ENERGY EFFICIENCY:
THE FIRST FUEL FOR A CLEAN ENERGY FUTURE

RESOURCES FOR MEETING MARYLAND'S ELECTRICITY NEEDS

February 2008

Report Number E082

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(202) 429-8873 phone, (202) 429-2248 fax, http://aceee.org

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RESOURCES FOR MEETING MARYLAND'S ELECTRICITY NEEDS

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ACKNOWLEDGMENTS

The authors express their appreciation to the Energy Foundation, Campbell Foundation, and Town Creek Foundation, whose combined support made this report possible.

In addition, we express our appreciation to Walt Auburn and Ely Jacobsohn with the Maryland Energy Administration, Harvey Sachs with ACEEE, Joseph Orlando with the CHP Regional Application Center at the University of Maryland, and Ed Osann with Potomac Resources for reviewing the report draft. In addition, we thank Ruth Kiselewich, Mary M. Straub, Bill Wolf, and Ed Berman with BGE, Susan Gray with the Power Plant Research Program, Steven Estomin and Christina Mudd with Exeter Associates, and Calvin Timmerman with the Maryland Public Service Commission for providing data used in this study and reviewing the draft. Finally, thanks to Renee Nida with ACEEE for editing the report.

ABOUT THE AMERICAN COUNCIL FOR AN ENERGY-EFFICIENT ECONOMY (ACEEE)

ACEEE is a nonprofit organization dedicated to advancing energy efficiency as a means of promoting both economic prosperity and environmental protection. For more information, see http://www.aceee.org. ACEEE fulfills its mission by:

- Conducting in-depth technical and policy assessments
- Advising policy-makers and program managers
- Working collaboratively with businesses, public interest groups, and other organizations
- Organizing conferences and workshops
- Publishing books, conference proceedings, and reports
- Educating consumers and businesses

Projects are carried out by staff and selected energy efficiency experts from universities, national laboratories, and the private sector. Collaboration is key to ACEEE's success. We collaborate on projects and initiatives with dozens of organizations including federal and state agencies, utilities, research institutions, businesses, and public interest groups.

ACEEE is not a membership organization. Support for our work comes from a broad range of foundations, governmental organizations, research institutes, utilities, and corporations.

EXECUTIVE SUMMARY

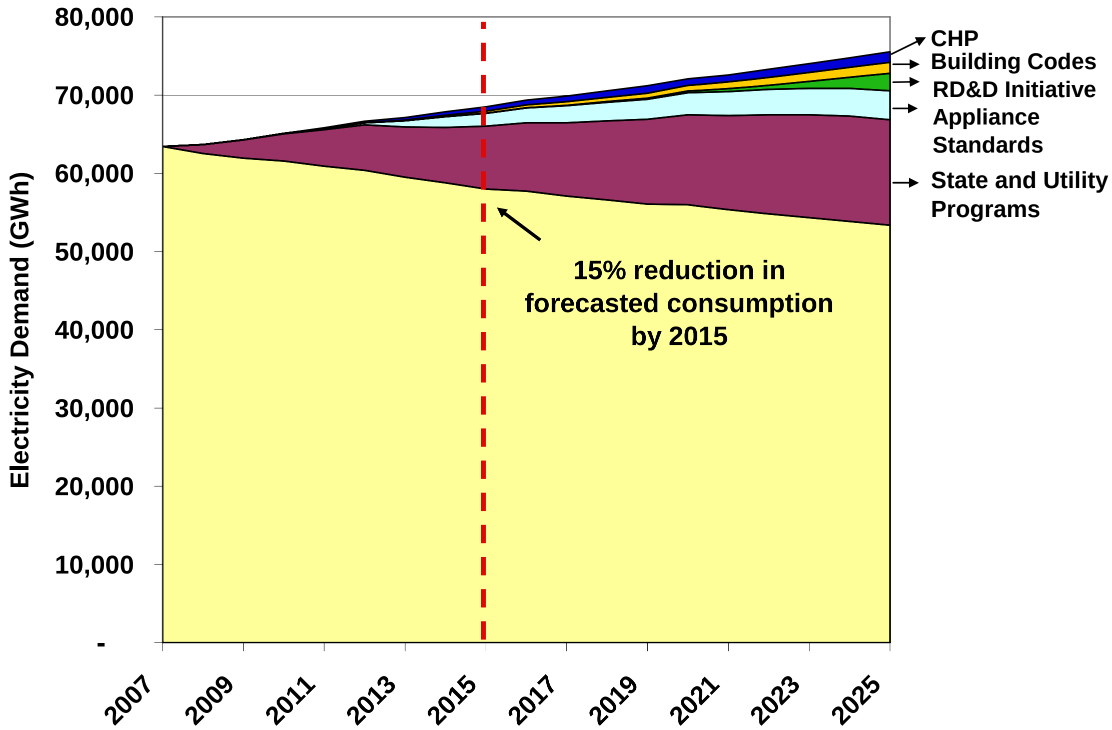
Maryland faces daunting challenges for its energy future. The growing demand for electricity and the stall in power system capacity calls into question our ability to keep the lights on past 2011–2012. Consumers are reeling from the recent surge in electricity prices that strain household budgets, imperil jobs, and create uncertainty for the state's economy. Building new generation or transmission resources cannot meet these challenges in the near term—they cannot be brought online in time to forestall blackouts, and they will further increase electricity prices. Energy efficiency and demand response are the only resources that can be mobilized now to stave off the prospect of power curtailments in the next few years. Because they cost less than conventional powerplants, these demand-side resources are also the best way to help customers reduce their electricity bills.

Energy efficiency and demand response are not only the least-cost resources for meeting Maryland's future electricity needs: they also help the economy by creating new "green collar" jobs. Maryland has begun to lay the groundwork for a clean energy future with the recent enactment of a renewable electricity standard, appliance efficiency standards, and its participation in the Regional Greenhouse Gas Initiative (RGGI). Despite these important steps, much more is needed. In 2007, Governor O'Malley set a goal to reduce per-capita electricity usage 15% by 2015. The Maryland General Assembly is now considering the Governor's request to write this target into law. Because the energy policy choices the legislature makes today will define Maryland's energy future for years to come, this report provides a detailed assessment of energy-saving options to help policy-makers reach informed decisions.

The energy efficiency policies assessed in this report hold the potential to meet 15% of forecasted electricity consumption by 2015, enough to meet Governor O'Malley's goal, and 29% by 2025 (see Figure ES-1). Our resource assessment identifies over 22,000 GWh of cost-effective electricity efficiency, more than sufficient to meet the projected 2015 policy suite savings of 10,500 GWh. Reducing summer peak demand (those times when utilities face the greatest strain on their electricity systems) is equally important as reducing overall electricity consumption. These energy efficiency initiatives, along with expanded demand response programs, have the potential to reduce summer peak demand by 32% in 2015 and 47% in 2025.

These energy savings and demand reductions will reduce customer electricity bills, help stave off possible power blackouts, and give Maryland a head start on reducing carbon dioxide emissions, all while boosting the economy. Few policies offer this four-way payoff of lower consumer bills, increased energy security, a cleaner environment, and a stronger economy.

Figure ES-1. Share of Projected Electricity Demand Met by Efficiency Resource Policies



Policy Recommendations

ACEEE recommends, and has assessed in this report, the following policies:

- An Energy Efficiency Resource Standard (EERS) requiring 15% electricity savings per capita by 2015, relative to 2007 per capita consumption
- Extend the electricity savings target by 1.5% of total sales per year from 2016–2025, ultimately reaching savings equal to 29% of the state's forecasted sales in 2025
- Implementation of existing federal and state appliance standards, supplemented by a suite of new state standards
- More stringent residential and commercial building energy codes
- A clean energy research, development, and deployment (RD&D) initiative funded by the state to meet the state's unique needs while helping to build a "green collar" energy industry in the state
- Policies to encourage new combined heat and power (CHP) systems in the industrial, institutional, and commercial sectors
- Expanded utility demand response programs to reduce peak demand for electricity

The EERS represents the core of these policies, providing a foundation upon which the appliance standards, building codes, and RD&D can be layered to fully achieve the goals.

Table ES-1 presents electricity and peak demand savings results by policy for 2015 and 2025.

Table ES-1. Electricity and Peak Demand Savings by Energy Efficiency Policy

	2015		2025	
	GWh	**MW**	**GWh**	**MW**
Appliance Standards	1,636	346	3,705	785
Building Energy Codes	264	61	1,403	325
State RD&D Initiative	21	4	2,235	433
Utility & State Programs	8,046	1,709	13,473	2,864
Combined Heat & Power	553	62	1,348	134
Energy Efficiency Subtotal	*10,520*	*2,183*	*22,164*	*4,542*
Expanded Demand Response	NA	3,135	NA	3,982
Total	**10,520**	5,318	**22,164**	8,524
Percent Savings of Reference Forecast	**15%**	**32%**	**29%**	**47%**

Economic and Jobs Impacts

The energy savings from these efficiency policies can cut the electricity bills of participating customers by a net $860 million in 2015 and $2.6 billion in 2025. While these savings will require some public and customer investment, they yield an impressive return of $4 in reduced consumer electricity bills for every dollar invested. By 2015, an average household will save a net $8 on their monthly electricity bill from residential efficiency programs. In addition, because of the current volatility in energy prices, efficiency strategies have the added benefit of improving the balance of demand and supply in energy markets, thereby stabilizing regional electricity prices for the future. These reduced wholesale prices can save a typical household another $2 on monthly electricity bills.

Investments in efficiency have the additional benefit of creating new, high-quality "green-collar" jobs for the state. Our analysis shows that these investments will create more than 12,000 new jobs in the state (see Table ES-2), including well-paying trade and professional jobs needed to design and install energy efficiency measures. These new jobs, including both direct and indirect employment effects, would be the equivalent of some 100 new manufacturing plants relocating to Maryland, but without the public costs for infrastructure or the environmental impacts of new facilities.

Table ES-2. Economic Impact of Expanded Energy Efficiency on Maryland

Macroeconomic Impacts	2015	2025
Jobs (Actual)	8,067	12,241
Wages (Million 2006 $)	462	780

Conclusions

Based on the analyses behind this report, we are confident that the state can meet Gov. O'Malley's energy efficiency goals with positive economic and environmental benefits. Energy efficiency policies can more than offset projected load growth in the state over the next 18 years, deferring costly new electric power generation and transmission projects and reducing the risk of blackouts over the next 3–4 years.

All of the choices for the state's energy future bear costs. The key question for Maryland policy-makers is: which kinds of investments provide the best return for Maryland electricity customers? This analysis shows that demand-side investments are the better choice, and thus should be pursued first. While new supply investments may well be needed, investing on the demand side now is Maryland's best energy, economic, and environmental strategy.

Reducing demand for electricity with efficiency will also reduce air pollutant emissions from the combustion of fossil fuels at power plants, giving the state a cleaner energy future at an affordable cost. Reduced global warming emissions will also contribute to meeting Maryland's RGGI commitments, while actually saving consumers money.

Maryland is poised to take the next steps toward its energy future. The current path is not sustainable—it threatens the security of Maryland's power system, and could raise customer electricity bills still further. A clean energy policy suite, beginning with energy efficiency, can meet the state's growing needs for electricity, making the power system more reliable while reducing consumer bills and cutting global warming pollution. This clean energy path will also strengthen, not weaken, the state's economy by stimulating investment and creating good jobs.

INTRODUCTION

In recent years, Maryland has taken a number of important steps to create a clean energy future for the state. The state has enacted a renewable electricity standard and appliance efficiency standards, and has joined the Regional Greenhouse Gas Initiative (RGGI).[4] A number of diverse, external forces motivated these steps, including a surge in electricity prices, concerns about a looming capacity shortage that could lead to blackouts in the next few years (PSC 2007; Fahrenthold et al. 2008), and an increased sense of urgency by some state leaders to respond to global warming. In spite of these important steps, the state still only ranked 47th among the 50 states in energy efficiency spending according to ACEEE's recent survey of state energy efficiency policies (Eldridge et al. 2007).

Energy efficiency and demand response represent the least-cost resources available to meet the growing demand for electricity and contain the rise in electricity costs to consumers in the state, while creating new "green collar" jobs to support the continued growth in the state's economy and addressing environmental concerns. A growing consensus is emerging that the state must do more to realize this clean energy resource, and Governor Martin O'Malley has set a goal for the state of reducing per-capita electricity usage and peak demand 15% by 2015[5] (SB 205). The Maryland Legislature in its 2008 session will consider putting this target into law along with efficiency and clean energy policies necessary to realize this goal.

Because the energy policy choices the state makes now will define Maryland's energy future for years to come, it is important that the legislature and other policy-makers be aware of the policy options available to them. The goal of this study is to assess the opportunities for electric efficiency in the state and to suggest various policies for the state to tap into these resources. Our results are designed to help educate the public and policy-makers about the importance of energy efficiency and to facilitate policy development in Maryland for the next several years by identifying policy and technical opportunities for achieving major energy efficiency savings.

This report is organized into the following sections:

Background: Highlights recent actions and future opportunities in Maryland on energy efficiency and demand response.

Current and Forecast Electricity Use in Maryland: Discusses the electricity sector in Maryland and the electricity forecast used in this analysis.

Methodology: Provides a broad overview of the methodology used in the policy analysis and energy efficiency resource assessment.

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[4] The Regional Greenhouse Gas Initiative is a cooperative effort among 10 Northeastern and Mid-Atlantic states to reduce carbon dioxide emissions. The agreement requires electric generators to obtain carbon allowances equal to their annual emissions, with at least 25% of each state's allowances sold at auction. Maryland joined RGGI in April 2007. See http://www.rggi.org/ for more information.

[5] Relative to 2007 per-capita electricity consumption and peak demand.

Policy Analysis: Outlines the recommended policies for Maryland to adopt to achieve efficiency targets by 2015 and sustain aggressive energy efficiency and demand response through 2025, and presents electricity impacts, costs, and macroeconomic impacts from recommended sets of policies.

Energy Efficiency Resource Assessment: Estimates the total potential for cost-effective efficiency in the state's residential, commercial, and industrial sectors by 2025 through the implementation of specific technology measures. The resource assessment goes beyond what the state can achieve through specific policies, and offers insights into additional opportunities for efficiency.

These sections are supplemented by detailed appendices providing additional explanation, assumptions, and analysis details.

BACKGROUND

Maryland has been taking important steps in recent years to promote energy efficiency. The state has been among the leaders on appliance efficiency adopting state-level standards, waiving sales tax on ENERGY STAR® consumer appliances, embracing the California auto emissions standards, and adopting recent building energy codes (Eldridge et al. 2007). While the state has enacted a renewable electricity standard, it is generally considered ineffective due to its modest targets (MEA 2008). On the clean distributed energy front, the Public Service Commission (PSC) has laid the groundwork for a regulatory structure that should allow clean technologies to compete on a level playing field (Brooks et al. 2006; Orlando 2008).

Despite these efforts, the state has been slow to move forward with "retail" energy efficiency efforts that would result in significant energy efficiency resources. While the state's utilities ran energy efficiency and demand response programs in the 1980s and early 1990s, with the state's rush to "utility restructuring" in the late 1990s, most of these efforts were abandoned. By 2004, per capita spending on utility energy efficiency programs in the state was about \$0.01, placing the state 47th in spending nationally, compared to over \$10 per capita in the top ten states (Eldridge et al. 2007). Recent proposals by the investor-owned utilities (BGE 2007) suggest significant expansion of utility efforts on both energy efficiency and demand response, but these are just beginning to be deployed in the marketplace. It is thus important that the state take steps to create the infrastructure to sustain aggressive levels of energy efficiency in order to allow utility and other programs to ramp up to planned levels and expand even further.

In leading states, energy efficiency is meeting 1 to 2% of the state's electricity consumption each year (Nadel et al. 2006) at a cost of less than 3¢ per kilowatt-hour (kWh) (Kushler et al. 2004), compared with a utility avoided cost of 8 to 13¢ per kWh in Maryland (BGE 2008). States across the country, including California, Connecticut, Massachusetts, Minnesota, New York and Vermont, are realizing the benefits of energy efficiency today, and have enacted policies and programs that are needed to tap into their energy efficiency resources. Results from these states show that energy efficiency represents a low-cost, low-risk strategy to help meet the state's future electricity needs (York et al. 2008).

Together, energy efficiency and demand response can delay or completely avoid the need for expensive new generation and transmission investments (Elliott et al. 2007a, 2007b), thus keeping the future cost of electricity affordable for the state and freeing up energy dollars to be spent on other resources to expand the state's economy. Further, clean distributed generation moves new generation investments near to energy users' sites, avoiding the need for new utility generation and transmissions investments. In addition, a greater share of the dollars invested in energy efficiency go to local companies that create new jobs compared with conventional electricity resources where much of the money flows out of state to equipment manufacturers and energy suppliers.

While experience has demonstrated that this energy efficiency resource is cost-effective and achievable, we have learned that it will not occur without policy action because of market barriers. These barriers include:

- Awareness of energy efficiency opportunities—as one industrial manager characterized it, "you have to know what fruit looks like if you are going to harvest the low-hanging fruit" (Johnson 2008).
- Principal-agent barrier where the person making the efficiency investment does not benefit from the energy savings (e.g., a landlord installing efficient lighting when the tenant reaps the energy bill savings).
- Regulatory barriers (e.g., regulation may discourage utilities from investing in energy efficiency because they cannot fully recover their costs).
- Financial hurdles—the "Warren Buffet problem" that the private sector is inclined to do one large deal rather than lots of small deals, and energy efficiency is by its nature dispersed.

Programs and policies are thus required to overcome these barriers and allow energy efficiency resources to be realized to their full potential.

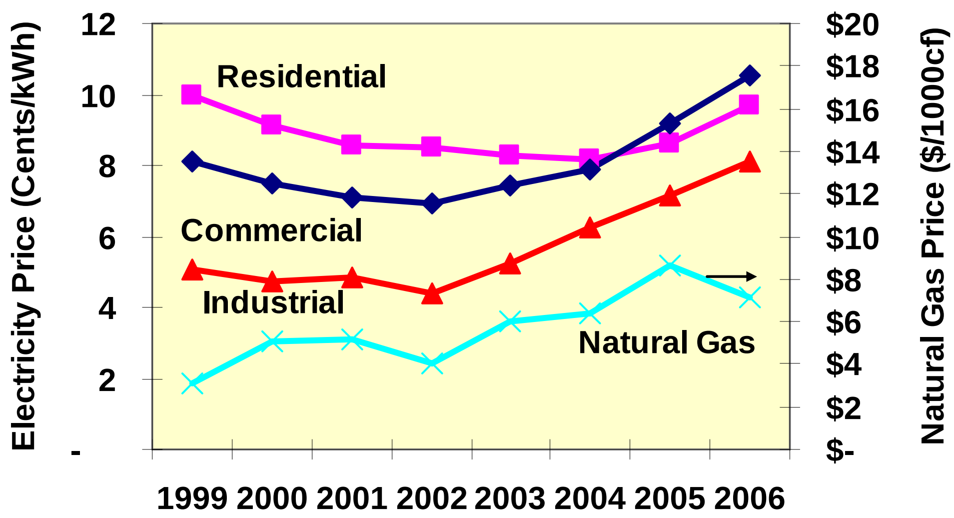
Energy efficiency provides the added benefit of making other clean energy resources such as renewables more affordable. By reducing the demand for energy, efficiency lowers the level of work needed from renewable power, such as solar or wind. Efficiency thus provides the leverage needed to allow renewable energy to meet a greater share of the state's future energy needs. This synergy between energy efficiency and renewable energy allows the two resources together to displace a larger share of conventional energy resources (see Prindle et al. 2007).

CURRENT AND FORECASTED ELECTRICITY USE IN MARYLAND

Electricity consumption in Maryland has fallen over the past four years by about 7% overall, with a significant share of this reduction coming from closures or reductions in the operation of some manufacturing facilities. Sharply higher electricity prices are the main force behind this drop. Retail rates were frozen by electricity restructuring legislation in

1999, and these rate caps began to expire in 2004, hitting different customer classes in different utility service areas at different times. As rate caps expired, most customers were exposed to greatly increased market prices for power generation (see Figure 1), through either competitive electricity service providers or standard offer prices passed through distribution utilities.

Figure 1. Maryland Average Retail Electricity Price, 1999–2006 (2006$)



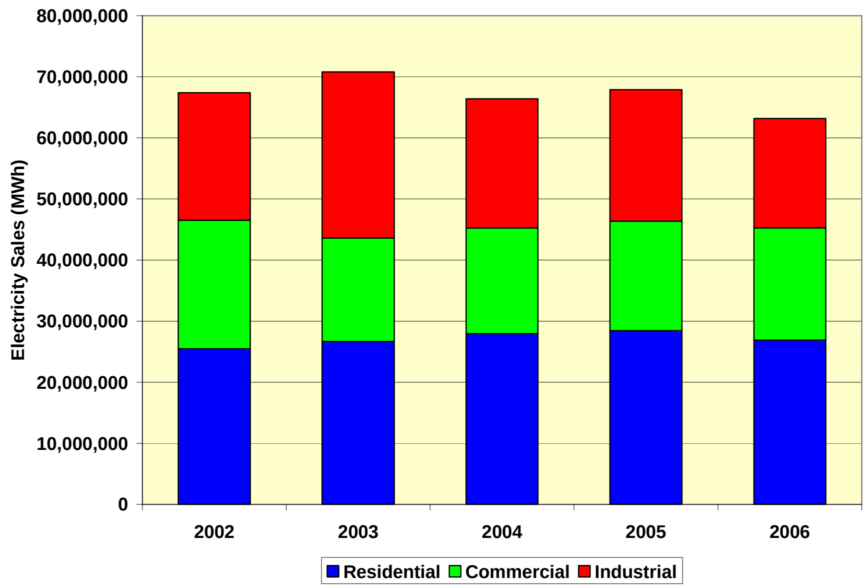
Source: EIA (2007a, 2008)

Rising natural gas prices have been a major factor in driving up wholesale electricity prices in the last five years (see Figure 1). The PJM wholesale power market, in which Maryland participates, is heavily affected by natural gas fuel prices, as natural gas units are the marginal generating units a high proportion of the time. Because marginal generation prices set the overall PJM price, these higher gas prices strongly influence wholesale power prices, and in turn the standard offer prices most Maryland customers pay for power supply.

While demand for electricity has moderated in all customer classes, the volatility in industrial sector electricity consumption particularly complicates the development of the industrial reference case. The industrial electricity consumption reported by EIA (2007b), presented in Figure 2, shows this substantial variation in industrial electricity sales. The variation is due to several factors related to the operation of just a few large, energy-intensive manufacturing facilities. Among these facilities are the state's two largest electric consumers, ArcelorMittal Sparrow's Point steel mill located near Baltimore and Eastalco Aluminum Company's aluminum smelter, a division of Alcoa, located near Buckeystown.

The output from these facilities has varied widely over the past few years, as data from Economy.com (2007) suggests. Specifically, most of the energy-intensive activities at the Eastalco facility were suspended in December of 2005 due to increases in the price of electricity. While attempts have been made to provide a new, lower-cost source of electricity for this facility (Cumber 2007), it appears unlikely that this facility will return to full operation because Alcoa has shifted production to facilities in low electricity cost locations, including Trinidad. While this does reduce electricity use in the state, this neither benefits the state's economy nor addresses global warming concerns because the emissions are just shifted to another location.

Figure 2. Electricity Sales in Maryland by Sector



Source: EIA (2007b)

The Sparrows Point steel mill has also reduced its level of operation in recent years due to ownership uncertainties. These uncertainties result from the terms of the ArcelorMittal merger, which requires the firm to divest the Sparrows Point operation. ArcelorMittal has encountered difficulties in locating a purchaser for Sparrows Point in the current tight credit market (WSJ 2007). Therefore, ArcelorMittal has been hesitant to make major capital investments in this facility.

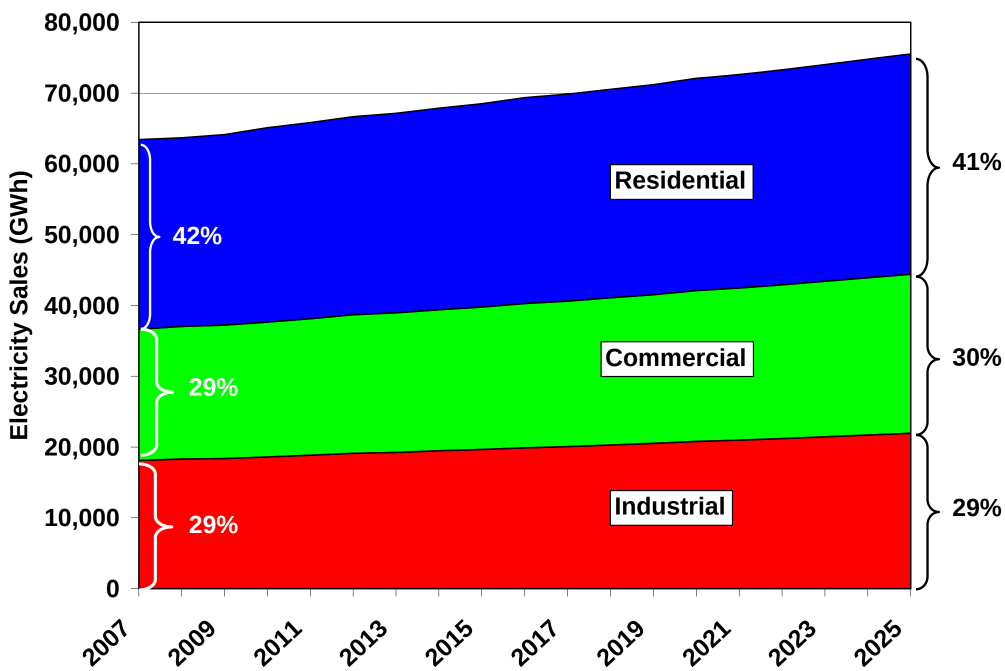
In addition, a number of moderately large chemical plants operating in the greater Baltimore area contribute to these variations in electricity consumption, as some of these facilities are also operating at reduced levels of output due to high natural gas prices and global competition.

Electricity and Peak Demand Forecasts

Developing an accurate projection of electricity usage in Maryland over the next 10–15 years is complicated by these recent, dramatic changes in usage and electricity prices in the state. ACEEE considered these issues in developing its reference case forecast for Maryland's future electricity usage. Specific to the industrial sector variation, while the 350 MW Eastalco load is unlikely to return to operation, our analysis incorporates a significant increase in other manufacturing. Once the ownership issues are resolved with the Sparrows Point steel mill and as chemical facilities within Maryland are projected to increase operations as the economy recovers and high global shipping costs increase the competitiveness of domestic production, we would anticipate that much of the recent reductions in load would reverse as the plants return to full operations (Matthews 2007; Elliott et al. 2008).

We consulted multiple sources, including PJM, Maryland distribution utilities, and the Maryland Power Plant Research Program (PPRP). Ultimately, we used the U.S. Department of Energy's Energy Information Administration's (EIA) electricity sales data for current sales (EIA 2007b), PJM demand forecasts as the basis for total electricity sales growth rates (PJM 2007), and PPRP for the ratio of growth rates among sectors (PPRP 2007). The electricity forecast used in this report is presented in Figure 3, and a summary of peak demand and electricity forecasts is shown in Table 1. This forecast does not include the impacts of national energy efficiency standards passed in recent legislation as is discussed in the next section. A more detailed discussion of these sources and assumptions used in the developing the forecasts are in Appendix A.

Figure 3. Projected Electricity Consumption in Maryland by Customer Sector



Source: ACEEE, as discussed in the text.

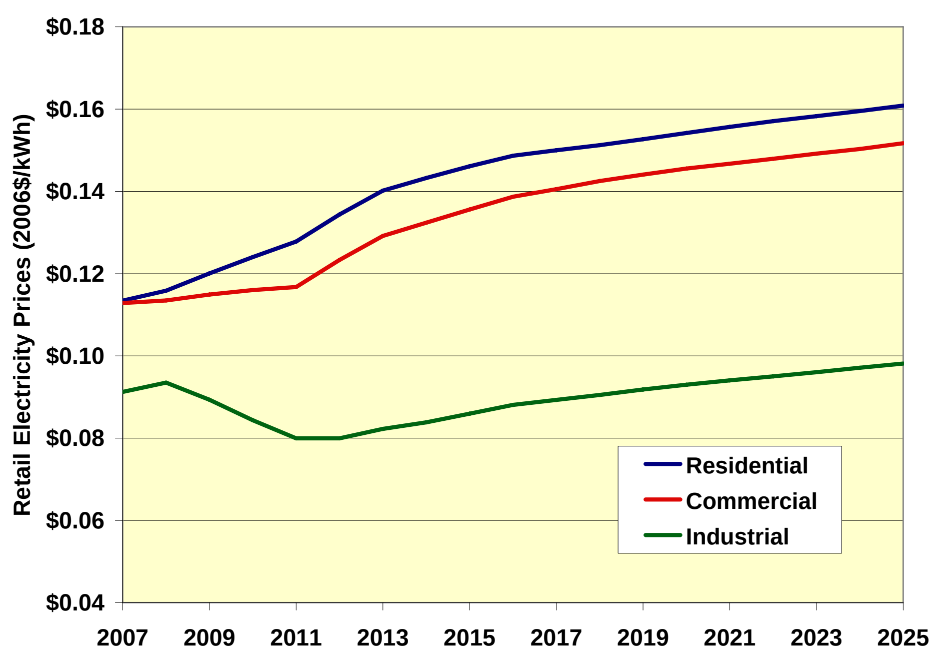
Table 1. Projected Electricity Consumption and Peak Summer Demand in Maryland*

	2010	2015	2020	2025	Average Annual Growth Rate 2007–2025 (%)
Electricity (GWh)					
Residential	27,463	28,731	29,991	31,104	0.83%
Commercial/Other	19,053	20,126	21,305	22,482	1.1%
Industrial	18,598	19,645	20,795	21,945	1.1%
Total	**65,114**	**68,502**	**72,092**	**75,530**	**0.97%**
Summer Peak Demand (MW)					
Residential	7,680	8,093	8,474	8,860	1.0%
Commercial	5,156	5,485	5,824	6,196	1.3%
Industrial	2,656	2,826	3,000	3,192	1.3%
Total	**15,511**	**16,437**	**17,350**	**18,327**	**1.2%**

Source: ACEEE estimates of reference forecast electricity consumption based on various sources. These values represent consumer consumption and do not include loss or plant energy use. Note that commercial and industrial sector growth rates are based on a combined commercial and industrial forecast.

