High Efficiency Furnace (<=300,000 Btu/h) (AFUE>=92%) | 15% | $654 | 2 | 18 | 5.75 |
| Infrared Heater (low intensity - two stage) | 26% | $948 | 2 | 17 | 5.66 |
| Condensing Boiler (>300,000 Btu/h) (Th.eff.=>90%) | 13% | $7,860 | 2 | 18 | 4.46 |
| Boiler Heating Pipe Insulation | 2% | $243 | 1 | 15 | 4.11 |
| High Efficiency Steam Boiler (>300,000 Btu/h) (Th.Eff.>=80%) | 5% | $5,352 | 2 | 25 | 2.94 |
| High Efficiency Steam Boiler (<=300,000 Btu/h) (AFUE >=82%) | 9% | $3,552 | 2 | 25 | 2.60 |
| Boiler Reset Controls | 5% | $993 | 1 | 20 | 2.57 |
| Boiler blowdown heat exchanger (steam) | 6% | $60,000 | 1 | 20 | 2.31 |
| High Efficiency Hot Water Boiler (<=300,000 Btu/h) (AFUE =85%-90%) | 6% | $1,231 | 2 | 20 | 2.15 |
| Boiler Tune-Up | 2% | $300 | 1 | 2 | 2.06 |
| Condensing Boiler (<=300,000 Btu/h) (AFUE>90%) | 16% | $3,305 | 2 | 18 | 2.00 |

| Commercial Natural Gas Measure Level TRC Screening Results | | | | | |
|---|---|---|---|---|---|
| Measure Name | Savings Factor | Measure Cost | Cost Type: 1=Full 2=Incr. | Useful Life | TRC B/C Ratio |
| Gas Unit Heater - Condensing (AFUE =93%) | 14% | $2,640 | 2 | 21.5 | 1.92 |
| Demand Controlled Ventilation | 12% | $3,450 | 1 | 15 | 1.36 |
| Boiler O2 Trim Controls | 2% | $10,000 | 1 | 20 | 0.92 |
| Destratification Fans (HVLS) | 25% | $20,000 | 1 | 12.5 | 0.77 |
| Heat Recovery from Air to Air | 13% | $8,886 | 1 | 20 | 0.75 |
| Boiler Parallel Positioning | 2% | $14,500 | 1 | 20 | 0.64 |
| Exhaust Hood - Demand Ventilation | 25% | $16,500 | 2 | 15 | 0.30 |
| Insulate and Seal Ducts (New Aerosol Duct Sealing) | 7% | $13,595 | 1 | 20 | 0.29 |

### 6.5 Commercial Technical and Economic Savings Potential

The technical potential for commercial natural gas energy efficiency in Maryland is 36.8% of the projected 2015 and 2020 commercial natural gas sales. As can be seen in Table 6-4 most of the savings potential is found in measures that impact natural gas space heating use (building envelope and HVAC controls.)

**Table 6-4: Commercial Natural Gas Technical Potential by End Use**

| Commercial Natural Gas Technical Potential Savings by End Use | | |
|---|---|---|
| End Use | 2015 MMBTU | 2020 MMBTU |
| Building Envelope | 4,849,419 | 5,089,474 |
| Cooking | 815,958 | 856,350 |
| HVAC Controls | 4,664,472 | 4,895,372 |
| Space & Water Heating | 556,095 | 583,622 |
| Space Heating | 14,356,667 | 15,067,349 |
| Water Heating | 3,274,803 | 3,436,912 |
| **Total** | **28,517,414** | **29,929,080** |
| *% of Annual Sales Forecast* | *36.8%* | *36.8%* |

Table 6-5, shows a breakdown of commercial sector economic potential. Once again, space heating, and measures that impact space heating, together represent a significant portion (over 80%) of the total economic potential.

**Table 6-5: Commercial Natural Gas Economic Potential by End Use**

| Commercial Natural Gas Economic Potential Savings by End Use | | |
|---|---|---|
| End Use | 2015 MMBTU | 2020 MMBTU |
| Building Envelope | 1,425,484 | 1,496,048 |
| Cooking | 829,614 | 870,681 |
| HVAC Controls | 2,178,401 | 2,286,236 |
| Space & Water Heating | 565,401 | 593,390 |
| Space Heating | 10,094,365 | 10,594,055 |
| Water Heating | 2,756,948 | 2,893,422 |
| **Total** | **17,850,213** | **18,733,832** |
| *% of Annual Sales Forecast* | *23.0%* | *23.0%* |

## 6.6 Base Case Achievable Potential Savings (Base Case – 60% Market Penetration)

The achievable potential is a subset of the economic potential and is limited by various market and adoption barriers. Because this analysis has adopted a replace-on-burnout approach for replacing standard efficiency equipment with high efficiency technologies, each year the eligible market is limited to those measures that are expected to reach the end of their useful life and be targeted for replacement. For example, if a measure has a 20 year useful life, only half of the existing units would be expected to burnout during the 10 year timeframe, and only 1/20 would be eligible for replacement annually.

In the commercial base case scenario, the natural gas achievable potential represents the attainable savings if: (1) the market penetration of the selected replace on burnout measures represents 60% of the equipment available for replacement with energy efficiency equipment in each year, and (2) 10% of all available retrofit measures are installed each year. Although this methodology simplifies what an adoption curve might look like in practice, it succeeds in providing a concise method for estimating achievable savings potential over a specific period of time.

Table 6-6 provides the achievable potential in the 60% market penetration base case scenario by measure type. The achievable potential for natural gas efficiency savings in 2015 is estimated at 3,948,704 MMBTUs, or 5.1% of commercial natural gas sales in 2015. As program participation continues, the achievable potential savings increases to 8,884,583 MMBTUs in 2020, or 10.9% of 2020 commercial sales.

### Table 6-6: Commercial Natural Gas Achievable MMBTu Savings Potential (60% Market Penetration) by Measure Type

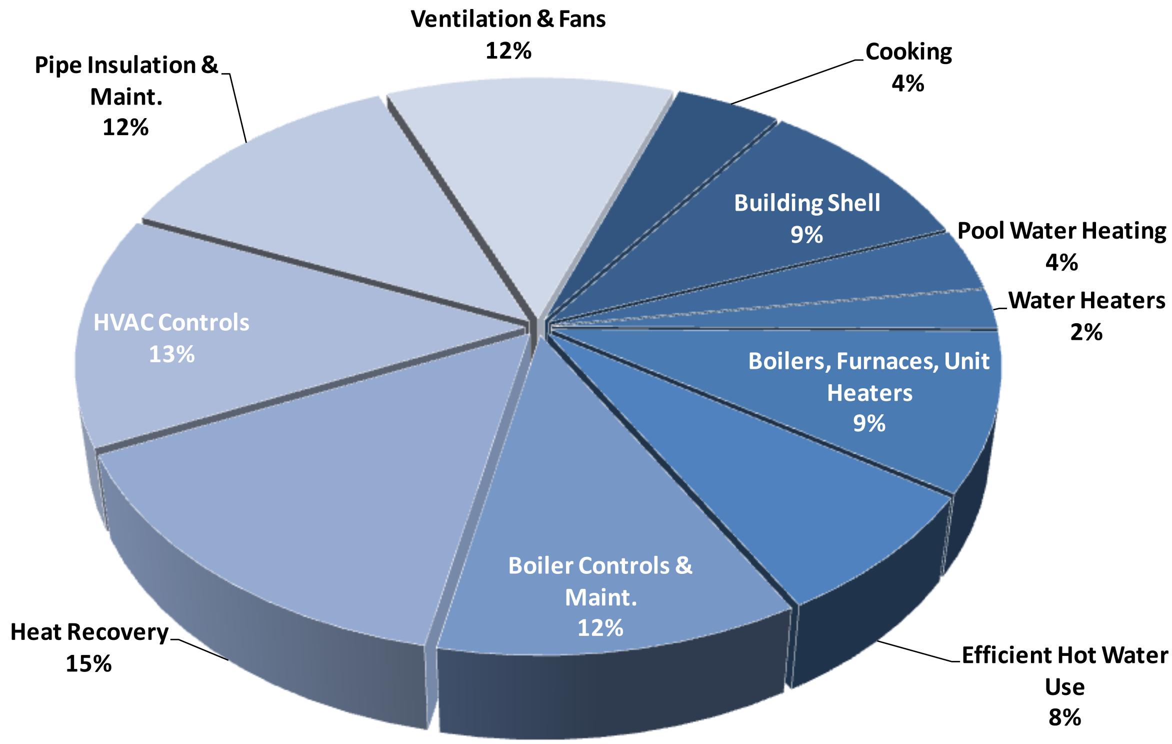
| Commercial Natural Gas Achievable MMBTu Savings Potential (60% Market Penetration) by Measure Type (MMBTU) | | |
|---|---|---|
| **Measure Name** | **Achievable Potential 2015** | **Achievable Potential 2020** |
| **Water Heating End Use** | | |
| Faucet aerator | 43,669 | 98,256 |
| Low Flow Pre-Rinse Spray Nozzle (1.25 gpm) | 5,818 | 13,091 |
| Low flow shower head (1.5 GPM) | 63,737 | 143,409 |
| Pool Cover | 58,000 | 130,501 |
| Ozone Commercial Laundry System (Gas HW) | 82,752 | 186,192 |
| High Efficiency Clothes Washer | 31,063 | 69,891 |
| Heat Recovery Water Heater | 77,469 | 174,306 |
| Wastewater, Filtration/Reclamation | 67,472 | 151,812 |
| Circulation Pump Time Clocks | 66,561 | 149,761 |
| Indirect Water Heater - Combined appliance efficiency rating (CAE)>=85% (EF=.82/.59 EF Baseline) | 17,823 | 40,102 |
| Solar pool heater | 82,735 | 186,154 |
| Graywater Heat Exchanger/GFX | 60,971 | 137,185 |
| Pipe wrap | 10,765 | 24,222 |
| On-Demand, Tankless Water Heater (.85 TE/.8 TE Baseline) (>200,000 BTU) | 911 | 2,049 |
| Condensing Stand Alone Commercial Water Heater (.96 TE/.8 TE) (Baseline >75000 btu) | 0 | 0 |
| High Efficiency (95%) Gas Pool Water Heater | 0 | 0 |
| On-Demand, Tankless Water Heater (>=.95 EF) (<=200,000 Btu/h) | 0 | 0 |
| On-Demand, Tankless Water Heater (.82 EF/.59 EF Baseline) (<=200,000 BTU/h) | 0 | 0 |
| High Efficiency Stand Alone Commercial Water Heater (0.67 EF/.59 EF) (Baseline <=75000 Btu) | 0 | 0 |
| Solar Water Heating w/gas auxiliary tank (SEF=1.5) | 0 | 0 |
| **Space & Water Heating** | | |
| Combination Water Heater/Furnace (.86 EF, .90 AFUE) | 8,559 | 19,257 |
| Combination Water Heater/Boiler (Non-Condensing) (0.86 EF, 85 AFUE) | 3,668 | 8,253 |
| Combination Water Heater/Boiler (Condensing)(0.9 EF, 0.9 AFUE) | 59,915 | 134,809 |
| **Building Envelope** | | |

| Commercial Natural Gas Achievable MMBTu Savings Potential (60% Market Penetration) by Measure Type (MMBTU) | | |
|---|---|---|
| **Measure Name** | **Achievable Potential 2015** | **Achievable Potential 2020** |
| Integrated Building Design, Envelope Only (30% > code) | 33,754 | 75,945 |
| Air Sealing | 335,604 | 755,110 |
| Improved Roof/Ceiling Insulation (to R32) | 0 | 0 |
| Improved Wall Insulation (to R12) | 0 | 0 |
| Triple Glazing Low Emissivity Windows | 0 | 0 |
| Double Glazing Low Emissivity Windows | 0 | 0 |
| Improved Below-Grade Insulation (to R6) | 0 | 0 |
| **HVAC Controls** | | |
| Commissioning | 0 | 0 |
| EMS Optimization | 28,746 | 64,678 |
| EMS install | 0 | 0 |
| Programmable Thermostat | 291,581 | 656,058 |
| Zoning | 206,890 | 465,503 |
| Retrocommissioning | 0 | 0 |
| **Cooking** | | |
| Energy Star Fryer | 62,871 | 141,459 |
| Energy Star Steam Cooker | 78,113 | 175,754 |
| Energy Star Oven | 13,882 | 31,234 |
| Energy Star Griddle | 16,325 | 36,732 |
| **Space Heating** | | |
| Stack Heat Exchanger (Condensing Economizer) | 178,453 | 401,519 |
| Stack Heat Exchanger (Standard Economizer) | 72,179 | 162,403 |
| Insulate steam lines/condensate tank | 32,861 | 73,938 |
| Repair/Replace malfunctioning steam traps | 332,388 | 747,873 |
| High Efficiency Hot Water Boiler (>300,000 Btu/h) (Th.eff.=85%-90%) | 2,466 | 5,548 |
| Exhaust Hood Makeup Air | 74,011 | 166,524 |
| High Efficiency Furnace (<=300,000 Btu/h) (AFUE>=92%) | 180,277 | 405,624 |
| Infrared Heater (low intensity - two stage) | 41,940 | 94,366 |

| Commercial Natural Gas Achievable MMBTu Savings Potential (60% Market Penetration) by Measure Type (MMBTU) | | |
|---|---|---|
| **Measure Name** | **Achievable Potential 2015** | **Achievable Potential 2020** |
| Condensing Boiler (>300,000 Btu/h) (Th.eff.=>90%) | 5,369 | 12,081 |
| Boiler Heating Pipe Insulation | 107,208 | 241,218 |
| High Efficiency Steam Boiler (>300,000 Btu/h) (Th.Eff.>=80%) | 28,242 | 63,544 |
| High Efficiency Steam Boiler (<=300,000 Btu/h) (AFUE >=82%) | 60,834 | 136,875 |
| Boiler Reset Controls | 290,109 | 652,746 |
| Boiler blowdown heat exchanger (steam) | 200,669 | 451,506 |
| High Efficiency Hot Water Boiler (<=300,000 Btu/h) (AFUE =85%-90%) | 22,655 | 50,973 |
| Boiler Tune-Up | 96,662 | 217,491 |
| Condensing Boiler (<=300,000 Btu/h) (AFUE>90%) | 16,752 | 37,693 |
| Gas Unit Heater - Condensing (AFUE =93%) | 4,401 | 9,901 |
| Demand Controlled Ventilation | 391,572 | 881,038 |
| Boiler O2 Trim Controls | 0 | 0 |
| Destratification Fans (HVLS) | 0 | 0 |
| Heat Recovery from Air to Air | 0 | 0 |
| Boiler Parallel Positioning | 0 | 0 |
| Exhaust Hood - Demand Ventilation | 0 | 0 |
| Insulate and Seal Ducts (New Aerosol Duct Sealing) | 0 | 0 |
| ***Total*** | ***3,948,704*** | ***8,884,583*** |
| % of Annual Sales Forecast | 5.1% | 10.9% |
| Note: Measures in the above Table with "0" achievable potential are ones that did not pass the TRC Test. | | |

Figure 6-2 details the commercial sector achievable sector savings by end-use. Heat Recovery measures offer the largest opportunity for natural gas savings, followed closely by HVAC controls, ventilation fans, pipe insulation and maintenance, and boiler controls and maintenance. It should be noted that HVAC controls refer only to system controls such as programmable thermostats and energy management systems. Controls such as boiler O2 trim, reset and parallel positioning are included under space heating.

**Figure 6-2: Commercial Sector End-Use Savings as a % of Base Case Achievable (60%) Potential (2020)**




For the achievable potential, the 60% market penetration scenario assumes that consumers would receive a financial incentive equal to approximately 40% of the incremental cost of the natural gas efficiency measure. In addition, for the low, base case and high case scenarios an overall non-incentive or administrative budget was developed that included the programmatic costs necessary to achieve the potential savings for each scenario. These costs included marketing, education, program delivery, fulfillment, program tracking, reporting, and evaluation.