We also developed retail electricity price forecasts (see Figure 4) and natural gas price forecasts based on current prices from EIA and forecasts from ICF's IPM model (ICF 2007). More details on the methodology and assumptions used to develop these projections are presented in Appendix A.

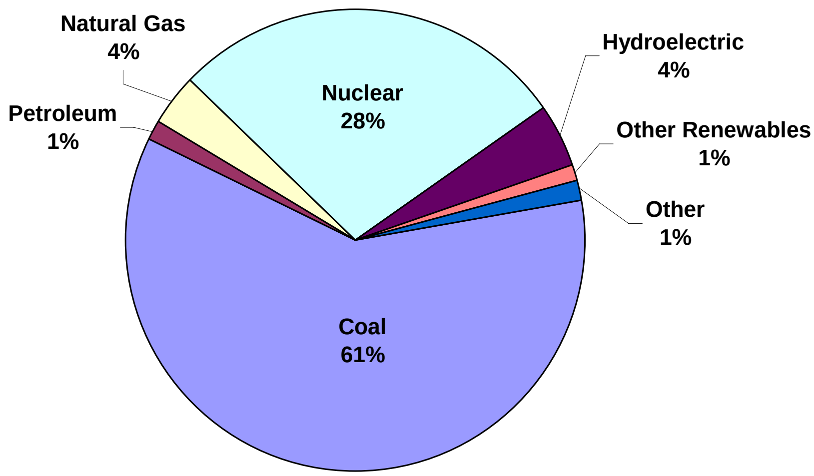
Figure 4. Retail Electricity Price Forecast by Sector



Electricity Generation by Fuel Type

In 2006, Maryland generated about 49,000 GWh of electricity, which was sold into the PJM market. The majority of this in-state generated electricity (60%) came from coal-fired power plants (see Figure 5). By comparison, the national average mix of electricity generation is 50%. At the same time, the state consumed 63,173 GWh of electricity in 2006, making the state a net importer of electricity.

Figure 5. 2006 Maryland Electricity Generation by Fuel Type
Total Generation: 48,957 GWh



Source: EIA (2007a)

METHODOLOGY

For this study, we perform two primary tasks: assess the overall potential in the state for increased cost-effective electricity efficiency; and determine what can be achieved by a specific suite of new or expanded energy policies and programs at the state level.

The first task is to estimate the total cost-effective efficiency resource potential in the state available through existing technologies and practices that have reasonable market share. We review specific measures that are technically feasible for each sector; analyze costs, savings, and current market share/penetration; and estimate total potential from implementation of the resource mix. We do not review emerging technologies with very low market share for this analysis. See Appendix C for a detailed methodology of the resource potential analysis by sector.

The resource assessment then provides inputs on costs and savings potential for the second task, the program and policy analysis. For this analysis, we developed a suite of energy efficiency and demand response policy recommendations based on successful models implemented in other states and in consultation with stakeholders in Maryland. We drew upon our resource assessment and evaluations of these policies in other states to estimate the electricity savings and the investments required to realize the savings.

In addition, we estimated the reductions in peak demand that would occur as a result of these energy efficiency policies and programs. We applied these reductions to the projected peak demand forecast and then applied a suite of demand response policies to further reduce the projected peak demand. The estimation of demand reduction from efficiency is discussed in Appendix B.1 and the demand response policy analysis is presented in Appendix B.3. These two analyses were done in isolation from each other based on past program experience, and while we made an attempt to avoid double counting between demand reductions resulting from energy efficiency and demand response efforts, we remain concerned that interactions may exist between these policies that might lower the total estimated demand reductions. To our knowledge, we are not aware of aggressive energy efficiency and demand response programs of the level proposed being deployed together.

Based on the results from the policy analysis, we then estimated the benefits and costs of the policies and estimated CO2 emissions reductions. We then ran ACEEE's macroeconomic model, DEEPER, to estimate the policy impacts on jobs, wages, and gross state product (GSP). For a more detailed discussion of DEEPER and the macroeconomic analysis, see Appendix D.

In the next two sections of the report, we present the results of the policy analysis first, followed by the efficiency resource assessment. The policy analysis shows specific actions needed to be taken by the state in order to tap into the efficiency resource potential.

POLICY ANALYSIS

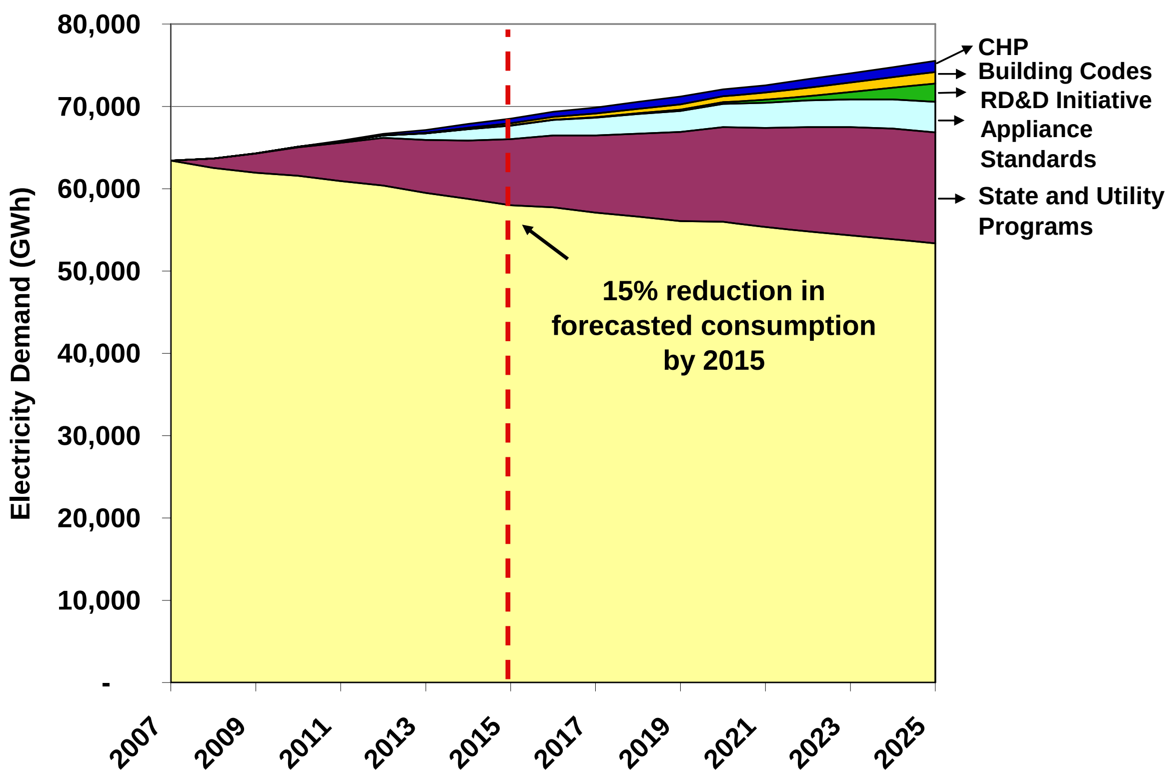
In this section, we outline a suite of six specific policies suggested for implementation or extension in Maryland:

- Energy Efficiency Resource Standard (EERS) requiring 15% electricity savings per capita by 2015[6] and 1.5% savings per year from 2016–2025
- Implementation of existing federal and state appliance standards, supplemented by a suite of new state standards
- More stringent residential and commercial building energy codes
- A clean energy research, development, and deployment (RD&D) initiative to meet the state's unique needs while helping to build a "green collar" energy industry in the state
- Policies to encourage new combined heat and power (CHP) systems in the industrial, institutional, and commercial sectors
- Expanded utility demand response programs to reduce peak demand for electricity

[6] Relative to electricity consumption per capita in 2007, which was about 11,100 kWh. This is the same level as specified in Maryland's Strategic Electricity Plan (MEA 2008).

The EERS represents the core of these policies, providing a framework within which the appliance standards, codes, and RD&D contribute to the targets and are complemented by other energy efficiency programs to fully achieve the goals. This overall policy suite, which is described in detail below and with all key assumptions and data in Appendix B.1, has the potential to reduce electricity use in Maryland by 15% by 2015 and 29% by 2025, relative to forecasted electricity sales (see Table 4 and Figure 6 for a summary of the electricity savings by policy). This is the equivalent to reducing 2007 per-capita electricity consumption by 16% and 28% in 2015 and 2025, respectively, relative to 2007 sales. Figure 6 shows that the efficiency scenario will reduce the demand for electricity supply, not just moderate its growth.

Figure 6. Share of Projected Electricity Demand Met by Efficiency Resource Policies



The 15% electricity savings per capita target set by the Governor has created some confusion both for analysts and for the policy community. Most energy analysts and utility planners are more familiar with targets based on total savings relative to a forecasted value. It is important to note, however, that often states, including Maryland, do not have widely accepted electricity sales and peak demand forecasts, making it challenging to assess targets as a percentage of forecasted sales. As we discuss later, it will be important for Maryland to develop consistent data and forecasts to insure that the Governor's goals are realized.

Similarly, population estimates vary, making per-capita reductions difficult to assess on a consistent basis. As shown in Tables 2 and 3, the percent reductions can be calculated relative to the reference forecast or to 2007 year data. We hope that readers can use these tables to relate the target values for different bases to each other. For the remainder of the report, we will present savings *as a percent of reference forecast consumption for a given year* to be consistent. We will, however, note in several instances what the savings are as a percent of 2007 per-capita sales in order to compare the savings potential with the proposed targets in the state.

Table 2. Electricity Efficiency by Policy in 2015 and 2025

	Annual Electricity Savings			
Policies	**2015**		**2025**	
	GWh	% Savings*	GWh	% Savings*
Appliance Standards	1,636	2.4%	3,705	5%
Residential and Commercial Building Codes	264	0.4%	1,403	2%
State RD&D Initiative	21	0.0%	2,235	3%
State and Utility Programs	8,046	11.7%	13,473	18%
CHP	553	0.8%	1,348	2%
Total	**10,520**	**15%**	**22,164**	**29%**

* Relative to the reference forecast.

Table 3. Electricity Efficiency Relative to Reference Forecast, 2007 Per-Capita Usage, and Total 2007 Consumption

	2007	2015	2025
Electricity Consumption in Reference Forecast (GWh)	63,430	68,502	75,530
Electricity Consumption in Policy Scenario (GWh)	63,430	57,982	53,366
% Savings Relative to Reference Forecast	**-**	**15%**	**29%**
% Savings Relative to Total 2007 Consumption	-	**9%**	**16%**
Per-Capita Electricity Usage in Reference Forecast (kWh)	11,087	11,028	11,278
Per-Capita Electricity Usage in Policy Scenario (kWh)	11,087	9,335	7,968
% Savings Relative to 2007 Per-Capita Sales	-	**16%**	**28%**

The reduction in electricity consumption across the board resulting from the efficiency policies will also reduce summer peak electricity by 13% by 2015 and 25% by 2025. An additional suite of demand response policies and programs discussed in this section reduces summer peak demand by 19% in 2015 and 22% in 2025. Together, efficiency and demand response programs have the potential to reduce summer peak demand by 32% in 2015 and 47% in 2025, as shown in Table 4.

Table 4. Total Summer Peak Demand Reductions from Energy Efficiency and Demand Resources Policies and Programs

Policies	2015		2025	
	MW	% Savings*	MW	% Savings*
Appliance Standards	346	2.1%	785	4.3%
Building Energy Codes	61	0.4%	325	1.8%
State RD&D Initiative	4	0.0%	433	2.4%
State and Utility Programs	1,709	10%	2,864	16%
CHP	62	0.4%	134	0.7%
Subtotal—Energy Efficiency	*2,183*	*13%*	*4,542*	*25%*
Demand Response	3,135	19%	3,982	22%
Total	5,318	32%	8,524	47%

* Relative to the reference forecast.

Descriptions of Policies

The following section describes each policy and a summary of results of the analyses. Details on data sources, analysis approach, and assumptions are contained in Appendix B.

Energy Efficiency Resource Standard

Some 15 states currently have in place or are developing EERS policies (Nadel et al. 2006). The fundamental concept of an EERS is to set quantitative, long-term energy savings targets for utilities. In the past, targets tended to be set in terms of funding levels, or were short term (typically 3 years or less). This approach did not allow efficiency to be treated like a utility system resource; EERS policies seek to remedy this situation. Long-term EERS targets allow utilities to plan for the long term and also provide an incentive to minimize costs while reaching savings goals. EERS targets are also typically set independently of specific program, technology, or market targets, in order to give utilities maximum flexibility to find the least-cost path toward meeting the targets. See Text Box 1 for a description of leading state EERS policies.

In July 2007, Governor O'Malley set a goal of reducing per capita electricity usage and peak demand 15% by 2015, relative to 2007 per-capita usage. We therefore modeled an EERS policy designed along the following lines:

- Electricity savings from appliances efficiency standards, both state and federal, building energy codes, and RD&D programs go toward meeting the goals. These policies and programs are discussed later in this section.

- The balance of the goal is met by consumer energy efficiency programs operated by the state and retail electric providers.

- State and utility-run programs were assumed to cover a typical range of residential, commercial, industrial technologies, and markets. They may include performance contracting and other types of "bulk procurement" approaches, which seek bids to obtain savings typically from larger customers, often through energy service company intermediaries. Utility programs serve all sectors because the Governor's goals cannot be met if one or more sectors are excluded.

- Consumption targets:[7]
  - 15% savings per capita by 2015 as a percentage of per-capita sales in 2007 (equivalent to 15% overall savings in 2015 or about 1.8% savings per year).
  - Extend a target of 1.5% savings per year of forecast sales from 2016 through 2025, ultimately reaching 28% of reference forecast consumption.

We also considered the impacts of energy efficiency policies on summer peak demand complemented by dedicated demand response programs implemented by utilities, which serve primarily to reduce peak demand rather than total consumption (see pages 17-18) for specific demand response policy recommendations). These combined efforts were targeted to achieve peak demand targets consistent with Gov. O'Malley's proposal of:

- Target of 15% reduction in 2007 summer peak demand by 2015
- Target of 25% reduction in 2007 summer peak demand by 2025

Appliance standards, building codes and RD&D contribute about 3 percentage points of the 15% reduction in electricity consumption by 2015 target. The remainder of the goal, about 8,000 GWh in 2015, is met through utility- and state-run programs mentioned above. By 2025, standards, codes and R&D could meet 7% of the 28% overall savings target. Utility- and state-run efficiency programs (including implementation of measures developed through the proposed RD&D initiative) meet the remainder of the target, or 13,500 GWh. For the Total Resource Cost (TRC) test, the present-value cost of these programs run through 2025 is $3.6 billion and present-value benefits are $9.4 billion, for a net benefit of about $5.8 billion.[8] Costs include investments by consumers, utility incentives, and administrative costs. Benefits assume avoided utility costs (see Appendix B).

Appliance Standards. Lighting and appliance standards, first authorized by Congress in the 1970s and legislated again in 1987, 1992, 2005, and 2007, have become a core energy policy for the United States, setting performance targets for dozens of common household and business products and systems. Individual states have played and continue to play an important role in advancing standards for the nation. In the 1980s, states' initiative in developing standards in the face of federal inaction led to the landmark National Appliance Energy Conservation Act of 1987. Since then, state enactment of standards on products not covered by federal law has led to many new federal standards. Maryland enacted appliance standards for nine products in 2004 (SB 394) and seven additional products in 2007 (HB 909); ACEEE analysis indicates that additional state standards are merited, as discussed below.

[7] Percentage targets for electricity and peak demand reductions were derived from Maryland Strategic Electricity Plan goal of reducing electricity per-capita consumption 15% by 2015 relative to 2007 per-capita consumption and peak demand 15% by 2015 relative to 2007 peak demand.
[8] Costs and benefits reported in this section are given in present value, 2006 dollars, assuming a 5% real discount rate. See the next section on Costs and Benefits of Policy Scenario.

Text Box 1
Energy Efficiency Policies in Leading States*

Connecticut: Connecticut has operated utility-administered energy efficiency programs for many years. In 2005, the Connecticut legislature modified its Renewable Portfolio Standard to include efficiency. Starting in 2007, the state's utilities must procure a minimum 1% of electricity sales from "Class III" resources such as energy efficiency and combined heat and power, rising by 1% per year to 4% in 2010. In 2007, the Connecticut legislature substantially increased efficiency efforts in the state still further, requiring the state's utilities to acquire "all available energy efficiency and demand reduction resources that are cost-effective, reliable and feasible." Initial proposals by the state's utilities to meet this mandate call for tripling energy efficiency spending in the state over a five-year period, and reducing sales below current levels by 2017 (Sosland 2008).

Massachusetts, New York and New Jersey: Massachusetts is in the process of adopting legislation similar to a draft bill in Connecticut requiring utilities to acquire all cost-effective efficiency (as of this writing, the bill has passed both houses of the legislature and a conference committee hopes to soon work out a final bill). State officials, utilities and others are discussing programs and policies that would immediately double energy efficiency spending and savings, reducing electricity use by 1.5% per year by 2010, and continued increases thereafter that could exceed 2% per year (Sherman 2008). In New York, the Public Service Commission is midway through a docket that will direct how the state and its utilities will meet Governor Spitzer's goal to reduce electricity use by 15% in 2015 from forecasted levels. Draft strategies involve a combination of state and utility programs, building codes, and equipment efficiency standards. In New Jersey, the legislature authorized the Board of Public Utilities to set energy savings targets for utilities that will require reducing electricity use by 20% by 2020 from forecasted levels. In all three states, these recent policy initiatives are expected to help meet targets established in the multi-state Regional Greenhouse Gas Initiative.

California: California has been pursuing efficiency policies for many years, using efficiency to reduce electricity use approximately 15% over the 1973-2003 period. About half of these savings came from utility energy efficiency programs and the balance from state energy codes and equipment efficiency standards (Rosenfeld 2007). In 2004 the state Public Utilities Commission set energy savings goals for investor-owned utilities for 2004 through 2013, which are expected to save more than 1% of total forecast electricity sales per year. Savings from efficiency measures installed in 2007 under investor-owned utility efficiency programs totaled 3,703 million kWh, which is over 1.5% of electricity sales by these utilities (CPUC 2008). In the next few years California will need to further expand their energy use reduction efforts to meet climate change goals enacted into law in 2006 which calls for reducing greenhouse gas emissions to 1990 levels by 2020.

Minnesota and Illinois: In 2007, these two states both set mandatory energy savings targets for utilities. The Minnesota legislation, which was championed by Governor Pawlenty, calls for electric and gas utilities to reduce consumption by 1.5% per year with efficiency. At least 1% per year must come from efficiency programs, the balance can come from codes, standards, education programs and other measures. The Illinois legislation establishes steadily increasing targets, starting at 0.2% of electricity sales in 2008 (utilities previously had no significant programs) and ramping up to 2% per year in 2015 and beyond.

Vermont: The state Public Service Commission established Efficiency Vermont (EV), an independent "efficiency utility" that delivers efficiency programs statewide. Efficiency Vermont is administered by a very experienced local non-profit organization that is contractually required to achieve energy and demand goals. Over the 2000-2007 period, EV efficiency program savings were equal to about 7% of Vermont's 2007 electricity requirements. For 2007–2008, EV ramped up its program to reduce consumption over two years by 3.5% of sales, an average of 1.75% annually (VEIC 2007). These savings are being achieved entirely by EV programs, without taking credit for savings from codes and standards.

*Unless otherwise specified, further information on these state policies can be found in Nadel et al. (2006).

None of these standards were factored into the reference case, because it was based on usage data prior to the dates that these standards would begin to affect energy consumption. We therefore attribute savings from these standards towards meeting the overall 15% per capita savings goal. We estimate that by 2015, the state could reduce its overall electricity consumption by 1,600 GWh, or 2.4%, through federal and state efficiency standards. By 2025, standards would reduce sales by 3,700 GWh, or 5% compared to the reference case.

*Building energy codes***.** Like appliance standards, building energy codes have become a foundation stone of energy policy. By focusing on the largest source of growth in building energy usage—new buildings—codes capture important "lost opportunity" efficiency technologies that would otherwise be difficult or very expensive to install after the building is built. Unlike appliance standards, however, codes are primarily administered at the state and local level; an initial attempt to set federal building energy performance standards in the 1970s was repealed in the 1980s. Since then, building code officials organizations have developed model codes that states can adopt, and the Energy Policy Act of 1992 requires states to consider national model energy codes for residential buildings (currently the International Energy Conservation Code or IECC) and to adopt the ASHRAE 90.1 standard for non-residential buildings. The IECC also includes non-residential standards, and includes the ASHRAE 90.1 standard by reference; so many states use the IECC for both building types.

Maryland currently implements the 2006 IECC code for both residential and non-residential buildings. The 2006 IECC for non-residential buildings references the 2004 ASHRAE 90.1 standard. For this analysis, we modeled the following scenario, based on legislation that passed the U.S. House in 2007**:**

- A new state code is adopted in 2012, effective 2013, reducing energy usage 30% in new residential and non-residential buildings compared to 2006 IECC and ASHRAE 90.1-2004. The 30% reduction is ASHRAE's savings target for the 90.1-2010 code. A proposal for 30% savings in residential buildings is now pending before the IECC.

- A second new state code is adopted in 2020, effective 2021, reducing energy use 50% from 2006 IECC and ASHRAE 90.1-2004. DOE, AIA and others are working on designs and strategies for meeting these savings levels. 50% savings is also the threshold for new building tax incentives enacted into federal law in 2005.

The new building codes require a commitment by the state to enforce the higher standards. We estimate savings assuming that codes are initially enforced in 70% of new buildings, growing to 90% enforcement (see Appendix B.1). The updated codes would reduce electricity consumption by 2% by 2025 compared to the reference forecast at a present-value cost of $460 million and savings of $780 million. Net savings are roughly $300 million.

State RD&D Initiative. Several states support active research, development, and demonstration programs, designed to develop technologies appropriate to each state's climate, economy, and other resources.[9] For this analysis, we assumed a policy initiative along the following lines:

- Establish a state RD&D entity, funded through public benefits sources such as the RGGI allowance auction proceeds, to undertake Maryland-specific research into energy efficiency technologies and help develop energy efficiency jobs and businesses in Maryland. This effort would coordinate with similar programs in many other states, but a Maryland fund could specifically target end-uses and business opportunities for which there is strong Maryland interest. In order to meet long-term savings goals, RD&D of new technologies is critical, so as to sustain continued improvements in energy efficiency after currently commercialized technologies and practices are widely adopted.

There are many areas where focus could potentially be very productive. For example, residential construction remains largely a craft. Much research is needed in ways to improve quality (and efficiency) through industrialization of building foundation and shell construction, and through better thermal distribution (for heating and air conditioning). Because Maryland's climate includes the humidity and pest (termite) challenges of the South and reasonably high heating and cooling loads, technologies and practices developed in Maryland are likely to have widespread impact on the industry, with revenues to Maryland firms.

Savings from RD&D would go toward meeting the state's electricity targets. Based on successful programs in New York and other states as discussed in Appendix B, we estimate that an RD&D effort in Maryland could reduce electricity consumption by 3% in 2025 relative to the electricity reference case. Present value investment and administrative costs for this program total about $330 million and avoided electricity costs total over $920 million.

Combined Heat and Power (CHP). CHP provides substantial overall efficiencies by generating both thermal and electric power from a single fuel source. This co-generation approach bypasses most of the thermal losses inherent in traditional thermal electricity generation, where half to two-thirds of fuel input is rejected as waste heat. By combining heat and power in a single process, CHP systems can produce efficiencies of 70% or greater.

The economics of CHP projects historically have not been strong in Maryland, largely due to the high price of natural gas relative to historic electric rates and the uncertainties regarding air quality permitting, which typically fail to credit displaced utility emissions toward the increases in onsite emissions at CHP sites (Orlando 2008). Accordingly, the state has not been noted as among the leaders on CHP development, and currently has only 829 MW of installed capacity at 18 sites in the state (EEA 2008) representing 6.6% of summer capacity demand in the state (EIA 2006). Other states have installed more CHP—for example, the 3,494 MW installed in New Jersey represents 18.4% of summer capacity (EIA 2006). Expectation is that as electric prices and policies reach parity with these states, one can expect levels similar to what has been achieved in those states.

[9] See http://www.asertti.org/

The state has adopted standard interconnection procedures and output-based emissions standards for CHP systems (Eldridge et al. 2007). Discussions have begun on stand-by rate proceeding at the PSC, and there are some discussions about a "cogen" natural gas tariff similar to those in place in New Jersey and New York (Orlando 2008). In addition, the University of Maryland hosts the Mid-Atlantic CHP Regional Application Center, giving the state an important technical resource.

With the recent increases in electric prices, the attractiveness of CHP is improving, so that the current economic potential without incentives is estimated to be an additional 300 MW. However, barriers continue to exist, so additional policy steps would be helpful to encourage consideration of CHP, particularly for systems smaller than 5 MW. We examined, and recommend, the following policies:

- Formally initiate a PSC rulemaking on standby tariffs;
- Proceed with enacting a "cogen" tariff for natural gas;
- Establish a state CHP resource standard of 800,000 kWh by 2025 that is additional to the state's current RPS and the end-use EERS recommended above; and
- Use a portion of the PBF funds to establish an institutional CHP revolving loan fund that supports both CHP and district energy systems.

To estimate the potential impacts of this policy we analyzed the impact of an incentive of $600 per installed kW of CHP on the projected level of market installation and assumed that the difference between this level and the projected level without incentives would reflect the impact of the policies. The public costs for this policy would include $500,000 in program and administrative costs for a state CHP effort along with incentive payments of $600 /kW. For more details see Appendix E.

Demand Response. Many utilities, states, and electricity transmission organizations operate demand response programs, which are distinguished from energy efficiency programs by the fact that their main goal is to reduce electricity demand at peak hours, and not to reduce total energy consumption. While some demand response programs can reduce overall energy usage, and some efficiency programs reduce peak demand, the primary objectives of the program designs and technologies used for these purposes are different.

Beyond the specific demand-reduction targets set up in the EERS policy category, we recommend the following utility policies be pursued:

- Establish standard demand response technical protocol for the state, coordinated with transmission system operator (PJM) programs and policies. Some utilities, notably BGE, have already filed plans for advanced electricity metering and demand response. We recommend that policies be set statewide to be consistent with these initiatives, so that customers and service providers in these markets have a single set of technical requirements to follow.

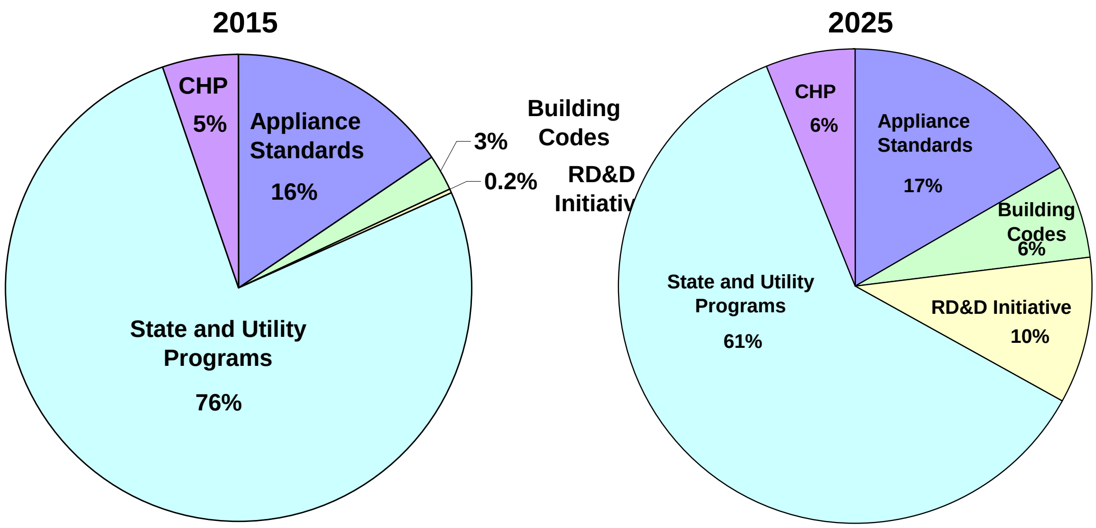
- Consider mandating smart metering/control enabling requirement for new connections/major renovations. This is but one way of coordinating demand response with other policies. Enabling demand response technologies can be made a condition of electricity service, and could also be included in building code provisions. This will ensure that all new buildings and renovations are capable of demand response. In addition, the design and delivery of energy efficiency and demand response programs should be coordinated where appropriate, to reduce total DSM program costs, and to maximize both energy and capacity benefits from DSM dollars.

These demand response programs would reduce summer peak demand by about 3,000 MW by 2015 and about 4,000 MW by 2025, or 15% and 28% of forecasted summer peak demand, respectively. Costs for these programs in 2015 total about $156 million. We estimate that investments made through 2016 have a present value policy cost of $564 million and benefits of $1.6 billion, for a net benefit of about $1.1 billion. We do not estimate costs beyond 2016 because significant uncertainty exists about the long-term costs of demand response programs due to the rapidly evolving technology. In addition, we do not attribute any energy consumption savings to the demand response programs because the current evaluation experience has yet to confirm such an effect (York and Kushler 2005). See Appendix B.3 for a detailed description of the demand response policy recommendations and costs.

Overall Policy Scenario Results in Maryland

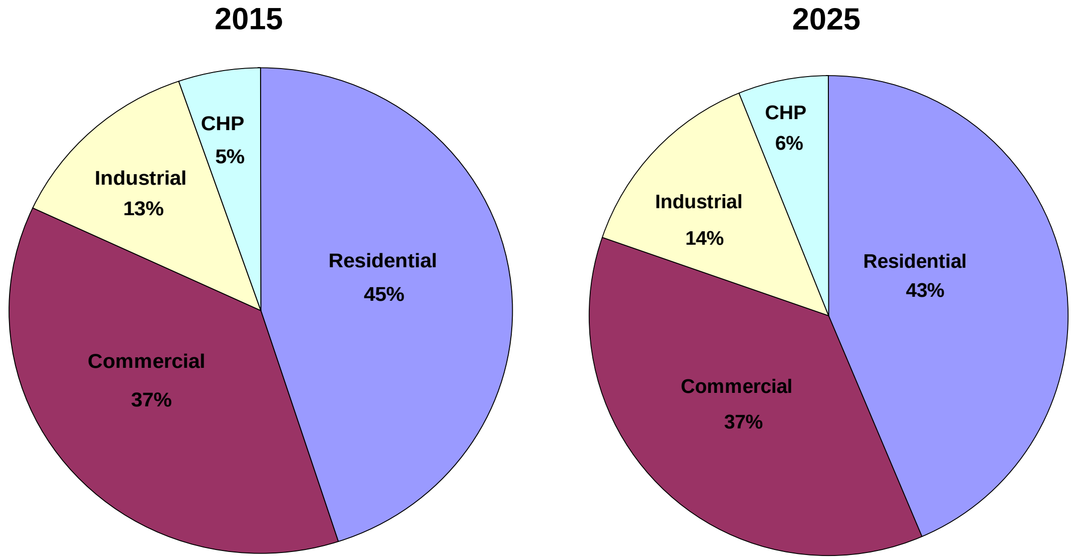
As shown in Table 2 and Figure 6 above , we estimate a potential of 22,164 GWh in 2025 from energy efficiency policies and programs. See Figure 7 for a breakdown of these savings by policy.

Figure 7. Electricity Efficiency in 2015 and 2025 by Policy



We also estimated the share of the roughly 22,000 GWh potential by sector (see Figure 8). More details on the policy analysis methodology and assumption by sector is provided in Appendix B.

Figure 8. Electricity Efficiency in 2015 and 2025 by Sector



In Text Box 2, we show statewide savings and costs for residential programs through the year 2015, including a subset of utility- and state-run programs specifically, and a second category of all residential programs and policies including codes, standards, and R&D. The figures are also translated into per household estimates by distributing all savings and costs across all Maryland households, including participants and non-participants.

Costs and Benefits of Policy Scenario

Costs necessary to run the recommended policies and programs include program/administrative costs to administer the programs, incentives provided to consumers from utilities for utility-run programs, and direct consumer investments for efficiency measures. Table 5 shows annual costs for the policies in 2015, undiscounted. See Appendix B.1 for costs by year.

Table 5. Annual Costs for Efficiency Programs and Policies in 2015 (Millions of 2006$)

Policies	Utility Incentives	Consumer Investments	Program/ Admin	Total Costs
Appliance Standards	NA	$140	$0.2	$140
Building Energy Codes	NA	$49	$1.5	$51
State RD&D Initiative	NA	$2	$5	$7
Utility & State Programs	$139	$139	$31	$308
CHP	$6	$10	$1	$16
Demand Response	**NA**	**NA**	**NA**	**$156**
Total	**$144**	**$339**	**$38**	**$522**

Note: These costs are undiscounted. For demand response programs, we estimate total costs based on BGE proposals, however do not give a breakdown by incentives and administrative costs because those costs are wrapped into the total cost figure, estimated at $76 per participant. Because the utilities would pay for the cost of the DR device (smart thermostat or smart switch), there would be no consumer investment cost except for those installed in new construction.

Text Box 2

State and Per Household Savings & Costs from Residential Programs Implemented in 2008 through 2015 (2006$, undiscounted)

	Residential Utility & State Programs		All Residential Programs/ Policies	
Statewide Savings and Costs (Million $)				
Statewide Savings*				
Total Savings:	$	7,292	$	9,359
Net Savings:	$	5,723	$	7,465
Statewide Costs Over 8-Year Period				
Incentives**	$	697	$	697
Remaining Consumer Investments	$	697	$	1,005
Total Investment Costs:	*$*	*1,395*	*$*	*1,702*
Program/Admin Costs	$	174	$	192
Total Costs	$	1,569	$	1,894
Per Household Savings and Costs ($)				
Maryland Households in 2015 (millions):		2.3		2.3
Household Savings*				
Total Savings:	$	3,194	$	4,099
Net Savings:	$	2,507	$	3,270
Monthly Savings in 2015:	$	11.46	$	13.01
Per Household Costs over 8-Year Period				
Incentives**	$	305	$	305
Remaining Consumer Investments	$	305	$	440
Total Investment Costs:	*$*	*611*	*$*	*746*
Program/Admin Costs	*$*	*76*	*$*	*84*
Costs passed on to Ratepayers***	$	382	$	389
Monthly Costs passed on to Ratepayers***	$	3.98	$	4.06

* Savings are through the life of the measures, which extend up to 20 years beyond 2015.
**Incentives are for state and utility programs only (50% of investment costs), not codes and standards.
*** Includes incentives and program/admin costs.

Tables 6 and 7 show results from the Total Resource Cost Test and the Participant's Test, with a breakdown of total costs (present value in 2006$) by policy type over the lifetime of all measures. Benefits for the Participant's Test from these programs are calculated assuming avoided retail prices of electricity, as shown in Appendix A. We present the results here using a 5% real discount rate, and in Appendix B.1 we also show the same results using a 3% and 7% real discount rate. See Figure 9 for a representation of the results using the various discount rates.

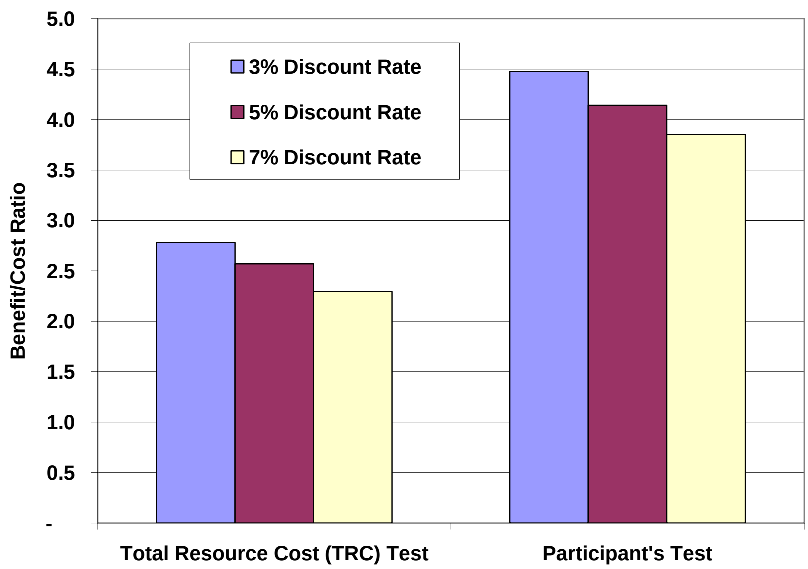
Table 6. Total Resource Cost (TRC) Test

Policies	NPV Costs (Million 2006$)	NPV Benefits (Million 2006$)	Net Benefit	B/C Ratio
Appliance Standards	$ 1,086	$ 2,223	$ 1,137	2.0
Building Energy Codes	$ 460	$ 776	$ 316	1.7
State RD&D Initiative	$ 326	$ 922	$ 596	2.8
Utility and State Programs	$ 3,591	$ 9,419	$ 5,827	2.6
CHP	$ 185	$ 987	$ 803	5.3
Demand Response	$ 564	$ 1,639	$ 1,075	2.9
Total	$ 6,211	$ 15,966	$ 9,754	2.6

Table 7. Participant's Test

Policies	NPV Costs (Million 2006$)	NPV Benefits (Million 2006$)	Net Benefit	B/C Ratio
Appliance Standards	$ 1,084	$ 3,279	$ 2,195	3.0
Building Energy Codes	$ 450	$ 1,224	$ 774	2.7
State RD&D Initiative	$ 275	$ 1,390	$ 1,115	5.1
Utility and State Programs	$ 3,302	$ 14,918	$ 11,616	4.5
CHP	$ 180	$ 1,098	$ 918	6.1
Total	$ 5,290	$ 21,909	$ 16,619	4.1

Figure 9. Results of TRC and Participant's Test Using Three Discount Rates



Macroeconomic Analysis: Impact of Policies on Maryland's Economy, Employment, and Energy Prices

In this section of the report we present the results of an assessment of the macroeconomic impacts of our suite of energy efficiency policy recommendations on the economy of Maryland. These policies result in a substantial reduction in consumer energy expenditures, while creating a significant number of new jobs. In fact, continued investments in energy efficiency resources would continue to yield energy resource benefits for many years into the future. Maryland has the opportunity to transition its energy markets to a more sustainable energy market to benefit consumers and the environment.

Methodology

This economic evaluation is undertaken in three steps. First, we calibrate ACEEE's economic assessment model called DEEPER (Dynamic Energy Efficiency Policy Evaluation Routine) to reflect the economic profile of the Maryland economy (Laitner 2007), incorporating the anticipated investment patterns that are assumed in the reference case (e.g., construction of new electric power plants projected in the forecast). Second, we transform the set of key efficiency scenario results from the policy analysis above into inputs for the economic model. The resulting inputs include such parameters as:

1. The level of annual program spending that drives the policy scenario;
2. The electricity savings that result from the various energy efficiency policies or the level of alternative electricity generation from onsite renewable and combined heat and power technologies; and
3. The capital and operating costs associated with those technology investments.

Finally, the model is run to check both the logic and the internal consistency of the modeling results. A detailed description of the economic model is presented in Appendix D.

Impacts of Recommended Energy Efficiency Policies

Three sets of impacts for the benchmark years of 2015 and 2025 were estimated using the investment and savings results from the policy scenario. For each benchmark year, the change in a sector's spending pattern relative to the reference scenario was matched to the appropriate sectoral impact coefficient. These negative and positive changes were summed to generate the estimated net result shown in the series of tables that follow.

Table 8 presents the estimated change in Maryland's electricity production patterns from the efficiency scenario compared to the reference case, along with the investment and program costs required to achieve these savings. These patterns are driven by the energy efficiency policy initiatives outlined in the policy analysis (a detailed table with data for the years 2010, 2015, 2020 and 2025 can be found in Appendix D).

Table 8 also presents the changes in consumer expenditures that result from these policies. While we present the full cost of the energy efficiency policies, programs and investments, the utility customers will likely borrow a portion of the money to pay for these investments. Thus, consumer outlays, estimated at $1 million in 2008 and rising to $2.6 billion in 2023, include actual "out-of-pocket" spending for programs and investments, along with money borrowed to underwrite the larger technology investments. The annual electricity savings reported in the table are a function of reduced electricity purchases from the Maryland utilities at the initial electricity prices in a given year.

Table 8. Changes in Maryland Electricity Production and the Financial Impacts from Energy Efficiency Policy Scenario: 2015 & 2025

(Millions of 2006 $)	2015	2025
Annual Policy and Program Costs*	$183	$171
Annual Technology Investments*	$484	$832
Efficiency Gains (GWh)	10,520	22,164
Change from Reference Case	15.4%	29.3%
Annual Consumer Outlays	$665	$1,211
Annual Electricity Savings	$1,403	$3,265
Electricity Supply Cost Adjustment	$-123	$-588
Net Consumer Savings	$861	$2,642
Net Cumulative Energy Savings	$1,947	$20,684

* Policy and program costs include administrative costs to run programs plus incentives provided to consumers. Annual technology investments are the total investments in efficiency measures, regardless of whether utility incentives or consumers contribute the costs.

This set of energy efficiency policies spurs both program costs and technology investments that change the patterns of electricity consumption and production. Program spending of $183 million in 2015 leverages $484 million in efficiency technology investments in that same year. The initial impacts on electricity production are quite large in 2015, reducing electricity demand by 10,520 GWh (about 15% below reference case demand). Both program spending and investments rise to $171 and 832 million dollars, respectively, by 2025. The cumulative impact of activities over the time horizon steadily reduces the demand for conventional electricity generation so that by 2025 energy efficiency displaces the forecasted electricity production by about 29%.

Our analysis also explores the impact of reduced consumption on electricity prices. Previous research has shown that in tight markets, small changes in energy demand can have large impacts on energy prices, particularly for natural gas (see Elliott and Shipley 2005; Elliott 2006). The changed electricity production patterns, including both reduced electricity demands and efficiency technology investments, produces a negative adjustment in the electricity supply costs (see Table 10) due to the lower capital and operating expenditures associated with the energy efficiency policy scenario—in other words, the efficiency policies reduce wholesale electricity prices, as shown in the *Electricity Supply Cost Adjustment.* This is equivalent to a 2 mil reduction in wholesale electricity prices in 2015 and a 1.1 cent reduction in 2025, compared to the reference case.

The category of net consumer savings estimates the consumers' total savings from both lower electricity consumption and lower costs, minus consumer outlays. In 2008, businesses and households save $1,403 million in reduced electricity consumption, $123 million in reduced electricity prices, and spend $665 million in outlays for a net savings of $861 million. Adding the electricity supply cost adjustment savings to the overall savings from reduced participants' bills through efficiency policies, which is shown as *Annual Electricity Savings,* and subtracting consumer costs, this totals an estimated savings of $861 million in 2015 and rising to nearly $3 billion in 2025, annually. As electricity savings increases and as costs further decline, the cumulative net consumer savings quickly rises to a net gain of about $1.9 billion by 2015 and $20.7 billion by 2025.

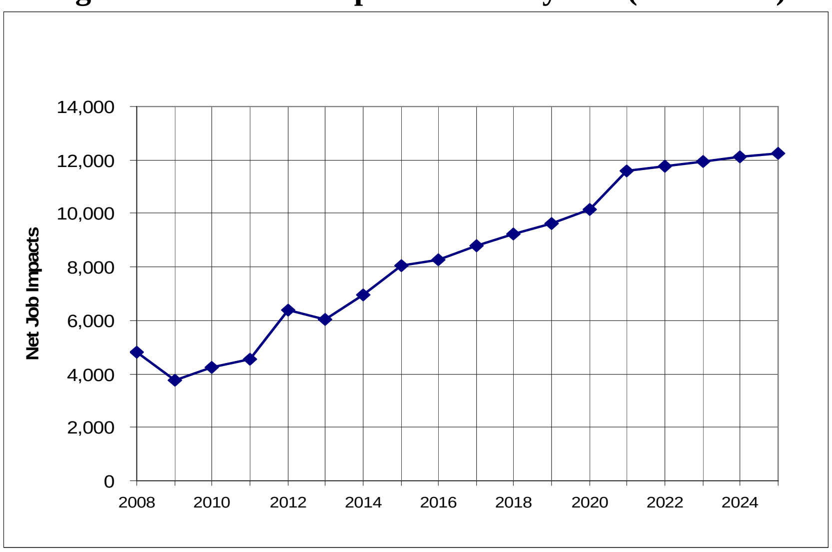
Once each of the net sector spending changes has been evaluated for a given year, the DEEPER model then evaluates impact on jobs and wages sector-by-sector, and evaluates their contribution to the state's GSP. Table 9 highlights the net impacts, again for the benchmark years 2015 and 2025.

Table 9. Economic Impact of Energy Efficiency Investment in Maryland

Macroeconomic Impacts	2015	2025
Jobs (Actual)	8,067	12,241
Wages (Million $2006)	462	780
GSP (Million $2006)	1,164	751

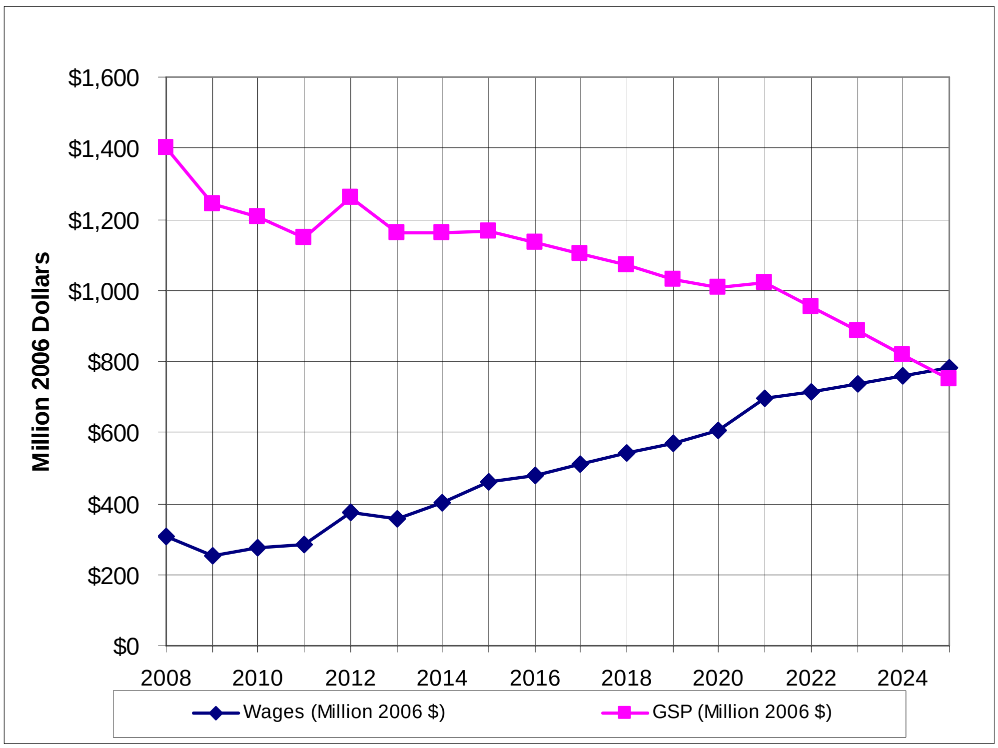
The analysis estimates a net contribution to the Maryland employment base as measured by full-time jobs equivalent of over 8,000 in 2015 and over 12,000 in 2025 (see Figure 10). In other words, once the job gains and losses are netted out in each year, the analysis provides the net annual employment benefit of the policies that impacts the larger Maryland economy. Figure 10 provides year-by-year impacts on net jobs in Maryland. The increase in jobs and the changes in job mix result in a net gain to the state's wage and salary compensation, measured in millions of 2006 dollars, as shown in Table 11 and Figure 11.

Figure 10. Net Job Impacts for Maryland (2008-2025)



The impact of the policies on Maryland's GSP might suggest a somewhat counterintuitive result, however. While job and wage benefits continue to grow throughout the study period, as can be seen in Figure 11, the impact on GSP declines though remains positive throughout the time period. The reason for this decline is that the electric utilities are a capital-intensive sector, but one that is also generally non-labor intensive. Movement away from greater capital intensity to a more labor-intensive energy policy shifts the composition of GSP away from utility plant investment toward more productive and more labor-intensive spending. As it turns out, this generates a positive impact on GSP, though produces downward-sloping impacts compared to how the changed spending patterns influence jobs and wages.

Figure 11. Wages and Gross State Product Impacts for Maryland (2008-2025)

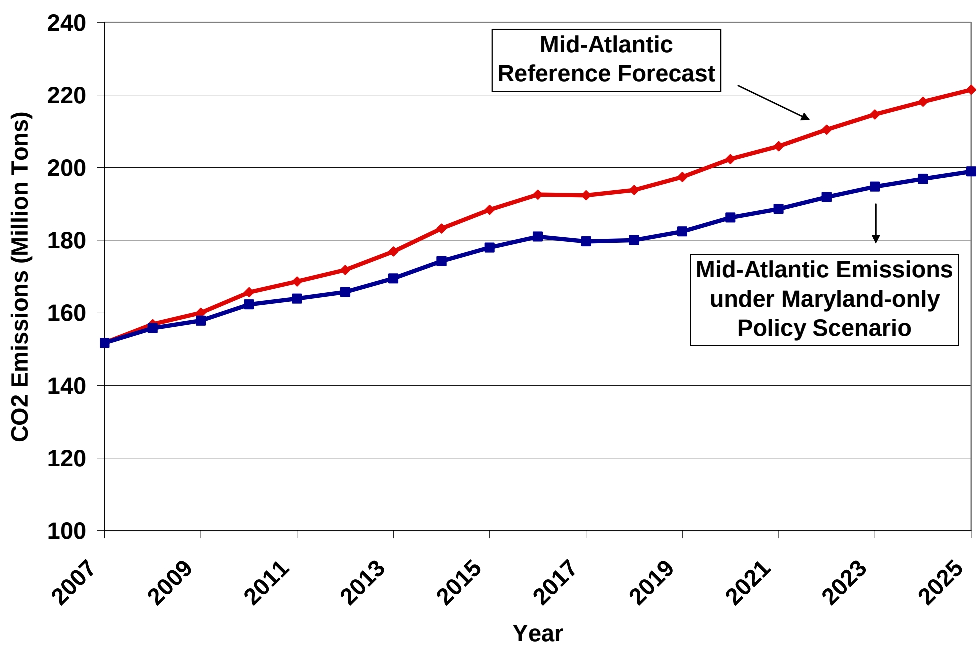


Carbon Dioxide Emissions Reductions

The policy scenario described above would reduce carbon dioxide (CO_2) emissions by about 10 million tons in 2015 and 23 million tons in 2025 for the Mid-Atlantic region (see Appendix B.1 for assumptions and methodology). In 2006, CO_2 emissions attributable to electricity generation in Maryland alone were about 34 million tons (EIA 2007a). Electricity savings from Maryland efficiency policies, however, would have an impact across the Mid-Atlantic region due to the nature of the PJM wholesale market. We therefore estimate these CO_2 reductions from energy efficiency program and policies relative to the entire Mid-Atlantic region.

The reductions are equivalent to a 6% and 10% drop in reference forecast CO_2 emissions for the entire Mid-Atlantic power pool region by 2015 and 2025, respectively (see Figure 12). It is important to note, however, that the percent reductions in Maryland-specific emissions are much greater. If the entire region, which includes Pennsylvania, New Jersey, Maryland, Delaware, and the District of Columbia, reduces electricity consumption similar to the Maryland policy scenario, there would be a significantly greater drop in CO_2 emissions in the region.

Figure 12. Mid-Atlantic CO_2 Emissions in Reference Forecast and Maryland Policy Scenario



ENERGY EFFICIENCY RESOURCE ASSESSMENT

This section presents results from the assessment of cost-effective energy efficiency resources in residential and commercial buildings, the industrial sector, and combined heat and power (CHP). Detailed information on methodology and results are shown in Appendix C.

Energy Efficiency in Residential Buildings

To examine the economic potential for energy efficiency resources in Maryland's residential sector, we considered a scenario with widespread adoption of cost-effective energy efficiency measures during the 18-year period from 2008 to 2025. We evaluated a number of efficiency measures that might be adopted in existing and new residential homes based on their relative cost-effectiveness. An upgrade to a new measure is deemed cost-effective if its levelized cost[10] of conserved energy (CCE) is less than 11.5 cents per kWh

[10] Levelized cost is a level of investment necessary each year to recover the total investment over the life of the measure.

saved, which is based on current average residential electricity prices in Maryland (EIA 2008); however, the overwhelming majority (98%) of the total efficiency potential has a levelized cost of 8 cents per kWh saved or less and nearly 40% of the measures have a cost of 3 cents per kWh or less. For all measures, we estimate a levelized cost of about 4 cents per kWh saved (see Table 10). See Appendix C.1 for a detailed methodology and specific efficiency opportunities and cost-effectiveness for residential buildings (Table C.1). Also shown in Appendix C.1 is a characterization of a typical household in Maryland and the resulting energy bill savings from implementation of efficiency measures described below.

Table 10. Residential Energy Efficiency Potential and Costs by End-Use

End-Use	Savings in 2025 (GWh)	Savings in 2025 (%)	% of Efficiency Potential	Levelized Cost of Saved Energy ($/kWh Saved)
Existing Homes				
HVAC	3,315	11%	34%	$ 0.048
Water Heating	1,087	3%	11%	$ 0.074
Lighting	2,037	7%	21%	$ (0.003)
Refrigeration	279	1%	3%	$ 0.060
Appliances	55	0%	0.6%	$ 0.082
Furnace Fans	371	1%	4%	$ 0.066
Plug Loads	700	2%	7%	$ 0.030
Electricity Use Feedback	815	3%	8%	$ 0.024
Subtotal	**8,660**	**28%**	**90%**	**$ 0.037**
New Homes	**965**	**3%**	**10%**	**$ 0.059**
Total	**9,624**	**31%**	**100%**	**$ 0.039**

We estimate an economic potential for efficiency resources of about 9,624 GWh in the residential sector in the 17-year period of 2008–2025, or a potential savings of 31% of the reference case electricity consumption in 2025 (Table 10). Existing homes can reduce electricity consumption by 28% through the adoption of a variety of efficiency measures (see Appendix C, Table C.1). While newly-constructed homes built today can readily achieve 15% energy savings (ENERGY STAR® new homes meet this level of efficiency), we also estimate that new homes can reach 30% and 50% energy savings cost-effectively. We estimate that new residential homes can yield electricity savings of about 965 GWh by 2025, or 10% of total potential savings in the residential sector.

In the residential sector, the major opportunities for electricity efficiency resources are through improved whole-house performance (e.g., insulation measures, duct sealing and repair, reduced air infiltration, and ENERGY STAR® windows) and more efficient heating, ventilation, and air conditioning (HVAC) equipment and systems.[11] HVAC equipment, air distribution, and load reduction measures account for over one-third, or 34%, of potential savings (38% including more efficient furnace fans).

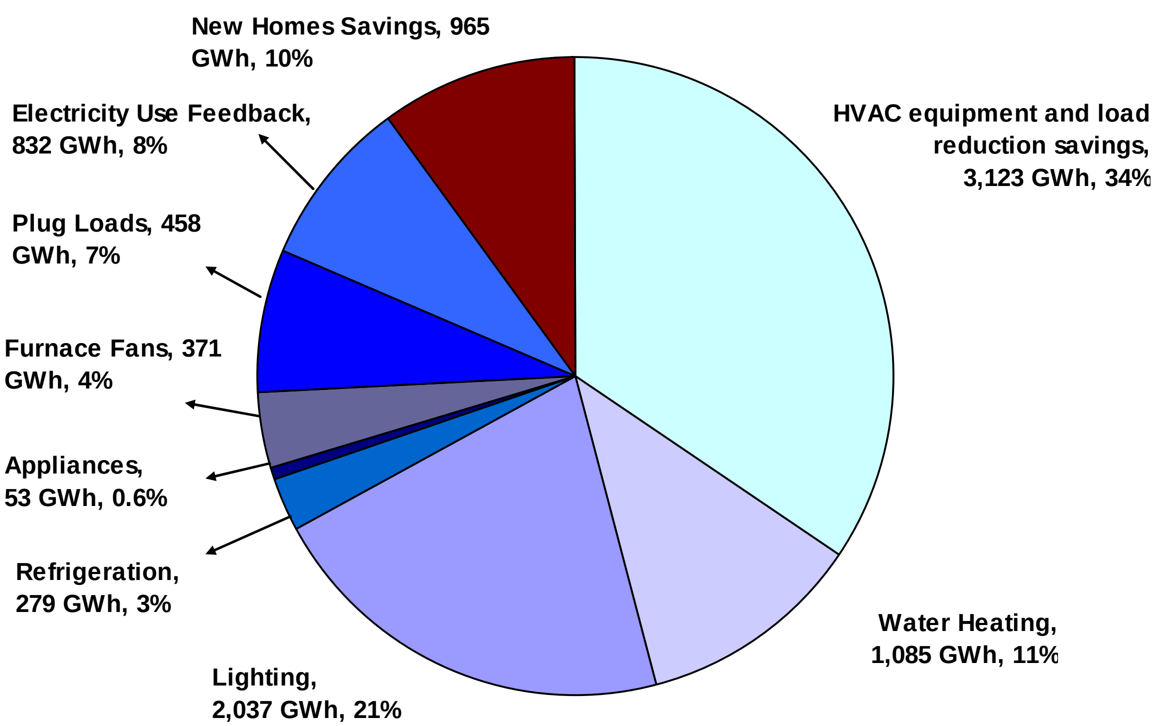
Substantial savings are also attributed to improvements in lighting systems and water heating (including both more efficient water heaters as well as water-consuming appliances). As a fraction of total savings potential in the residential sector, lighting constitutes 21% and

[11] Savings from air-conditioners assume a baseline of 13 SEER equipment, which is the recently updated federal standard.

water heating 11% of potential savings (see Figure 13). There is considerable potential for efficiency resources in both existing and new homes in Maryland simply by replacing household incandescent light bulbs with more efficient compact fluorescent light bulbs (CFL). Measures to reduce hot water loads (such as high-efficiency clothes washers, low-flow showerheads, and water heater jackets and pipe insulation) can yield additional savings for households with electric water heaters. The use of more efficient water heaters, particularly advanced technologies such as heat-pump water heaters, can further reduce electricity used for water heating.

More efficient household appliances can also yield significant savings. Our analysis shows the savings potential of replacing existing refrigerators, clothes washers and dishwashers with units that are better than minimum ENERGY STAR® models (Consortium for Energy Efficiency [CEE] "Tier 2" in most cases), or by having builders install these more efficient models in new homes. Another 7% of the total savings potential can be attributed to reducing the power consumption of electronic devices that use considerable amounts of energy in standby mode. We include a measure for reducing television power consumption in active mode, which is based on ENERGY STAR's Draft 2 Specification revision. These measures are among the most cost-effective in the residential sector. The balance of potential savings comes from installing a real-time energy use feedback mechanism. Although involving a behavioral component, in-home monitors that allow residents to track how much electricity their house is using have been documented to result in significant and persistent savings even without the aid of educational and instructional materials.

Figure 13. Residential Energy Efficiency Potential in 2025 by End-Use in Maryland



TOTAL: 9,624 GWh
31% of Projected Electricity Consumption in 2025

Energy Efficiency in Commercial Buildings

We examined thirty-six energy efficiency measures in the commercial buildings sector to determine the potential for electricity resources from energy efficiency. Thirty-three of these measures are applicable to existing buildings, and each of these measures was categorized by end-use: HVAC; water heating; refrigeration; lighting; office equipment; and appliances/other. In addition we examined savings for new buildings that are 15%, 30% and 50% better than current energy code. To calculate the potential from each of these measures, we first gathered information on baseline electricity consumption in Maryland commercial buildings, and then characterized new measures by collecting data on savings, costs, lifetime of the measure, and the percent of buildings for which the measure is applicable. See Appendix C.2 for a detailed description of the methodology.