The overall benefit/cost screening results for the commercial sector 40%, 60%, and 80% market penetration scenario are shown below in Table 6-7. For the base case scenario (60% market penetration), the net present value costs (in $2012) to the state of Maryland are approximately $472 million dollars including both total incentive payments as well as the associated costs (i.e. marketing, labor, monitoring, etc.) of administering energy programs between 2012 and 2021. The net present value benefits of $1,147 million dollars represent the lifetime benefits of all measures installed during the same time period. For the base case market penetration scenario, the TRC benefit/cost ratio for the commercial sector program portfolio is 2.43.

**Table 6-7: Commercial Sector Cost Effectiveness Screening Results – 60% Market Penetration**

| Table 6-7: Commercial Sector Cost Effectiveness Screening Results for Three Market Penetration Scenarios | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Market Penetration Scenario** | **MMBTu Savings 2015** | **% of 2015 Forecast** | **MMBTu Savings 2020** | **% of 2020 Forecast** | **Present Value of Total Benefits ($2012)** | **Present Value of Total Costs ($2012)** | **Benefit /Cost Ratio** |
| Low Case - 40% | 2,632,469 | 3.4% | 5,923,056 | 7.3% | $764,425,380 | $313,702,061 | 2.44 |
| Medium Case - 60% | 3,948,704 | 5.1% | 8,884,583 | 10.9% | $1,146,638,069 | $472,223,055 | 2.43 |
| High Case - 80% | 5,264,938 | 6.8% | 11,846,111 | 14.6% | $1,528,850,759 | $623,982,978 | 2.45 |

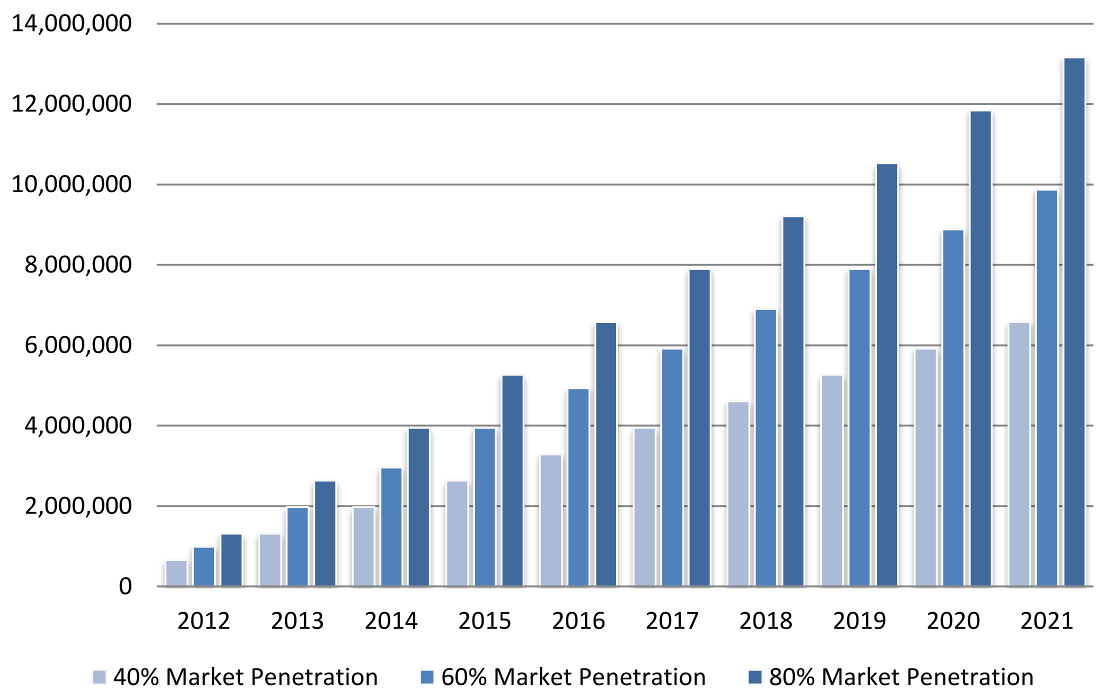
### 6.7 Commercial Achievable Market Penetration Scenario Results

Estimates of achievable potential were developed based on an assumption that the maximum penetration rates for energy efficiency measures over the 10 year study period range from 40% to 80%. We have used the 60% market penetration case as the base case for determining achievable potential. The low case scenario achieves approximately 40% market penetration by 2021; the high case achieves 80% market penetration. As noted earlier, the 60% market penetration assumed financial incentives equal to 40% of the measure incremental cost. The high up-front cost of energy efficient technologies is an important adoption barrier and altering incentive levels is likely to have an impact on the achievable market potential. The low and high case scenarios illustrate the impacts of changing the incentive level. Financial incentives equal to 50% and 30% of the measure incremental cost were used for the 80% and 40% market penetration scenarios, respectively.

Additionally, program administrative costs were also varied for each scenario to represent the assumption that more aggressive marketing, promotion and program staffing that would be necessary to achieve greater levels of customer participation. However this is not a linear relationship as some administrative costs are either fixed costs or do not vary proportionately with increased program participation. Therefore, administrative costs represent 25% of the total DSM budget for the 60% market penetration scenario, 20% of the total DSM budget for the high market penetration scenario and 30% of the total DSM budget for the low market penetration scenario. The decline in administrative costs as a percent of the total DSM budget as assumed market penetration increases reflects both economies of scale for program administration and increased incentives budgets that are necessary to achieve higher levels of customer participation.

Figure 6-3 graphically illustrates the low and high case achievable savings by year and compares it to the equivalent base case scenario savings. Table 6-8 through Table 6-13 show that the achievable potential MMBtu savings by 2021 range from a low of 8.0% in the 40% market penetration scenario to a high of 16.1% in the 80% market penetration scenario.

**Figure 6-3: Achievable Potential Savings (MMBtu) Results for all Market Penetration Scenarios**




Tables 6-8 to 6-13 provide detailed information on the projected annual MMBTu savings and required budgets for the three achievable potential scenarios based on 40%, 60% and 80 long-term market penetration.

**Table 6-8: Commercial Incremental and Cumulative Annual MMBTU Achievable Savings (80% Market Penetration)**

| Incremental Annual MMBTU Savings - Achievable 80% | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **End-Use** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Building Envelope | 123,119 | 123,119 | 123,119 | 123,119 | 123,119 | 123,119 | 123,119 | 123,119 | 123,119 | 123,119 |
| Cooking | 57,064 | 57,064 | 57,064 | 57,064 | 57,064 | 57,064 | 57,064 | 57,064 | 57,064 | 57,064 |
| HVAC Controls | 175,739 | 175,739 | 175,739 | 175,739 | 175,739 | 175,739 | 175,739 | 175,739 | 175,739 | 175,739 |
| Space and Water Heating | 24,047 | 24,047 | 24,047 | 24,047 | 24,047 | 24,047 | 24,047 | 24,047 | 24,047 | 24,047 |
| Space Heating | 713,016 | 713,016 | 713,016 | 713,016 | 713,016 | 713,016 | 713,016 | 713,016 | 713,016 | 713,016 |
| Water Heating | 223,249 | 223,249 | 223,249 | 223,249 | 223,249 | 223,249 | 223,249 | 223,249 | 223,249 | 223,249 |
| **Total** | **1,316,235** | **1,316,235** | **1,316,235** | **1,316,235** | **1,316,235** | **1,316,235** | **1,316,235** | **1,316,235** | **1,316,235** | **1,316,235** |
| *% of Annual Forecast Sales* | *1.8%* | *1.8%* | *1.7%* | *1.7%* | *1.7%* | *1.7%* | *1.6%* | *1.6%* | *1.6%* | *1.6%* |
| **Cumulative Annual MMBTU Savings - Achievable 80%** | | | | | | | | | | |
| **End-Use** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Building Envelope | 123,119 | 246,239 | 369,358 | 492,477 | 615,597 | 738,716 | 861,835 | 984,955 | 1,108,074 | 1,231,193 |
| Cooking | 57,064 | 114,127 | 171,191 | 228,255 | 285,318 | 342,382 | 399,445 | 456,509 | 513,573 | 570,636 |
| HVAC Controls | 175,739 | 351,478 | 527,217 | 702,956 | 878,695 | 1,054,435 | 1,230,174 | 1,405,913 | 1,581,652 | 1,757,391 |
| Space and Water Heating | 24,047 | 48,095 | 72,142 | 96,189 | 120,237 | 144,284 | 168,332 | 192,379 | 216,426 | 240,474 |
| Space Heating | 713,016 | 1,426,032 | 2,139,048 | 2,852,064 | 3,565,080 | 4,278,096 | 4,991,112 | 5,704,128 | 6,417,145 | 7,130,161 |
| Water Heating | 223,249 | 446,498 | 669,747 | 892,996 | 1,116,245 | 1,339,495 | 1,562,744 | 1,785,993 | 2,009,242 | 2,232,491 |
| **Total** | **1,316,235** | **2,632,469** | **3,948,704** | **5,264,938** | **6,581,173** | **7,897,407** | **9,213,642** | **10,529,877** | **11,846,111** | **13,162,346** |
| *% of Annual Forecast Sales* | *1.8%* | *3.5%* | *5.2%* | *6.8%* | *8.4%* | *10.0%* | *11.5%* | *13.0%* | *14.6%* | *16.1%* |

**Table 6-9: Commercial Annual Incentives and Budgets Associated with the 80% Market Penetration Achievable Scenario**

| Annual Incentives by End-Use (80% Market Penetration) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **End-Use** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Building Envelope | $11,579,348 | $11,579,348 | $11,579,348 | $11,579,348 | $11,579,348 | $11,579,348 | $11,579,348 | $11,579,348 | $11,579,348 | $11,579,348 |
| Cooking | $31,827 | $31,827 | $31,827 | $31,827 | $31,827 | $31,827 | $31,827 | $31,827 | $31,827 | $31,827 |
| HVAC Controls | $3,672,983 | $3,672,983 | $3,672,983 | $3,672,983 | $3,672,983 | $3,672,983 | $3,672,983 | $3,672,983 | $3,672,983 | $3,672,983 |
| Space and Water Heating | $1,144,938 | $1,144,938 | $1,144,938 | $1,144,938 | $1,144,938 | $1,144,938 | $1,144,938 | $1,144,938 | $1,144,938 | $1,144,938 |
| Space Heating | $16,308,674 | $16,308,674 | $16,308,674 | $16,308,674 | $16,308,674 | $16,308,674 | $16,308,674 | $16,308,674 | $16,308,674 | $16,308,674 |
| Water Heating | $5,416,624 | $5,416,624 | $5,416,624 | $5,416,624 | $5,416,624 | $5,416,624 | $5,416,624 | $5,416,624 | $5,416,624 | $5,416,624 |
| **Total** | **$38,154,393** | **$38,154,393** | **$38,154,393** | **$38,154,393** | **$38,154,393** | **$38,154,393** | **$38,154,393** | **$38,154,393** | **$38,154,393** | **$38,154,393** |
| **Annual Utility Budgets(80% Market Penetration)** | | | | | | | | | | |
| **Budget Category** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Incentive Budget | $38,154,393 | $38,154,393 | $38,154,393 | $38,154,393 | $38,154,393 | $38,154,393 | $38,154,393 | $38,154,393 | $38,154,393 | $38,154,393 |
| Program Marketing/Education | $3,100,044 | $3,177,935 | $3,258,194 | $3,340,915 | $3,426,195 | $3,514,138 | $3,604,853 | $3,698,453 | $3,795,061 | $3,894,802 |
| Program Delivery | $4,292,369 | $4,400,218 | $4,511,346 | $4,625,882 | $4,743,962 | $4,865,730 | $4,991,335 | $5,120,935 | $5,254,699 | $5,392,802 |
| Program Tracking & Reporting | $1,192,325 | $1,222,283 | $1,253,152 | $1,284,967 | $1,317,767 | $1,351,592 | $1,386,482 | $1,422,482 | $1,459,639 | $1,498,001 |
| Program Verification & Evaluation | $953,860 | $977,826 | $1,002,521 | $1,027,974 | $1,054,214 | $1,081,273 | $1,109,185 | $1,137,986 | $1,167,711 | $1,198,401 |
| **Total** | **$47,692,991** | **$47,932,655** | **$48,179,605** | **$48,434,131** | **$48,696,532** | **$48,967,126** | **$49,246,248** | **$49,534,250** | **$49,831,503** | **$50,138,399** |
| *Estimated # of FTE's* | *63.8* | *64.0* | *64.3* | *64.6* | *64.9* | *65.3* | *65.7* | *66.1* | *66.6* | *67.1* |

**Table 6-10: Commercial Incremental and Cumulative Annual MMBTU Achievable Savings (60% Market Penetration)**

| Incremental Annual MMBTU Savings - Achievable 60% | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **End-Use** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Building Envelope | 92,340 | 92,340 | 92,340 | 92,340 | 92,340 | 92,340 | 92,340 | 92,340 | 92,340 | 92,340 |
| Cooking | 42,798 | 42,798 | 42,798 | 42,798 | 42,798 | 42,798 | 42,798 | 42,798 | 42,798 | 42,798 |
| HVAC Controls | 131,804 | 131,804 | 131,804 | 131,804 | 131,804 | 131,804 | 131,804 | 131,804 | 131,804 | 131,804 |
| Space and Water Heating | 18,036 | 18,036 | 18,036 | 18,036 | 18,036 | 18,036 | 18,036 | 18,036 | 18,036 | 18,036 |
| Space Heating | 534,762 | 534,762 | 534,762 | 534,762 | 534,762 | 534,762 | 534,762 | 534,762 | 534,762 | 534,762 |
| Water Heating | 167,437 | 167,437 | 167,437 | 167,437 | 167,437 | 167,437 | 167,437 | 167,437 | 167,437 | 167,437 |
| **Total** | **987,176** | **987,176** | **987,176** | **987,176** | **987,176** | **987,176** | **987,176** | **987,176** | **987,176** | **987,176** |
| *% of Annual Forecast Sales* | *1.3%* | *1.3%* | *1.3%* | *1.3%* | *1.3%* | *1.2%* | *1.2%* | *1.2%* | *1.2%* | *1.2%* |
| **Cumulative Annual MMBTU Savings - Achievable 60%** | | | | | | | | | | |
| **End-Use** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Building Envelope | 92,340 | 184,679 | 277,019 | 369,358 | 461,698 | 554,037 | 646,377 | 738,716 | 831,056 | 923,395 |
| Cooking | 42,798 | 85,595 | 128,393 | 171,191 | 213,989 | 256,786 | 299,584 | 342,382 | 385,179 | 427,977 |
| HVAC Controls | 131,804 | 263,609 | 395,413 | 527,217 | 659,022 | 790,826 | 922,630 | 1,054,435 | 1,186,239 | 1,318,043 |
| Space and Water Heating | 18,036 | 36,071 | 54,107 | 72,142 | 90,178 | 108,213 | 126,249 | 144,284 | 162,320 | 180,355 |
| Space Heating | 534,762 | 1,069,524 | 1,604,286 | 2,139,048 | 2,673,810 | 3,208,572 | 3,743,334 | 4,278,096 | 4,812,858 | 5,347,620 |
| Water Heating | 167,437 | 334,874 | 502,310 | 669,747 | 837,184 | 1,004,621 | 1,172,058 | 1,339,495 | 1,506,931 | 1,674,368 |
| **Total** | **987,176** | **1,974,352** | **2,961,528** | **3,948,704** | **4,935,880** | **5,923,056** | **6,910,232** | **7,897,407** | **8,884,583** | **9,871,759** |
| *% of Annual Forecast Sales* | *1.3%* | *2.6%* | *3.9%* | *5.1%* | *6.3%* | *7.5%* | *8.6%* | *9.8%* | *10.9%* | *12.1%* |