Table 11 and Figure 14 show results for energy efficiency potential in commercial buildings by 2025. Results by specific measure are shown in Appendix C.2. We estimate that by 2025, Maryland can reduce its commercial building electricity consumption by 35% at a levelized cost of about $0.02 per kWh saved.[12]

The largest share (49%) of the resource potential is in the lighting sector, which includes measures such as replacing incandescent lamps, fluorescent lighting improvements, and lighting control measures such as daylight dimming systems and occupancy sensors. The second largest share comes from HVAC measures: reduced HVAC loads; improved heating and cooling systems; and HVAC equipment control measures (19%). Measures to reduce HVAC loads include low-e replacement windows, duct testing and sealing, and roof insulation. Equipment upgrades include high-efficiency unitary air conditioners and heat pumps for smaller buildings and high-efficiency chillers and systems for larger buildings. Measures to further increase HVAC efficiency through controls include energy management systems and whole-building retrocommissioning.

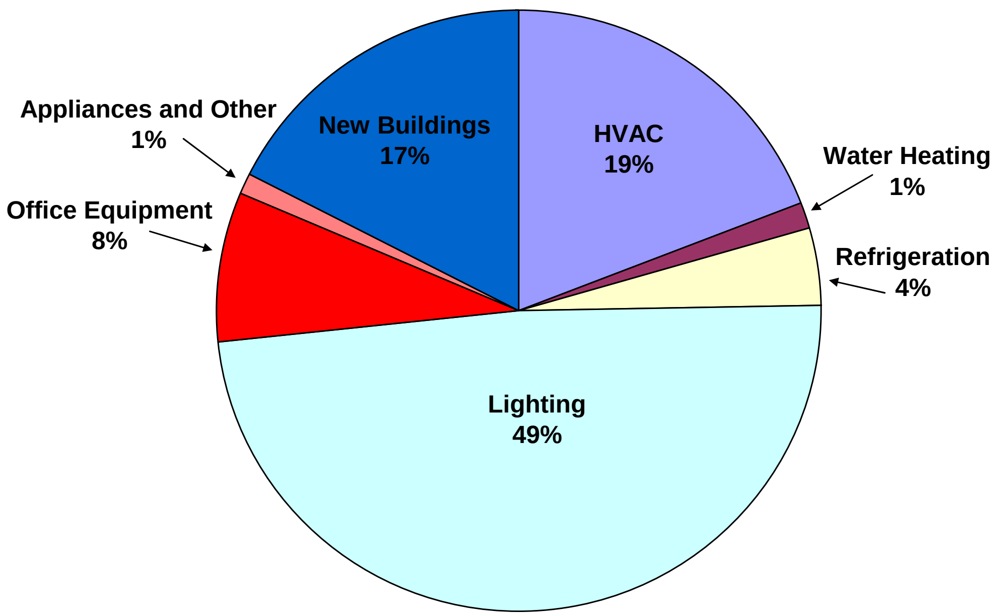
Table 11. Commercial Energy Efficiency Potential and Costs by End-Use

End-Use	Savings Potential in 2025 (GWh)	Savings Potential in 2025 (%)	% of Efficiency Resource Potential	Weighted Levelized Cost of Saved Energy ($/kWh)
Existing Buildings				
HVAC	1,517	6.7%	19%	$ 0.037
Water Heating	100	0.4%	1%	$ 0.033
Refrigeration	349	1.6%	4%	$ 0.019
Lighting	3,847	17%	49%	$ 0.011
Office Equipment	636	2.8%	8%	$ 0.003
Appliances and Other	89	0.4%	1%	$ 0.012
Subtotal	6,539	29%	83%	$ 0.017
New Buildings	1,382	6%	17%	$ 0.036
Total	**7,921**	**35%**	**100%**	**$ 0.020**

[12] Assuming a 5% discount rate.

New, high-performance commercial buildings built today can cost-effectively reduce electricity consumption by 15 to 50% compared to building energy codes. As shown in Table 8, we estimate that efficient new buildings can reduce total electricity consumption by about 6% in 2025, which represents 17% of the total potential.

Figure 14. Commercial Energy Efficiency Potential in 2025 by End-Use in Maryland

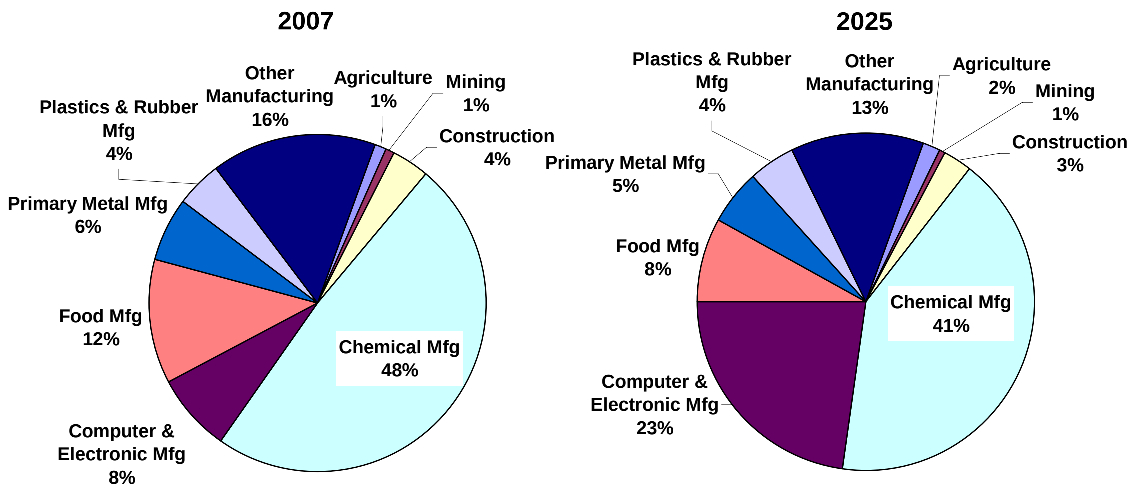


TOTAL: 7,921 GWh
35% of Projected Electricity Consumption in 2025

Energy Efficiency in Industry

The industrial sector is the most diverse economic sector encompassing agriculture, mining, construction and manufacturing. Because electricity use and efficiency opportunities vary by individual industry—if not individual facility—it is important to develop a disaggregated forecast of industrial electricity consumption. Unfortunately this energy use data are not available at the state level, so ACEEE has developed a method to use state-level economic data to estimate disaggregated electric use. This study drew upon national industry data to develop a disaggregated forecast of economic activity for the sector. We then applied electricity intensities derived from industry group electricity consumption data reported and the value of shipments data to characterize each sub-sector's share of the industrial sector electricity consumption (see Figure 15). Due to changes in economic activity and changes in energy intensity as discussed in Appendix C, we see a significant intra-sectoral shift in energy consumption. As the figure shows, a significant increase is projected in the share of industrial electricity use by computer and electronic manufacturing, with corresponding reductions in other industrial sub-sectors. These intra-sectoral shifts are important because they identify where new investments are being made and where energy efficiency opportunities are concentrated.

Figure 15. Estimated Electricity Consumption for the Largest Consuming Industries in Maryland in 2007 and 2025



We then applied industry specific end-use data to apportion electricity consumption to key end-uses that was then used to estimate the potential energy savings of 10 measures judged to be cost effective at forecasted electricity rates, applied at an industry level. This analysis found economic savings from these measures of 1,720 million kWh or 20% of industrial electricity use. In addition, this analysis did not consider process-specific efficiency measures that would be applied at the individual site level because available data does not allow this level of analysis. However, based on experience from site assessments by the U.S. Department of Energy and other entities, we would anticipate an additional economic savings of 5–10%, primarily at large energy-intensive manufacturing facilities such as the ArcelorMittal Sparrow Point steel mill and chemical plants, all in the BG&E service territory. So the overall economic industrial efficiency resource opportunity is on the order of 25–30%.

Combined Heat and Power

Combined heat and power, also known as cogeneration, involves the sequential production of two or more usable energy outputs (e.g., electricity and thermal energy, either heating or cooling) from a single fuel input. By harnessing much of the energy normally wasted in power-only generation, significant improvements in efficiency can be realized relative to separate production of power and thermal energy (see Elliott and Spurr 1999).

This report undertook an assessment of the unrealized potential for CHP in the state of Maryland by assessing the electricity end-uses at existing industrial, commercial and institutional sites across the state, as discussed in Appendix E. In addition the analysis looked at likely future sites that will be built in the future. These facilities would replace a thermal system (usually a boiler) with the CHP system that also produces power and that is primarily intended to replace purchased power that would otherwise be required at the site.

An additional application of CHP considered by this analysis is in the production of power and cooling through the use of thermally activated technologies such as absorption refrigeration. This application has the benefit of producing electricity to satisfy onsite power requirements and displacing electrically generated cooling, which reduces demand for electricity from the grid, particularly at periods of peak demand (see Elliott and Spurr 1999).

Two potentials were assessed, with results presented in Table 12:

- *Technical potential*—the potential not taking economic considerations into account
- *Economic potential*—the potential where the system investment is justified by the anticipated cost of avoided electricity and the cost of fuel (in this case assumed to be natural gas). These economic considerations are discussed in detail in Appendix E.

Table 12. Technical and Economic Potential for CHP in Maryland by System Size

	50-500 kW	500 kW-1,000 kW	1-5 MW	5-20 MW	>20 MW	All Sizes
	MW	MW	MW	MW	MW	MW
Economic Potential	168	17	37	0	70	291
Technical Potential	705	864	1,041	543	931	4,084

Based on typical operating conditions, this economic capacity would produce the results as presented in Table 13.

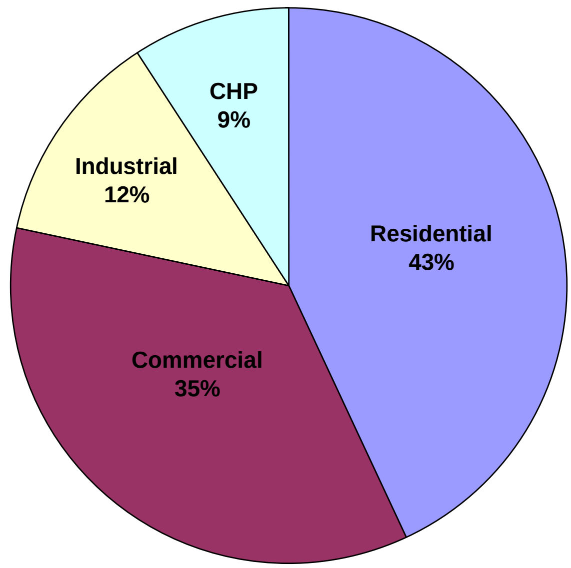
Table 13. Impacts of Economic CHP Capacity

Year	Capacity (MW)	Avoided Cooling Electricity (MW)	Fuel Conserved (billion Btu/year)	Avoided Boiler Fuel (billion Btu/year)	Electricity Generated (million kWh)	Avoided Cooling Electricity (million kWh)
Economic Potential	291	10	18,877	7,311	2,001	29

Overall Energy Efficiency Resource Potential in Maryland

We estimate a total cost-effective resource potential of about 22,400 GWh from currently available energy efficiency technologies and practices in residential and commercial buildings, industrial facilities, and CHP systems (see Figure 16 for a summary of the total electricity savings potential by sector). These resources are clearly sufficient to meet the projected 2015 policy suite savings of 10,500 GWh and have the potential to meet the policies analyzed through 2025. It is important to note, however, that the efficiency resource potential only characterizes current, cost-effective technologies. New, emerging technologies and reductions in the costs of existing technologies not currently cost-effective will expand the cost-effective resource potential significantly based on past analyses (see Shipley and Elliott 2006). The policy suite does consider a portion of this uncharacterized potential with the RD&D initiative, which will help reduce technology cost and accelerate the development of new technologies and practices.

Figure 16. Share of Energy Efficiency Resource Potential in 2025 by Sector



Total: 22,384 GWh

The resource potential also characterizes energy efficiency technology costs for each sector. Table 14 shows an average levelized cost for all measures analyzed in the residential, commercial, industrial, and CHP resource assessments. These costs are used for the policy analysis to estimate technology investment costs for efficiency programs, and are highly supported by past reviews of energy efficiency programs' measured and verified efficiency measures (Elliott et al. 2003).

Table 14. Technology Costs by Sector from Resource Assessment

Sector	Levelized Cost ($/kWh)*
Residential	$0.039
Commercial	$0.020
Industrial	$0.026
CHP*	$0.045

Note: We assume a discount rate of 5% and an average lifetime of 13 years for residential and commercial measures and 15 years for industrial measures based on the resource assessment. Note that the cost of CHP varies by year due to variation in the price of natural gas.

DISCUSSION AND RECOMMENDATIONS ON ADDITIONAL CONSIDERATIONS

While this study has attempted to make use of the best publicly available information, it is important for the reader to understand the uncertainties associated with the results and how the results of this report are intended to be used. As was noted earlier, this report represents the third in a series of state policy analyses (see Elliott et al. 2007a, 2007b for studies in Florida and Texas). In contrast to many other state energy efficiency studies that focus on a detailed assessment of the technical and economic potential for energy efficiency and conservation, these reports are intended to assess the cost-effective energy efficiency resources that can be realized through a specific suite of policies and by doing so to assist state policy leaders, legislators, and regulators in development of high-level policies and regulations. The efficiency resource assessment is conducted to provide policy-makers a level of confidence that the estimated policy impacts are realistic. The resource assessment is not intended to provide detailed, measure-level assessments that would be needed to support the development of the detailed program plans that are needed to realize the efficiency potential. Some entities, such as BG&E, have already undertaken some of these studies and we anticipate more analysis will be needed in the future both to most effectively target efforts as well as to assess the success of the policies and programs.

State Center for Energy Data and Forecasts

To enable this additional analysis, Maryland needs a robust and consistent set of energy data and forecasts. One of the biggest challenges ACEEE faced in undertaking this study was the availability of consistent data and forecasts for the state. This problem is common in many other states we have analyzed, and results from a combination of factors. The movement in the 1990s toward utility restructuring not only resulted in the suspension of most energy efficiency utility programs, but also led to termination of many energy data collection and market surveying activities. This problem is not unique to states. Budget cuts over the past decade have resulted in the termination of important data sources by federal agencies such as DOE's Energy Information Administration and the U.S. Census Bureau.

If Maryland is serious about realizing the benefits of energy efficiency resources, the state and utilities must be focused and strategic about identifying data needs and following through on collection of these data resources. They should work together to develop and implement a coordinated plan for collecting this information in order to effectively design and evaluate the performance of efficiency programs.

To accomplish this task, a state agency such as PSC or MEA should be designated as the energy data coordinator for the state. While utilities such as BG&E are resuming the collection of some of this data, it is important that the collection is comprehensive and consistent across the state. This entity should consider developing data resources including the following:

- A consensus statewide electricity and peak demand reference forecast on which to base the current and future efficiency targets.
- Appliance saturation surveys (similar coordinated surveys conducted by each utility, or perhaps a single survey with each utility on the steering committee and the study designed to provide utility-specific breakdowns).

- New construction baseline surveys (e.g., a statewide survey with utility-specific information). These should include building size and key features suggestive of energy efficiency.

- End-use load-shape studies to help identify the contribution of each major sectoral end-use to peak electrical demand. Power costs are particularly high during peak demand periods, and understanding and reducing the major loads at times of peak demand can be very cost-effective.

- Measurement and verification studies using common methodologies and reporting formats to provide data on measure and program costs and savings.

By having a single entity with the responsibility and resources to collect and analyze energy data, the state will be able to verify that its policies are achieving their goals, and future analysts will have the necessary data to identify energy efficiency opportunities and design programs to realize these energy efficiency resources. While having good data and forecasts will not save energy by itself, it represents an important enabling infrastructure.

Additional Considerations

Data is not the only infrastructure required for the state to realize its energy efficiency resource potential. Unlike supply resources, energy efficiency resources do not necessarily involve major capital investments such as power plants and transmission lines. Rather, efficiency is much more focused on human and informational infrastructure. Energy efficiency tends to be more labor intensive than are supply resources, requiring a trained workforce to identify and implement the efficiency resources whether they are industrial plant process optimization or residential HVAC tune-ups.

One of the challenges facing energy efficiency resources will be building an adequate workforce to meet the demands of the market. This issue is moving to the forefront in many states seeking to expand energy efficiency, and requires a focused response by state leaders, particularly with universities and community colleges. Leading states like Texas, New York and California are mobilizing their workforce training infrastructure to begin to develop the energy efficiency experts and technicians needed to meet future market demand. Fortunately, Maryland already has expertise on energy efficiency within the University of Maryland system, which needs to be nurtured and expanded across the state. The state should consider forming an energy workforce coordinating council that can bring together the key players across the state so they can begin to prepare to meet the needs that a clean energy future will generate.

CONCLUSION

Maryland is poised to make important decisions about its energy future, choosing between a clean energy path or continuing on its current path that has led to rapidly rising energy bills and environmental concerns. Energy efficiency resources represent the least cost resource available to meet the state's future energy needs. By fully implementing the available energy efficiency resources, the state can benefit from lower electricity bills, cleaner air and reduced greenhouse gas emissions, while jump-starting clean energy economy in the state and creating "green-collar" jobs. In addition, energy efficiency resources lay a foundation for expanding the share of the state's electricity that can be met from other clean energy resources such as renewables by containing the rate of electricity growth in the state.

Governor O'Malley has set ambitious energy efficiency goals for the state, and this study confirms that the resources are available to attain these goals. The policies and programs we suggest have been demonstrated to deliver these efficiency resources in other states in the U.S. What is needed is a commitment by the Maryland leaders to the clean energy path. The state and its utilities have begun to lay the groundwork for these policies and programs. The next step is to commit to the targets that the Governor has proposed and adopt policies to achieve these goals.

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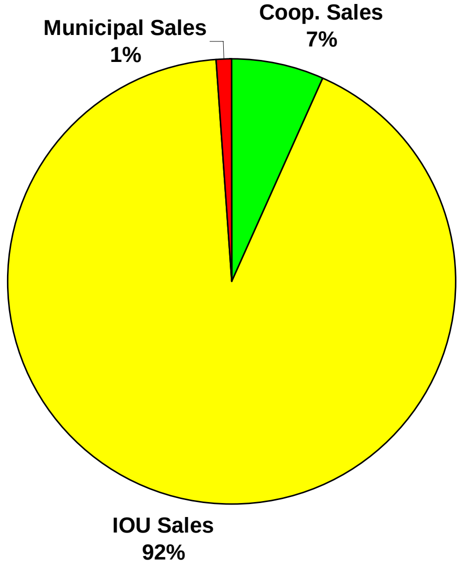
APPENDIX A. ELECTRICITY AND PEAK DEMAND REFERENCE CASE

A.1. Background

Electricity is delivered in Maryland to consumers by three types of providers: investor-owned utilities (IOUs), rural electric cooperatives (coops), and municipal electric suppliers. As can been seen Figure A.1, IOUs dominate the sales in the state.

Figure A.1. Electricity Deliveries by Supplier Type



Source: EIA (2006)

Legislation passed in 1999 mandated that electricity sales in Maryland be restructured to give customers the choice of the source of their electricity power from the IOUs. Of IOU sales, 63% are bundled services distributed by the utility itself, and 37% are delivered to third parties for distribution (EIA 2006).

A.2. Methodology

The first task in developing a state energy efficiency potential assessment is to determine a disaggregated reference case of energy consumption and peak demand in the state. When developing a reference case, it is preferable to use forecasts that are specific to the state or region and that are agreed upon by key stakeholders. The Power Plant Research Program (PPRP) of the Maryland Department of Natural Resources developed electricity consumption and peak demand forecasts for the Public Service Commission in 2007. We used these forecasts as a starting point to share with stakeholders. Based on feedback from stakeholders who viewed the PPRP forecasts as low, we used base year sales and peak demand data from PPRP and developed a forecast using annual growth rates derived from PJM, which is more widely accepted.

Electricity

The PPRP forecast extends to 2016 and disaggregates electricity consumption into three sectors: residential consumption; commercial/industrial consumption, and other (street lighting and company use/losses). The group also presents three scenarios, a base case, low case, and high case. In the base case, total electricity consumption in the state is projected to grow at an average annual rate of 0.55% between 2006 and 2016, and 0.48%, 0.83%, and -0.97% in the residential, commercial/industrial, and other categories, respectively (PPRP 2007). Based on feedback from stakeholders who have concerns that the PPRP forecasts tend to be low, we then looked into PJM electricity demand forecasts.

PJM, the regional transmission operator in the Mid-Atlantic, projects electricity demand on an annual basis. We use their 2008 forecast, which projects demand through 2023, to estimate a forecast for Maryland. PJM does not estimate electricity demand for specific states, but does look at specific geographic zones. For the BGE, Pepco, Allegheny Power (APS), and Delmarva Power & Light zones (DPL), the four regions that fall within the state Maryland, PJM projects electricity demand to grow at an average annual rate of 0.86%, 1.25%, 0.59%, and 1.56%, respectively, between 2008 and 2023 (PJM 2007). We derive a forecast specific to Maryland by estimating the portion of electricity demand in each geographic region that falls within Maryland, and prorate regional sales data by Maryland electricity sales data by utility (EIA 2006).

Using these various sources, we derive an electricity forecast for this analysis. For the base year, we start with 2006 electricity sales data by sector for Maryland from EIA's Electric Power Annual (we made adjustments to the EIA data, which we discuss in detail in the next paragraph) (EIA 2007b). We then apply the annual growth rates from the PJM forecast for electricity demand in all sectors, extending beyond 2023 to 2025 using the 2008-2023 average annual growth rate of 1.0%. PJM's estimates begin in 2008, and we therefore use growth rates from PPRP to determine 2007 and 2008-year estimates. We also use PPRP forecasts to estimate the ratio of growth rates by sector and apply these to the PJM forecast. This methodology results in a 0.83% average growth rate in residential sales from 2007 to 2025, slightly slower than commercial and industrial sales (1.08%). See Table A.1 for odd-year data from the electricity forecast used in this analysis.

EIA's *2007 Electric Power Annual* misrepresented Maryland's 2006 electricity sales data in the commercial and industrial sectors, which was due to changes in BGE's reporting methodology (EIA 2008). As a result, industrial sales were estimated to be only half what they were the previous year. Significant reduction in operations of the state's EastAlco aluminum facility resulted in a major reduction in industrial sales in 2006, contributing to a large portion of the inter-sectoral shift in load. We adjusted the base year 2006 industrial and commercial consumption to account for this misrepresentation.

Peak Demand

For a peak demand forecast, we first looked at the summer peak demand forecasts developed by the Maryland Department of Natural Resources' PPRP. This base case forecast shows summer peak growing from 14,935 in 2006 to 16,381 in 2016, an average annual growth rate of 0.93% (PPRP 2007). To be consistent with the electricity forecast, we also consulted the PJM forecast.

PJM Interconnection's 2008 Load Report shows summer peak load for the entire region growing at an average rate of 1.6% per year for the next ten years (PJM 2007). For the BGE, Pepco, Allegheny Power (APS), and Delmarva Power & Light zones (DPL), the four regions that fall within the state Maryland, PJM projects 1.1%, 1.4%, 0.9%, and 1.9% average annual growth rates, respectively, for the next fifteen years. The PJM peak demand forecasts by geographic region are slightly higher than the PRPP forecast for Maryland. This is because the PJM forecast is largely weather-related and does not take into account price impacts (Estomin 2007).

Given the feedback and data we received from utility stakeholders on the reference case assumptions, we adjust the Maryland PPRP's peak demand reference to align with the PJM forecasts. To develop a modified forecast for the state of Maryland, we use the 2006 base year summer peak demand for Maryland of 14,935 MW from the PPRP. We then apply annual growth rates using an adjusted PJM forecast, which we derive by estimating the portion of peak demand from the PJM regions that fall within Maryland. This includes all of BGE and portions of Pepco, APS and DPL. We estimate these portions using electricity sales data by utility and by state from the Electricity Information Administration (EIA 2006). See Table A.2 for odd-year summer peak demand estimates used in the reference case for this analysis.

Population

Population estimates were needed for this analysis to determine per-capita sales data. We consulted several sources, including Economy.com (2007) and the Census Bureau. Both sources estimate that population in Maryland will grow at an average annual rate of about 0.5%. The Maryland Department of Planning estimates population to grow at an annual rate of about 0.7%. We used an adjustment of the October 2006 population forecasts provided by the Maryland Department of Planning for this analysis, which Exeter Associates adjusted to account for changes due to BRAC (Base Relocation and Closure) as part of the 2007 Statewide Electricity Forecast prepared by Exeter Associates, Inc. for the Maryland Power Plant Research Program.

Electricity Prices

We also developed a retail electricity price reference forecast by sector, as is shown in Table A.4, to estimate consumer bill savings used for the Participant Test. This was developed using average 2007 YTD electricity prices by sector through October 2007 from EIA's Electric Power Monthly (EIA 2008) as a base year. We then extended these retail prices through 2025 using an IPM forecast of Mid-Atlantic wholesale electricity prices (ICF 2007), and adjusting to retail prices using an adder from retail and wholesale electricity prices for the Mid-Atlantic Area Council (MAAC) power pool reported in the *Annual Energy Outlook* (EIA 2007c). For the Total Resource Cost (TRC) test, we used a levelized average avoided utility cost of marginal electricity of $96.87 per MWh, provided by BGE (Wolf 2008). These are estimated from levelized average on-peak avoided costs of about $135/MWh in the summer and $104/MWh non-summer and off-peak avoided costs of about $85/MWh in the summer and $75/MWh non-summer. We also use a levelized avoided summer capacity price, $81.87/kW-year, from BGE's avoided cost assumptions to estimate savings from demand response summer peak reductions (BGE 2008). Table A.5 shows the natural gas retail price forecast used for the CHP analysis, which is explained in more detail in Appendix E.

Table A.1. Retail Electricity Sales Forecast by Sector (GWh)

	2007	2009	2011	2013	2015	2017	2019	2021	2023	2025	Average annual growth rate
Residential	26,786	26,950	27,705	28,179	28,731	29,239	29,674	30,132	30,607	31,104	0.83%
Existing	26,786	26,424	26,657	26,382	26,191	26,012	25,800	25,649	25,555	25,518	
New Construction	0	526	1,048	1,797	2,540	3,227	3,874	4,483	5,052	5,586	
Commercial	18,543	18,826	19,291	19,716	20,126	20,555	21,006	21,479	21,970	22,482	1.08%
Existing	18,543	18,284	18,034	17,879	17,720	17,531	17,321	17,175	17,057	17,002	
New Construction	0	542	1,258	1,837	2,407	3,023	3,685	4,304	4,912	5,480	
Industrial	18,100	18,376	18,830	19,244	19,645	20,063	20,504	20,966	21,445	21,945	1.08%
Total	**63,430**	**64,279**	**65,826**	**67,139**	**68,502**	**69,857**	**71,184**	**72,577**	**74,021**	**75,530**	**0.97%**

Table A.2. Summer Peak Demand Forecast by Sector

	2007	2009	2011	2013	2015	2017	2019	2021	2023	2025	Average annual growth rate
Residential	7,389	7,561	7,760	7,933	8,109	8,265	8,424	8,566	8,725	8,898	**1.0%**
Commercial	4,949	5,110	5,228	5,370	5,496	5,622	5,770	5,908	6,059	6,223	**1.3%**
Industrial	2,550	2,633	2,693	2,766	2,831	2,896	2,972	3,044	3,122	3,206	**1.3%**
Total	**14,888**	**15,304**	**15,681**	**16,069**	**16,437**	**16,782**	**17,166**	**17,518**	**17,906**	**18,327**	**1.2%**

Table A.3. Maryland Population Forecast

	2007	2009	2011	2013	2015	2017	2019	2021	2023	2025	Average annual growth rate
Population estimate	5,721,219	5,899,113	6,023,823	6,116,896	6,211,425	6,290,284	6,370,155	6,466,814	6,580,980	6,697,163	**0.9%**

Source: Maryland Department of Planning.

Table A.4. Maryland Retail Electricity Price Forecast (2006$ per kWh)

	2007	2009	2011	2013	2015	2017	2019	2021	2023	2025	Average annual growth rate
Residential	$0.113	$0.120	$0.128	$0.140	$0.146	$0.150	$0.153	$0.156	$0.158	$0.161	1.96%
Commercial	$0.113	$0.115	$0.117	$0.129	$0.136	$0.141	$0.144	$0.147	$0.149	$0.152	1.66%
Industrial	$0.091	$0.089	$0.080	$0.082	$0.086	$0.089	$0.092	$0.094	$0.096	$0.098	0.41%
All Sectors Average	**$0.111**	**$0.114**	**$0.115**	**$0.125**	**$0.131**	**$0.136**	**$0.139**	**$0.142**	**$0.144**	**$0.147**	**1.56%**

Table A.5. Maryland Retail Gas Price Forecast (2006$ per MMBtu)

	2007	2009	2011	2013	2015	2017	2019	2021	2023	2025	Average annual growth rate
Residential	$15.9	$ 15.1	$ 14.3	$ 14.0	$ 14.3	$ 14.5	$ 14.8	$ 14.9	$ 15.2	$ 15.5	-0.16%
Commercial	$12.9	$ 12.1	$ 11.2	$ 10.8	$ 11.0	$ 11.2	$ 11.4	$ 11.5	$ 11.7	$ 11.9	-0.47%
Industrial	$12.5	$ 11.3	$ 10.1	$ 9.6	$ 10.0	$ 10.2	$ 10.5	$ 10.6	$ 10.8	$ 11.1	-0.68%

APPENDIX B. DETAILED POLICY ANALYSIS

B.1 Policy Scenario Results and Assumptions

The policy scenario models specific policies and programs to capture available energy efficiency resources. In this section, we present electricity impacts and policy costs in Tables B.1 through B.5. Key assumptions are provided in the notes and sources field within each table. Total annual electricity savings, which include prior year savings, are shown in Table B.1. Annual investment costs for these efficiency resources, which include utility incentives and consumer investments, are shown in Table B.2. Utility incentives, which represent a fraction of total investments, are shown in Table B.3. Finally, program and administrative costs bore by utilities and state agencies to administer programs, are shown in Table B.4.

Table B.1. Total Annual Electricity Savings by Policy (GWh)

	2007	2009	2011	2013	2015	2017	2019	2021	2023	2025
Appliance Standards	0	25	135	784	1,636	2,170	2,561	3,061	3,391	3,705
Building Energy Codes	0	0	0	79	264	456	644	877	1,154	1,403
State RD&D Initiative	0	0	0	7	21	52	133	341	873	2,235
Utility and State Programs	0	2,313	4,654	6,456	8,046	9,378	10,842	12,072	13,143	13,473
CHP	0	0	111	332	553	722	944	906	1,127	1,348
Total	0	2,338	4,899	7,658	10,520	12,778	15,125	17,257	19,688	22,164

Notes and Sources

Appliance Standards: Savings from appliance standards are from 2007 enacted state standards, pending federal standards, and additional opportunities for state standards enacted in 2008 and effective in 2010. We assume a 14-year average life. Estimates are from ASAP (2008) as shown in Appendix B.2.

Building Energy Codes: We assume that new residential and commercial building codes are adopted in 2012, effective in 2013, at a 30% savings level in electricity consumption relative to current code. This assumes enforcement starting at 70% compliance in the first year, 80% in second year, and 90% in subsequent years (NY DPS 2007). We assume the savings level increases to 50% in 2020, effective 2021. Prior-year savings degrade at 2.7% per year. We assume a 20-year average lifetime.

State RD&D Initiative: Savings assume results from NYSERDA program, which saved $150 m saved over 10 years in the state. We assume 67% of savings are from electricity measures and prorate by population in Maryland. We assume 3.5% of total saved in 1st yr, 6.5% in second, and 10%, 15%, 25% and 40% in subsequent years (ACEEE estimate)

Utility and State Programs: We assume a 15% per-capita savings target (relative to 2007 sales) by 2015 based on Governor O'Malley's goal. This is equivalent to a 14.5% overall target by 2015, relative to forecasted sales, or an average of 1.8% savings per year. We extend a 1.5% savings per year target to 2025 and assume an average lifetime a 13 years.

CHP: Net displaced purchased electricity from CHP is based on the difference between the forecasted installations in a business as usual and incentive case as discussed in Appendix E. CHP systems are assumed to have a 20 year life.

Table B.2. Total Annual Investments by Policy (Million 2006$)

	2007	2009	2011	2013	2015	2017	2019	2021	2023	2025
Appliance Standards	$0	$3	$16	$81	$140	$156	$156	$170	$170	$170
Building Codes	$0	$0	$0	$40	$49	$48	$46	$110	$104	$98
State RD&D Initiative	$0	$0	$0	$2	$2	$6	$14	$37	$93	$239
Utility and State Programs	$0	$327	$334	$190	$277	$185	$209	$487	$468	$326
CHP	$0	$0	$27	$27	$15	$15	$15	$15	$15	$0
Demand Response	0	$11	$59	$117	$156	NA	NA	NA	NA	NA
Total	$0	$330	$377	$339	$484	$410	$441	$818	$851	$832

Notes and sources

Appliance Standards: Costs are from preliminary ASAP analysis on state opportunities for appliance standards and an assessment of state savings from federal standards (ASAP 2008).

Building Energy Codes: We assume an investment cost of $0.83 per kWh for 30% better than code residential homes and $0.94 per kWh for a 50% savings home. For commercial buildings, we assume an investment cost of $0.20 per kWh for 30% better than code building and $0.52 per kWh for 50%savings.

State RD&D Initiative: We assume costs similar to NYSERDA costs, prorated by state population, to be $5 million per year.

Utility and State Programs: We assume participant investment costs are 1/2 of the total investment costs. For total investments, we assume a $0.37 per kWh investment cost for residential efficiency, $0.19 for commercial, and $0.27 for industrial. These estimates are from the energy efficiency resource assessment and supported by past reviews of M&V efficiency measures (Elliott et al. 2003)

CHP: We assume a installed capacity weighted cost per installed kW of CHP of $1,602 for 2009-2014, $1,400 for 2015-2019 and $1,240 for 2020 on as is discussed in appendix E.

Demand Response: Note that costs for Demand Response programs represent total costs rather than investment costs only. We estimate total costs based on BGE proposals, however do not give a breakdown by incentives and administrative costs because those costs are wrapped into the total cost figure, estimated at $76 per participant. Because the utilities would pay for the cost of the DR device (smart thermostat or smart switch), there would be no consumer investment cost except for those installed in new construction.

Table B.3. Total Annual Incentives by Policy (Million 2006$)

	2007	2009	2011	2013	2015	2017	2019	2021	2023	2025
Appliance Standards	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Building Energy Codes	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
State RD&D Initiative	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Utility and State Programs	$0	$164	$167	$95	$139	$92	$105	$243	$234	$163
CHP	$0	$0	$10	$10	$6	$6	$6	$6	$6	$0
Total	$0	$164	$177	$105	$144	$98	$110	$249	$240	$163

Notes and sources

Appliance Standards: No Incentives

Building Codes: No Incentives

State RD&D Initiative: No Incentives

Utility and State Programs: We assume utility and state programs' incentives are 1/2 of the total investment costs. For total investments, we assume efficiency costs from the resource assessment (see Table B.2), and an average 13-year measure life for residential and commercial measures and 15 years for industrial measures.

CHP: We assume an incentive of $600 per installed kW of CHP capacity.

Table B.4. Total Annual Program/Administrative Costs by Policy (Million 2006$)

	2007	2009	2011	2013	2015	2017	2019	2021	2023	2025
Appliance Standards	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Building Codes	$0	$0	$0	$2	$2	$2	$2	$2	$2	$2
State RD&D Initiative	$0	$5	$5	$5	$5	$5	$5	$5	$5	$5
Utility and State Programs	$0	$37	$37	$21	$31	$21	$23	$18	$15	$1
CHP	$0	$1	$1	$1	$1	$1	$1	$1	$1	$0
Total	$0	$42	$43	$28	$38	$28	$31	$25	$23	$7

Notes and sources

Appliance Standards: Costs are from ASAP and ACEEE report on state opportunities for appliance standards (Nadel et al. 2006).

Building Codes: We assume $1.5 million dollars per year to implement and enforce codes, based on recommendations in New York (NY DPS 2007)

State RD&D Initiative: We assume costs similar to NYSERDA costs, prorated by state population. Program/admin costs are matched by private sector in consumer investment costs.

Utility and State Programs: We assume residential programs have average administrative costs of 25% of incentives, 20% for commercial programs, and 15% for industrial programs (Elliott et al. 2003).

CHP: We assume program and administrative costs of $500,000 per year, with the majority going to support technical assistance to prospective sites.

Peak Demand Reductions

Electricity savings from energy efficiency policies and programs, which are shown in Table B.1, also have an impact on peak demand reductions. We estimate peak demand reductions from efficiency using coincidental peak factors by sector developed for a forthcoming appliance standards analysis (ASAP 2008). We note, however, that estimating peak demand effects from efficiency is not a straightforward, and therefore these should be taken as approximate. Table B.5 shows estimates of summer peak reductions by year and by policy, including additional impacts from demand response. See Appendix B.3 for a complete description of the demand response policies.

Table B.5. Total Annual Summer Peak Demand Reductions by Policy (MW)

	2007	**2009**	**2011**	**2013**	**2015**	**2017**	**2019**	**2021**	**2023**	**2025**
Appliance Standards	0	5	29	166	346	459	543	648	718	785
Building Energy Codes	0	0	0	18	61	105	149	203	267	325
State RD&D Initiative	0	0	0	1	4	10	26	66	169	433
Utility and State Programs	0	491	988	1,371	1,709	1,992	2,304	2,565	2,794	2,864
CHP	0	0	12	37	62	77	91	105	120	134
Energy Efficiency Subtotal	*0*	*496*	*1,029*	*1,594*	*2,183*	*2,644*	*3,112*	*3,588*	*4,068*	*4,542*
Demand Response Programs	0	653	1,644	2,530	3,135	3,599	3,877	3,915	3,947	3,982
Total	**0**	**1,150**	**2,673**	**4,124**	**5,318**	**6,243**	**6,990**	**7,504**	**8,015**	**8,524**

Cost Benefit Analysis

The tables below show results of the Total Resource Cost (TRC) Test and the Participant's Test using three discount rates: 3%, 5%, and 7%. For the TRC avoided costs, we assume BGE's utility avoided costs discussed in Appendix A. We note, however, that the success of increased efficiency and demand response programs will likely change the value of the incremental energy and capacity avoided. Estimating these effects, however, were out of the scope of this project and we therefore use consistent avoided cost values.

Table B.6. Total Resource Cost (TRC) Test Using 3% Discount Rate

Policies	NPV Costs (Million 2006$)	NPV Benefits (Million 2006$)	Net Benefit	B/C Ratio
Appliance Standards	$ 1,385	$ 3,044	$ 1,659	2.2
Building Energy Codes	$ 599	$ 1,127	$ 528	1.9
State RD&D Initiative	$ 444	$ 1,423	$ 980	3.2
Utility and State Programs	$ 4,326	$ 12,212	$ 7,886	2.8
CHP	$ 221	$ 1,421	$ 1,200	6.4
Demand Response	$ 641	$ 1,956	$ 1,315	3.1
Total	$ 7,616	$ 21,184	$ 13,568	2.8

Table B.7. Total Resource Cost (TRC) Test Using 5% Discount Rate

Policies	NPV Costs (Million 2006$)	NPV Benefits (Million 2006$)	Net Benefit	B/C Ratio
Appliance Standards	$ 1,086	$ 2,223	$ 1,137	2.0
Building Energy Codes	$ 460	$ 776	$ 316	1.7
State RD&D Initiative	$ 326	$ 922	$ 596	2.8
Utility and State Programs	$ 3,591	$ 9,419	$ 5,827	2.6
CHP	$ 185	$ 987	$ 803	5.3
Demand Response	$ 564	$ 1,639	$ 1,075	2.9
Total	$ 6,211	$ 15,966	$ 9,754	2.6

Table B.8. Total Resource Cost (TRC) Test Using 7% Discount Rate

Policies	NPV Costs (Million 2006$)	NPV Benefits (Million 2006$)	Net Benefit	B/C Ratio
Appliance Standards	$ 860	$ 1,651	$ 791	1.9
Building Energy Codes	$ 357	$ 545	$ 188	1.5
State RD&D Initiative	$ 241	$ 606	$ 364	2.5
Utility and State Programs	$ 3,025	$ 7,387	$ 4,362	2.4
CHP	$ 156	$ 704	$ 548	4.5
Demand Response	$ 498	$ 899	$ 401	1.8
Total	$ 5,137	$ 11,792	$ 6,654	2.3

Table B.9. Participant's Test Using 3% Discount Rate

Policies	NPV Costs (Million 2006$)	NPV Benefits (Million 2006$)	Net Benefit	B/C Ratio
Appliance Standards	$ 1,383	$ 4,509	$ 3,126	3.3
Building Energy Codes	$ 586	$ 1,783	$ 1,197	3.0
State RD&D Initiative	$ 383	$ 2,148	$ 1,766	5.6
Utility and State Programs	$ 3,990	$ 19,332	$ 15,341	4.8
CHP	$ 215	$ 1,589	$ 1,374	7.4
Total	$ 6,557	$ 29,361	$ 22,804	4.5

Table B.10. Participant's Test Using 5% Discount Rate

Policies	NPV Costs (Million 2006$)	NPV Benefits (Million 2006$)	Net Benefit	B/C Ratio
Appliance Standards	$ 1,084	$ 3,279	$ 2,195	3.0
Building Energy Codes	$ 450	$ 1,224	$ 774	2.7
State RD&D Initiative	$ 275	$ 1,390	$ 1,115	5.1
Utility and State Programs	$ 3,302	$ 14,918	$ 11,616	4.5
CHP	$ 180	$ 1,098	$ 918	6.1
Total	$ 5,290	$ 21,909	$ 16,619	4.1

Table B.11. Participant's Test Using 7% Discount Rate

Policies	NPV Costs (Million 2006$)	NPV Benefits (Million 2006$)	Net Benefit	B/C Ratio
Appliance Standards	$ 858	$ 2,425	$ 1,567	2.8
Building Energy Codes	$ 349	$ 856	$ 508	2.5
State RD&D Initiative	$ 199	$ 913	$ 713	4.6
Utility and State Programs	$ 2,773	$ 11,710	$ 8,937	4.2
CHP	$ 152	$ 779	$ 627	5.1
Total	$ 4,331	$ 16,683	$ 12,352	3.9

Carbon Dioxide Emissions Reductions

In order to estimate annual regional emissions reductions, we first obtained data on projected electricity generation and carbon dioxide emissions from 2007 to 2025 for the Mid-Atlantic Area Council (MAAC) power pool region as reported by the *Annual Energy Outlook* (EIA 2007c). We then calculated an *output emission rate*, defined as the ratio of emissions (lbs) to electricity generation (MWh). Using data from eGRID on subregion emission rates and converting to standard tons (EPA 2007e), we calculated a *net marginal emissions factor* (ton/MWh), which is our *output emission rate* multiplied by the ratio of marginal to average emission rates. We then took our *emissions factor* and multiplied by Maryland's estimated electricity savings (GWh) from the policy scenario in order to determine the regional *carbon dioxide emissions savings* for the 18-year period.

B.2. Appliance Standards

For this analysis, we considered three categories of lighting/appliance standards, listed below. Savings estimates for each product are shown in Table B.12 and more details on each product will be released in a forthcoming analysis (ASAP 2008).

- Federal legislated standards and federal rulemakings enacted or likely to be enacted after July 2006 (based on minimizing life-cycle cost):
  - Residential appliances: dishwashers, clothes washers and dryers, refrigerators, dehumidifiers, room air conditioners, and ranges and ovens
  - Electric motors
  - Residential boilers
  - General service incandescent lamps
  - Distribution transformers (dry-type and liquid)
  - Fluorescent lamps
  - Commercial clothes washers
  - Commercial refrigeration
  - Commercial boilers
  - Residential water heaters
  - Pool heaters
  - Direct heaters
  - Packaged terminal air conditioners and heat pumps
  - Battery chargers
  - Residential central AC/HPs
- State standards enacted in 2007, and to become effective in 2009:
  - Bottle-type water dispensers
  - Commercial hot-food holding cabinets
  - Walk-in refrigerators and freezers
  - State-regulated incandescent reflector lamps (BRs, ERs and R20s)
  - Metal halide lamp fixtures
  - Single-voltage external power supplies (effective 2012)
  - Residential furnaces and furnace fans
- Additional opportunities for state standards to be enacted 2008, effective 2010 (based on ASAP 2008)
  - Fluorescent fixtures
  - Nightlights
  - Compact audio equipment
  - DVD players
  - Portable electric spas

Table B.12. Energy Savings in Maryland from State and Federal Standards by Product

Products	Energy Savings in 2015		Energy Savings in 2030	
	(TWh)	(Tril. Btu)	(TWh)	(Tril. Btu)
Federal Legislation - 2007				
Reflector lamps (BR and R20)*	0.04	0.44	0.04	0.41
External power supplies*	0.02	0.26	0.05	0.48
Metal halide lamp fixtures*	0.09	0.98	0.28	2.83
Walk-in refrigerators and freezers*	0.05	0.52	0.09	0.90
Dishwashers				
electricity	0.002	0.02	0.00	0.04
natural gas	*NA*	0.01	*NA*	0.02
Water	*Bil. Gal.-->*	0.09	*Bil. Gal.-->*	0.18
Electric Motors -- not covered by EPAct	0.01	0.14	0.06	0.57
Electric Motors – covered by EPAct	0.01	0.12	0.05	0.48
Residential Dehumidifiers	0.01	0.05	0.03	0.30
Boilers (nat. gas)	*NA*	0.05	*NA*	0.34
Boilers (oil)	*NA*	0.04	*NA*	0.28
General Service Incandescent Lamps - Tier 1	0.92	9.91	0.92	9.25
General Service Incandescent Lamps - Tier 2	-	-	0.19	1.95
Federal Rulemakings				
Dry type transformers - medium voltage	0.00	0.03	0.01	0.11
Liquid immersed transformers	0.06	0.63	0.22	2.20
Fluorescent lamps	0.48	5.18	0.76	7.69
Incandescent Reflector lamps	0.06	0.69	0.06	0.64
Ranges and Ovens (gas, not self-cleaning)	*NA*	0.09	*NA*	0.49
Commercial clothes washers				
Electricity	0.00	0.03	0.01	0.09
natural gas	*NA*	0.04	*NA*	0.14
Water	*NA*	0.08	*NA*	0.24
Commercial refrigeration	0.06	0.64	0.10	0.98
Commercial boilers	*NA*	0.03	NA	0.18
Water Heaters (res)				
Electricity	0.02	0.20	0.07	0.73
natural gas	*NA*	0.35	*NA*	1.97
Pool heaters	*NA*	0.06	*NA*	0.38
Vending machines	0.00	0.04	0.02	0.16
Direct heaters	*NA*	0.02	*NA*	0.11
Electricity	(0.00)	(0.01)	(0.01)	(0.06)
PTACs and PTHPs	0.00	0.05	0.03	0.28
Refrigerators	0.03	0.37	0.37	3.76
Fluorescent ballasts	0.01	0.10	0.09	0.95
Clothes dryers (residential)				
Electricity	0.02	0.18	0.15	1.46
natural gas	*NA*	0.02	*NA*	0.14
Room AC	0.01	0.07	0.06	0.55
Battery chargers	0.01	0.11	0.03	0.28
Furnaces (nat. gas) - Tier 1*	*NA*	0.00	*NA*	0.01
Furnaces (nat. gas) - Tier 2*	*NA*	0.73	*NA*	5.10
Furnaces (oil)	*NA*	0.01	*NA*	0.07
Res. central air conditioners & heat pumps				
cooling (includes A/C and HP)	-	-	0.50	4.98
heating (HP in heating mode only)	-	-	0.39	3.94

Products	Energy Savings in 2015		Energy Savings in 2030	
	(TWh)	(Tril. Btu)	(TWh)	(Tril. Btu)
Residential Clothes Washers				
electricity – machine	0.00	0.03	0.09	0.88
electricity - water heating	0.01	0.14	0.36	3.58
natural gas	*NA*	0.09	*NA*	2.65
Water	*Bil. Gal.-->*	0.77	*Bil. Gal.-->*	21.63
Small Electric Motors	0.01	0.05	0.08	0.81
State Standards				
Furnace fans*	0.04	0.48	0.31	3.11
Heating	*0.04*	*0.41*	0.26	2.65
Cooling	*0.01*	*0.07*	0.05	0.46
Fluorescent Fixtures	0.09	0.92	0.32	3.20
Metal halide ballasts (Calif. Only)	0.05	0.49	0.20	1.96
Nightlights	0.01	0.14	0.02	0.24
Neon sign power supplies	0.04	0.41	0.11	1.11
Compact audio equipment	0.04	0.48	0.04	0.45
DVD players	0.01	0.14	0.01	0.13
Portable electric spas	0.01	0.10	0.02	0.17
Water dispensers*	0.01	0.07	0.01	0.08
Hot food holding cabinets*	0.01	0.06	0.01	0.14

* Products marked with asterisks were covered under Maryland's 2007 appliance standards bill. In our analysis, we count these standards only under Maryland's 2007 bill category, however we present them in different categories here.

B.3. Demand Response

It is difficult to apply "best practice" programs for demand response to use in Maryland because current demand response programs and applications are relatively young, and to date few "best practices" have been identified and confirmed. Many key technologies (such as smart meters, smart thermostats, and home and building automation networks) are in early phases of commercial availability, while institutional practices for their cost and benefit estimation and regulatory treatment are still evolving. Most areas that have more than ten years of history with specific demand response programs have offered those options to relatively few customers, and are achieving minimal peak load reductions; other areas that are trying to grow their demand response capabilities have to date managed to cut peak load by only a few percentage points. Thus there is a limited amount of actual demand response experience available to guide Maryland's ambitious energy savings and peak load reduction goals.

Therefore, the demand response measures proposed here build upon several established elements already under way in Maryland and the Mid-Atlantic states. First, in recognition of the fact that the Maryland utilities are on the path toward universal deployment of smart meters over the next five years, this report recommends that the demand response measures already proposed by BGE for Public Service Commission approval, be universally deployed across Maryland. Second, to shift some of the demand response financial and marketing burden away from utilities and their ratepayers, this report recommends that the state adopt new energy-related building codes for new residential and commercial buildings to expedite the penetration of high-efficiency, lower-demand air conditioning with smart communicating thermostats and advanced meters. Third, this report recommends that Maryland leverage the substantial analysis into demand response, advanced metering and smart communicating thermostats already conducted by BGE and California utilities and adopt common programs and device specifications to be used by every utility in the state; this will reduce the time and effort required to develop, analyze and implement new programs, lower the costs of device acquisition, and increase the effectiveness of customer education and marketing statewide.

If the recommendations below were implemented, ACEEE analysis (see Table B.5) suggests that they could lower Maryland's peak demand in 2015 by 3,135 MW or 19% below the peak load reference forecast. In combination with the energy efficiency measures recommended above, the cumulative effect would be to drop the state's peak demand by a total of 5,318 MW or 32% below 2015 levels, and 8,524 MW and 47% by 2025.

There are three fundamental policy questions to be considered in Maryland's demand response policy decisions:

1. Given that the costs of electric capacity and reliability affect every citizen in the state, and that demand response measures are among the most effective and cost-effective ways to improve capacity and reliability, do you want to require that every citizen participate in demand response measures, or to let demand response participation be voluntary? Although Maryland's current demand response proposals are voluntary and opt-in, this report assumes that the maximum demand response is desired and can be achieved by requiring every home and business to participate to a limited degree.

2. Since Maryland's utilities are moving toward deployment of advanced interval meters for all electric customers by 2015 or earlier, do you want to install demand response measures that leverage those meters by broadening customers' ability to manage their energy usage in response to time and price, or approve demand response measures that perpetuate direct load control by the utility without improving customers' capabilities? Demand response installation of smart communicating thermostats with programmable features will let customers begin to understand dynamic energy prices (as from Critical Peak Pricing rates and other information delivered by the advanced metering systems) and respond to those prices with deliberate changes in their energy use; those changes will be identified and credited through the customer's advanced meter. In contrast, demand response programs that emphasize the installation of switches for direct load control of air conditioning (or other appliances) in an emergency situation will solve the grid emergency, but will not improve the customer's ability to manage energy use over time or respond to dynamic rates with deliberate energy choices. This report assumes that the best way to leverage Maryland's investment in smart meters will be to require that a preponderance of the new demand response devices will be smart thermostats that expand long-term options and capabilities for the customer as well as for the utility and grid operator.

3. There has been some resistance within the popular press to the notion that smart communicating thermostats that enable the utility to control the customer's appliances – under specific circumstances, with customer compensation for the option – has objectionable, "Big Brother" elements (this is particularly true in California in recent months). However, the electric industry has a long and successful history with direct load control of customer appliances, particularly heating, ventilation, and air conditioning systems and hot water heaters (as practiced by PEPCO). Since Maryland's current utility demand response proposals contemplate that these programs will reach at least half of their customers, with extensive marketing and compensation for participation, and customer surveys have shown that customers are willing to participate, this study assumes that Maryland will be able to position these programs in a way that emphasizes the customer control and benefits rather than the limited negatives attending the programs.

Some caveats are in order:

- The projections below do not include the amount of demand response that industrial and commercial customers will be providing through third-party curtailment service companies into the PJM Load Response programs. To date there is limited experience with these relatively young programs, and it is not clear how effective the curtailment service companies will be at recruiting additional program participants (particularly since the Federal Energy Regulatory Commission recently eliminated the incentive payment for PJM demand response participation). Therefore it is difficult to predict the impact of these programs and this report does not attempt to do so. The projections here include only utility-initiated and building code impacts on residential and commercial customers; industrial customer demand response will increase the peak reduction savings estimated, whether it comes through PJM-organized demand response or utility programs offered directly to industrial customers.
- The technologies and capabilities for demand response and building automation are changing so rapidly that it is difficult to predict what options might be available after the year 2015. Therefore, the state is wise to adopt advanced meter specifications that allow the meters to be remotely updated and reprogrammed.
- Similarly, well-designed smart thermostats will serve as enabling technologies for simple direct load control today, customer-driven price-responsive demand tomorrow, and become the gateway to future home automation networks. Thus, this report recommends that Maryland mandate smart thermostats for all residential and commercial customers with central air conditioning or heat pumps, and use load control switches only to manage window air conditioners.
- As the technology for on-premise energy management improves, more and more end users will begin actively managing their energy usage in response to the real-time price of energy; this will be enabled and accelerated by smart meters, smart communicating thermostats, and better time-of-use rates such as critical peak pricing. Although it is probable that a high proportion of users will actively exercise such capabilities in and after 2015, this study has not attempted to

estimate the impact of this upon customer behavior and resulting peak loads; instead, we merely extrapolate the impact of direct load control-type measures out through 2025 even though those practices will likely become outmoded.

- We have not attempted to estimate how much energy savings might result from these demand response measures. However, there has been some attempt to reflect the interplay over time between the load reductions from air conditioner replacement programs and those from cycling more efficient air conditioners.
- These projections are built upon energy usage assumptions derived from average historical data and forecasts of population, customer counts, and peak load growth, all of which are inherently uncertain. Therefore the results should be viewed as approximate, intended for guidance as to the possibilities rather than as absolute claims about what demand response could produce in Maryland.

Demand Response Program Costs and Benefits

The demand response policy case has relatively low costs. These costs include the costs of the customer load control technology (smart thermostats and direct load control switches), plus the costs of installation, maintenance, and the incentive paid to each customer for participating in the program. The program costs do not include the cost of smart thermostats and the associated communications, control, and central office information technology costs required for meter data management, because the commitments for those investments have already been made by each utility and approved by the Commission, with those costs addressed and justified in other utility dockets. Second, because this scenario recommends that the smart thermostats be deployed state-wide, economies to scale should help hold down both the costs of device acquisition and the costs of program administration, marketing and maintenance.

For specific costs, this analysis used the cost estimates developed by BGE in its submittals to the Maryland Commission for its demand response program—specifically, that each new customer on the program would cost $52 per customer for device, installation. Building further on the BGE estimates, we assume that each established demand response customer will cost an average of $76 per year, which includes the cost of the customer's incentive payment as well as program administrative and on-going education and marketing costs.
Over time, the marketing and education should address the state's developing dynamic and time-of-use rates, to enable customers to change their electricity usage by exploiting the opportunities created by their smart meters, dynamic rates and smart thermostats. By 2015, the net present value of the demand program costs will total $564 million.

It is difficult to estimate the benefits of a successful demand response program because that success will change the value of the incremental capacity avoided. Small increments of demand reduction can be valued using the avoided utility summer peak cost of $81.67 per kilowatt; however, as large amounts of demand are avoided (e.g., possibly over 3,000 MW from demand response by 2015), the avoided cost of peak capacity is likely to be substantially different. Even so, the resulting drop in the avoided cost of capacity over that large reduction would be due in large part to the effects of the Maryland demand response program. Since PJM and other sources have not estimated the avoided cost or value of demand for such increments, we are forced to use the primary estimate ($81.67 per kilowatt), but acknowledge that it is likely to be wrong. The calculated benefit of demand response in 2015 equals $1,639 million in net present value terms, which produces a benefit cost ratio of 2.9.

Specific Demand Response Recommendations

ADVANCED METERING

1) The MDPSC should articulate common functional requirements and specifications for every utility's advanced meter, advanced metering infrastructure, and smart communicating thermostats. This is already under way with the findings of Docket 9111. This will reduce processing time for the Commission and the utilities, expedite the start and completion of each utility's AMI installation, and likely lower the costs and improve the cost-effectiveness of each utility's overall AMI effort.

2) Customers' meter data should be assumed to belong to the customer, who should be able to authorize its delivery to retail electric providers and curtailment service providers.

RESIDENTIAL DEMAND RESPONSE

3) Require all new residential and commercial construction to have high efficiency appliances and smart communicating thermostats. If identical smart thermostats are used statewide, it will enhance the state's ability to conduct demand response and energy conservation public education programs across all media markets.

4) Every Maryland residential and commercial customer should be given both a smart meter and a smart communicating thermostat, and participation in those programs should be either mandatory or opt-out rather than marketed and opt-in. Opportunities for direct load control switches should be limited (see point 6 below).

5) Nearly 75% of BGE's residential customers have central air conditioning or a central heat pump; similar percentages are likely for PEPCO and AP. These customers should receive smart thermostats rather than direct load control switches to maximize the value of the gains realized from installation of advanced interval meters (and avoid having to maintain the load control switch program or return to install the smart thermostat and reeducate the customer once all advanced meters have been installed).

6) If the direct load control switch is retained as a customer demand response option, investigate the feasibility and cost-effectiveness of installing load control switches on hot water heaters and swimming pools (where present) for all residences receiving central air conditioning direct load control switches. Half of BGE's customers' water heaters are fueled by electricity; the same proportion likely applies to the other utilities as well. For these facilities, a water heater DLC switch would increase the impact of a load control event. The key implementation question is whether both switch installations could be accomplished in a single truck roll to the customer's premise, to limit installation costs.

7) Since the lowest rate of central air conditioning use is in multi-family housing, single family duplexes, row houses, and dense urban areas (including Baltimore City and Baltimore, Montgomery, Prince George's and Calvert Counties), address those areas with accelerated, geographically concentrated programs for replacement of window air conditioners. Also consider putting load control switches on the replacement air conditioners, to allow renters and non-CAC customers to participate in and receive direct benefits from demand response programs. This would also provide additional peak load relief in the geographic areas that are most electrically congested.

8) Consider whether to use BGE's residential peak load control (Energy Smart Savers Program SM) statewide, to maximize the effectiveness of the utilities' marketing in the state's common media markets.

9) Participation in local or regional emergency conditions should be mandatory (subject to event-specific customer opt-out rules and limits); however, participation in economically-triggered DR should be subject to the participant's informed consent.

10) Residential Critical Peak Pricing programs should be made opt-out rather than voluntary opt-in, to increase the number of customers on those programs. However, it may be desirable to maintain current rate schemes for low-income customers, and allow them to participate in CPP programs on an opt-in rather than opt-out basis.

11) The state and utilities should conduct a thorough, aggressive customer education program addressing and explaining demand response, smart thermostats, critical peak pricing, and advanced meters, targeting residential and small commercial customers.