**Table 6-11: Commercial Annual Incentives and Budgets Associated with the 60% Market Penetration Achievable Scenario**

| Annual Incentives by End-Use (60% Market Penetration) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **End-Use** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Building Envelope | $6,947,609 | $6,947,609 | $6,947,609 | $6,947,609 | $6,947,609 | $6,947,609 | $6,947,609 | $6,947,609 | $6,947,609 | $6,947,609 |
| Cooking | $19,096 | $19,096 | $19,096 | $19,096 | $19,096 | $19,096 | $19,096 | $19,096 | $19,096 | $19,096 |
| HVAC Controls | $2,203,790 | $2,203,790 | $2,203,790 | $2,203,790 | $2,203,790 | $2,203,790 | $2,203,790 | $2,203,790 | $2,203,790 | $2,203,790 |
| Space and Water Heating | $686,963 | $686,963 | $686,963 | $686,963 | $686,963 | $686,963 | $686,963 | $686,963 | $686,963 | $686,963 |
| Space Heating | $9,785,204 | $9,785,204 | $9,785,204 | $9,785,204 | $9,785,204 | $9,785,204 | $9,785,204 | $9,785,204 | $9,785,204 | $9,785,204 |
| Water Heating | $3,249,974 | $3,249,974 | $3,249,974 | $3,249,974 | $3,249,974 | $3,249,974 | $3,249,974 | $3,249,974 | $3,249,974 | $3,249,974 |
| **Total** | **$22,892,636** | **$22,892,636** | **$22,892,636** | **$22,892,636** | **$22,892,636** | **$22,892,636** | **$22,892,636** | **$22,892,636** | **$22,892,636** | **$22,892,636** |
| **Annual Utility Budgets(60% Market Penetration)** | | | | | | | | | | |
| **Budget Category** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Incentive Budget | $22,892,636 | $22,892,636 | $22,892,636 | $22,892,636 | $22,892,636 | $22,892,636 | $22,892,636 | $22,892,636 | $22,892,636 | $22,892,636 |
| Program Marketing/Education | $2,441,881 | $2,507,435 | $2,575,213 | $2,645,315 | $2,717,850 | $2,792,931 | $2,870,679 | $2,951,222 | $3,034,698 | $3,121,252 |
| Program Delivery | $3,510,204 | $3,604,438 | $3,701,868 | $3,802,641 | $3,906,910 | $4,014,838 | $4,126,601 | $4,242,382 | $4,362,378 | $4,486,799 |
| Program Tracking & Reporting | $915,705 | $940,288 | $965,705 | $991,993 | $1,019,194 | $1,047,349 | $1,076,505 | $1,106,708 | $1,138,012 | $1,170,469 |
| Program Verification & Evaluation | $763,088 | $783,573 | $804,754 | $826,661 | $849,328 | $872,791 | $897,087 | $922,257 | $948,343 | $975,391 |
| **Total** | **$30,523,515** | **$30,728,370** | **$30,940,176** | **$31,159,246** | **$31,385,918** | **$31,620,545** | **$31,863,507** | **$32,115,205** | **$32,376,066** | **$32,646,547** |
| *Estimated # of FTE's* | *51.2* | *51.5* | *51.8* | *52.2* | *52.5* | *52.9* | *53.4* | *53.8* | *54.4* | *54.9* |

**Table 6-12: Commercial Incremental and Cumulative Annual MMBTU Achievable Savings (40% Market Penetration)**

| Incremental Annual MMBTU Savings - Achievable 40% | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **End-Use** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Building Envelope | 61,560 | 61,560 | 61,560 | 61,560 | 61,560 | 61,560 | 61,560 | 61,560 | 61,560 | 61,560 |
| Cooking | 28,532 | 28,532 | 28,532 | 28,532 | 28,532 | 28,532 | 28,532 | 28,532 | 28,532 | 28,532 |
| HVAC Controls | 87,870 | 87,870 | 87,870 | 87,870 | 87,870 | 87,870 | 87,870 | 87,870 | 87,870 | 87,870 |
| Space and Water Heating | 12,024 | 12,024 | 12,024 | 12,024 | 12,024 | 12,024 | 12,024 | 12,024 | 12,024 | 12,024 |
| Space Heating | 356,508 | 356,508 | 356,508 | 356,508 | 356,508 | 356,508 | 356,508 | 356,508 | 356,508 | 356,508 |
| Water Heating | 111,625 | 111,625 | 111,625 | 111,625 | 111,625 | 111,625 | 111,625 | 111,625 | 111,625 | 111,625 |
| **Total** | **658,117** | **658,117** | **658,117** | **658,117** | **658,117** | **658,117** | **658,117** | **658,117** | **658,117** | **658,117** |
| *% of Annual Forecast Sales* | *0.9%* | *0.9%* | *0.9%* | *0.8%* | *0.8%* | *0.8%* | *0.8%* | *0.8%* | *0.8%* | *0.8%* |
| **Cumulative Annual MMBTU Savings - Achievable 40%** | | | | | | | | | | |
| **End-Use** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Building Envelope | 61,560 | 123,119 | 184,679 | 246,239 | 307,798 | 369,358 | 430,918 | 492,477 | 554,037 | 615,597 |
| Cooking | 28,532 | 57,064 | 85,595 | 114,127 | 142,659 | 171,191 | 199,723 | 228,255 | 256,786 | 285,318 |
| HVAC Controls | 87,870 | 175,739 | 263,609 | 351,478 | 439,348 | 527,217 | 615,087 | 702,956 | 790,826 | 878,695 |
| Space and Water Heating | 12,024 | 24,047 | 36,071 | 48,095 | 60,118 | 72,142 | 84,166 | 96,189 | 108,213 | 120,237 |
| Space Heating | 356,508 | 713,016 | 1,069,524 | 1,426,032 | 1,782,540 | 2,139,048 | 2,495,556 | 2,852,064 | 3,208,572 | 3,565,080 |
| Water Heating | 111,625 | 223,249 | 334,874 | 446,498 | 558,123 | 669,747 | 781,372 | 892,996 | 1,004,621 | 1,116,245 |
| **Total** | **658,117** | **1,316,235** | **1,974,352** | **2,632,469** | **3,290,586** | **3,948,704** | **4,606,821** | **5,264,938** | **5,923,056** | **6,581,173** |
| *% of Annual Forecast Sales* | *0.9%* | *1.8%* | *2.6%* | *3.4%* | *4.2%* | *5.0%* | *5.8%* | *6.5%* | *7.3%* | *8.0%* |

**Table 6-13: Commercial Annual Incentives and Budgets Associated with the 40% Market Penetration Achievable Scenario**

| Annual Incentives by End-Use (40% Market Penetration) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **End-Use** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Building Envelope | $3,473,804 | $3,473,804 | $3,473,804 | $3,473,804 | $3,473,804 | $3,473,804 | $3,473,804 | $3,473,804 | $3,473,804 | $3,473,804 |
| Cooking | $9,548 | $9,548 | $9,548 | $9,548 | $9,548 | $9,548 | $9,548 | $9,548 | $9,548 | $9,548 |
| HVAC Controls | $1,101,895 | $1,101,895 | $1,101,895 | $1,101,895 | $1,101,895 | $1,101,895 | $1,101,895 | $1,101,895 | $1,101,895 | $1,101,895 |
| Space and Water Heating | $343,481 | $343,481 | $343,481 | $343,481 | $343,481 | $343,481 | $343,481 | $343,481 | $343,481 | $343,481 |
| Space Heating | $4,892,602 | $4,892,602 | $4,892,602 | $4,892,602 | $4,892,602 | $4,892,602 | $4,892,602 | $4,892,602 | $4,892,602 | $4,892,602 |
| Water Heating | $1,624,987 | $1,624,987 | $1,624,987 | $1,624,987 | $1,624,987 | $1,624,987 | $1,624,987 | $1,624,987 | $1,624,987 | $1,624,987 |
| **Total** | **$11,446,318** | **$11,446,318** | **$11,446,318** | **$11,446,318** | **$11,446,318** | **$11,446,318** | **$11,446,318** | **$11,446,318** | **$11,446,318** | **$11,446,318** |
| **Annual Utility Budgets(40% Market Penetration)** | | | | | | | | | | |
| **Budget Category** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Incentive Budget | $11,446,318 | $11,446,318 | $11,446,318 | $11,446,318 | $11,446,318 | $11,446,318 | $11,446,318 | $11,446,318 | $11,446,318 | $11,446,318 |
| Program Marketing/Education | $1,553,429 | $1,598,196 | $1,644,664 | $1,692,920 | $1,743,060 | $1,795,187 | $1,849,410 | $1,905,847 | $1,964,624 | $2,025,877 |
| Program Delivery | $2,289,264 | $2,355,237 | $2,423,715 | $2,494,829 | $2,568,720 | $2,645,539 | $2,725,446 | $2,808,616 | $2,895,235 | $2,985,503 |
| Program Tracking & Reporting | $572,316 | $588,809 | $605,929 | $623,707 | $642,180 | $661,385 | $681,362 | $702,154 | $723,809 | $746,376 |
| Program Verification & Evaluation | $490,556 | $504,694 | $519,367 | $534,606 | $550,440 | $566,901 | $584,024 | $601,846 | $620,407 | $639,751 |
| **Total** | **$16,351,883** | **$16,493,254** | **$16,639,992** | **$16,792,381** | **$16,950,719** | **$17,115,330** | **$17,286,560** | **$17,464,781** | **$17,650,392** | **$17,843,825** |
| *Estimated # of FTE's* | *33.0* | *33.3* | *33.5* | *33.8* | *34.1* | *34.5* | *34.9* | *35.2* | *35.7* | *36.1* |

# 7.0 INDUSTRIAL SECTOR ENERGY EFFICIENCY POTENTIAL

## 7.1 Introduction and Summary of Results

This section of the report provides the estimates of technical, economic and achievable potential for natural gas energy efficiency measures for the industrial sector in Maryland. The industrial sector includes businesses that manufacture a product, such as textile mills, paper mills, chemical manufacturing plants, and plants that manufacture computers and other types of electrical equipment.

Estimating energy efficiency potential for the industrial sector can be more challenging than it is for the residential and commercial sectors because of the significant differences in the way energy is used across manufacturing segments. How a paper mill uses energy is very different from how a semiconductor manufacturer does. Further, even within a particular industrial segment, energy use is influenced by the particular processes utilized, past investments in energy efficiency, the age of the facility, and the corporate operating philosophy. For example, energy use at a paper mill is dependent on whether the facility produces its own pulp or buys it. Further, the energy requirements of thermo-mechanical pulping are very different from kraft pulping.

Efficiency potential estimates can be developed using either a top-down or a bottom-up approach, depending on data availability. A top-down approach builds an energy profile based on local economic data, national energy consumption surveys and available studies related to conservation potential. A bottom-up approach combines utility sales data, local survey data and facility audits to identify the energy use characteristics of manufacturing segments and the potential for efficiency improvements.

Because industry-level energy consumption and audit data are not available for Maryland gas customers, it was necessary to gather economic data for industrial segments in the state and then to develop industry-specific energy use estimates using national energy intensities for each industry. The current analysis assumes that industries in the Maryland are similar to those in other jurisdictions. However, industrial processes in Maryland are believed to be less energy intensive than those in other regions of the U.S.

Approximately 79% of the natural gas used by Maryland's industrial sector is consumed by five manufacturing segments: chemicals, food products, nonmetallic mineral products, paper and primary metals. Process heat accounts for 40% of natural gas use, followed by conventional boiler use at 28% and 16% for cogeneration. Baseline natural gas demand is projected to increase by about 1.2% per annum; rising from 24.6 TBtu (trillion Btu) in 2009 to 28.4 TBtu in 2021.[33]

The technical potential savings for energy efficiency that could be achieved by 2020 is on the order of 4,042,010 MMBtu, or about 14% of the projected baseline gas usage. According to this analysis, there is still a large potential for natural gas efficiency savings in this sector. Table 7-1

[33] The baseline forecast reflects a midline perspective between the Energy Information Administration's Annual Energy Outlook 2011 for the U.S. [DOE/EIA-0383(2011), April 2011] and the observed historical trend in Maryland industrial gas consumption, 2003-2009.

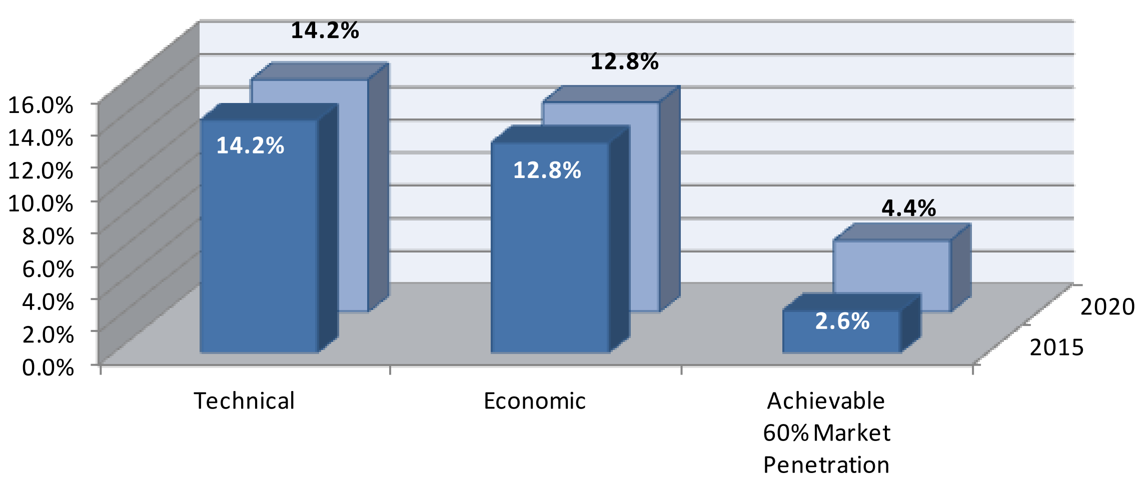
and Figure 7-1, below, summarize the technical, economic (based on the TRC test), and achievable economic savings potential by 2015 and 2020 for the 60% market measure penetration rate scenario. These scenarios also reflect the market driven implementation of certain measures that were modeled as non-retrofit measures. In other words, for these measures it was assumed that industrial customers would replace existing inefficient equipment at the end of the equipment's effective useful life.

Most of the industrial technical potential is economic and that economic potential represents about 8% of the total 2021 industrial sales. The amount of this economic potential that can be achieved by 2021 ranges is approximately 7% of projected 2021 industrial natural gas sales assuming a market penetration rate of 80% over the next ten years.

**Table 7-1: Natural Gas Energy Efficiency Potential Industrial Sector by 2015 and 2020**

| Summary of Industrial Natural Gas Efficiency Potential | | | |
|---|---|---|---|
| | **Technical** | **Economic** | **Achievable 60% Market Penetration** |
| **2015** | | | |
| Total MMBTU Savings | 4,008,769 | 3,619,976 | 728,595 |
| % of 2015 Forecast Industrial Sales | 14.2% | 12.8% | 2.6% |
| **2020** | | | |
| Total MMBTU Savings | 4,042,010 | 3,649,993 | 1,250,492 |
| % of 2020 Forecast Industrial Sales | 14.2% | 12.8% | 4.4% |

**Figure 7-1: Summary of Commercial Natural Gas Efficiency Potential in 2015 and 2020 (60% Market Penetration Scenario)**




## 7.2 Industrial Energy Efficiency Measures

The list of industrial energy efficiency measures was developed by GDS based on a review of measures included in other studies conducted by GDS and research of the latest natural gas technologies and efficiency standards. Only measures that are commercially available were considered.

GDS collected information on the costs, natural gas savings and useful lives for the industrial energy efficiency measures selected for inclusion in this study. Where appropriate, the industrial analysis used the same cost and savings relationships that were utilized in preparing the estimates of commercial sector natural gas energy efficiency potential. Otherwise, cost and savings estimates were adopted from available studies prepared for Massachusetts, New York, California or other states.

Thirty-seven (37) industrial technologies were adopted for examination as natural gas efficiency measures. The industrial natural gas energy efficiency measures reviewed in the study are listed on the following page in Table 7-2:

**Table 7-2: List of Industrial Natural Gas Energy Efficiency Measures Included in the Study**

| List of Industrial Energy Efficiency Measures | |
|---|---|
| **End Use Type** | **Measures/Programs Included** |
| Conventional Boiler Use | High Efficiency Hot Water Boiler (<=300,000 Btu/h) |
| | Condensing Boiler (<=300,000 Btu/h) |
| | High Efficiency Steam Boiler (<=300,000 Btu/h) |
| | High Efficiency Hot Water Boiler (>300,000 Btu/h) |
| | Condensing Boiler (>300,000 Btu/h) |
| | High Efficiency Steam Boiler (>300,000 Btu/h) |
| | Boiler Tune-Up |
| | Boiler Pipe Insulation |
| | Boiler Reset Controls |
| | Boiler O2 Trim Controls |
| | Electronic Parallel Positioning Controls |
| | Boiler Blowdown Heat Exchanger (Steam) |
| | Repair Malfunctioning Steam Traps |
| | Insulate Steam Lines / Condensate Tank |
| Process Heating | High Efficiency Hot Water Boiler (>300,000 Btu/h) |
| | Condensing Boiler (>300,000 Btu/h) |
| | High Efficiency Steam Boiler (>300,000 Btu/h) |
| | Direct Fired Make-up Air System |
| | Direct Contact Water Heater |
| | Boiler Tune-Up |
| | Boiler Pipe Insulation |
| | Boiler Reset Controls |
| | Boiler O2 Trim Controls |
| | Electronic Parallel Positioning Controls |
| | Waste-Heat Recovery |
| | Regenerative Thermal Oxidizer vs. STO |
| | Regenerative Thermal Oxidizer vs. CTO |
| | Improved Sensors & Process Controls |
| | Refrigeration Heat Recovery |
| Facility HVAC | High Efficiency Furnace (<=300,000 Btu/h) |
| | Gas Unit Heater - Condensing |
| | Infrared Heater (low intensity) |
| | Insulate and Seal Ducts |
| | Stack Heat Exchanger (Standard Economizer) |
| | Stack Heat Exchanger (Condensing Economizer) |
| | Heat Recovery: Air to Air |
| | Direct Fired Make-up Air System |

### 7.3 Characteristics of Industrial Energy Efficiency Measures

As noted above, GDS collected data and developed estimates of measure savings, measure cost and effective useful life for each of the industrial natural gas energy efficiency measures. Savings factors for each measure, which represent the percent savings in annual energy use resulting from implementation of the measure, were then applied to the applicable end-use energy. So, for example, process heating measure savings factors were applied to the estimated process heating end-use energy that is associated with equipment that has not yet been converted to the energy efficiency measure and is technically feasible for conversion. All of the industrial measure data and sources of information can be found in Appendix C.

Measures cost are defined as either full or incremental. Incremental measures are assumed to replace existing equipment at the end of its effective useful life and are generally characterized by incremental measure costs and savings (e.g., the incremental costs and savings of a high-efficiency versus a standard efficiency boiler). In contrast, full cost driven measures are retrofit measures that are generally characterized by full costs and savings (e.g., the full costs and savings associated with retrofitting ceiling insulation into an existing attic).

### 7.4 Industrial Measure Cost Effectiveness

In the calculation of a measure's cost-effectiveness, 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. This approach evaluates energy-efficient technologies on their own merit, and does not unfairly exclude one measure in favor of another. GDS screened individual industrial natural gas energy efficiency measures to determine their cost effectiveness in accordance with TRC test. Table 7-3 below shows the TRC cost effectiveness screening results for each measure. Those measures that did not pass the TRC test (benefit/cost ratio of less than 1.0) were not included in the estimate of economic and achievable economic potential.

**Table 7-3: Industrial Measure Cost-Effectiveness Screening Results**

| Industrial Natural Gas Measure Level TRC Screening Results | |
|---|---|
| **Measure Name** | **TRC Ratio** |
| Conventional Boiler Use | |
| Insulate Steam Lines / Condensate Tank | 7.98 |
| Repair Malfunctioning Steam Traps | 7.83 |
| High Efficiency Hot Water Boiler (>300,000 Btu/h) | 7.72 |
| Condensing Boiler (>300,000 Btu/h) | 5.29 |
| Boiler Pipe Insulation | 4.75 |
| High Efficiency Steam Boiler (>300,000 Btu/h) | 3.48 |
| Boiler Reset Controls | 2.98 |
| Boiler Blowdown Heat Exchanger (Steam) | 2.74 |
| High Efficiency Hot Water Boiler (<=300,000 Btu/h) | 2.55 |
| Boiler Tune-Up | 2.49 |
| High Efficiency Steam Boiler (<=300,000 Btu/h) | 2.40 |
| Condensing Boiler (<=300,000 Btu/h) | 2.37 |
| Boiler O2 Trim Controls | 1.10 |
| Electronic Parallel Positioning Controls | 0.76 |
| Process Heating | |
| Regenerative Thermal Oxidizer vs. STO | 20.60 |
| Boiler Pipe Insulation | 8.20 |
| Boiler Pipe Insulation | 8.20 |
| High Efficiency Hot Water Boiler (>300,000 Btu/h) | 7.72 |
| Refrigeration Heat Recovery | 5.65 |
| Condensing Boiler (>300,000 Btu/h) | 5.29 |
| High Efficiency Steam Boiler (>300,000 Btu/h) | 3.48 |
| Boiler Reset Controls | 2.98 |
| Boiler Tune-Up | 2.49 |
| Regenerative Thermal Oxidizer vs. CTO | 2.43 |
| Direct Fired Make-up Air System | 2.40 |
| Improved Sensors & Process Controls | 1.34 |
| Boiler O2 Trim Controls | 1.10 |
| Electronic Parallel Positioning Controls | 0.76 |
| Waste-Heat Recovery | 0.51 |
| Facility HVAC | |
| Stack Heat Exchanger (Condensing Economizer) | 12.71 |
| Stack Heat Exchanger (Standard Economizer) | 8.57 |
| High Efficiency Furnace (<=300,000 Btu/h) | 6.82 |
| Infrared Heater (low intensity) | 6.71 |
| Direct Fired Make-up Air System | 2.40 |
| Gas Unit Heater - Condensing | 2.28 |
| Heat Recovery: Air to Air | 0.86 |
| Insulate and Seal Ducts | 0.28 |

## 7.5 Industrial Technical and Economic Savings Potential

The technical potential for industrial natural gas energy efficiency in Maryland is 14.2% of the projected industrial natural gas sales. Tables 7-4 and 7-5 show a breakdown of industrial sector technical and economic potential by end use for 2015 and 2020. Measures that impact process heating represent a significant portion of the total technical and economic potential.

**Table 7-4: Industrial Sector Technical Natural Gas Savings Potential by 2015 and 2020 (60 % Market Penetration)**

| Industrial Natural Gas Technical Potential Savings by End Use | | |
|---|---|---|
| **End Use** | **2015 MMBTU** | **2020 MMBTU** |
| Conventional Boiler Use | 1,193,821 | 1,203,720 |
| Process Heating | 2,311,256 | 2,330,422 |
| Facility HVAC | 503,692 | 507,869 |
| **Total** | **4,008,769** | **4,042,011** |
| *% of Annual Sales Forecast* | *14.2%* | *14.2%* |

**Table 7-5: Industrial Sector Economic Natural Gas Savings Potential by 2015 and 2020 (60 % Market Penetration)**

| Industrial Natural Gas Economic Potential Savings by End Use | | |
|---|---|---|
| **End Use** | **2015 MMBTU** | **2020 MMBTU** |
| Conventional Boiler Use | 1,153,329 | 1,162,892 |
| Process Heating | 2,092,563 | 2,109,915 |
| Facility HVAC | 374,084 | 377,186 |
| **Total** | **3,619,976** | **3,649,993** |
| *% of Annual Sales Forecast* | *12.8%* | *12.8%* |

### 7.6 Base Case Achievable Potential Savings (Base Case – 60% Market Penetration)

The achievable potential is a subset of the economic potential and is limited by various market and adoption barriers. Because this analysis has adopted a replace-on-burnout approach for replacing standard efficiency equipment with high efficiency technologies, each year the eligible market is limited to those measures that are expected to reach the end of their useful life and be targeted for replacement. For example, if a measure has a 20 year useful life, only half of the existing units would be expected to burnout during the 10 year timeframe, and only 1/20 would be eligible for replacement annually.

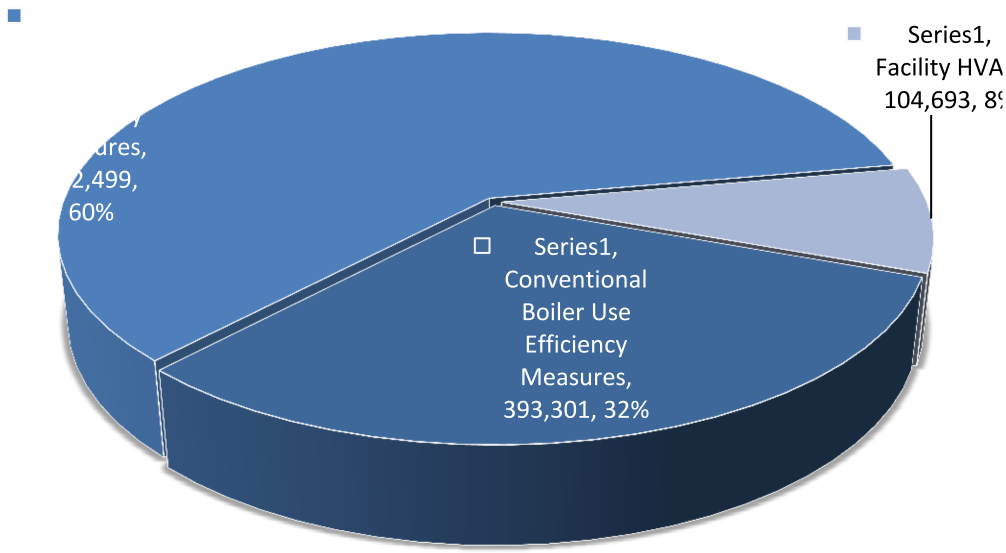
Table 7-6 below provides the achievable potential in the 60% market penetration base case scenario by measure type. As participation ramps up to 60% of the remaining eligible annual market turnover, the achievable potential for natural gas efficiency savings in 2015 is estimated at 728,595 MMBTUs, or 2.6% of industrial natural gas sales in 2015. As program participation continues, the achievable potential savings increases to 1,259,492 MMBTUs in 2020, or 4.4% of 2020 industrial natural gas sales. Figure 7-2 shows a pie chart that provides a breakdown of the achievable potential savings in 2020 by end use.

### Table 7-6: Industrial Natural Gas Achievable MMBTU Savings Potential (60% Market Penetration) by Measure Type

| Industrial Natural Gas Achievable MMBTu Savings Potential (60% Market Penetration) by Measure Type | | |
|---|---|---|
| **Measure Name** | **Achievable Potential 2015** | **Achievable Potential 2020** |
| Conventional Boiler Use | | |
| High Efficiency Hot Water Boiler (<=300,000 Btu/h) | 342 | 770 |
| Condensing Boiler (<=300,000 Btu/h) | 224 | 505 |
| High Efficiency Steam Boiler (<=300,000 Btu/h) | 397 | 894 |
| High Efficiency Hot Water Boiler (>300,000 Btu/h) | 22,281 | 50,132 |
| Condensing Boiler (>300,000 Btu/h) | 756 | 1,701 |
| High Efficiency Steam Boiler (>300,000 Btu/h) | 10,383 | 23,362 |
| Boiler Tune-Up | 49,428 | 49,428 |
| Boiler Pipe Insulation | 15,507 | 34,890 |
| Boiler Reset Controls | 29,075 | 65,419 |
| Boiler O2 Trim Controls | 4,885 | 10,990 |
| Electronic Parallel Positioning Controls | | |
| Boiler Blowdown Heat Exchanger (Steam) | 15,142 | 34,070 |
| Repair Malfunctioning Steam Traps | 86,528 | 108,160 |
| Insulate Steam Lines / Condensate Tank | 5,769 | 12,979 |
| Process Heating | | |
| High Efficiency Hot Water Boiler (>300,000 Btu/h) | 36,739 | 82,664 |
| Condensing Boiler (>300,000 Btu/h) | 1,526 | 3,433 |
| High Efficiency Steam Boiler (>300,000 Btu/h) | 17,121 | 38,523 |
| Direct Fired Make-up Air System | 14,493 | 32,609 |
| Direct Contact Water Heater | 5,437 | 12,234 |
| Boiler Tune-Up | 79,787 | 79,787 |
| Boiler Pipe Insulation | 25,031 | 56,320 |
| Boiler Reset Controls | 46,933 | 105,600 |
| Boiler O2 Trim Controls | 7,885 | 17,741 |
| Electronic Parallel Positioning Controls | | |
| Waste-Heat Recovery | | |
| Regenerative Thermal Oxidizer vs. STO | 23,509 | 52,895 |
| Regenerative Thermal Oxidizer vs. CTO | 17,075 | 38,418 |
| Improved Sensors & Process Controls | 140,800 | 176,000 |
| Refrigeration Heat Recovery | 25,011 | 56,274 |
| Facility HVAC | | |
| High Efficiency Furnace (<=300,000 Btu/h) | 13,119 | 29,518 |
| Gas Unit Heater - Condensing | 8,084 | 18,188 |
| Infrared Heater (low intensity) | 4,655 | 10,475 |
| Insulate and Seal Ducts | | |
| Stack Heat Exchanger (Standard Economizer) | 2,716 | 6,110 |
| Stack Heat Exchanger (Condensing Economizer) | 5,431 | 12,220 |
| Heat Recovery: Air to Air | | |
| Direct Fired Make-up Air System | 12,525 | 28,182 |
| ***TOTAL ACHIEVABLE (60% Market Penetration) POTENTIAL:*** | ***728,595*** | ***1,250,492*** |

For the achievable potential, the 60% market penetration scenario assumes that consumers would receive a financial incentive equal to approximately 40% of the incremental cost of the natural gas efficiency measure for most technologies. In addition, an overall non-incentive or administrative cost was assigned to each measure in order to run the achievable cost-effectiveness tests. Consistent with the commercial sector analysis, non-incentive costs were estimated to be 20% of the total utility budget. Non-incentive costs include administration, marketing, education, program delivery, fulfillment, data tracking and reporting, and evaluation.

**Figure 7-2: 2020 Industrial Achievable Savings By End Use (60% Market Penetration)**




The overall benefit/cost screening results for the industrial sector 60% market penetration scenario are shown below in Table 7-7. The net present value TRC costs (in $2012) to the State of Maryland (for the 60% market penetration case) are approximately $42.8 million dollars including both utility and participant costs. For these natural gas energy efficiency programs for the ten-year period from 2012 and 2021, the net present value TRC benefits (for the 60% market penetration scenario) of $117.9 million dollars represent the lifetime benefits of all measures installed during the same time period. For the base case market penetration scenario (60%), the TRC benefit/cost ratio for the industrial sector program portfolio is 2.75.

**Table 7-7: Industrial Sector TRC Cost Effectiveness Screening Results for Three Scenarios**

| Industrial Sector Cost Effectiveness Screening Results - 3 Market Penetration Scenario | | | | | |
|---|---|---|---|---|---|
| Benefit Cost Test | Present Value of Total Benefits ($2012) | Present Value of Utility Costs ($2012) | Present Value of Participant Costs ($2012) | Present Value of Total Costs ($2012) | Benefit/Cost Ratio |
| Low Case - 40% | $78,618,174 | $11,050,593 | $17,409,839 | $28,460,432 | 2.76 |
| Medium Case - 60% | $117,927,261 | $20,458,076 | $22,384,079 | $42,842,155 | 2.75 |
| High Case - 80% | $157,236,348 | $31,739,284 | $24,871,199 | $56,610,483 | 2.78 |

## 7.7 Industrial Achievable Market Penetration Scenario Results

Estimates of achievable potential were developed based on an assumption that the maximum penetration rates for energy efficiency measures over the 10 year study period range from a low of 40% to a high of 80%. GDS has used the 60% market penetration case as the base case for determining achievable potential. The low case scenario achieves approximately 40% market penetration by 2021; the high case achieves 80% market penetration. As noted earlier, the 60% market penetration assumed financial incentives equal to 40% of the measure incremental cost. The high up-front cost of energy efficient technologies is an important adoption barrier and altering incentive levels is likely to have an impact on the achievable market potential. The low and high case scenarios illustrate the impacts of changing the incentive level. Financial incentives equal to 50% and 30% of the measure incremental cost were used for the 80% and 40% market penetration scenarios, respectively.