12) State and local building codes should be changed to require advanced meters, smart communicating thermostats, and a linked hot water heater direct control switch for every new home and commercial establishment.

COMMERCIAL AND INDUSTRIAL DEMAND RESPONSE

13) Every MD industrial and commercial customer should receive an advanced interval meter no later than 2010. Every industrial and commercial customer that remains on default service should be required to be served under either real-time pricing or critical peak pricing rates.

14) Since PJM's DR programs require some degree of sophistication and time investment that prohibits participation by smaller or individual customers, consider directing MD's utilities create parallel DR programs for C&I customers that mirror PJM's programs with respect to many of the qualification and payment terms. This should get more DR built faster in MD, with most of the benefits accruing to Maryland's electricity customers and utilities while far exceeding their costs. Additionally, utilities could create locally targeted C&I DR programs to address specific T&D capacity and reliability issues and operate and pay for those on a separate but related basis from the PJM programs, since the utilities wd be

buying a different product (locational transmission and distribution capacity and reliability rather than generation capacity substitutes).

15) It is not clear that the utilities' proposed demand response programs allow third party curtailment service providers to recruit and serve Maryland's commercial and industrial customers. Since CSPs often use more aggressive marketing and creative energy savings practices than utilities, they should be able to enroll the utilities' C&I customers and package those load reductions into PJM's demand response market. Additionally, it is not clear that commercial tariff requirements for the customer to bear the costs of any metering required to participate in the Energy Saver or Load Reduction programs remain relevant once smart meters are installed.

16) Given the well-documented benefits of demand response for the Mid-Atlantic market, the State should ask the Federal Energy Regulatory Commission to reinstate the incentive payment for demand response associated with PJM's Load Response Program, to sustain and increase customer participation in demand response programs.

RELATED POLICY ISSUES

17) The MDPSC should adopt the grid modernization and smart grid-promoting provisions of the Energy Independence and Security Act (Title XIII), including assurance of cost recovery for utility investments in advanced technology and smart grid equipment, a prudence test to establish that non-smart technologies are justified when smart assets are available, and rapid depreciation and cost recovery of old assets that are replaced by smart grid technologies. The cost recovery mechanism authorized in Order 81637 (Case No. 9111) is a good step along this path.

18) To encourage investments in transmission and distribution automation and smart grid technologies on the utility's side of the meter, the Maryland utilities should be given a shareholder incentive for proven improvements in the delivery efficiency of their system (apart from customer end-use efficiency improvements), as measured in terms of the relative kW and kWh losses incurred from the point of generation to the customer's meter. The method and measurement of delivery efficiency (energy and capacity) should be determined in 2008 and 2009, and the first incentive payments should be made in 2011 and every year thereafter through at least 2015.

APPENDIX C. ENERGY EFFICIENCY RESOURCE ASSESSMENT

The purpose of an energy efficiency resource assessment is to estimate the total energy savings that can be achieved through the adoption of efficient, *cost-effective* technology measures. Our analysis estimates the cost-effective potential for energy efficiency in Maryland's residential, commercial, and industrial sectors during the period of 2008 to 2025. We relied on several resources for these analyses, including the Energy Information Administration's (EIA) *Annual Energy Outlook* (EIA 2007c), *Residential Energy Consumption Survey* (EIA 2003a), the *Commercial Building Energy Consumption Survey* (EIA 2006), the New York State Energy and Research Development Authority's 2003 electricity efficiency potential analysis (NYSERDA 2003), and the Database for Energy Efficient Resources (CEC 2001). We did not collect any primary data on technology performance. The set of efficiency measures includes only those that are currently commercially available with reasonable market share, and does not include emerging technologies.

C. 1 Residential Buildings

Overview of Approach

We analyzed twenty-eight electricity efficiency measures for existing residential buildings, which are grouped by end-use (HVAC, water heating, refrigeration, appliances, lighting, furnace fans, and plug loads) and three measures for new residential buildings (see Table A.1). For each measure, we estimated average measure lifetime, electricity savings (kWh) and costs per home upon replacement of the product or retrofitting of the measure. For a replacement-on-burnout measure,[13] the cost is the incremental cost of the efficient technology compared to the baseline technology. For retrofit measures, where existing equipment is not being replaced, such as improved insulation and infiltration reduction, the cost is the full installation cost of the measure. For measures modeled as replacement-on-burnout, the baseline is set according to the current market for that product, so the baseline efficiency is the minimum efficiency standard of that product. For measures modeled as retrofit, the baseline efficiency is that of estimated energy use in existing Maryland homes.

A measure is determined to be cost-effective if its levelized cost of saved energy, or cost of conserved energy (CCE), is less than 11.6 cents/kWh, the current average residential cost of electricity in Maryland (EIA 2008). Estimated levelized costs for each efficiency measure, which assume a discount rate of 5%, are shown in Table C.1. Equation one shows the calculation for cost of conserved energy.

Equation 1. *CCE = PMT ((Discount Rate), (Measure Lifetime), (Measure Cost)) / (Annual Savings per Measure (kWh))*

[13] In a replacement-on-burnout scenario, a consumer purchases the more efficient product at the time of replacement of that product.

Table C.1. Residential Energy Efficiency Measure Characterizations

Measures	End-Use Category	Annual savings per household (kWh)	Cost of Saved Energy ($/kWh)	Pass Cost-Effective Test?	% Turnover	Adjust-ment Factor	Inter-action Factor	% End-use Savings	Total Savings in 2025 (GWh)
Existing Buildings									
Seal Ductwork	HVAC (load)	639	$ 0.09	yes	100%	50%	100%	10.6%	678
Infiltration reduction	HVAC (load)	799	$ 0.01	no	100%	44%	89%	10.4%	667
Insulation, ceiling, R-38	HVAC (load)	479	$ 0.02	yes	100%	37%	78%	4.6%	294
Blow-in wall insulation	HVAC (load)	1,198	$ 0.03	yes	100%	17%	72%	4.9%	311
ENERGY STAR Windows	HVAC (load)	529	$ 0.06	yes	57%	47%	65%	3.0%	194
Cool Roof shingles	HVAC (load)	413	$ 0.04	yes	85%	82%	52%	4.9%	314
HVAC Load Reducing Measures								**38%**	
Central HP (heating cycle); HSPF 9	HVAC	625	$ 0.05	yes	92%	13%	62%	2%	96
Ground-Source HP (14 EER)	HVAC	2,684	$ 0.08	yes	92%	3%	62%	1%	87
Central AC/HP (cooling cycle) SEER 15; HSPF 9	HVAC	532	$ 0.05	yes	92%	72%	62%	7%	460
ENERGY STAR Dehumidifier	HVAC	112	$ 0.04	yes	100%	26%	62%	0.6%	38
Room A/C (11 EER)	HVAC	87	$ 0.04	yes	100%	13%	62%	0.2%	15
Ceiling Fan	HVAC	209	$ 0.07	yes	100%	59%	62%	2.5%	161
HVAC Equipment Measures								**13%**	
TOTAL HVAC								**52%**	**3,315**
High-efficiency showerheads	Water Heating	250	$ 0.00	yes	100%	26%	100%	7%	140
Faucet aerators	Water Heating	48	$ 0.01	yes	100%	28%	100%	1.4%	29
Water heater pipe insulation	Water Heating	65	$ 0.01	yes	57%	39%	100%	1.4%	30
H-axis clothes washer (2.0 MEF)	Water Heating	357	$ 0.08	yes	100%	22%	100%	7.9%	167
Dishwasher (Electric WH; 0.68 EF) (water heating)	Water Heating	43	$ 0.06	yes	100%	17%	100%	0.7%	15
GSHP desuperheater (14 EER)	Water Heating	627	$ 0.13	no	92%	27%	83%	12.9%	271
Efficient electric water heater (0.93 EF)	Water Heating	81	$ 0.09	yes	100%	17%	83%	1.1%	24
HP water heater (COP = 2.0)	Water Heating	1,505	$ 0.07	yes	100%	16%	83%	20%	411
Water Heating Savings								**52%**	**1,087**
Refrigerator (20%)	Refrigeration	114	$ 0.05	yes	89%	82%	100%	6.3%	207
Refrigerator (25%)	Refrigeration	29	$ 0.10	yes	89%	115%	100%	2.2%	72
Refrigeration Savings								**8%**	**279**
CLF & Efficient Incandescent Replacements	Lighting	1,010	$ (0.00)	yes	100%	95%	100%	50.0%	2,037
Lighting Savings								**50%**	**2,037**
Clothes washer (2.0 MEF)	Appliances	36	$ 0.08	yes	100%	50%	100%	2%	45
Dishwasher (0.68 EF)	Appliances	11	$ 0.08	yes	100%	36%	100%	0.5%	10
Appliances Savings								**3%**	**55**

Efficient Furnace Fan	Furnace Fans	255	$ 0.07	yes	94%	62%	100%	42%	371
Furnace Fan Savings								**42%**	**371**
Active Mode Standard for TV	Plug Loads	183	$ 0.03	yes	100%	74%	100%	16.4%	333
Set-top box power reduction	Plug Loads	120	$ 0.03	yes	100%	58%	100%	8.4%	171
1-watt standby	Plug Loads	264	$ 0.02	yes	100%	66%	100%	4.5%	367
Total Plug Load Savings								**20.9%**	**700**
In-home feedback monitor	All	1,256	$ 0.02	yes	100%	65%	40%	2.6%	815
New Construction Building Measures									
New home 15% better than code (ENERGY STAR home)	New Construction	888	$ 0.06	yes	100%	17%	100%	1%	66
New home 30% better than code (Proposed Code)	New Construction	1,776	$ 0.05	yes	100%	35%	100%	5%	279
New home 50% better than code (Tax-credit-eligible)	New Construction	2,960	$ 0.06	yes	100%	47%	100%	11%	619

Table C.2. Residential Energy Efficiency Baseline and New Measure Assumptions

Measures	Baseline Assumptions	New Measure Assumptions	Measure Notes
In-home feedback monitor	Standard Feedback Mechanism (monthly utility bills)	Monitor connected to meter that shows resident real-time and cumulative consumption	Electricity consumption from (EIA 2003a). Cost from Parker (2006). $150 for product+ cost for one hour installation. Savings from Stein (2004). Measure Life from ACEEE (2006a)
Seal Ductwork	Sachs et al. (2004)		Baseline consumption from EIA (2008). % Savings and measure life from Sachs et al. (2004), ACEEE estimate.
Infiltration reduction	Current Stock: 56% of households report no air infiltration.		Baseline consumption EIA (2008). Current Stock: X% "drafty" in EIA (2003). Average of Mid- & South Atlantic Census Region. Electricity Consumption from Sachs et al. (2004) (cooling only). Measure Life from SWEEP (2002). % Applicable from EIA (2003).
Insulation, ceiling	Assume currently have R-11 and upgrade to R-30	R-38	Baseline consumption from EIA (2008). Current Stock: X% "not well insulated", other % assume R-19 insulation. Average of Mid- & South Atlantic Census Region. Cost from CEC (2005a). % savings for a 2-story house on Long Island from 1994 ACEEE study on Gas DSM. % applicable from EIA (2003). Measure life from Sachs et al. (2004) & NYSERDA (2003).
Blow-in wall insulation	Little or no wall insulation	Blown-in celluose insulation	Baseline consumption from EIA (2008). Houses deemed "not well insulated" in EIA (2003). Average of Mid- & South Atlantic Census Region. Cost from CEC (2005a). Savings % and Units per household: Avg of colonial and ranch from 1994 NY Gas DSM study. % applicable from EIA (2003). Measure life from NYSERDA (2003).
Cool Roof shingles	Standard house with dark ashphalt shingles	ENERGY STAR rated thermal emittance and reflectance	Baseline consumption from EIA (2008). % savings and measure life from Sachs et al. (2004). % applicable = % households with asphalt shingles from Desjarlais (2005). Market share from EPA (2006).
ENERGY STAR Windows	Double-hung, single pane window	ENERGY STAR specification for North-Central region. U=0.40: SHGC=0.55 vinyl.	Baseline consumption from EIA (2008). Incremental cost NEEP (2006). Market share from EPA (2007c). Units per household (typical house replacing 300 sq. ft of windows, with typical windows being 15 sq. ft.) and electricity savings from ACEEE (2006a). Measure life from SWEEP (2002).
Central AC/HP (cooling cycle)	Baseline = 13 SEER; HSPF 7.7	SEER 15; HSPF 9	Costs from DOE (2001a). Baseline consumption from EIA (2003) (average of Mid-Atlantic and South-Atlantic) and incremental costs from ACEEE (2006a). Electricity savings from DOE (2001a) (cooling only) single package AC. Measure life from DOE (2001a). Market share from EPA (2006). Saturation from (EIA 2003).
Central HP (heating cycle)	Baseline is ASHP w/ electric water heater	HSPF 9	Baseline cost from Amann et. al. (2007). Baseline electricity consumption from ACEEE (2007). Saturation from EIA (2003). Measure life from DOE (2001a).
Efficient Furnace Fan	Single-speed furnace fan motor	Electronically Commutating Motor (ECM)	Baseline consumption and savings from Pigg (2003), for heating cycle only and adjusted by HDD. Incremental costs from ASAP (2008). New measure consumption: includes additional elec. Use from standby power (~30 kWh). Assumes heating cycle only and non-continuous operation. Measure life from DOE (2001b). Market share from ASAP (2008).
Ground-source Heat Pump	Conventional Air-Source Heat Pump	14 EER	Baseline cost Amann et. al. (2007). Baseline electricity consumption, incremental costs, electricity savings, new measure electricity consumption and measure life from ACEEE (2007).
GSHP w/ desuperheater	Electric Storage Water Heater (50 gallon; EF =0.90)	14 EER	Baseline electricity consumption, incremental costs, electricity savings, new measure electricity consumption and measure life from ACEEE (2007).
Efficient electric water	Conventional Electric	0.93 EF	Baseline consumption from GAMA (2007). Incremental costs = ACEEE estimate.

heater (0.93 EF)	Storage Water Heater (50 gallon; EF =0.90)		Measure life from NYSERDA (2003).
Heat pump water heater (COP = 2.0)	Conventional Electric Storage Water Heater (50 gallon; EF =0.90)	COP = 2.0	Baseline consumption from GAMA (2007). Incremental costs = ACEEE estimate. % savings and measure life from Sachs et al. (2004). Assume that homes applicable are those with electric water heaters and have 3 or more people.
High-efficiency showerheads	2.5 gpm measured at 80 psi. Assumes electric water heater.	2.2 gpm federal standard for new construction	Baseline consumption from EIA (2008). Savings assume replacement with flow rate of 2.0 gpm from Brown et al. (1987). Percent applicable is % of homes with electric water heating from EIA (2003). Costs for a low cost basic model from CEC (2001). Market share from BG&E (2005).
Faucet aerators	2.5 gpm. Assumes electric water heater.	2.2 gpm federal standard for new construction	Baseline consumption EIA (2008). Savings assume replacement with flow rate of 1.5 gpm, installed in home with electric DHW Frontier Associates (2006). Percent applicable is % of homes with electric water heating EIA (2003). Costs from CEC (2001). Market share from BG&E (2005).
Water heater pipe insulation	No pipe insulation.	Insulating 10 ft of exposed pipe	Baseline consumption from EIA (2008). Savings assumes pipe insulation is at least 3/4" thick. Savings from CL&P (2007), savings values are for 10 linear feet of hot pipe in unconditioned space. Percent applicable is % of homes with electric water heating EIA (2003). Costs from CEC (2001).
Dehumidifier	EPAct 2005 Standard	ENERGY STAR-rated	Baseline consumption is average basecase for all classes from DOE preliminary NIA spreadsheet. Baseline cost from DOE (2007b). Incremental costs are average of price estimates for 3 product classes in preliminary DOE spreadsheet, DOE (2007b). New measure electricity consumption is average of 15% improvement relative to EPAct 2005 standard. Market share from EPA (2006).
Room AC	9.7 EER	ENERGY STAR-rated room air conditioner (11 EER)	Electricity consumption EIA (2003). Incremental cost from ASAP (2008). Electricity savings from ASAP (2008) (baseline energy use * savings (based on upgrade from 9.8 to 10.8 EER)). Measure life from DOE (2007a). Market share from EPA (2006).
Refrigerator (20%)	Federal Standard for sales-weighted typical volume and type	ENERGY STAR rated 20% better than 2001 standard	Baseline consumption, incremental costs and measure life from PG&E (2007).
Refrigerator (25%)	Federal Standard for sales-weighted typical volume and type	ENERGY STAR rated 25% better than 2001 standard	Baseline consumption, incremental costs and measure life from PG&E (2007).
Clothes washer (water heating)	2.0 MEF	ENERGY STAR/ CEE Tier 2 H-Axis; 2.0 MEF	Baseline, incremental cost and electricity usage from EPA (2007f). Measure life is from ACEEE (2006a).
Dishwasher (water heating)	0.58 EF	ENERGY STAR/ CEE Tier 2; 0.68 EF	Baseline costs, electricity consumption, incremental costs and new measure electricity consumption from DOE (2007b). Measure life from ACEEE (2006a). Market share from EPA (2006).
Dishwasher	0.58 EF	ENERGY STAR/ CEE Tier 2; 0.68 EF	Baseline costs, electricity consumption, incremental costs and new measure electricity consumption from DOE (2007b). Measure life from ACEEE (2006a). Market share from EPA (2006).
Ceiling Fan	Conventional 3-speed Ceiling fan	ENERGY STAR 3-speed Ceiling Fan	Baseline consumption, savings and incremental costs from EPA (2004). Baseline = 295 kWh per unit. New Measure = 151 kWh savings per unit. Incremental Cost = $25 per unit. Average 2.15 units per household. Measure life from NYSERDA (2003). Market share

			from EPA (2006) (ceiling fan only, not light fixture).
CFL and Advanced Incandescent Replacements (indoor and outdoor)	Baseline house requires 25,659 incandescent lamp-hours per year.	80% CFL installation, 15% Advanced Incandescents	Average wattage, annual lamp-hours, baseline consumption and % of current installed incandescent lamps from Navigant (2002). Assumes 86% of lamp-hours incandescent. This is likely to be 5-10% high with increased CFL sales in recent years.
Active Mode Standard for TVs	Average of current TVs sold (25% pass, 75% do not)	Equivalent to ENERGY STAR Draft 2 Specification One TV per household (primary TV) affected	Baseline and new measure savings data and market share are from Chase (2008) and are based on the data set that was used in the ENERGY STAR Draft 2 TV specification revision. Measure life from Appliance Magazine (September 2007). No reliable incremental cost data is available. The cost variance among a range of non-energy-related TV components is dramatically more significant to the consumer, resulting in very low cost per kWh saved per household. Our estimate is set to result in a levelized cost similar to that for the 1-watt standby measure.
Set-top box power consumption	1.9 STBs per household. The vast majority of current STBs sold are digital.	Require digital set-top boxes to have a maximum sleep state power level of 10 watts and to automatically enter sleep mode after 4 hours without user input.	All data except cost is from Rainer (2008). No reliable incremental cost data is available. In the case of set-top boxes, efficiency measures are largely software-driven, likely resulting in very low cost per kWh saved per unit. Our cost estimate is set to result in a levelized cost similar to that for TVs.
1-watt standby power for consumer electronics	Home w/ 17-20 devices that consume standby power (1-9 watts).	Reduce to 1 watt	Baseline consumption, savings, incremental costs and measure life available from Sachs et al. (2004). ECOS Survey provides annual total energy use per product for % savings if needed.
New home 15% better than code (ENERGY STAR home)	Code-compliant home	15% better than code (ENERGY STAR home)	Baseline delivered electricity (HVAC + DHW) per household (across all households) from AEO (2007). Incremental costs and market share personal communication from Shadid (2007). Percent applicable for new homes assume that 30% and 50% new buildings are phased in one to two years prior to enactment of codes (30% in 2012 and 50% in 2020).
New home 30% better than code (Proposed Code)	Code-compliant home	30% better than code (Proposed Building Code)	Cost is an ACEEE estimate. Percent savings by end-use are from Dean (2008). See above for percent applicable.
New home 50% better than code (Tax-credit-eligible)	Code-compliant home	50% better than code (Tax-credit-eligible)	Cost is an ACEEE estimate. See above for percent applicable.

Existing Buildings

To estimate the efficiency resource potential in existing homes in Maryland by 2025, we first adjusted individual measure savings by an *Adjustment Factor*. This factor accounts for the technical feasibility of efficiency measures (the percent of Maryland homes that satisfy the base case conditions and other technical prerequisites such as number of household members, heating fuel type, etc) and the current market share of products that already meet the efficiency criteria. These assumptions are made explicit in Table B.2.

We then adjusted savings from the improved building envelope (insulation, windows, infiltration reduction, and duct sealing) to account for the reduced heating and cooling loads imparted by each of the envelope measures. Then we adjusted HVAC equipment savings to account for savings already realized from the reduced loads. Similarly, we adjusted water heating equipment savings to account for reduced water heating loads from the use of more efficient clothes washers, low-flow shower heads, water heater pipe insulation, and faucet aerators. The multiplier for these adjustments is called the *Interaction Factor*.

We then adjusted replacement measures with lifetimes more than 17 years to only account for the percent turning over in 17 years, which represents the time period of the analysis. Note that the multiplier, *Percent Turnover,* is only applicable to products being replaced upon burnout and not retrofit measures such as insulation and duct sealing and testing. These retrofit measures therefore have 100% of measures "turning over."

Equation 2 shows our calculation for efficiency resource potential, incorporating the three factors discussed above:

Equation 2. *Efficiency Resource Potential = ∑ (Annual Savings per Measure (kWh))* x *(Percent Turnover) x (Adjustment Factor)* x *(Interaction Factor)*

To calculate the efficiency resource potential savings by end-use in 2025, we present the savings as a percent of end-use electricity consumption (assuming current electricity consumption by end-use from AEO 2007). For the non-HVAC savings, we then multiply the "% savings" by projected residential electricity consumption for that end-use in 2025 to estimate the total savings potential in that year (see Equation 2). We assume that savings in the residential new construction sector cover projected new HVAC consumption, and therefore multiply the HVAC "% savings" by 2008 electricity consumption of this end use. See Equation 3 for a summary of how we derive the savings estimate for existing residential buildings.

Equation 3. *Efficiency Resource Potential by end-use in 2025 (GWh) = (% End-Use Savings)* x *(Electricity Consumption by sector in 2025* (GWh))*

* 2008 for HVAC

New Construction

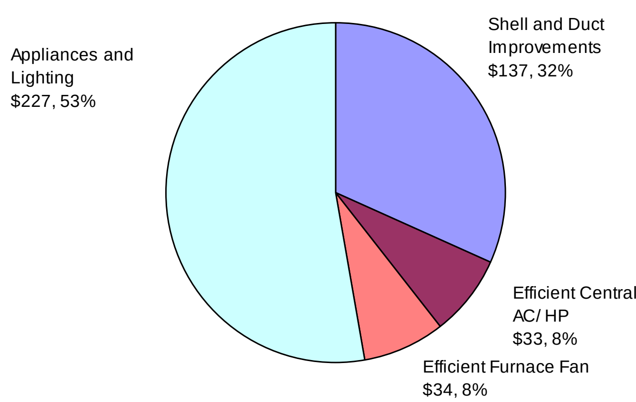
We estimate savings from new construction in a similar manner as existing home measures. We looked at three levels of efficiency in new homes: 15%, 30%, and 50% better than current energy code. In estimating new home energy savings, we use a similar approach as building codes, which address HVAC consumption only. We estimated *% Applicable* by allocating each home into one of the three bins, with 15% predominating the early years and 50% the later years. See Equation four for a summary of how we calculate savings in new construction.

Equation 4. *Efficiency Resource Potential in 2025 (GWh) = (% HVAC savings per home) x (Percent Applicable) x (Projected new HVAC consumption between 2008 and 2025 (GWh))*

Savings Characterization for a Typical MD Household

Below we summarize the annual electricity bill savings that a typical Maryland household can expect from implementing various efficiency measures described above. We characterize our "typical" home as a single-family, detached 2000 ft^2 house that utilizes natural gas for space heat and water heating and has a central air conditioner. For this type of house, we estimate potential electricity bill savings of 31%, or $431[14] annually by implementing the efficiency measures shown in Table 1 ($541 for homes with an electric water heater). Reductions in natural gas consumption from home retrofit measures and more efficient appliances, while not included in this analysis, would yield additional energy bill savings. For the 34% of Maryland residents that depend on electricity for heat (BGE 2005), we estimate total potential electricity savings to be nearly twice as much as homes using natural gas, or 6,284 kWh and $836 annually.

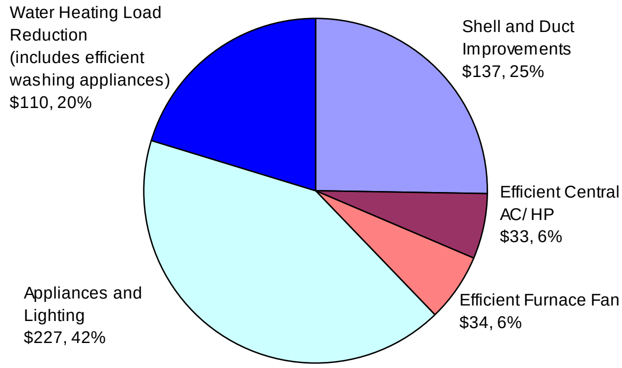
Figure C-1. Annual Electricity Bill Savings for Typical Gas-Heated Home (without electric water heater)



TOTAL: $431
(3,244 kWh, or 31% of annual baseline consumption)

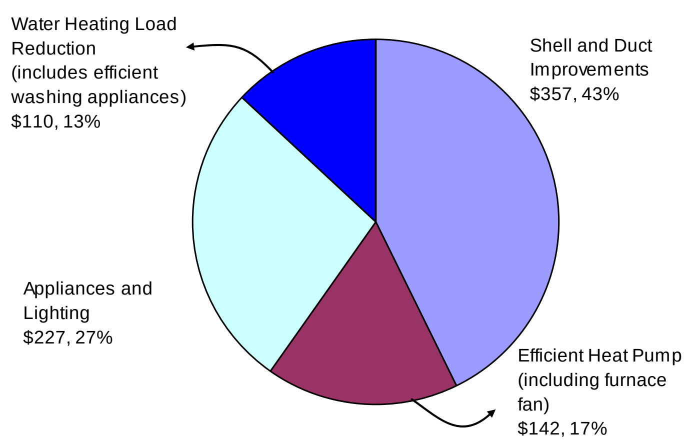
[14] We assume an average cost of electricity of 13 cents/kWh (Summit Blue 2008).

Figure C-2. Annual Electricity Bill Savings for Typical Gas-Heated Home (with electric water heater)



TOTAL: $541
(4,069 kWh, or 31% of annual baseline consumption)

Figure C-3.. Annual Electricity Bill Savings for Electric-Heated Home (with electric water heater)



TOTAL: $836
(6,284 kWh, or 36% of annual baseline consumption)

Because nearly half of all houses in Maryland are over 30 years old (BGE, 2005), there is potential for considerable energy savings as retrofit measures generally yield greater savings in older homes. Over one third of the savings in an electrically-heated home ($357 each year), is achievable through load reduction measures including added insulation, infiltration reduction, cool roof products, and new windows.

According to a Baltimore Gas & Electric (BGE) residential energy-use survey, the majority of homes in Maryland, including 54% of Baltimore households, depend on forced air systems for heating and cooling. Regardless of the heating fuel used, measures to improve air distribution, including duct sealing and high-efficiency furnace fans, offer among the highest savings opportunities in all Maryland homes. Because the majority of Maryland homes have relatively new heating systems - 58% are less than 15 years old - savings are from installing a new heat pump, electric furnace, or central air conditioner with higher rated efficiencies are likely to save less energy than forced air distribution improvements.

With respect to cooling, a third of homes in the BG&E service territory have room/window air conditioning units, including 60% of houses in Baltimore. The efficiency of room/window air conditioning units varies significantly either because the models are old and inefficient or because gaps between the window and unit are not sealed properly. Upgrading old room/window units to newer models with an energy-efficiency ratio (EER) of 11 can save residents 236 kWh, or around $30, annually. Ceiling fans and dehumidifiers are also fairly common appliances used in Maryland homes to improve comfort (40% and 80% of households, respectively). Simple upgrades to ENERGY STAR rated models would save an additional 134 kWh each year.

Over 50% of the total savings possible for a typical Maryland home stems from upgrading to advanced, high-efficient lighting (compact fluorescents lamps and advanced incandescent) and energy-efficient appliances including home electronics, an end use that has received a lot of attention at the federal level in recent years. Replacing 80% of home lighting with CFLs will save 981 kWh, or $130, annually. Upgrading to electronics with 1-watt stand-by power and televisions and set-top boxes with reduced power consumption in all modes save an estimated 567 kWh, or $75.

Roughly 40% of Maryland residents use conventional electric storage water heaters, which can be among the largest electricity consumers in a home. For these households, 20% of total achievable savings arises from more efficient water heating, including both reduced hot water consumption and distribution losses and savings from installing a higher efficiency electric storage water heater. For households of three or more people, a heat pump water heater may also be cost-effective and save dramatically: up to $200 each year.

Table C-3. Project Savings in Maryland Homes from Individual Efficiency Measures

Measure	Annual kWh Savings	Electricity Bill Savings
Shell and Duct Improvements		
Seal Ductwork	639	$ 85
Infiltration reduction	575	$ 77
Insulation, ceiling, R-38	307	$ 41
Blow-in wall insulation	710	$ 94
Cool Roof shingles	244	$ 32
Estar Window/Door	206	$ 27
Efficient HVAC Equipment		
Efficient Furnace Fan	255	$ 34
Central AC (cooling cycle) SEER 15; HSPF 9	249	$ 33
Central HP (heating cycle); HSPF 9	566	$ 75
Water Heating Load Reduction		
High-efficiency showerheads	250	$ 33
Faucet aerators	48	$ 6
Water heater pipe insulation	65	$ 9
H-axis clothes washer (2.0 MEF) (water heating)	357	$ 47
Dishwasher (Electric WH; 0.68 EF) (water heating)	43	$ 6
Water Heating Equipment		
Efficient electric water heater (0.93 EF)	61	$ 11
Heat pump water heater (COP = 2.0) (Not included in Figure 1)	1,143	$ 200
Appliances and Lighting		
Refrigerator (20% Less Than 2001 Standard)	114	$ 15
H-axis clothes washer (2.0 MEF)	36	$ 5
Dishwasher (Electric WH; 0.68 EF)	11	$ 1
80% CFL Installation	981	$ 130
Active Mode Standard for TVs equivalent to ENERGY STAR Draft 2 Spec	183	$ 24
Lower power consumption on Set-Top Boxes	120	$ 16
1-watt standby power for consumer electronics	264	$ 35
Other (not included in Figure 1)		
Room A/C (11 EER) (2 units per HH)	236	$ 31
Ceiling Fan (2.19 units per HH)	22	$ 3
Dehumidifier	112	$ 15

C. 2. Commercial Buildings

Overview of Approach

To estimate the resource potential for efficiency in commercial buildings, we first developed a disaggregate characterization of baseline electricity consumption in the state for current electricity use and a reference forecast (see Table C.4). Highly disaggregated commercial electricity consumption data is unfortunately not available at the state level. To estimate these data, we used total electricity consumption for the Maryland commercial sector from the overall electricity reference forecast (see Appendix A), and we disaggregated by end-use using data from CBECS 2003 and AEO 2007.