Additionally, program administrative costs were lowered from 20% (60% market penetration scenario) to 15% of the total DSM budget for the high market penetration scenario. Increased penetration in natural gas efficiency programs will result in some economies of scale for program administration. Similarly, program administrative costs were increased to 25% of the total DSM budget for the low market penetration scenario.

Figure 7-3 graphically illustrates the low and high case achievable savings by year and compares it to the equivalent base case scenario savings.

**Figure 7-3: Achievable Potential Savings Results for all Market Penetration Scenarios**

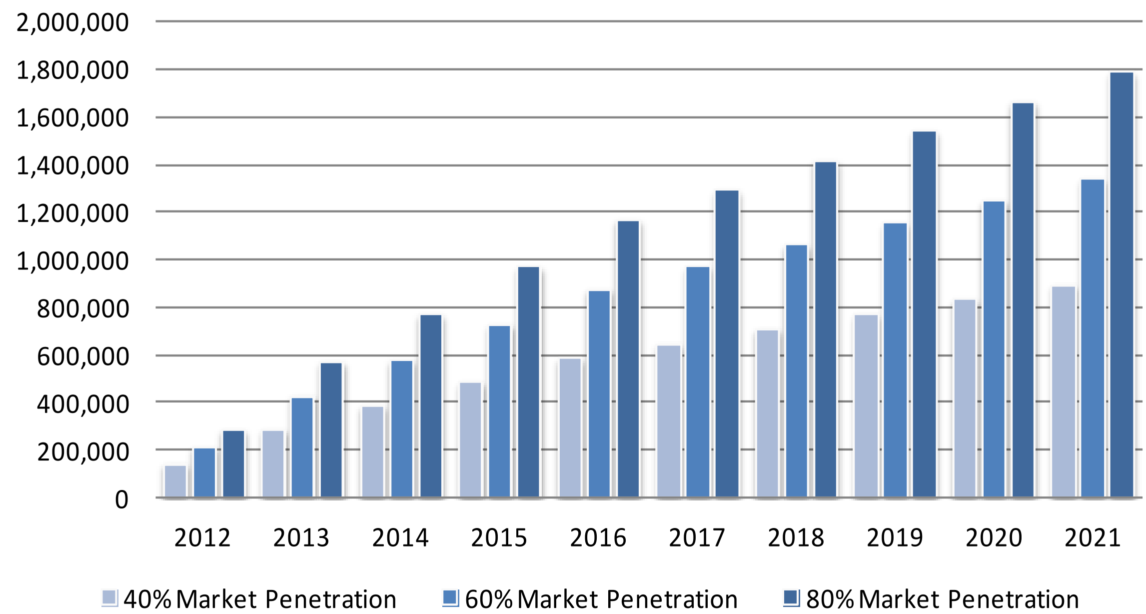



**Table 7-8: Benefit/Cost Ratios for All Market Penetration Scenarios Using the TRC Test**

| Industrial Sector Cost Effectiveness Screening Results - 3 Market Penetration Scenario | | | | | | | |
|---|---|---|---|---|---|---|---|
| Market Penetration Scenario | MMBTu Savings 2015 | % of 2015 Forecast | MMBTu Savings 2020 | % of 2020 Forecast | Present Value of Total Benefits ($2012) | Present Value of Total Costs ($2012) | Benefit/Cost Ratio |
| Low Case - 40% | 485,730 | 1.7% | 833,661 | 2.9% | $78,618,174 | $28,460,432 | 2.76 |
| Medium Case - 60% | 728,595 | 2.6% | 1,250,492 | 4.4% | $117,927,261 | $42,842,155 | 2.75 |
| High Case - 80% | 971,460 | 3.4% | 1,667,323 | 5.9% | $157,236,348 | $56,610,483 | 2.78 |

Tables 7-9 to 7-14 provide detailed annual information for the period 2012 to 2021 on the costs and savings for the 40%, 60% and 80% achievable potential scenarios.

## Table 7-9: Incremental and Cumulative Industrial Sector Annual MMBTU Achievable Savings (80% Market Penetration)

80% Market Penetration

| Incremental Annual MMBTU Savings - Achievable 80% | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| End-Use | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
| Conventional Boiler Use | 96,715 | 96,715 | 63,763 | 63,763 | 63,763 | 34,920 | 34,920 | 34,920 | 34,920 | 34,920 |
| Process Heating | 173,712 | 173,712 | 120,520 | 120,520 | 120,520 | 73,587 | 73,587 | 73,587 | 73,587 | 73,587 |
| Facility HVAC | 15,510 | 15,510 | 15,510 | 15,510 | 15,510 | 15,510 | 15,510 | 15,510 | 15,510 | 15,510 |
| **Total** | **285,936** | **285,936** | **199,793** | **199,793** | **199,793** | **124,017** | **124,017** | **124,017** | **124,017** | **124,017** |
| *% of Annual Forecast Sales* | *1.1%* | *1.0%* | *0.7%* | *0.7%* | *0.7%* | *0.4%* | *0.4%* | *0.4%* | *0.4%* | *0.4%* |
| **Cumulative Annual MMBTU Savings - Achievable 80%** | | | | | | | | | | |
| End-Use | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
| Conventional Boiler Use | 96,715 | 193,430 | 257,193 | 320,956 | 384,719 | 419,639 | 454,560 | 489,480 | 524,401 | 559,321 |
| Process Heating | 173,712 | 347,423 | 467,943 | 588,464 | 708,984 | 782,571 | 856,158 | 929,745 | 1,003,331 | 1,076,918 |
| Facility HVAC | 15,510 | 31,020 | 46,530 | 62,040 | 77,550 | 93,060 | 108,570 | 124,080 | 139,590 | 155,100 |
| **Total** | **285,936** | **571,873** | **771,666** | **971,460** | **1,171,253** | **1,295,270** | **1,419,288** | **1,543,305** | **1,667,323** | **1,791,340** |
| *% of Annual Forecast Sales* | *1.1%* | *2.1%* | *2.8%* | *3.4%* | *4.1%* | *4.6%* | *5.0%* | *5.4%* | *5.9%* | *6.3%* |

## Table 7-10: Annual Incentives and Budgets Associated with the 80% Market Penetration Achievable Scenario

| Annual Incentives by End-Use (80% Market Penetration) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| End-Use | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
| Conventional Boiler Use | $928,815 | $928,815 | $928,815 | $928,815 | $928,815 | $928,815 | $928,815 | $928,815 | $928,815 | $928,815 |
| Process Heating | $2,247,181 | $2,247,181 | $2,247,181 | $2,247,181 | $2,247,181 | $2,247,181 | $2,247,181 | $2,247,181 | $2,247,181 | $2,247,181 |
| Facility HVAC | $285,539 | $285,539 | $285,539 | $285,539 | $285,539 | $285,539 | $285,539 | $285,539 | $285,539 | $285,539 |
| **Total** | **$3,461,535** | **$3,461,535** | **$3,461,535** | **$3,461,535** | **$3,461,535** | **$3,461,535** | **$3,461,535** | **$3,461,535** | **$3,461,535** | **$3,461,535** |
| **Annual Utility Budgets(80% Market Penetration)** | | | | | | | | | | |
| Budget Category | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
| Incentive Budget | $3,461,535 | $3,461,535 | $3,461,535 | $3,461,535 | $3,461,535 | $3,461,535 | $3,461,535 | $3,461,535 | $3,461,535 | $3,461,535 |
| Program Marketing/Education | $281,250 | $288,316 | $295,598 | $303,102 | $310,839 | $318,818 | $327,048 | $335,540 | $344,305 | $353,354 |
| Program Delivery | $389,423 | $399,207 | $409,289 | $419,680 | $430,393 | $441,440 | $452,836 | $464,594 | $476,729 | $489,259 |
| Program Tracking & Reporting | $108,173 | $110,891 | $113,691 | $116,578 | $119,554 | $122,622 | $125,788 | $129,054 | $132,425 | $135,905 |
| Program Verification & Evaluation | $86,538 | $88,713 | $90,953 | $93,262 | $95,643 | $98,098 | $100,630 | $103,243 | $105,940 | $108,724 |
| **Total** | **$4,326,918** | **$4,348,661** | **$4,371,066** | **$4,394,158** | **$4,417,964** | **$4,442,513** | **$4,467,836** | **$4,493,965** | **$4,520,933** | **$4,548,776** |
| *Estimated # of FTE's* | *5.8* | *5.8* | *5.8* | *5.9* | *5.9* | *5.9* | *6.0* | *6.0* | *6.0* | *6.1* |

## Table 7-11: Incremental and Cumulative Industrial Sector Annual MMBTU Industrial Achievable Savings (60% Market Penetration)

| Incremental Annual MMBTU Savings - Achievable 60% | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| End-Use | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
| Conventional Boiler Use | 72,536 | 72,536 | 47,822 | 47,822 | 47,822 | 26,190 | 26,190 | 26,190 | 26,190 | 26,190 |
| Process Heating | 130,284 | 130,284 | 90,390 | 90,390 | 90,390 | 55,190 | 55,190 | 55,190 | 55,190 | 55,190 |
| Facility HVAC | 11,633 | 11,633 | 11,633 | 11,633 | 11,633 | 11,633 | 11,633 | 11,633 | 11,633 | 11,633 |
| **Total** | **214,452** | **214,452** | **149,845** | **149,845** | **149,845** | **93,013** | **93,013** | **93,013** | **93,013** | **93,013** |
| *% of Annual Forecast Sales* | *0.8%* | *0.8%* | *0.5%* | *0.5%* | *0.5%* | *0.3%* | *0.3%* | *0.3%* | *0.3%* | *0.3%* |

| Cumulative Annual MMBTU Savings - Achievable 60% | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| End-Use | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
| Conventional Boiler Use | 72,536 | 145,072 | 192,895 | 240,717 | 288,539 | 314,730 | 340,920 | 367,110 | 393,301 | 419,491 |
| Process Heating | 130,284 | 260,567 | 350,957 | 441,348 | 531,738 | 586,928 | 642,118 | 697,308 | 752,499 | 807,689 |
| Facility HVAC | 11,633 | 23,265 | 34,898 | 46,530 | 58,163 | 69,795 | 81,428 | 93,060 | 104,693 | 116,325 |
| **Total** | **214,452** | **428,905** | **578,750** | **728,595** | **878,440** | **971,453** | **1,064,466** | **1,157,479** | **1,250,492** | **1,343,505** |
| *% of Annual Forecast Sales* | *0.8%* | *1.6%* | *2.1%* | *2.6%* | *3.1%* | *3.4%* | *3.8%* | *4.1%* | *4.4%* | *4.7%* |

## Table 7-12: Annual Incentives and Budgets Associated with the Industrial Sector 60% Market Penetration Achievable Scenario

| Annual Incentives by End-Use (60% Market Penetration) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| End-Use | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
| Conventional Boiler Use | $557,289 | $557,289 | $557,289 | $557,289 | $557,289 | $557,289 | $557,289 | $557,289 | $557,289 | $557,289 |
| Process Heating | $1,348,308 | $1,348,308 | $1,348,308 | $1,348,308 | $1,348,308 | $1,348,308 | $1,348,308 | $1,348,308 | $1,348,308 | $1,348,308 |
| Facility HVAC | $171,323 | $171,323 | $171,323 | $171,323 | $171,323 | $171,323 | $171,323 | $171,323 | $171,323 | $171,323 |
| **Total** | **$2,076,921** | **$2,076,921** | **$2,076,921** | **$2,076,921** | **$2,076,921** | **$2,076,921** | **$2,076,921** | **$2,076,921** | **$2,076,921** | **$2,076,921** |
| **Annual Utility Budgets(60% Market Penetration)** | | | | | | | | | | |
| Budget Category | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
| Incentive Budget | $2,076,921 | $2,076,921 | $2,076,921 | $2,076,921 | $2,076,921 | $2,076,921 | $2,076,921 | $2,076,921 | $2,076,921 | $2,076,921 |
| Program Marketing/Education | $221,538 | $227,486 | $233,635 | $239,995 | $246,575 | $253,387 | $260,441 | $267,748 | $275,321 | $283,174 |
| Program Delivery | $318,461 | $327,010 | $335,850 | $344,992 | $354,452 | $364,244 | $374,383 | $384,888 | $395,774 | $407,062 |
| Program Tracking & Reporting | $83,077 | $85,307 | $87,613 | $89,998 | $92,466 | $95,020 | $97,665 | $100,405 | $103,245 | $106,190 |
| Program Verification & Evaluation | $69,231 | $71,089 | $73,011 | $74,998 | $77,055 | $79,183 | $81,388 | $83,671 | $86,038 | $88,492 |
| **Total** | **$2,769,228** | **$2,787,813** | **$2,807,029** | **$2,826,904** | **$2,847,469** | **$2,868,755** | **$2,890,798** | **$2,913,633** | **$2,937,299** | **$2,961,839** |
| *Estimated # of FTE's* | *4.6* | *4.7* | *4.7* | *4.7* | *4.8* | *4.8* | *4.8* | *4.9* | *4.9* | *5.0* |

## Table 7-13: Incremental and Cumulative Industrial Sector Annual MMBTU Achievable Savings (40% Market Penetration)

| Incremental Annual MMBTU Savings - Achievable 40% | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| End-Use | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
| Conventional Boiler Use | 48,357 | 48,357 | 31,882 | 31,882 | 31,882 | 17,460 | 17,460 | 17,460 | 17,460 | 17,460 |
| Process Heating | 86,856 | 86,856 | 60,260 | 60,260 | 60,260 | 36,793 | 36,793 | 36,793 | 36,793 | 36,793 |
| Facility HVAC | 7,755 | 7,755 | 7,755 | 7,755 | 7,755 | 7,755 | 7,755 | 7,755 | 7,755 | 7,755 |
| **Total** | **142,968** | **142,968** | **99,897** | **99,897** | **99,897** | **62,009** | **62,009** | **62,009** | **62,009** | **62,009** |
| *% of Annual Forecast Sales* | *0.5%* | *0.5%* | *0.4%* | *0.4%* | *0.4%* | *0.2%* | *0.2%* | *0.2%* | *0.2%* | *0.2%* |

| Cumulative Annual MMBTU Savings - Achievable 40% | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| End-Use | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
| Conventional Boiler Use | 48,357 | 96,715 | 128,596 | 160,478 | 192,359 | 209,820 | 227,280 | 244,740 | 262,200 | 279,661 |
| Process Heating | 86,856 | 173,712 | 233,972 | 294,232 | 354,492 | 391,285 | 428,079 | 464,872 | 501,666 | 538,459 |
| Facility HVAC | 7,755 | 15,510 | 23,265 | 31,020 | 38,775 | 46,530 | 54,285 | 62,040 | 69,795 | 77,550 |
| **Total** | **142,968** | **285,936** | **385,833** | **485,730** | **585,627** | **647,635** | **709,644** | **771,653** | **833,661** | **895,670** |
| *% of Annual Forecast Sales* | *0.5%* | *1.0%* | *1.4%* | *1.7%* | *2.1%* | *2.3%* | *2.5%* | *2.7%* | *2.9%* | *3.2%* |