Table C.4. Baseline Commercial Electricity Consumption by End-Use

End-Use	Baseline Consumption in 2008 (GWh)	Baseline Consumption in 2025 (GWh)
HVAC	*4,642*	*5,571*
Water Heating	564	677
Refrigeration	1,311	1,573
Lighting	7,646	9,176
Office Equipment	2,611	3,134
Appliances and Other	1,959	2,351
All Electricity:	18,734	22,482

We then estimated commercial square footage in the state using jobs data from Economy.com (2007) and square footage by census region (CBECS 2006) and developing a square foot per employee metric for the South Atlantic and Mid Atlantic census regions. We then extrapolated an average of these data for the state of Maryland and applied to the number of jobs in the state (Economy.com 2007). Using this methodology, we estimate 1,284 million square feet of commercial floorspace in the state.

We then estimated electricity savings from efficiency measures on either a per-unit or a per-square foot commercial floorspace basis (see Equations 5 and 6). We analyzed 33 efficiency measures for existing commercial buildings, which are grouped by end-use (see Table C.1), and 3 new building measures. For each measure, we estimated electricity savings (kWh) and costs per building upon replacement of the product or installation of the measure. Electricity savings per square foot were calculated on an end-use basis. For example, we multiply percent savings for a lighting measure by the baseline electricity intensity (kWh per sq.ft.) for the lighting end-use. *Percent Applicable, Percent Turnover,* and *Interaction Factor* are as defined above in the Residential methodology. Note that the multiplier, *Percent Turnover,* is only applicable to products being replaced upon burnout and not retrofit measures such as insulation and duct sealing and testing. Measures were considered to be cost-effective if the cost per kWh saved (as shown in Equation 1) were less than current retail electricity prices in the commercial sector, or $0.115/kWh in 2007 (EIA 2008).

Equation 5. *Efficiency Resource Potential in 2025 (GWh) = (Annual Savings per Measure* (kWh)*) x (Maryland product stock in millions) x (Percent Applicable)* x *(Interaction Factor) x (Percent Turnover)*

OR

Equation 6. *Efficiency Resource Potential in 2025 (GWh) = (Annual Savings per Measure (kWh per square foot)) x (Commercial floor space in Maryland in millions of square feet) x (Percent Applicable)* x *(Interaction Factor) x (Percent Turnover)*

Efficiency Measures

Table C.1. shows the thirty-six efficiency measures examined for this analysis, grouped by end-use, costs, savings (kWh) per product or square foot, *Percent Applicable, Interaction Factor*, *Percent Turnover,* and total savings potential (GWh) in 2025. See Table C.2. for a description of the measure and baseline assumptions.

Table C.3. Commercial Energy Efficiency Measure Characterizations

Measures	End-Use	Measure Life (Years)	Annual kWh svgs per unit	2007 Maryland Stock	kWh svgs per s.f.	Incremental cost per unit	Incremental cost per s.f.	Cost of Saved Energy (2006$/kWh saved)	% Applicable (units or floorspace)	% Turnover	Interaction Factor	Savings in 2025 (GWh)
Existing Buildings												
HVAC												
Duct testing and sealing	HVAC	10	24,828	NA	0.53	$ 3,375	NA	$ 0.02	25%	100%	100%	171
Cool roof	HVAC	20	5,513	NA	0.13	$ 3,750	$ 0.25	$ 0.05	80%	85%	100%	117
Roof insulation	HVAC	20	NA	NA	0.28	NA	$ 0.12	$ 0.03	35%	100%	100%	125
Low-e replacement windows	HVAC	25	NA	NA	0.26	NA	$ 0.07	$ 0.02	75%	68%	100%	173
Efficient ventilation fans & motors w VFD	HVAC	10	21,977	NA	0.21	$ 6,650	NA	$ 0.04	40%	100%	89%	95
Load-Reducing Measures Subtotal												**681**
High-effic. unitary AC & HP	HVAC	15	1,783	NA	0.32	$ 872	NA	$ 0.05	53%	100%	88%	194
Packaged Terminal HP and AC	HVAC	15	226	NA	0.28	$ 88	NA	$ 0.04	5%	100%	88%	16
Efficient room air conditioner	HVAC	13	87	NA	0.27	$ 35	NA	$ 0.04	4%	100%	88%	12
High-efficiency chiller system	HVAC	23	30,347	NA	0.72	$ 9,900	NA	$ 0.02	33%	74%	88%	199
HVAC Equipment Measures Subtotal	HVAC											**421**
Dual Enthalpy Control	HVAC	10	2,208	NA	0.20	$ 889	NA	$ 0.05	46%	100%	76%	92
HVAC tuneup (smaller buildings)	HVAC	3	882	NA	0.36	$ 158	NA	$ 0.07	23%	100%	76%	81
Energy management system install	HVAC	15	19,395	NA	0.32	$ 6,380	NA	$ 0.03	33%	100%	76%	104
Retrocommissioning	HVAC	7	NA	NA	0.35	NA	$ 0.25	$ 0.05	41%	100%	76%	139
HVAC Control Measures Subtotal	HVAC											**416**
HVAC Subtotal												**1,517**
Water Heating												
Commercial clothes washers - 2.0 MEF	Water Heating	11	705	43,537	NA	$ 316	NA	$ 0.04	14%	100%	100%	4
Heat pump water heater	Water Heating	12	14,155	NA	0.27	$ 4,067	NA	$ 0.03	28%	100%	99%	96
												100
Refrigeration												
Walk-in coolers & freezers	Refrigeration	12	8,220	22,569	NA	$ 957	NA	$ 0.01	50%	100%	100%	93
Reach-in coolers & freezers	Refrigeration	9	1,838	57,494	NA	$ 341	NA	$ 0.03	90%	100%	100%	95
Ice-makers (to level of 2010 standard)	Refrigeration	10	958	37,668	NA	$ 200	NA	$ 0.03	80%	100%	100%	29

Measures	End-Use	Measure Life (Years)	Annual kWh svgs per unit	2007 Maryland Stock	kWh svgs per s.f.	Incremental cost per unit	Incremental cost per s.f.	Cost of Saved Energy (2006$/kWh saved)	% Applicable (units or floorspace)	% Turnover	Interaction Factor	Savings in 2025 (GWh)
Supermarket (built-up) refrigeration system	Refrigeration	10	392,880	769	NA	$ 39,158	NA	$ 0.01	30%	100%	100%	91
Vending machines (to tier 2 ENERGY STAR level)	Refrigeration	10	507	63,847	NA	$ 30	NA	$ 0.01	50%	100%	100%	16
Vending miser	Refrigeration	10	808	63,847	NA	$ 167	NA	$ 0.03	50%	100%	100%	26
												349
Lighting												
Fluorescent lighting improvements	Lighting	14	122	NA	1.60	$ 4	NA	$ 0.00	56%	100%	100%	1,153
HID lighting improvements	Lighting	2	447	NA	1.55	$ 60	NA	$ 0.06	12%	100%	100%	239
Replace incandescent lamps	Lighting	13	180	NA	4.12	$ (22)	NA	$ (0.01)	22%	100%	100%	1,185
Outdoor lighting -- improved efficiency	Lighting	14	261	########	NA	$ 60	NA	$ 0.02	90%	100%	100%	280
LED exit signs	Lighting	10	272	339,437	NA	$ (16)	NA	$ (0.01)	50%	100%	100%	46
Occupancy sensor for lighting	Lighting	10	361	NA	1.11	$ 48	NA	$ 0.02	38%	100%	66%	364
Daylight dimming system	Lighting	20	143	NA	2.08	$ 68	NA	$ 0.04	25%	85%	62%	349
Retrocommissioning	Lighting	7	NA	NA	0.58	NA	$ 0.25	$ 0.05	41%	100%	57%	173
Outdoor lighting -- controls	Lighting	14	174	########	NA	$ 43	NA	$ 0.03	30%	100%	74%	46
												3,835
Office Equipment												
Office equipment	Office Equip.	5	1,410	-	0.99	$ 0.01	$ 20	$ 0.003	50%	100%	100%	636
												636
Appliances/Other												
Hot Food Holding Cabinets	Appliances	15	3,375	7,530	NA	$ 453	NA	$ 0.01	25%	100%	100%	6
Commercial clothes washers - 2.0 MEF	Appliances	11	339	43,537	NA	$ 316	NA	$ 0.04	29%	100%	100%	4
Dry-type distribution transformers (to TP-1)	Miscellaneous	30	1,951	44,706	NA	$ 328	NA	$ 0.01	90%	57%	100%	78
												89
Existing Buildings Subtotal												**6,528**
New Buildings												
Efficient new building (15% savings)	ALL	15	NA	NA	1.72	NA	$ 0.35	$ 0.02	18%	100%	100%	100
Efficient new building (30% savings)	ALL	15	NA	NA	3.44	NA	$ 0.70	$ 0.02	35%	100%	100%	398

Tax credit eligible building (50% svgs)	ALL	15	NA	NA	5.73	NA	$ 3.00	$ 0.05	47%	100%	100%	885
												1,382
											TOTAL	**7,910**

Table C.4. Commercial Energy Efficiency Measure and Baseline Assumptions

Measures	End-Use	Notes
Retrocommissioning	ALL	Base electricity intensity is for HVAC and lighting end-uses in Maryland. We assume 10% savings for these end-uses (Sachs et al. 2004) in all commercial floorspace for buildings greater than 100,000 sq. ft. and 50% of floorspace in buildings 50,000 sq.ft. or greater (CBECS 2003). Lifetime estimate from Xcel Energy (2006). Costs per sq.ft. are from Sachs et al. (2004).
HVAC tuneup (smaller buildings)	HVAC	Percent savings applies to commercial units according to the California Refrigerant and Air Charge (RCA) program report (CPUC 2006). We assume this is applicable to 60% of units (CPUC 2006) in buildings less than or equal to 25,000 sq. ft. in Maryland (CBECS 2003). Baseline electricity use per unit assumes an average 4.5 ton system per CA program experience and baseline electricity intensity assumes HVAC end-use consumption in Maryland for buildings less than 25,000 sq.ft.. Lifetime is an ACEEE estimate. Cost estimates are from DEER 2004-05 (CEC 2005a).
Duct testing and sealing	HVAC	Savings per unit and base kWh/sq. ft. are for an average retail or education building: 21,721 sq. ft.. Percent savings apply to whole-building electricity consumption (SWEEP 2002). The baseline is an assumed air loss of 29% fan flow; savings are based on sealing supply and return ducts to max. leakge of 15% of system flow. Costs, which assume $300 per ton, lifetime, and percent applicable are ACEEE estimates.
Energy management system install	HVAC	We assume 10% cooling savings and 7.5% heating and ventilation savings (NYSERDA 2003). Baseline electricity intensity is the average HVAC end-use consumption in Maryland. Per-unit savings are for a 60,000 s.f. building. Lifetime and cost estimates are derived from NYSERDA 2003. Percent applicable is an ACEEE estimate.
Cool roof	HVAC	We assume 4% HVAC load savings (ACEEE 1997) off the baseline electricity intensity for HVAC end-uses in MD (CBECS 2003), an incremental cost of $0.25 per s.f. (SWEEP 2002), and a 20-year average lifetime (SWEEP 2002). Percent applicable is an ACEEE estimate. Savings and cost per unit are based on a 15,000 s.f. building from ACEEE Mid-Atlantic study (1997).
Roof insulation	HVAC	Percent savings, which apply to baseline whole-building electricity use (CBECS 2003), electricity savings per s.f., average lifetime, and incremental cost are from ACEEE 1997. Percent applicable is an ACEEE estimate.
Low-e replacement windows	HVAC	Percent savings apply to whole-building electricity consumption (ACEEE 1997). Incremental costs assume $2 per window (SWEEP 2002). Lifetime estimate from SWEEP 2002. Percent applicable is an ACEEE estimate.
Efficient ventilation fans & motors w VFD	HVAC	Basecase per-unit consumption assumes a 50 hp fan with 60% load factor, 93% efficiency (ODP, EPAct levels) and 3653 op. hrs./yr (21-50 hp category from ACEEE stds svgs analysis). Percent savings applies to ventilation only (we assume the ventilation end-use electricity intensity for Maryland as the basecase). Incremental cost assumes $125/hp for VFD and $8/hp for better fan (SWEEP 2002). Lifetime estimate from SWEEP 2002. Percent applicable is an ACEEE estimate.

High-effic. unitary AC & HP	HVAC	New measure assumes 12 EER relative to 2010 standard. Per-unit baseline is per DOE standards analysis (DOE 2005). Baseline electricity intensity (per sq.ft.) is heating, cooling, and ventilation end-uses in Maryland. Measure life is from LBNL (2003). Maryland stock based on an adjustment to a national estimate (ADL 1999). Incremental costs are derived from DOE 2005. Percent applicable is the percent of floorspace with cooling from unitary equipment (ADL 2001)
Packaged Terminal HP and AC	HVAC	New measure percent and per-unit savings and cost estimates are from an ACEEE submission to ASHRAE using web data (Nadel 2005). Measure life is from ASHRAE (Nadel 2005). Baseline electricity intensity (per sq.ft.) is heating, cooling, and ventilation end-uses in Maryland. Percent applicable is the percent of cooling floorspace from packaged terminal units (ADL 2001).
Efficient room air conditioner	HVAC	Electricity consumption from BG&E spreadsheet, RECS 2001 (EIA 2003). Incremental cost from ASAP spreadsheet (DOE screening TSD for FY2005). Electricity savings from ASAP spreadsheet (baseline energy use * savings (based on upgrade from 9.8 to 10.8 EER)). Measure life from DOE 2007 framework document and 1997 TSD). Baseline electricity intensity (per sq.ft.) is for cooling end-use in Maryland. We assume 52% current market share in Maryland (EPA 2006) and percent applicable assumes 4% percent of cooling floorpace using room AC units (ADL 2001).
High-efficiency chiller system	HVAC	Basecase unit assumes .634 kW/ton T24 from DEER, 150 ton avg (from TX and NY studies), 1593 national avg. full-load op hrs from 90.1-1999 analysis. New measure percent savings are derived from estimates provided in SWEEP 2002 and ACEEE 1997. Baseline electricity intensity (per sq.ft.) is heating, cooling, and ventilation end-uses in Maryland. Lifetime estimate from ASHRAE Handbook (HVAC Applications). Costs are from DEER and assume a 150 ton average unit (CEC 2005a). Percent applicable assumes percentage of cooling floorspace using chillers (ADL 2001).
Dual Enthalpy Control	HVAC	Basecase electricity intensity is the estimate for heating, cooling, and ventilation end-uses in Maryland. Savings per unit assume 276 kWh per ton an average 11-ton unit (CL&P 2007). Average measure life is 10 years (CL&P 2007). Incremental costs per unit are from NYSERDA 2003. Percent applicable estimates that 90% of unitary systems could benefit and assumes a 5% current market share (ACEEE estimate).
Heat pump water heater	Water Heating	We assume savings, cost and lifetime estimates are from NYSERDA 2003. Percent applicable is based on engineering estimates for NYSERDA 2003, which assume the measure is applicable to 70% of food service floorspace and 30% of lodging, education, and health care floorspace but then multiply by 2 since these building types are more energy and hot-water intensive than the average commercial building.
Walk-in coolers & freezers	Refrigeration	Savings, cost, and lifetime estimates are from an ACEEE analysis (Nadel et al. 2006) based on a PG&E case study (2005). We estimate current stock in Maryland based on national estimates (ADL 1993), assume a 2% annual growth rate, and assume Maryland's share of national commercial building floorspace as an indicator of percent stock. Percent applicable is an ACEEE estimate.
Reach-in coolers & freezers (to level of 2010 standard)	Refrigeration	Savings, stock, lifetime, and cost estimates are from a PG&E case study (2005). The savings estimate is a weighted average of different types of reach-ins (PG&E 2005). We estimate state stock using national stock data (PG&E 2005) and using percent commercial building floorspace. Percent applicable is an ACEEE estimate.
Ice-makers (to level of 2010 standard)	Refrigeration	Savings, stock, cost, and lifetime estimates are from PG&E case study (2005). Estimate state stock using percent commercial building floorspace. Percent applicable is an ACEEE estimate.

Supermarket (built-up) refrigeration system	Refrigeration	Per-unit savings are from ADL (1996) and assume an average new 45,000 sq. ft. supermarket. We estimate current stock in Maryland based on national estimates (ADL 1996), assume a 2% annual growth rate, and assume Maryland's share of national commercial building floorspace as an indicator of percent stock. Percent applicable is an ACEEE estimate. Cost, percent applicable, and lifetime data are from NYSERDA (2003).
Vending machines (to tier 2 ENERGY STAR level)	Refrigeration	Savings, cost, and lifetime estimates are from ASAP (2008) based on ENERGY STAR calculator estimates. Percent applicable is from NYSERDA 2003. Stock estimates are from the 2005 TSD (DOE 2005).
Vending miser	Refrigeration	Savings, cost and lifetime estimates are from NYSERDA 2003. Stock estimates are from the 2005 TSD (DOE 2005).
Hot Food Holding Cabinets	Appliances	Savings, cost, and lifetime estimates are from ASAP (2008) based on PG&E case study (PG&E 2004b)
Commercial clothes washers - 2.0 MEF	Appliances	Stock estimate is based on national stock data (DOE 2007) and prorated to Maryland based on commercial building floorspace. Average lifetime estimate is from DOE 2007. Savings assume MEF of 2.0, which represent about 80% of products on ENERGY STAR's product lists, and baseline is 1.26 MEF, the DOE standard. Savings estimate is for dryer and machine electricity use only and calculated based on DOE's 2007 TSD (DOE 2007). Percent applicable accounts for market share of efficient products and % of washers with electric water heating.
Commercial clothes washers - 2.0 MEF	Water Heating	Savings from electric water heating are calculated using data in the DOE's TSD (DOE 2007). Percent applicable accounts for market share of efficient products and % of washers with electric dryers. Other assumptions are same as above.
Dry-type distribution transformers (to TP-1)	Miscellaneous	Savings and cost estimates from ACEEE analysis (Nadel et al. 2006).
Fluorescent lighting improvements	Lighting	Basecase assumes 84000 annual kWh used per comm. bldg and an average 14k s.f. bldg (Navigant 2002). We assume 50% are 3 lamp fixtures with 34W lamps and magnetic ballasts and other 50% are 2 lamp fixtures with standard T8 lamps and electronic ballasts (Navigant 2002). Savings case is super T8 lamps with efficient low BF ballasts. Costs are $2 extra for ballast, $1 extra for each of 2 lamps. Percent applicable is the fluorescent percent of lighting stock (Navigant 2002).
HID lighting improvements	Lighting	Basecase is the same as above. New measure savings and costs are from PG&E case study on Metal Halide Lamps & Fixtures (PG&E 2004a). Percent applicable is the percentage of commercial electricity use for lighting that comes from HIDs (Navigant 2002).
Replace incandescent lamps	Lighting	Basecase is same as above. Savings assume and average 75 W incandescent lamp replaced with 23W CFL, 9.5 hrs/day. Costs are $10 CFL incremental cost, save $8 labor each from replacing 4 incandescent lamps (2000 hr life). Percent applicable assumes that 32% of commercial electricity use for lighting is from incandescents (Navigant 2002) and ACEEE estimates that 70% of sockets are applicable for the new measure.
Occupancy sensor for lighting	Lighting	Basecase is same as above. Savings assume 30% energy reduction in individual offices and rooms and 7.5% reduction in open spaces. Incremental cost and lifetime estimates are from NYSERDA (2003). Percent applicable is from Sachs et al. (2004).
Daylight dimming system	Lighting	Basecase same as above. Savings apply for lamps on perimeter of buildings (35% applicable). Incremental cost and lifetime estimates are from NYSERDA 2003. Percent applicable is from PIER 2003.

LED exit signs	Lighting	Savings assume an Energy-Star qualified LED exit sign. Savings, cost, and measure life estimates are from EPA's ENERGY STAR calculator (EPA 2007d). We estimate current stock in Maryland based on national estimates (E-Source 1994), assume a 2% annual growth rate, and assume Maryland's share of national commercial building floorspace as an indicator of percent stock. Percent applicable is an ACEEE estimate.
Outdoor lighting -- improved efficiency	Lighting	We use data from the PG&E case study (PG&E 2004a) and Navigant (2002) to estimate savings and measure lifetime. National stock estimates from Navigant 2002 are used to calculate Maryland stock based on commercial building floorspace. Percent applicable is an ACEEE estimate, assuming that 10% of the efficient measure are already in use. Incremental cost data is from California's DEER database of efficiency measures.
Outdoor lighting -- controls	Lighting	The baseline is the above "outdoor lighting-improved efficiency" measure and we assume 20% savings from lighting controls. Costs are from DEER 2001 and assume each control on average controls three fixtures. Percent applicable is an ACEEE estimate.
Office equipment	Miscellaneous	Basecase, new measure savings, lifetime estimate, costs, and percent applicable are from NYSERDA 2003. New measure assumes a high-efficiency fax, printer, computer display, internal power supply, and a low mass copier.
Efficient new building (15% savings)	ALL	Basecase is the estimate for HVAC, lighting, and water heating end-use electricity intensities for MD buildings built from 2000-2003 (CBECS 2003). Incremental cost per square foot and measure life are from NGRID (2007). Percent applicable for new buildings assume that 30% and 50% new buildings are phased in one to two years prior to enactment of codes (30% in 2012 and 50% in 2020).
Efficient new building (30% savings)	ALL	Basecase is the same as above. In New York, estimates show that commercial buildings can reach 30% beyond code at an investment of $0.54/kWh. To be conservative, we estimate $0.70/kWh by doubling the costs of a 15% beyond code building. Measure life is from NGRID (2007).
Tax credit eligible building (50% svgs)	ALL	Basecase is the same as above. Costs are from Sachs et al. (2004) and assume a $1.80/sq.ft. tax credit. Measure life is from NGRID (2007).

C. 3. Industrial

Overview of Approach

The analysis of electricity savings potential was accomplished in several steps. First, the industrial market in Maryland was characterized at a disaggregated level and electricity consumption for key end-uses was estimated. Then cost effective energy-saving measures were selected based on the projected average retail industrial electricity price. The economic potential savings for these measures was estimated by applying the efficiency measures to electricity end-use consumption. The following sections described the process for estimating the savings potential in Maryland.

Market Characterization and Estimation of Base Year Electricity Consumption

The industrial sector is made up of a diverse group of economic entities spanning agriculture, mining, construction and manufacturing. Significant diversity exists within most of these industry sub-sectors, with the greatest diversity within manufacturing. The various product categories within manufacturing are classified using the North American Industrial Classification System (NAICS) (Census 2002).[15]

Comprehensive, highly-disaggregated electricity data for the industrial sector is not available at the state level. To estimate the electricity consumption, this study drew upon a number of resources, all using the NAICS system and a consistent sample methodology. Fortunately, a conjunction of the various economic censuses for each state allows us to use a common base-year of 2002.

Unfortunately, disaggregated state-level electricity consumption data was not reported for the sub-sectors within primary metal manufacturing (such as iron, steel, and aluminum facilities) because of the limited number of facilities that resulted in the withholding of data to protect confidentiality. This lack of data is a significant problem since two of these facilities represent a significant share of the industrial electricity consumption as the electricity market section of the background discussed in the body of the text. We attempted to disaggregate beyond the sub-sector or industry group level (iron and steel mills under primary metal manufacturing, for example) by using site specific data from utilities and the facilities.

We then used national industry electricity intensities derived from industry group electricity consumption data reported in the *2002 Manufacturing Energy Consumption Survey* (MECS) (EIA 2005) and value of shipments data reported in the *2002 Annual Survey of Manufacturing* (ASM) (Census 2005) to apportion industrial electricity consumption. These intensities were then applied to the value of shipments data for the manufacturing energy groups (three-digit NAICS) in Maryland. These electricity consumption estimates were then used to estimate the share of the industrial sector electricity consumption for each sub-sector.

[15] The industry sector is comprised of four sub-sectors: Manufacturing, Mining, Agriculture, and Construction. Each subsector is further broken down into individual industry groups reflecting the many different definitions for the term ‘industrial.’

Preparation of Baseline Industrial Electricity Forecast

As is the case for state-level energy consumption data, no state-by-state disaggregated electricity consumption forecasts are publicly available. Several alternate data sources were used to calculate estimated electricity consumption growth rates for each state and sub-sector. We made the assumption that electricity consumption will be a function of gross state value of shipments (VOS). Electricity consumption, however, will not grow at the same rate as value of shipments. This is because in general, energy intensity (energy consumed per value of output) decreases with time.

Because state-level disaggregated economic growth projections are not publicly available, data was used from Moody's Economy.com. The average growth rate for specific industrial-subsectors was estimated based on Economy.com's estimates of gross state product. We used this estimated industrial electric consumption distribution to apportion the EIA estimate (cite) of industrial electricity consumption.

Twelve industrial sub-sectors were chosen to represent manufacturing electricity use in Maryland (Table C.5). The manufacturing (NAICS 31-33) sub-sectors include computer and electronic products, food, chemical, transportation equipment, machinery, printing and related support activities, fabricated metal products, plastics and rubber products, and primary metals. In order to simplify the analysis and to obtain information that would be of greatest significance to the state, only sub-sectors with value of shipments greater than 4% of total Maryland's industrial sector were included. The sectors of agriculture, mining, and construction were also included in this analysis given their important role in the state's economy. These sub-sectors account for over 80% of Maryland's total industrial value of product shipments.

Market Characterization Results

In 2006, the State of Maryland industrial sector consumed 17,915 MWh of electricity. Within the manufacturing sector, chemical manufacturing (NAICS 325) dominates at 50.7% of the electricity use.

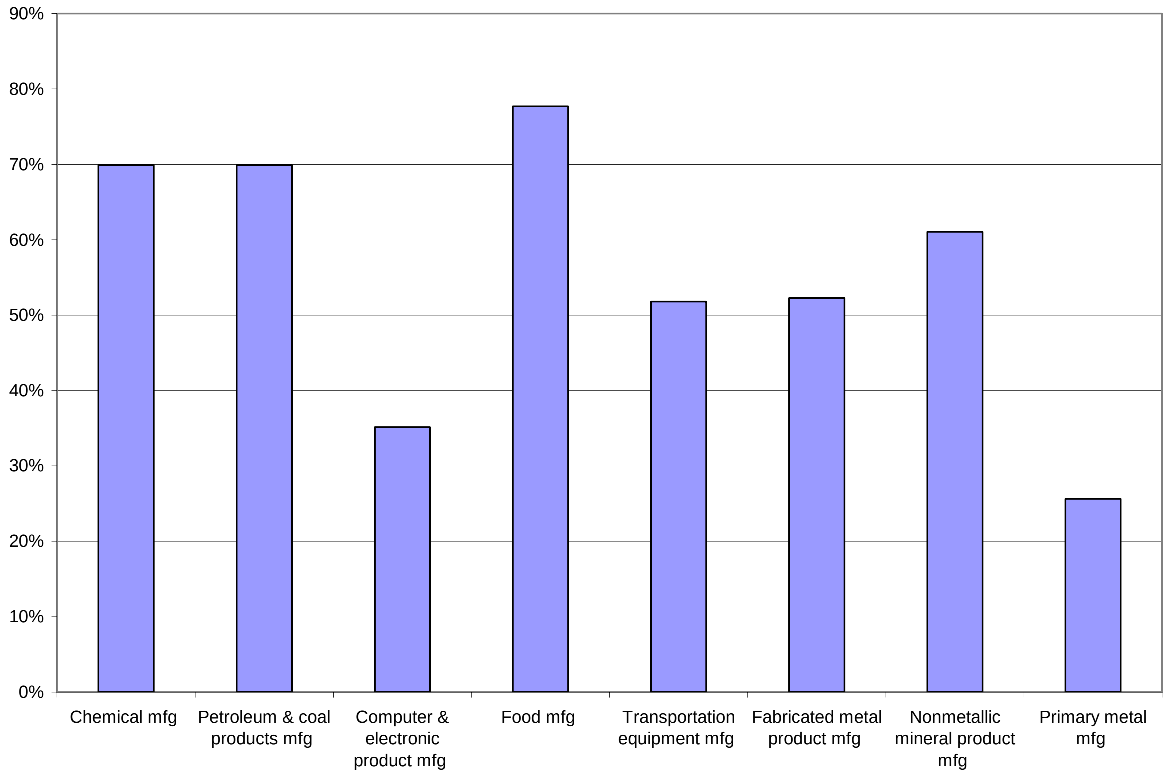
Table C.5. Base-Case Electricity Consumption by Industry in Maryland (Calibrated to 2002 Electric Power Annual)

NAICS Code	Industry Name	Base-Case Electricity Consumption (M kWh)	Percent of Total Industrial Consumption
11	Agriculture	171	1%
21	Mining	90	0%
23	Construction	681	3%
334	Computer and electronic product manufacturing	604	3%
311	Food manufacturing	2,843	14%
325	Chemical manufacturing	8,076	39%
336	Transportation equipment manufacturing	416	2%
333	Machinery manufacturing	376	2%
323	Printing and related support activities	510	2%
332	Fabricated metal product manufacturing	743	4%
326	Plastics and rubber products manufacturing	719	3%
331	Primary metal manufacturing	4,720	23%
331111	Iron and Steel	1,100	
3313	Aluminum	2,974	
3312	Other Metals	646	
N/A	Other	925	4%
Total Industrial Consumption		20,875	

Industrial Electricity End Uses

In order to determine the electricity savings for any technology, the fraction of the electricity to which the technology is applicable must be determined. Much of the energy consumed by industry is directly involved in processes required to produce various products. Electricity accounts for about a third of the primary energy used by industries (EIA 2005). Electricity is used for many purposes, the most important being to run motors, provide lighting, provide heating, and to drive electrochemical processes. While detailed end-use data is only available for each manufacturing sub-sector and group through the MECS survey (EIA 2005), motor systems are estimated to consume 60% of the industrial electricity (Xenergy 1998). The fraction of total electricity attributed to motors is presented in Figure C.6.