## Table 7-14: Annual Incentives and Budgets Associated with the Industrial Sector 40% Market Penetration Achievable Scenario

| Annual Incentives by End-Use (40% Market Penetration) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| End-Use | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
| Conventional Boiler Use | $278,645 | $278,645 | $278,645 | $278,645 | $278,645 | $278,645 | $278,645 | $278,645 | $278,645 | $278,645 |
| Process Heating | $674,154 | $674,154 | $674,154 | $674,154 | $674,154 | $674,154 | $674,154 | $674,154 | $674,154 | $674,154 |
| Facility HVAC | $85,662 | $85,662 | $85,662 | $85,662 | $85,662 | $85,662 | $85,662 | $85,662 | $85,662 | $85,662 |
| **Total** | **$1,038,460** | **$1,038,460** | **$1,038,460** | **$1,038,460** | **$1,038,460** | **$1,038,460** | **$1,038,460** | **$1,038,460** | **$1,038,460** | **$1,038,460** |
| **Annual Utility Budgets(40% Market Penetration)** | | | | | | | | | | |
| Budget Category | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
| Incentive Budget | $1,038,460 | $1,038,460 | $1,038,460 | $1,038,460 | $1,038,460 | $1,038,460 | $1,038,460 | $1,038,460 | $1,038,460 | $1,038,460 |
| Program Marketing/Education | $140,934 | $144,995 | $149,211 | $153,589 | $158,138 | $162,867 | $167,787 | $172,907 | $178,239 | $183,796 |
| Program Delivery | $207,692 | $213,677 | $219,890 | $226,342 | $233,046 | $240,015 | $247,265 | $254,810 | $262,668 | $270,858 |
| Program Tracking & Reporting | $51,923 | $53,419 | $54,973 | $56,585 | $58,261 | $60,004 | $61,816 | $63,703 | $65,667 | $67,714 |
| Program Verification & Evaluation | $44,505 | $45,788 | $47,119 | $48,502 | $49,938 | $51,432 | $52,985 | $54,602 | $56,286 | $58,041 |
| **Total** | **$1,483,515** | **$1,496,341** | **$1,509,653** | **$1,523,479** | **$1,537,844** | **$1,552,778** | **$1,568,313** | **$1,584,482** | **$1,601,321** | **$1,618,870** |
| *Estimated # of FTE's* | *3.0* | *3.0* | *3.0* | *3.1* | *3.1* | *3.1* | *3.2* | *3.2* | *3.2* | *3.3* |

# 8.0 PROGRAM POTENTIAL

## 8.1 Purpose of this Chapter

This chapter presents program outlines of six new natural gas energy-efficiency programs for implementation in Maryland by a program administrator. These outlines present program concepts and would need to be further developed before programs are implemented. Fuel switching measures were not including in the study scope of work. These programs are based on energy-efficiency programs that have been successful in the mid-Atlantic and the northeast regions of the US. These recommended programs incorporate several features identified in recent best practices studies. These programs are cost effective according to the Total Resource Cost (TRC) Test and will provide significant natural gas savings for natural gas customers in Maryland. This chapter of the report provides information on the estimated costs, savings and participants for these recommended programs. The overall statewide budget for these recommended programs was established so that the overall additional cost per month per Maryland natural gas customer on his/her natural gas bill would be approximately $1 per month. Based on an analysis by GDS, this equates to an overall annual spending level by natural gas utilities in the State of 1.25% of retail natural gas revenues every year from 2012 to 2021. This compares to an overall annual spending level by electric utilities in the State of 1.07% of retail electric revenues in the year 2010. If we start these natural gas energy efficiency programs in 2012, the State can save 1.0% of forecast annual natural gas sales by 2015 and 2.0% of forecast annual natural gas sales by 2020.

Four residential and two commercial/industrial natural gas energy-efficiency programs are presented in this chapter:

- Residential Natural Gas Products Program
- Residential Home Retrofit Program
- Residential HVAC Efficiency Program
- Residential New Construction Program[34]
- Commercial High-Efficiency Heating Program
- Commercial Energy Efficiency Program

GDS has reviewed several best practices reports and recommends that the program administrator should have the infrastructure, resources, and expertise to implement the marketing, promotion, data tracking and reporting, and other aspects of these new natural gas energy-efficiency programs. The program administrator will need to manage program delivery and ramp up operations that entail building key stakeholder relationships and program ally networks in the State. Interactions between the above natural gas energy efficiency programs and existing EmPower Maryland electric programs were not addressed in this study. However, these potential program synergies that can benefit both electric and gas programs should be considered in the future.

The program administrator in conjunction with trade allies (equipment supply houses, HVAC contractors, plumbers, home builders) must have experience providing information to

[34] For this residential new construction program, incentives can be paid to home buyers and/or builders to build homes to a higher energy efficiency level than required by Maryland's building energy code.

consumers about efficient natural gas equipment and explaining bill-savings opportunities. To meet market conditions, a strong communication platform along with regular and persistent exposure at the local or community level will be requisite. Database management skills, customer identification expertise, understanding decision drivers, experience with end-user equipment, and market behavior must be part of the administrator's delivery infrastructure. Finally, maintaining existing and building new customer relationships will remain a key factor in the success of all residential, commercial and industrial sector energy-efficiency program efforts, particularly for high efficiency natural gas space heating equipment given the often large capital investment associated with the ultimate decision.

### 8.1.1 Program Marketing Expertise

Marketing this suite of recommended natural gas energy efficiency programs will require significant expertise and an array of marketing methods. Among them will be TV and radio advertising, a website that offers both advice on and one-stop shopping for energy-efficiency materials and resources, print advertisements, direct mail, bill inserts, cooperative advertising, articles in trade association newsletters, booths at trade shows and conferences, and personal visits to customers. The result of all these efforts will be to provide customers with multiple points of contact on natural gas energy efficiency so as to reinforce the message and encourage them to take advantage of efficiency programs.

### 8.1.2 Outreach and Education

Each program will include coordinated education and outreach program that is directed at key program allies, such as plumbers, HVAC contractors, equipment distributors and supply houses, design engineering firms, and homebuilders. These efforts can encourage program allies (e.g., contractors and plumbers) to promote, sell, and install high-efficiency natural gas equipment.

### 8.1.3 Measurement and Verification

The program administrator will need to monitor emerging natural gas energy-efficient technologies and building practices and will add such measures to programs when they are commercially available, cost effective, and well tested. The program administrator will conduct measurement and verification activities for all programs to verify that energy-efficiency measures are installed and operating properly. GDS recommends that the program administrator follow the measurement and verification protocols provided in the International Performance Measurement and Verification Protocol (IPMVP).

### 8.1.4 Program Descriptions

Residential programs are discussed first, followed by commercial and industrial programs. The assumptions for the costs, savings, and useful lives of natural gas energy-efficiency measures are provided in the appendices to this report. The projected budget, number of program participants, and natural gas savings for each program are provided at the end of this chapter.

### 8.2 Residential Programs

This section provides a description of four recommended residential natural gas energy efficiency programs.

#### 8.2.1 Residential Efficient Natural Gas Products Program

**Program Description**
This program will be available for all residential buildings in Maryland that use natural gas water-heating systems and related appliances. This program provides education and financial incentives to promote the purchase and installation of high-efficiency natural gas water-heating equipment. A key element of the program will be payment of a financial incentive to customers who purchase such equipment.

**Program Goals**
Program goals include:

- Increasing the demand for residential high-efficiency natural gas water heaters;
- Training trade allies such as plumbing and heating contractors on the benefits of high-efficiency natural gas water-heating equipment and on proper installation and service procedures;
- Increasing customer knowledge of the benefits of high-efficiency natural gas water heaters and where to obtain them; and,
- Monitoring customer perception of the performance and reliability of high-efficiency natural gas water-heating equipment and the savings achieved.

**Program Strategy**
The program is designed to address market barriers that prevent or limit the purchase and installation of high-efficiency natural gas water-heating equipment and related kitchen/laundry appliances. Such barriers include lack of consumer awareness of available equipment, lack of information on the savings such equipment can achieve, and concerns about the performance of the equipment. To be as cost effective as possible, the program will target customers seeking to purchase and install a new natural gas water-heating system.

The majority of consumers replace their water heater and appliances because of sudden failure of their existing model—a circumstance that typically does not encourage consumers to make the extra effort to find advanced technologies and evaluate lifetime cost savings. This program will aim to provide information and technical assistance to consumers that will encourage them to purchase and install high-efficiency gas water-heating equipment at the time they replace equipment or build a new home. This program does not emphasize the early-replacement market because of the greater expense involved with getting customers to replace perfectly good equipment before the end of its useful life.

**Program Marketing**
Marketing will consist of direct mail and outreach to contractors and builders, bill inserts to residential customers, attendance at trade ally training events, and promotion on the radio and utility and program administrator websites. Although direct customer marketing is expected to

generate a portion of the leads for this program, significant emphasis will be placed on meeting with heating and plumbing contractors and equipment distributors at trade shows and training sessions to encourage these key market actors to influence customer purchasing behavior toward high-efficiency natural gas water-heating equipment.

**Eligible Measures**
Table 8-1 lists the eligible energy efficiency measures for this program.

**Table 8-1: Eligible Measures for High Efficiency Water Heating Equipment Program**

| Eligible Measures for High Efficiency Water Heating Equipment Program | |
|---|---|
| **Product** | **Rating** |
| Clothes Washer (Tier 1) | MEF=2.0 |
| Clothes Washer (Tier 2) | MEF=2.2 |
| Clothes Washer (Tier 3) | MEF=2.4 |
| High Efficiency Dish Washer | Consortium for Energy Efficiency Tier 1 |
| High Efficiency Gas Storage Tank Water Heater | EF=0.67 or greater |

**Special Considerations**
On a continuing basis, new cost-effective opportunities for water-heating customers should be evaluated. The development of new standards by the U.S. Department of Energy (DOE) regarding ENERGY STAR certification for high-efficiency water-heating equipment should also be carefully monitored.[35]

**Natural Gas Savings Achieved by the Program**
The appendices to this report provide the assumptions used for the per unit costs, savings, and useful lives of the high-efficiency heating equipment included in this program. The estimates of future program costs and natural gas savings for this program are provided in Section 8.4

### 8.2.2 Residential Home Retrofit Program[36]

**Program Description**
This program will be available to all existing residential buildings in Maryland that have natural gas space-heating systems. The program will offer a financial incentive to residential customers who purchase and install insulation, weatherization and air sealing measures that reduce the amount of air leakage through the building shell. The program will offer a pre-qualified list of contractors who are eligible to provide services to residential natural gas customers for this program. The customer will be required to have a home energy audit at their expense. GDS

[35] The U.S. Department of Energy (DOE) issued a final rule amending the energy conservation standards for residential water heaters, direct heating equipment, and pool heaters on March 31, 2010. The standards established in the final rule will be applied starting April 16, 2015 for residential water heaters, and April 16, 2013 for residential direct heating equipment and pool heaters.

[36] This program may be offered to all homeowners with natural gas space-heating systems. Section 8.4 tables include a modified program offered to limited income households. The limited income retrofit program is also briefly mentioned under the special considerations of Section 8.2.2

recommends that the program should be modeled after the Home Performance with ENERGY STAR Program design.

**Program Strategy for Existing Homes**

Contractors wishing to offer this program to natural gas customers must provide evidence of (1) must be enrolled in an EPA/DOE registered Home Performance with Energy Star program (HPwES) offered by the program administrator, (2) registration as a Home Improvement Contractor in the State of Maryland and (3) insurance in amounts and coverage at the program administrator's specified levels.

The program administrator will reach out to the contractor community to increase the number of pre-qualified contractors participating. As part of the terms of being a pre-qualified HPwES contractor, the contractor will be required to be a Building Performance Institute (BPI) certified installation contractor. Pre and post blower door and ambient CO testing would be required to address health and safety concerns. BPI is a recognized global leader in setting building science-based standards.[37] BPI certification ensures that knowledge and competency are demonstrated by means of written and field testing. In this manner, the program will assist in building an infrastructure of trained and certified contractors to deliver the highest quality workmanship to customers and the public.

For quality control purposes, the first five installations of newly enlisted contractors will be subject to inspection, and samplings of all contractors' work will be inspected throughout their tenure at the program. The inspection process will consist of a visual review of all work reported to be performed at the job site. Infrared scanning and blower door testing will be selectively employed to inspect wall insulation and air-sealing work that cannot be observed with the naked eye. Infrared scanning is not only a quality tool but also raises insulation installation standards. Ongoing annual training will be offered to familiarize contractors with industry building science best practices.

It will be the responsibility of the installation contractor to complete and submit incentive applications with proper supporting documentation to verify that the work has been performed. Work completed through the program will be required to meet all applicable state and local code requirements. It is anticipated that all measures installed will meet ENERGY STAR guidelines, where applicable.

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[37] For example, all contractors who participate in the EmPOWER Maryland utility and/or MEA's residential weatherization services programs must become certified through the Building Performance Institute (BPI), a national resource for building science technology that sets the standards for assessing and improving the energy performance of homes (www.bpi.org). Participating contractors in these Maryland residential weatherization services programs must successfully complete the BPI certification process. Accreditation is highly encouraged as well. The initiative has subsidized a portion of the contractor's costs for training, certification, and accreditation through a favorable incentive structure. The initiative places a strong emphasis on building science technology, using energy analysis software, and tailoring sales and marketing techniques to the residential contracting business. In order for contractors to become BPI certified/accredited, they need to demonstrate the ability to use advanced diagnostic testing equipment when assessing a home.

**Program Marketing**

The program will be marketed to residential heating customers through contractor allies (home builders, renovation contractors, plumbers, HVAC contractors, equipment suppliers, etc.), home shows, direct mail promotions, and bill inserts. It will also be marketed through an electronic newsletter and the program administrator's website. The program administrator will explore offering audio and video links on the website that describe the program, educate the public about the value of weatherization, and describe the process and products available.

**Eligible Measures**

Table 8-2 lists the eligible measures for the existing home component of this program. This program will provide an incentive to program participants from a range of 35 to 50 percent of the cost of installed weatherization measures in residential heating customers' homes. A maximum incentive will need to be determined. Measures eligible for an incentive will include attic and attic stair insulation, wall insulation, floor insulation, basement and crawl space insulation, rim joist insulation, duct insulation, heating-system pipe insulation, attic ventilation (only in conjunction with attic insulation), ductwork leakage testing and sealing, air-infiltration testing and sealing, and Energy Star windows. To be eligible for an incentive, a pre-qualified HPwES contractor must install the program measures; do-it-yourself work will not be eligible.

**Table 8-2: Residential Building Envelope Program – Eligible Measures**

| Residential Building Envelope Program – Eligible Measures | |
|---|---|
| **Product** | **Rating** |
| Air sealing | 7ACH@50 Pascal or less |
| Duct sealing | Leakage less than 6% of Floor Area |
| Attic Insulation | R38 or greater |
| HVAC Tune-Up | 5%-10% operational efficiency improvement |
| High Efficiency Furnace (Tier 1) | 92% AFUE |
| High Efficiency Furnace (Tier 2) | 94% AFUE |
| Water Heater Pipe Wrap | R-3.5 |
| Low Flow Showerhead | <2 gallon/minute |
| Low Flow Faucet Aerator | <1.5 gallon/minute |
| In-Home Inspection | n/a |

**Special Considerations**

In addition, program administrator may also consider offering 100% incentives to targeted limited income households with natural gas space heating. In addition to the improvements listed above, a limited income retrofit program may also offer efficient clothes washer and furnace replacements to homes with equipment that cannot be serviced through general maintenance.

**Natural Gas Savings Achieved by Program**

The appendices to this report provide the assumptions used for the per unit costs, savings, and useful lives of the high-efficiency heating equipment included in this program. The estimates of future program costs and natural gas savings for this program are provided in Section 8.4

### 8.2.3 Residential HVAC Program

**Program Description**

This program will be available for all residential buildings in Maryland that use natural gas space heating. This program will provide information and financial incentives to promote the purchase and installation of high-efficiency natural gas heating equipment. A key element of the program will be payment of a financial incentive to customers who purchase high-efficiency natural gas space-heating equipment (e.g., high-efficiency furnaces) or would like to improve their existing equipment's general efficiency. According to the 2011 Maryland baseline study, 42.5% of households in Maryland use natural gas for space heating.

**Program Goals**

Program goals include:

- Increasing customer knowledge of the performance and reliability of high-efficiency gas heating equipment and the energy savings they can achieve;
- Increasing market sector awareness of high-efficiency natural gas heating equipment;
- Increasing customer knowledge of where to obtain high-efficiency natural gas heating equipment;
- Monitoring customer perception of the performance and reliability of high-efficiency gas heating equipment and the savings achieved; and
- Training program allies such as plumbing and heating contractors on the benefits of high-efficiency natural gas heating equipment and on proper installation and service procedures.

**Program Strategy**

The program is designed to address market barriers that prevent or limit the purchase, installation, or maintenance of high-efficiency natural gas heating equipment. Such barriers include lack of consumer awareness of available equipment, lack of information on the savings such equipment can achieve, and concerns about the performance of the equipment. To be as cost effective as possible, the program will target customers seeking to install a new natural gas heating system when they are replacing equipment or building a new home; the market will thus include both existing homes and new construction. The program will not emphasize the early-replacement market because of the greater expense involved in getting customers to replace perfectly good equipment before the end of its useful life.

**Program Marketing**

The program will be marketed in a variety of ways, including, but not limited to, direct mail campaigns, bill inserts, brochures, program ally events, sponsorships and contractor job-site visits, and the utility website.

A strong emphasis will be placed on working with home builders and contractors (HVAC contractors and plumbers) who install and service natural gas heating equipment. The existing home market is seen as the primary user of high-efficiency forced hot water and steam heating systems, whereas the new construction market is seen as the primary user of high-efficiency furnaces. Information collected from field services contractors suggests that installation contractors and/or distributors can influence customers to purchase high-efficiency products versus standard-efficiency products. An incentive program to motivate suppliers to sell and customers to purchase high-efficiency natural gas heating products should be evaluated. The purpose of the incentive will be to promote energy efficiency as an investment to customers.

**Eligible Measures**

Residential heating customers (builders and/or homeowners) will be encouraged to purchase or tune-up high-efficiency natural gas space-heating equipment by offsetting a portion of the incremental cost of the unit (this is the difference in the purchase and installation cost of a high-efficiency unit as compared with a standard-efficiency model) or maintenance cost. Financial incentives will be available up to $400, depending on the type and efficiency of equipment installed. Table 8-3 shows a proposed list of eligible equipment for this program. Note that data on the incremental costs of high-efficiency natural gas space heating equipment is provided in the appendices to this report.

**Table 8-3: Residential HVAC Program Eligible Measures**

| Residential HVAC Program Eligible Measures | |
|---|---|
| **Efficiency Measure** | **Rating** |
| Furnaces (Tier 1) | AFUE 90% (CEE Tier 1) |
| Furnaces (Tier 2) | AFUE >92% or greater |
| HVAC Tune-Up | 5%-10% operational efficiency improvement |
| Duct sealing | Leakage less than 6% of Floor Area |
| Note: AFUE = annual fuel utilization efficiency | |

It is anticipated that given changes in the marketplace and cost effectiveness of the equipment, it will be necessary to review and change incentive levels during program years one and two. Natural gas utilities in New England, for example, which have operated energy-efficiency programs for over a decade, reduced financial incentives as market penetration of high-efficiency equipment began to increase rapidly as a result of marketing strategies. The same level of market penetration could be expected in Maryland as natural gas energy efficiency programs evolve.

**Natural Gas Savings Achieved by the Program**

The appendices to this report provide the assumptions used for the per unit costs, savings, and useful lives of the high-efficiency heating equipment included in this program. The estimates of future program costs and natural gas savings for this program are provided in Section 8.4

### 8.2.4 Residential New Construction Program

**Program Description**

This program is designed to encourage builders and consumers to build high-efficiency homes. This program will support energy-efficient new home construction through the existing Maryland ENERGY STAR Labeled Homes program. This statewide program combines the strength of multiple organizations to encourage builders to construct their homes to a higher level of energy efficiency than standard codes require. ENERGY STAR homes are nationally recognized for lower operating costs and energy consumption; increased durability, comfort, and safety; and higher resale value. ENERGY STAR homes feature the best in efficient building practices and technologies, including increased insulation levels, high-efficiency heating and air-conditioning equipment, superior duct systems, and high-performance windows. All segments of the housing market are eligible to participate in this program, including new and existing residential single-family and multifamily units, townhouses, and condominium developments.

**Program Strategy for New Homes**

The program administrator will build off the nationally recognized ENERGY STAR band and will be responsible for reviewing and certifying each participating home in to ensure it meets the ENERGY STAR Labeled Homes strict criteria. Review and certification are critical, as national certification requirements for air sealing and leakage were recently strengthened.

In order to earn an ENERGY STAR Labeled Homes certificate, each house, or sampling of model units within a larger development, will be performance tested on completion to verify the quality of installed energy features. This will involve conducting a blower-door test to measure the building's overall air leakage and a ventilation test to verify airflow rates.

The program administrator will need to hire staff or contractors to perform several tasks. Builders who participate in the program will be guided by program staff through the efficient building process and through inspection and final testing, including verification of energy-efficiency installation techniques and the final ENERGY STAR rating test. Over the longer term, program staff will work with program allies to open the Maryland market of ENERGY STAR raters to all interested and qualified rating contractors.

Participants will have their building plans evaluated with a building energy simulation model (such as REM/rate), inspections during construction, and ongoing builder consultation performed by the builder's choice of home energy raters. This model, which has been successful in other states, allows greater market demand for building energy-service providers, and explains the market to those businesses throughout the state. As the program evolves, incentives will still be awarded to builders, but program staff will oversee and train the home energy raters who provide the building and testing services, and then these raters will take over the testing and inspection services.

The program administrator will pay a portion of the costs of providing technical support and certification testing services, from program sign-up through certification testing for each qualifying home. Efforts should be made to leverage resources from the existing EmPOWER Maryland New Construction Program.

**Program Marketing**

Marketing will consist primarily of direct outreach to builders, developers, and home inspectors throughout Maryland's most active building regions. A toll-free telephone number and website should provide additional resources. In addition, the program administrator may sponsor ENERGY STAR training sessions specifically for builders and homebuyers throughout the year to encourage new participants and to enhance the efficient building expertise of existing participants.

**Eligible Measures**

The Residential ENERGY STAR Homes Program offers incentives geared specifically to home buyers and builders, as shown in Table 8-4.

**Table 8-4: Residential New Construction Program – Eligible Measures**

| Residential Building Envelope Program – Eligible Measures | |
|---|---|
| **Product** | **Rating** |
| Single Family Construction | Must meet Energy Star rating criteria |
| Multi-Unit Construction | Must meet Energy Star rating criteria |

**Special Considerations**

Participation in this program could be affected by certain barriers, including downturns in the Maryland new-housing market and ENERGY STAR's new, stricter performance requirements.

**Natural Gas Savings Achieved by Program**

The appendices to this report provide the assumptions used for the per unit costs, savings, and useful lives of the high-efficiency heating equipment included in this program. The estimates of future program costs and natural gas savings for this program are provided in Section 8.4

## 8.3 Commercial Programs

### 8.3.1 Commercial High-Efficiency Heating Equipment Program

**Program Description**

This program will be available to all commercial, industrial, governmental, institutional, non-profit, and multifamily facilities in Maryland that use natural gas space and water heating equipment. The eligible equipment in this program includes a range of innovative technologies in space and water heating systems that are applicable across Maryland's diverse commercial customer and industrial customer base. A key element of this program will be the payment of a financial incentive to customers who purchase high-efficiency natural gas space and water heating equipment and to trade allies who promote this equipment. The prescriptive and customer incentives that will be offered are set to reduce the incremental cost between the standard options and high-efficiency equipment in each product category and size range.

**Program Goals**

This program is designed to overcome supply- and demand-side market barriers to the purchase and installation of high-efficiency space and water heating equipment. Such barriers include lack of awareness on the part of businesses of available equipment, lack of information on the savings such equipment can achieve, and concerns about the reliability and performance of the equipment. Another barrier is that commercial contractors often bid the lowest-cost equipment in order to win contracts in competitive bids for new projects.

**Program Strategy**

In the small commercial business segment and the smaller multifamily segment, the application of space- and water-heating technology is similar to that used in the residential sector. Efficiency ratings for smaller heating equipment (up to 300,000 btu input) are measured using AFUE ratings. Those for larger heating equipment, which exceeds the size range for AFUE, are measured using a thermal efficiency or steady-state rating.

Since many of the trade allies serving the residential market also serve the smaller multifamily and commercial markets, this program will often be promoted together with the Residential HVAC Program. Trade ally training activities should be leveraged with the residential activities. Trade ally training in the larger equipment markets should be conducted through product training workshops, participating in industry working groups and trade associations, outreach to engineering firms, advertisements in trade publications, trade shows and seminars, and field calls and site visits.

**Program Marketing**

This program should be promoted primarily to engineers, equipment vendors, contractors, and other trade allies. New approaches to expand the market and to verify target audiences within each market segment should be evaluated through a review of the market for natural gas space and water heating equipment, including market size and penetration, as well as customer buying processes. In addition, market barriers and new market developments will be evaluated to ascertain the effectiveness of marketing campaigns and the inclusion of new alternatives in energy-efficiency equipment. These evaluations will play an integral part in directing efforts and targeting audiences over the course of the program.

**Eligible Measures**

The eligible measures for this program will include a variety of product types and a broad range of equipment sizes that are appropriate for the commercial market segments (see Table 8-5 below). This range will provide equal opportunity for participation among small and large commercial and industrial natural gas customers in Maryland. Eligible measures will include natural gas–fired, low-intensity infrared heaters, high-efficiency condensing unit heaters, and direct-fired make-up air systems that are appropriate for the larger commercial and industrial segments. Boiler incentives are available in a two-tiered matrix: Tier 1 for high-efficiency non-condensing boilers and Tier 2 for high-efficiency fully condensing boilers. Additionally, other heat saving measures such as pool heating, energy efficient clothes washing and low-flow water saving devices are also available.

The program administrator will have the right to negotiate lower incentive amounts per unit for multiple installations at a single site. In large multifamily complexes and facilities, customers and/or contractors making bulk equipment purchases will have a lower incremental cost per unit. Negotiating custom incentives for such large projects will help to keep the program within budget and maintain cost effectiveness. Financial incentives should be set to help participants reduce the true incremental costs of high efficiency equipment, considering the bulk purchase cost of installing multiple pieces of high-efficiency heating equipment.

**Table 8-5: Examples of Eligible Measures for the Commercial/Industrial High Efficiency Space and Water Heating Equipment Program**

| Examples of Eligible Measures for the C/I High Efficiency Space and Water Heating Equipment Program | |
|---|---|
| **Product** | **Rating** |
| High Efficiency Furnace (<=300,000 Btu/h) | > 92% AFUE |
| Infrared heaters (all sizes) | Low intensity |
| High Efficiency Steam Boiler (<=300,000 Btu/h) | > 82% AFUE |
| High Efficiency Hot Water Boiler (<=300,000 Btu/h) | AFUE =85%-90% |
| High Efficiency Hot Water Boiler (>300,000 Btu/h) | AFUE =85%-90% |
| Condensing Boiler (>300,000 Btu/h) | Th.eff.=>90% |
| High Efficiency Stand Alone Commercial Water Heater (<=75000 Btu) | > 67% Thermal Efficiency |
| Condensing Stand Alone Commercial Water Heater(>75000 btu) | > 96% Thermal Efficiency |
| Indirect fired water heaters | CAE >= 85% |
| On-Demand Tankless Water Heaters | EF of 0.82 or higher |

**Natural Gas Savings Achieved by Program**
The appendices to this report provide the assumptions used for the per unit costs, savings, and useful lives of the energy efficiency measures included in this program. The estimates of future program costs and natural gas savings for this program are provided in Section 8.4

### 8.3.2 Commercial Energy-Efficiency Program

**Program Description**
This program will offer both prescriptive and custom incentives for the purchase of other high-efficiency natural gas equipment. Virtually any energy-efficient technology or system design that is cost effective according to the TRC test and is not covered by another program offering may be eligible for an incentive under this program. This program is open to all gas sales customers on any of Maryland's gas utility commercial or industrial tariffs.

Footnote – GDS recommends if there is a measure that is not cost effective via the TRC but is combined with others that overall would be cost effective, that this measure be allow in the program.

**Program Strategy**

Customers may apply for program services or incentives via a variety of channels, including contacting the program administrator's representatives, plumbing and heating contractors, engineering firms, energy-service companies, and equipment vendors. After reviewing the customers' energy-efficiency needs, this program will offer them appropriate services. Customers will then be able to take advantage of a suite of either prescriptive or custom incentives. Incentives provided through this program must be pre-approved by program administrator program staff before delivery and installation of product(s) and/or service(s).

**Eligible Measures for Prescriptive Component**

Eligible prescriptive energy-efficiency measures include programmable thermostats, boiler reset controls, steam trap replacements, pipe and duct insulation, building shell (wall, roof, floor, and crawlspace) insulation, and high-efficiency windows. Prescriptive incentives will be targeted primarily toward the small and medium-sized commercial and industrial (C&I) customers. The program administrator will rely primarily on contractors and engineers to locate qualified facilities and to install eligible prescriptive measures. This effort will be supported by an extensive outreach and education effort to contractors and engineers, as well as promotions directed at customers themselves. Energy audits and pre-approval may be required for installation of some measures, such as insulation and windows where saving potential can vary significantly by customer site. The program administrator will reserve the right to negotiate incentives for multiple installations at a single site and/or multiple installations within a portfolio of properties.

The program will provide standardized incentives for a suite of measures, including building-shell insulation, pipe duct insulation, windows, and air-sealing measures. Table 8-6 lists examples of the measures eligible for prescriptive incentives that will be offered by this program. A more detailed list of the range of measures eligible for this program is included in the appendices of this report. The program administrator will continually investigate new technologies, including building-automation and energy-management systems.

**Table 8-6: Examples of Eligible Measures for the Commercial Energy Efficiency Program**

| Examples of Eligible Measures for the Commercial Energy Efficiency Program |
|---|
| **Eligible Prescriptive Measures** |
| Programmable thermostat |
| Digital boiler reset control |
| Steam trap replacement |
| Pipe or duct insulation; duct sealing |
| Building shell insulation (roof, floor, wall) |
| Premium-efficiency windows (U-Value: 0.35 or lower) |
| Air sealing |
| ENERGY STAR gas fryers and other cooking equipment |

**Custom Incentives**

Eligible custom measures will be available for commercial and industrial projects that are cost-effective according to the TRC test and demonstrate more efficient use of natural gas than typical industry practices or greater efficiency than the minimum building code requirements. Incentives will be limited to 50 percent of the eligible installed project costs, with a cap of $100,000 per site and/or project for existing buildings and $250,000 for new construction.

Custom incentives will be classified as either Tier 1 or 2. Tier 1 projects will involve less complex technologies and/or highly cost effective technologies and will receive incentives based on $1.00 per first year therm saved. Examples include redesigned HVAC systems, energy-recovery applications, building-automation and energy-management systems, and advanced technology burners and/or burner controls. Tier 2 projects will be more complex and representative of underused technologies and will receive incentives based on $2.00 per first year therm saved. Few applications are expected to reach this threshold. Incentives cannot be applied to normal maintenance costs or to disabling or abandoning equipment without an energy-efficiency replacement.

**Natural Gas Savings Achieved by Program**

The appendices to this report provide the assumptions used for the per unit costs, savings, and useful lives of the energy efficiency measures included in this program. The estimates of future program costs and natural gas savings for this program are provided in Section 8.4

## 8.4 Projected Program Budgets, Participants, and Natural Gas Savings

Detailed estimates of program budgets, participants and natural gas savings were developed for each of the six recommended programs. The overall statewide budget was established so that the overall additional cost per month per Maryland natural gas customer on his/her natural gas bill would be approximately $1 per month. Based on an analysis by GDS, this equates to an overall spending level by natural gas utilities in the State of 1.25% of retail natural gas revenues. The annual budget was allocated 50% to the residential sector and 50% to the commercial and industrial sectors. Detailed tables for each recommended program are provided below and show projections for program budgets, program participants, and program natural gas savings. The specific six programs recommended by GDS in this report will save a significant amount of natural gas and serve thousands program participants annually.

Table 8-7 below provides recommended annual budgets at a state-wide level for the four residential energy efficiency programs. Table 8-8 provides recommended annual budgets at a state-wide level for the two commercial/industrial energy efficiency programs.

## Table 8-7: Estimated Annual Budgets, Program Participants and Natural Gas Savings (MMBTu) for Four Residential Programs

| Residential Efficient Natural Gas Products | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|
| Incremental Annual Measures | 9,917 | 10,257 | 10,593 | 10,941 | 11,250 | 11,570 | 11,889 | 12,227 | 12,547 | 12,866 |
| Cumulative Annual Measures | 9,917 | 20,174 | 30,767 | 41,708 | 52,958 | 64,528 | 76,417 | 88,644 | 101,191 | 114,057 |
| | | | | | | | | | | |
| Incremental Annual MMBTu Savings | 8,482 | 8,773 | 9,060 | 9,358 | 9,622 | 9,896 | 10,168 | 10,457 | 10,731 | 11,004 |
| *% of Annual Residential Sales* | *0.01%* | *0.01%* | *0.01%* | *0.01%* | *0.01%* | *0.01%* | *0.01%* | *0.01%* | *0.01%* | *0.01%* |
| Cumulative Annual MMBTu Savings | 8,482 | 17,255 | 26,315 | 35,673 | 45,294 | 55,190 | 65,358 | 75,816 | 86,547 | 97,551 |
| *% of Annual Residential Peak Demand* | *0.01%* | *0.02%* | *0.03%* | *0.04%* | *0.05%* | *0.06%* | *0.08%* | *0.09%* | *0.10%* | *0.11%* |
| | | | | | | | | | | |
| Incentives | $711,200 | $735,590 | $759,660 | $784,640 | $806,750 | $829,770 | $852,590 | $876,860 | $899,780 | $922,700 |
| Administrative Costs | $304,800 | $315,253 | $325,569 | $336,274 | $345,750 | $355,616 | $365,396 | $375,797 | $385,620 | $395,443 |
| ***Total Utility Costs*** | ***$1,016,000*** | ***$1,050,843*** | ***$1,085,229*** | ***$1,120,914*** | ***$1,152,500*** | ***$1,185,386*** | ***$1,217,986*** | ***$1,252,657*** | ***$1,285,400*** | ***$1,318,143*** |

| Residential Retrofit (Standard) | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|
| Incremental Annual Measures | 12,459 | 12,887 | 13,309 | 13,745 | 14,135 | 14,536 | 14,934 | 15,356 | 15,761 | 16,163 |
| Cumulative Annual Measures | 12,459 | 23,216 | 34,322 | 45,792 | 57,578 | 67,994 | 76,978 | 86,199 | 95,635 | 105,291 |
| | | | | | | | | | | |
| Incremental Annual MMBTu Savings | 32,515 | 33,648 | 34,743 | 35,874 | 36,898 | 37,945 | 38,988 | 40,083 | 41,152 | 42,199 |
| *% of Annual Residential Sales* | *0.04%* | *0.04%* | *0.04%* | *0.04%* | *0.04%* | *0.04%* | *0.05%* | *0.05%* | *0.05%* | *0.05%* |
| Cumulative Annual MMBTu Savings | 32,515 | 66,162 | 100,905 | 136,779 | 173,677 | 211,400 | 244,825 | 279,156 | 314,367 | 350,430 |
| *% of Annual Residential Peak Demand* | *0.04%* | *0.08%* | *0.12%* | *0.16%* | *0.20%* | *0.25%* | *0.28%* | *0.32%* | *0.36%* | *0.41%* |
| | | | | | | | | | | |
| Incentives | $1,566,992 | $1,621,676 | $1,674,285 | $1,728,740 | $1,777,959 | $1,828,449 | $1,879,016 | $1,931,625 | $1,983,140 | $2,033,780 |
| Administrative Costs | $671,568 | $695,004 | $717,551 | $740,889 | $761,982 | $783,621 | $805,293 | $827,839 | $849,917 | $871,620 |
| ***Total Utility Costs*** | ***$2,238,560*** | ***$2,316,680*** | ***$2,391,836*** | ***$2,469,629*** | ***$2,539,941*** | ***$2,612,070*** | ***$2,684,309*** | ***$2,759,464*** | ***$2,833,057*** | ***$2,905,400*** |

| Limited Income Retrofit Program | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|
| Incremental Annual Measures | 2,528 | 2,616 | 2,700 | 2,791 | 2,870 | 2,949 | 3,031 | 3,116 | 3,198 | 3,280 |
| Cumulative Annual Measures | 2,528 | 5,144 | 7,844 | 10,635 | 13,505 | 15,942 | 18,059 | 20,231 | 22,454 | 24,729 |
| | | | | | | | | | | |
| Incremental Annual MMBTu Savings | 5,481 | 5,671 | 5,852 | 6,055 | 6,226 | 6,397 | 6,570 | 6,755 | 6,927 | 7,118 |
| *% of Annual Residential Sales* | *0.01%* | *0.01%* | *0.01%* | *0.01%* | *0.01%* | *0.01%* | *0.01%* | *0.01%* | *0.01%* | *0.01%* |
| Cumulative Annual MMBTu Savings | 5,481 | 11,152 | 17,004 | 23,059 | 29,285 | 35,616 | 40,915 | 46,356 | 51,927 | 57,642 |
| *% of Annual Residential Peak Demand* | *0.01%* | *0.01%* | *0.02%* | *0.03%* | *0.03%* | *0.04%* | *0.05%* | *0.05%* | *0.06%* | *0.07%* |
| | | | | | | | | | | |
| Incentives | $659,384 | $681,204 | $702,354 | $726,756 | $747,361 | $767,967 | $788,606 | $809,853 | $830,492 | $859,181 |
| Administrative Costs | $282,593 | $291,945 | $301,009 | $311,467 | $320,298 | $329,129 | $337,974 | $347,080 | $355,925 | $368,220 |
| ***Total Utility Costs*** | ***$941,978*** | ***$973,149*** | ***$1,003,363*** | ***$1,038,222*** | ***$1,067,659*** | ***$1,097,096*** | ***$1,126,580*** | ***$1,156,933*** | ***$1,186,417*** | ***$1,227,401*** |

| Residential HVAC Efficiency Program | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|
| Incremental Annual Measures | 5,089 | 5,263 | 5,436 | 5,615 | 5,773 | 5,936 | 6,101 | 6,274 | 6,438 | 6,601 |
| Cumulative Annual Measures | 5,089 | 10,352 | 15,788 | 21,403 | 27,176 | 33,112 | 37,177 | 41,346 | 45,610 | 49,965 |
| | | | | | | | | | | |
| Incremental Annual MMBTu Savings | 27,762 | 28,713 | 29,658 | 30,634 | 31,495 | 32,382 | 33,287 | 34,232 | 35,124 | 36,011 |
| *% of Annual Residential Sales* | *0.03%* | *0.03%* | *0.03%* | *0.04%* | *0.04%* | *0.04%* | *0.04%* | *0.04%* | *0.04%* | *0.04%* |
| Cumulative Annual MMBTu Savings | 27,762 | 56,475 | 86,133 | 116,767 | 148,262 | 180,644 | 207,558 | 235,202 | 263,521 | 292,502 |
| *% of Annual Residential Peak Demand* | *0.03%* | *0.07%* | *0.10%* | *0.14%* | *0.17%* | *0.21%* | *0.24%* | *0.27%* | *0.31%* | *0.34%* |
| | | | | | | | | | | |
| Incentives | $1,085,550 | $1,122,775 | $1,159,750 | $1,197,900 | $1,231,575 | $1,266,175 | $1,301,650 | $1,338,625 | $1,373,475 | $1,408,075 |
| Administrative Costs | $465,236 | $481,189 | $497,036 | $513,386 | $527,818 | $542,646 | $557,850 | $573,696 | $588,632 | $603,461 |
| ***Total Utility Costs*** | ***$1,550,786*** | ***$1,603,964*** | ***$1,656,786*** | ***$1,711,286*** | ***$1,759,393*** | ***$1,808,821*** | ***$1,859,500*** | ***$1,912,321*** | ***$1,962,107*** | ***$2,011,536*** |

| Efficient New Construction | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|
| Incremental Annual Measures | 869 | 899 | 929 | 959 | 986 | 1,014 | 1,042 | 1,071 | 1,100 | 1,128 |
| Cumulative Annual Measures | 869 | 1,768 | 2,697 | 3,656 | 4,642 | 5,656 | 6,698 | 7,769 | 8,869 | 9,997 |
| | | | | | | | | | | |
| Incremental Annual MMBTu Savings | 11,080 | 11,462 | 11,845 | 12,227 | 12,575 | 12,929 | 13,291 | 13,659 | 14,027 | 14,381 |
| *% of Annual Residential Sales* | *0.01%* | *0.01%* | *0.01%* | *0.01%* | *0.01%* | *0.02%* | *0.02%* | *0.02%* | *0.02%* | *0.02%* |
| Cumulative Annual MMBTu Savings | 11,080 | 22,542 | 34,387 | 46,614 | 59,189 | 72,118 | 85,409 | 99,068 | 113,096 | 127,476 |
| *% of Annual Residential Peak Demand* | *0.01%* | *0.03%* | *0.04%* | *0.05%* | *0.07%* | *0.08%* | *0.10%* | *0.11%* | *0.13%* | *0.15%* |
| | | | | | | | | | | |
| Incentives | $921,000 | $952,800 | $984,600 | $1,016,400 | $1,045,300 | $1,074,700 | $1,104,800 | $1,135,400 | $1,166,000 | $1,195,400 |
| Administrative Costs | $614,000 | $635,200 | $656,400 | $677,600 | $696,867 | $716,467 | $736,533 | $756,933 | $777,333 | $796,933 |
| ***Total Utility Costs*** | ***$1,535,000*** | ***$1,588,000*** | ***$1,641,000*** | ***$1,694,000*** | ***$1,742,167*** | ***$1,791,167*** | ***$1,841,333*** | ***$1,892,333*** | ***$1,943,333*** | ***$1,992,333*** |

| ALL PROGRAMS COMBINED | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|
| Cumulative Annual MMBTu Savings | 85,319 | 173,586 | 264,744 | 358,892 | 455,708 | 554,968 | 644,066 | 735,598 | 829,458 | 925,602 |
| *% of Annual Residential Peak Demand* | *0.10%* | *0.20%* | *0.31%* | *0.42%* | *0.53%* | *0.64%* | *0.75%* | *0.85%* | *0.96%* | *1.07%* |
| | | | | | | | | | | |
| Incentives | $4,944,126 | $5,114,045 | $5,280,649 | $5,454,436 | $5,608,945 | $5,767,061 | $5,926,662 | $6,092,363 | $6,252,887 | $6,419,136 |
| Administrative Costs | $2,338,197 | $2,418,591 | $2,497,564 | $2,579,615 | $2,652,715 | $2,727,479 | $2,803,046 | $2,881,346 | $2,957,428 | $3,035,677 |
| ***Total Utility Costs*** | ***$7,282,323*** | ***$7,532,636*** | ***$7,778,213*** | ***$8,034,051*** | ***$8,261,660*** | ***$8,494,540*** | ***$8,729,707*** | ***$8,973,709*** | ***$9,210,314*** | ***$9,454,813*** |

## Table 8-8: Estimated Annual Budgets, Program Participants and Natural Gas Savings (MMBTu) for Two Commercial/Industrial Programs

| High Efficiency Heating | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|
| Incremental Annual Measures | 3,417 | 3,535 | 3,650 | 3,770 | 3,877 | 3,987 | 4,097 | 4,213 | 4,323 | 4,433 |
| Cumulative Annual Measures | 3,417 | 6,952 | 10,602 | 14,373 | 18,250 | 22,236 | 26,333 | 30,546 | 34,869 | 39,303 |
| | | | | | | | | | | |
| Incremental Annual MMBTu Savings | 115,810 | 119,778 | 123,704 | 127,763 | 131,380 | 134,652 | 132,179 | 135,888 | 139,411 | 142,901 |
| Cumulative Annual MMBTu Savings | 115,810 | 235,588 | 359,292 | 487,055 | 618,435 | 753,087 | 885,266 | 1,021,154 | 1,160,565 | 1,303,465 |
| *% of Annual C&I Sales* | *0.16%* | *0.31%* | *0.47%* | *0.63%* | *0.79%* | *0.95%* | *1.11%* | *1.26%* | *1.43%* | *1.59%* |
| | | | | | | | | | | |
| Incentives | $1,381,011 | $1,428,327 | $1,475,150 | $1,523,549 | $1,566,678 | $1,611,087 | $1,655,500 | $1,702,434 | $1,747,132 | $1,791,498 |
| Administrative Costs | $591,862 | $612,140 | $632,207 | $652,949 | $671,433 | $690,466 | $709,500 | $729,615 | $748,771 | $767,785 |
| ***Total Utility Costs*** | ***$1,972,873*** | ***$2,040,467*** | ***$2,107,357*** | ***$2,176,498*** | ***$2,238,111*** | ***$2,301,553*** | ***$2,364,999*** | ***$2,432,048*** | ***$2,495,904*** | ***$2,559,283*** |

| Commercial Energy Efficiency | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|
| Incremental Annual Measures | 5,302 | 5,484 | 5,664 | 5,850 | 6,015 | 6,186 | 6,356 | 6,537 | 6,708 | 6,878 |
| Cumulative Annual Measures | 5,302 | 10,786 | 16,450 | 22,300 | 28,315 | 34,501 | 40,857 | 47,394 | 54,102 | 60,981 |
| | | | | | | | | | | |
| Incremental Annual MMBTu Savings | 230,658 | 238,561 | 209,364 | 216,180 | 222,128 | 199,193 | 204,459 | 210,122 | 215,379 | 220,624 |
| Cumulative Annual MMBTu Savings | 230,658 | 469,220 | 678,584 | 894,763 | 1,116,891 | 1,316,084 | 1,520,543 | 1,730,665 | 1,946,045 | 2,166,669 |
| *% of Annual C&I Sales* | *0.27%* | *0.54%* | *0.79%* | *1.04%* | *1.30%* | *1.53%* | *1.76%* | *2.01%* | *2.26%* | *2.51%* |
| | | | | | | | | | | |
| Incentives | $3,717,736 | $3,845,112 | $3,971,161 | $4,101,453 | $4,217,558 | $4,337,110 | $4,456,670 | $4,583,019 | $4,703,349 | $4,822,782 |
| Administrative Costs | $1,593,315 | $1,647,905 | $1,701,926 | $1,757,766 | $1,807,525 | $1,858,762 | $1,910,001 | $1,964,151 | $2,015,721 | $2,066,907 |
| ***Total Utility Costs*** | ***$5,311,051*** | ***$5,493,017*** | ***$5,673,087*** | ***$5,859,218*** | ***$6,025,082*** | ***$6,195,872*** | ***$6,366,671*** | ***$6,547,170*** | ***$6,719,070*** | ***$6,889,689*** |

| ALL PROGRAMS COMBINED | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|
| Cumulative Annual MMBTu Savings | 346,468 | 704,808 | 1,037,876 | 1,381,819 | 1,735,326 | 2,069,171 | 2,405,809 | 2,751,819 | 3,106,610 | 3,470,134 |
| *% of Annual C&I Sales* | *0.40%* | *0.82%* | *1.20%* | *1.60%* | *2.01%* | *2.40%* | *2.79%* | *3.19%* | *3.61%* | *4.03%* |
| | | | | | | | | | | |
| Incentives | $5,098,747 | $5,273,439 | $5,446,311 | $5,625,002 | $5,784,235 | $5,948,198 | $6,112,169 | $6,285,453 | $6,450,481 | $6,614,280 |
| Administrative Costs | $2,185,177 | $2,260,045 | $2,334,133 | $2,410,715 | $2,478,958 | $2,549,228 | $2,619,501 | $2,693,765 | $2,764,492 | $2,834,691 |
| ***Total Utility Costs*** | ***$7,283,924*** | ***$7,533,485*** | ***$7,780,444*** | ***$8,035,717*** | ***$8,263,194*** | ***$8,497,425*** | ***$8,731,670*** | ***$8,979,218*** | ***$9,214,974*** | ***$9,448,971*** |