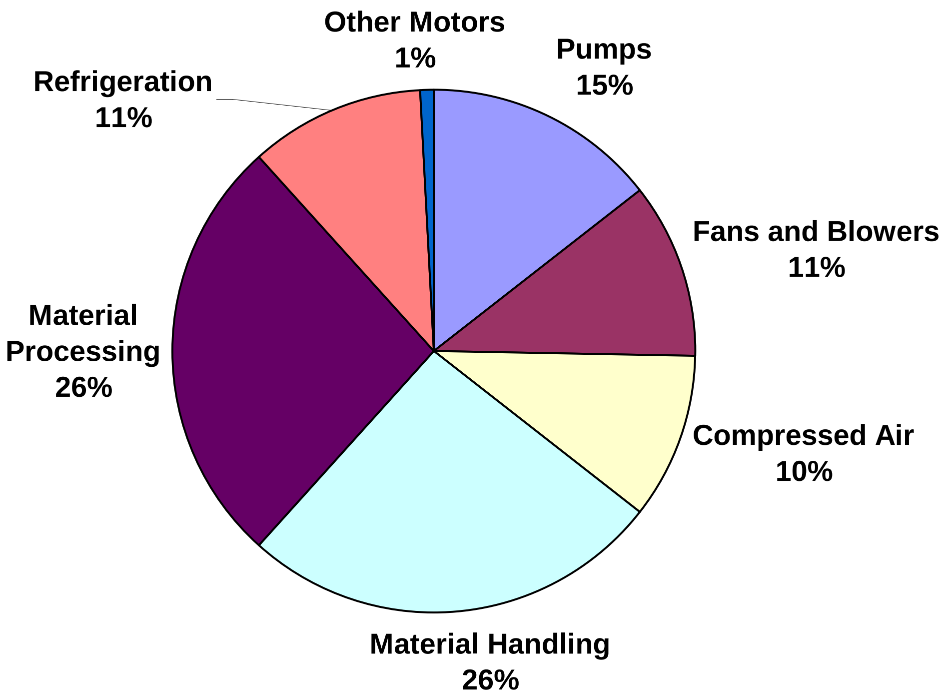
Figure C.6. Percent of Total Electricity Consumption by Motor Systems



Source: XENERGY (1998)

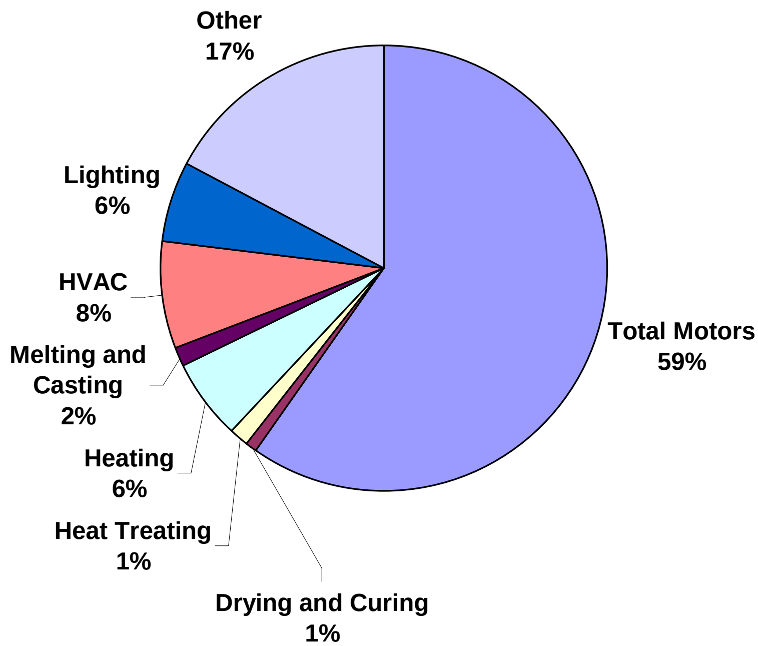
Motors are used for many diverse applications from fluid applications (pumps, fans, and air and refrigeration compressors), to materials handling and processing (conveyors, machine tools and other processing equipment). The distribution of these motor uses varies significantly by industry, with material processing being the largest consumer in the sector. Figure C.7 shows the breakdown of motors use in the state.

Figure C.7. Weighted Average of Motor Industrial Motor System Use in Maryland



While lighting and space conditioning represent a relatively small share of the overall industrial sector electricity consumption, they are important in some of the key industries found in the region such as transportation equipment manufacture and computer and electronics manufacturing, and the electricity savings potential can be significant. The total weighted average of end-use electricity consumption is included in Figure C.8.

Figure C.8. Weighted Average of Total Industrial Electricity End-Uses in Maryland



Overview of Efficiency Measures Analyzed

The first step in our technology assessment was to collect limited information on a broad "universe" of potential technologies. Our key sources of information included the U.S. Department of Energy, Office of Industrial Technologies; the Center for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET); Lawrence Berkeley National Laboratory (LBNL) and American Council for an Energy-Efficient Economy reports; and information from NYSERDA. We did not collect any primary data on technology performance.

Oftentimes, no one source provided all of the information we sought for our assessment (energy use, energy savings compared to average current technology, investment cost, operating cost savings, lifetime, etc.). We therefore made our best effort to combine readily available information along with expert judgment where necessary.

We identified 14 measures that were cost effective at the projected industrial electricity rates in Maryland (Table C.6). The cost and performance of these measures has been developed over the past decade by ACEEE from research into the individual measures and review of past project performance. The costs of many of these measures has increased in recent years as a result of significant increases in key commodity costs such as copper, steel and aluminum, as well as overall manufacturing costs due to energy prices and market pressures. The estimates presented in Table C.6 represent ACEEE most current estimates. We present the full normalized installed measure cost (i.e., the full cost required to install a measure per unit of saved energy) as well as the levelized cost (i.e., the annual cost of the measure amortized over the life of the measure).

Table C.6 Cost and Performance of Industrial Measures

		Cost of Saved Energy		
Measure	**Measure Life**	**Installed Cost/kWh**	**Levelized cost/kWh**	**Annual Savings for End-Use**
Sensors & Controls	15	0.145	0.014	3%
EIS	15	0.635	0.061	1%
Duct/Pipe insulation	20	0.653	0.052	20%
Electric supply	15	0.104	0.010	3%
Lighting	15	0.212	0.020	23%
Advanced efficient motors	25	0.491	0.035	6%
Motor management	5	0.079	0.018	1%
Lubricants	1	0.000	0.000	3%
Motor system optimization	15	0.097	0.009	1%
Compressed air manage	1	0.000	0.000	17%
Compressed air -advanced	15	0.001	0.000	4%
Pumps	15	0.083	0.008	20%
Fans	15	0.249	0.024	6%
Refrigeration	15	0.034	0.003	10%

In addition, we estimated the average normalized cost of industrial energy efficiency investments to be $0.27/kWh saved. This estimate was arrived at by estimating the sum of the annual incremental savings for each measure in each industry based on end-use energy distribution and dividing the corresponding total investment required.

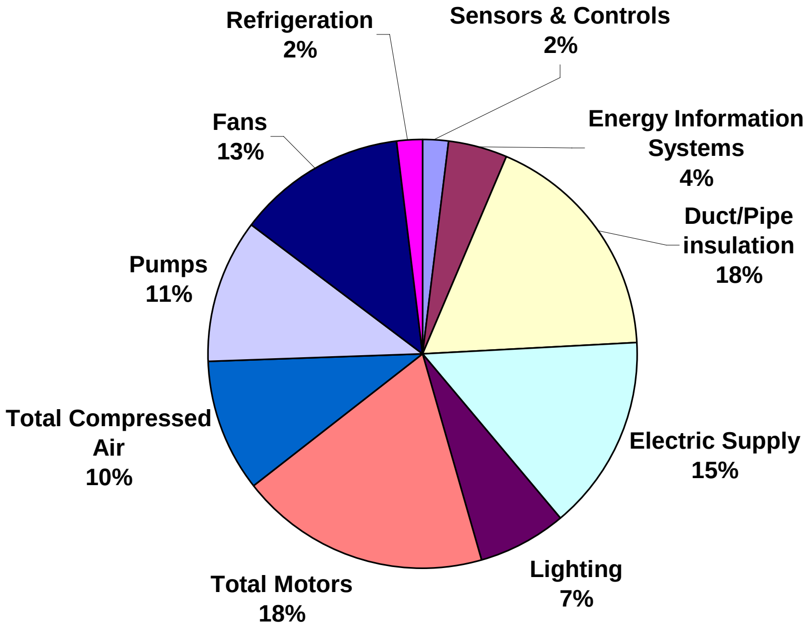
Electricity Savings Potential: Potential for Energy Savings

We sought to identify technologies that could have a large potential impact in terms of saving energy. These may be technologies that are specific to one process or one industry sector, or so-called "cross-cutting" technologies that are applicable to a variety of sectors. In estimating energy savings, we first identified the specific energy savings of each technology by comparing the energy used by the efficient technology to the energy required by current processes. Our second step was to "scale up" this savings estimate to see how much energy savings—for industry overall—this technology would achieve. For the most part, we derived specific energy savings information from the various technology assessment studies noted above.

In scaling up the technology-specific energy savings, we relied on our general knowledge of the various industrial processes to which this technology could be applied. We also took into account structural limitations to the penetration of the technology. Additionally, we recognized that market penetration, in the absence of significant policy support, can take time given the slowness of stock turnover in many industrial facilities.

In Maryland, a diverse set of efficiency measures will provide electricity savings for industry. The application of these measures contributes to total economic savings potential of 20 %. This savings are distributed as presented in Figure C.9.

Figure C.9. Fraction of Savings Potential by Measure - Maryland



In addition, this analysis did not consider process-specific efficiency measures that would be applied at the individual site level because available data does not allow this level of analysis. However, based on experience from site assessments by U.S. Department of Energy and others entities, we would anticipate an additional economic savings of 5-10%, primarily at large energy intensive manufacturing facilities such as the ArcelorMittal Sparrow Point steel mill and chemical plants all in the BG&E service territory. So the overall economic industrial efficiency resource opportunity is on the order of 25-30%.

APPENDIX D. THE DEEPER MODEL AND MACRO ANALYSIS

The Dynamic Energy Efficiency Policy Evaluation Routine—or the DEEPER Model—is a 15-sector quasi-dynamic input-output impact model of the U.S. economy.[16] Although an updated model with a new name, the model has a 15-year history of use and development. See, for example, Laitner, Bernow, and DeCicco (1998) and Laitner (2007) for a review of past modeling efforts. The model is generally used to evaluate the macroeconomic impacts of a variety of energy efficiency (including renewable energy) and climate policies at both the state and national level. The national model now evaluates policies for the period 2008 through 2050. Although, the DEEPER Model for the Maryland specific analysis will cover the period between 2008 through 2025. As it is now designed, the model solves for the set of energy prices that achieves a desired and exogenously determined level of greenhouse gas emissions (below some previously defined reference case). Although the model does include non-CO_2 emissions and other emissions reduction opportunities, it currently focuses on energy-related CO_2 emissions and on the prices, policies, and programs necessary to achieve the desired emissions reductions. DEEPER is an Excel-based analytical tool that consists generally of six sets of key modules or groups of worksheets. These six sets of modules now include:

Global data: The information in this module consists of the economic time series data and key model coefficients and parameters necessary to generate the final model results. The time series data includes the projected reference case energy quantities such as trillion Btus and kilowatt-hours, as well as the key energy prices associated with their use. It also includes the projected gross domestic product, wages and salary earnings, and levels of employment as well as information on key technology cost and performance characteristics. The sources of economic information include data from the Energy Information Administration, the Bureau of Economic Analysis, the Bureau of Labor Statistics, and Economy.com. The cost and performance characterization of key technologies is derived from available studies completed by ACEEE and others, as well as data from the Energy Information Administration's (EIA) National Energy Modeling System (NEMS). One of the more critical assumptions in this study is that alternative patterns of electricity consumption will change and/or defer the mix of investments in conventional power plants. Although we can independently generate these impacts within DEEPER, we can also substitute assumptions from the ICF Integrated Planning Model (IPM) and similar models as they may have different characterizations of avoided costs or alternative patterns of power plant investment and spending.

Macroeconomic model: This set of modules contains the "production recipe" for the region's economy for a given "base year"—in this case, 2006, which is the latest year for which a complete set of economic accounts are available for the regional economy. The I-O data, currently purchased from the Minnesota IMPLAN Group (IMPLAN 2007), is

[16] There is nothing particularly special about this number of sectors. The problem is to provide sufficient detail to show key negative and positive impacts while maintaining a manageable sized model. If we choose to reflect a different mix of sectors and stay within the 15 x 15 matrix, that can be done easily. If we wish to expand the number of sectors, that would take some minor programming changes or adjustments to reflect the larger matrix.

essentially a set of input-output accounts that specify how different sectors of the economy buy (purchase inputs) from and sell (deliver outputs) to each other. In this case, the model is now designed to evaluate impacts for 15 different sectors, including: Agriculture, Oil and Gas Extraction, Coal Mining, Other Mining, Electric Utilities, Natural Gas Distribution, Construction, Manufacturing, Wholesale Trade, Transportation and Other Public Utilities (including water and sewage), Retail Trade, Services, Finance, Government, and Households.

Investment, Expenditures and Energy Savings: Based on the scenarios mapped into the model, this worksheet translates the energy policies into a dynamic array of physical energy impacts, investment flows, and energy expenditures over the desired period of analysis. It estimates the needed investment path for an alternative mix of energy efficiency and other technologies (including efficiency gains on both the end-use and the supply side). It also provides an estimate of the avoided investments needed by the electric generation sector. These quantities and expenditures feed directly into the final demand module of the model which then provides the accounting that is needed to generate the set of annual changes in final demand (see the related module description below).

Price dynamics: There are two critical drivers that impact energy prices within DEEPER. The first is a set of carbon charges that are added to retail prices of energy depending on the level of desired level of emission reductions and also depending on the available set of alternatives to achieve those reductions. The second is the price of energy as it might be affected by changed consumption patterns. In this case DEEPER employs an independent algorithm to generate energy price impacts as they reflect changed demand. Hence, the reduced demand for natural gas in the end-use sectors, for example, might offset increased demand by utility generators. If the net change is a decrease in total natural gas consumption, the wellhead prices might be lowered. Depending on the magnitude of the carbon charge, the change in retail prices might either be higher or lower than the set of reference case prices. This, in turn, will impact the demand for energy as it is reflected in the appropriate modules. In effect, then, DEEPER scenarios rely on both a change in prices and quantities to reflect changes in overall investments and expenditures.

Final demand: Once the changes in spending and investments have been established and adjusted to reflect changes in prices within the other modules of DEEPER, the net spending changes in each year of the model are converted into sector-specific changes in final demand. This, in turn, drives the input-output model according to the following predictive model:

$$X = (I-A)^{-1} * Y$$

where:

X = total industry output by sector

I = an identity matrix consisting of a series of 0's and 1's in a row and column format for each sector (with the 1's organized along the diagonal of the matrix)

A = the production or accounting matrix also consisting of a set of production coefficients for each row and column within the matrix

Y = final demand, which is a column of net changes in final demand by sector

This set of relationships can also be interpreted as

$\Delta X = (I-A)^{-1} * \Delta Y$

which reads, a change in total sector output equals $(I-A)^{-1}$ times a change in final demand for each sector. Employment quantities are adjusted annually according to exogenous assumptions about labor productivity in each of the sectors (based on Bureau of Labor Statistics forecasts).

Results: For each year of the analytical time horizon (again out to 2025 for the Maryland specific analysis), the model copies each set of results into this module in a way that can also be exported to a separate report.

Further results from Maryland's DEEPER analysis is provided to show macroeconomic trends between 5-year time periods. Although similar 2015 & 2025 results were presented in the body of this report, differences between 5-year time periods offer more reference points for the reader to understand Maryland's macroeconomic trends under the efficiency scenario. This section highlights the net changes Maryland's economy will experience as the result of our efficiency scenario.

Changes in Maryland's electricity production patterns from the efficiency scenario in comparison to the reference case are summarized in Table D.1, for the selected years 2010, 2015, 2020 and 2025. Again, these patterns are driven by the energy efficiency policy initiatives outlined in the policy analysis. Note that in comparison to the reference case the efficiency scenario rises/falls etc.

Table D.1. Changes in Maryland Electricity Production and Financial Impacts from Energy Efficiency Policy Scenario: 2010, 2015, 2020 & 2025

(Millions of 2006 $)	**2010**	**2015**	**2020**	**2025**
Efficiency Gains (GWh)	3,553	10,520	16,110	22,164
Change from Reference Case	5.5%	15.4%	22.3%	29.3%
Policy Cost	218	183	130	171
Investment	371	484	443	832
Annual Consumer Outlays	492	665	661	1,211
Annual Electricity Savings	420	1,403	2,291	3,265
Electricity Supply Cost Adjustment	-21	-123	-312	-588
Net Consumer Savings	-52	861	1,943	2,642
Net Cumulative Energy Savings	-372	1,947	9,567	20,684

The macroeconomic module of the DEEPER model traces how each set of changes works or ripples its way through the Maryland economy in each year of the assessment period. This module estimates the number of jobs and amount of wages each sector provides the Maryland economy. Although net jobs and wages were discussed in the body of this paper, changes in sectoral spending are provided here for those interested in detailed results. Table D.2 summarizes the estimated change in sector spending within Maryland, given the policy and program expenditures for the same benchmark years.

Table D.2. Changes in Sector Spending (Millions of 2006 Dollars)

Sector	2010	2015	2020	2025
Agriculture	-$0.9	$3.5	$8.9	$12.6
Oil and Gas Extraction	-$3.2	$8.6	$23.2	$34.9
Coal Mining	-$0.0	$0.1	$0.2	$0.3
Other Mining	-$0.5	$1.4	$3.9	$5.9
Construction	$241.6	$243.2	$122.4	$343.7
Manufacturing	-$8.9	$59.8	$142.3	$191.5
Petroleum Refining	-$10.3	$30.8	$81.5	$120.3
Electric Utility Services	$1,158.2	$546.8	-$122.9	-$964.7
Natural Gas Utility Services	-$0.2	$1.9	$4.4	$5.8
Transportation Other Public Utilities	-$1.8	$5.0	$13.4	$16.9
Wholesale Trade	-$2.7	$107.4	$236.9	$319.7
Services	$14.7	$307.4	$649.6	$857.1
Financial Services	$30.5	$119.1	$152.7	$174.3
Governmental Services	$10.4	$18.7	$27.4	$29.9

There are other support spreadsheets as well as routines in visual basic programming that support the automated generation of model results and reporting. For more detail on the model assumptions and economic relationships, please refer to the forthcoming model documentation (Laitner 2008). For a review of how an I-O framework might be integrated into other kinds of modeling activities, see Hanson and Laitner (2007). While not an equilibrium model we borrow from some key concepts of mapping technology representation into DEEPER using the general scheme outlined in Laitner and Hanson (2007).

APPENDIX E. COMBINED HEAT AND POWER

Technical Potential for CHP

This section provides an estimate of the technical market potential for combined heat and power (CHP) in the industrial, commercial/institutional, and multi-family residential market sectors. Two different types of CHP markets were included in the evaluation of technical potential. Both of these markets were evaluated for high load factor (80% and above) and low load factor (51%) applications resulting in four distinct market segments that are analyzed.

Traditional CHP

Traditional CHP electrical output is produced to meet all or a portion of the base load for a facility and the thermal energy is used to provide steam or hot water. Depending on the type of facility, the appropriate sizing could be either electric or thermal limited. Industrial facilities often have "excess" thermal load compared to their on-site electric load. Commercial facilities almost always have excess electric load compared to their thermal load. Two sub-categories were considered:

High load factor applications: This market provides for continuous or nearly continuous operation. It includes all industrial applications and round-the-clock commercial/institutional operations such colleges, hospitals, hotels, and prisons.

Low load factor applications: Some commercial and institutional markets provide an opportunity for coincident electric/thermal loads for a period of 3,500 to 5,000 hours per year. This sector includes applications such as office buildings, schools, and laundries.

Combined Cooling Heating and Power (CCHP)

All or a portion of the thermal output of a CHP system can be converted to air conditioning or refrigeration with the addition of a thermally activated cooling system. This type of system can potentially open up the benefits of CHP to facilities that do not have the year-round thermal load to support a traditional CHP system. A typical system would provide the annual hot water load, a portion of the space heating load in the winter months and a portion of the cooling load in during the summer months. Two sub-categories were considered:

Low load factor applications. These represent markets that otherwise could not support CHP due to a lack of thermal load.

Incremental high load factor applications: These markets represent round-the-clock commercial/institutional facilities that could support traditional CHP, but with cooling, incremental capacity could be added while maintaining a high level of utilization of the thermal energy from the CHP system. All of the market segments in this category are also included in the high load factor traditional market segment, so only the incremental capacity for these markets is added to the overall totals.

The estimation of technical market potential consists of the following elements:

- Identification of applications where CHP provides a reasonable fit to the electric and thermal needs of the user. Target applications were identified based on reviewing the electric and thermal energy consumption data for various building types and industrial facilities.
- Quantification of the number and size distribution of target applications. Several data sources were used to identify the number of applications by sector that meet the thermal and electric load requirements for CHP.
- Estimation of CHP potential in terms of megawatt (MW) capacity. Total CHP potential is then derived for each target application based on the number of target facilities in each size category and sizing criteria appropriate for each sector.
- Subtraction of existing CHP from the identified sites to determine the remaining technical market potential.

The technical market potential does not consider screening for economic rate of return, or other factors such as ability to retrofit, owner interest in applying CHP, capital availability, natural gas availability, and variation of energy consumption within customer application/size class. The technical potential as outlined is useful in understanding the potential size and size distribution of the target CHP markets in the state. Identifying technical market potential is a preliminary step in the assessment of market penetration.

The basic approach to developing the technical potential is described below:

- *Identify existing CHP in the state.* The analysis of CHP potential starts with the identification of existing CHP. In Maryland, there are 18 operating CHP plants totaling 829 MW of capacity. This existing CHP capacity is deducted from any identified technical potential.

- *Identify applications where CHP provides a reasonable fit to the electric and thermal needs of the user*. Target applications were identified based on reviewing the electric and thermal energy (heating and cooling) consumption data for various building types and industrial facilities. Data sources include the DOE EIA *Commercial Buildings Energy Consumption Survey (CBECS),* the DOE *Manufacturing Energy Consumption Survey (MECS)* and various market summaries developed by DOE, Gas Technology Institute (GRI), and the American Gas Association. Existing CHP installations in the commercial/institutional and industrial sectors were also reviewed to understand the required profile for CHP applications and to identify target applications.

- *Quantify the number and size distribution of target applications*. Once applications that could technically support CHP were identified, the iMarket, Inc. *MarketPlace Database* and the *Major Industrial Plant Database* (MIPD) from IHI were utilized to identify potential CHP sites by SIC code or application, and location (county). The *MarketPlace*

Database is based on the Dun and Bradstreet financial listings and includes information on economic activity (8 digit SIC), location (metropolitan area, county, electric utility service area, state) and size (employees) for commercial, institutional and industrial facilities. In addition, for select SICs limited energy consumption information (electric and gas consumption, electric and gas expenditures) is provided based on data from Wharton Econometric Forecasting (WEFA). MIPD has detailed energy and process data for 16,000 of the largest energy consuming industrial plants in the United States. The *MarketPlace Database* and MIPD were used to identify the number of facilities in target CHP applications and to group them into size categories based on average electric demand in kilowatt-hours.

- *Estimate CHP potential in terms of MW capacity.* Total CHP potential was then derived for each target application based on the number of target facilities in each size category. It was assumed that the CHP system would be sized to meet the average site electric demand for the target applications unless thermal loads (heating and cooling) limited electric capacity. Tables E-1 through E-3 present the specific target market sectors, the number of potential sites and the potential MW contribution from CHP. There are two distinct applications and two levels of annual load making for four market segments in all. In traditional CHP, the thermal energy is recovered and used for heating, process steam, or hot water. In cooling CHP, the system provides both heating and cooling needs for the facility. High load factor applications operate at 80% load factor and above; low load factor applications operate at an assumed average of 4500 hours per year (51%) load factor. The high load factor cooling applications are also applications for traditional CHP, though the cooling applications have 25-30% more capacity than traditional. Therefore, the totals for the entire state, all four market segments, discount these applications to avoid double counting.

- *Estimate the growth of new facilities in the target market sectors.* The technical potential included economic projections for growth through 2020 by target market sectors in Maryland. The growth factors used in the analysis for growth between the present and 2020 by individual sector are shown in Table E-4. These growth projections provided by ACEEE were used in this analysis as an estimate of the growth in new facilities. In cases where an economic sector is declining, it was assumed that no new facilities would be added to the technical potential for CHP. Based on these growth rates the total technical market potential is summarized in Table E-5.

Table E.1. Maryland Technical Market Potential for CHP in Existing Facilities – Industrial Sector

SICs	Application	50-500 kW Sites	50-500 kW MW	500-1 MW Sites	500-1 MW (MW)	1-5 MW Sites	1-5 MW (MW)	5-20 MW Sites	5-20 MW (MW)	>20 MW Sites	>20 MW (MW)	Total Sites	Total MW
	Industrial (Traditional, High Load Factor)												
20	Food	132	19.8	29	21.8	23	57.5	2	19.2	2	103.4	188	221.7
22	Textiles	22	2.5	5	2.8	2	3.8	1	5.3			30	14.3
24	Lumber and Wood	64	1.9	6	0.9	1	0.5					71	3.3
25	Furniture	8	0.4									8	0.4
26	Paper	17	2.6	18	13.5	13	32.5	3	22	4	214.7	55	285.3
27	Printing/Publishing	45	6.8	2	1.5	1	2.5					48	10.8
28	Chemicals	56	8.4	35	26.3	40	100	4	28.5	2	109.5	137	272.7
29	Petroleum Refining	24	3.6	2	1.5							26	5.1
30	Rubber/Misc Plastics	40	1.8	30	6.8	13	9.8	3	17			86	35.3
32	Stone/Clay/Glass	1	0.2	1	0.8	1	2.5	3	18.7	1	23.2	7	45.3
33	Primary Metals	5	0.2	2	0.4	2	1.3	1	9.1	2	122.7	12	133.6
34	Fabricated Metals	26	1.2	6	1.4					1	38.5	33	41
35	Machinery/Computer Equip	2	0.1					1	8.2			3	8.3
37	Transportation Equip.	16	1.2	7	2.6	9	11.3	3	27.5			35	42.6
38	Instruments	9	0.7					1	7.4			10	8.1
39	Misc Manufacturing	8	0.3	2	0.4							10	0.7
	Total	475	51.4	145	80.4	105	221.5	22	162.9	12	612	759	1128.3

Table E.2. Maryland Technical Market Potential for CHP in Existing Facilities – Commercial, Traditional, High Load Factor

SICs	Application	50-500 kW Sites	50-500 kW MW	500-1 MW Sites	500-1 MW (MW)	1-5 MW Sites	1-5 MW (MW)	5-20 MW Sites	5-20 MW (MW)	>20 MW Sites	>20 MW (MW)	Total Sites	Total MW
Commercial, Multifamily(Traditional, High Load Factor)													
6513	Apartments	249	18.7	90	33.8	14	17.5					353	69.9
4222, 5142	Warehouses	10	1.5	4	3							14	4.5
4941, 4952	Water Treatment/Sanitary	18	2.7	8	6	8	20	1	12.5			35	41.2
7011, 7041	Hotels	352	39.6	88	49.5	25	46.9	3	28.1			468	164.1
8051, 8052, 8059	Nursing Homes	132	19.8	113	84.8	14	35					259	139.6
8062, 8063, 8069	Hospitals	35	5.3	27	20.3	48	120	2	25			112	170.5
8221, 8222	Colleges/Universities	56	8.4	37	27.8	30	75	12	150	1	25	136	286.2
9223, 9211, 9224	Prisons	14	2.1	11	8.3	15	37.5	4	50			44	97.9
	Total	866	98	378	233.3	154	351.9	22	265.6	1	25	1421	973.8
Commercial (Traditional, Low Load Factor)													
7542	Carwashes	38	5.7									38	5.7
8412	Museums	31	4.7	3	2.3	1	2.5					35	9.4
7211, 7213, 7218	Laundries	12	1.8	1	0.8							13	2.6
7991, 00, 01	Health Clubs	123	18.5	8	6							131	24.5
7992, 7997-9904, 7997-9906	Golf/Country Clubs	107	16.1	9	6.8							116	22.8
8211, 8243, 8249, 8299	Schools	506	19	108	20.3	12	7.5					626	46.7
	Total	817	65.6	129	36	13	10					959	111.6

Table E.3. Maryland Technical Market Potential for CHP in Existing Facilities – Commercial, Cooling

SICs	Application	50-500 kW Sites	50-500 kW MW	500-1 MW Sites	500-1 MW (MW)	1-5 MW Sites	1-5 MW (MW)	5-20 MW Sites	5-20 MW (MW)	>20 MW Sites	>20 MW (MW)	Total Sites	Total MW
Commercial (Cooling, High Load Factor)													
7011, 7041	Hotels- Cooling	352	52.8	88	66	25	62.5	3	37.5			468	218.8
8051, 8052, 8059	Nursing Homes- Cooling	132	23.8	113	101.7	14	42					259	167.5
8062, 8063, 8069	Hospitals- Cooling	35	6.3	27	24.3	48	144	2	30			112	204.6
	Total	519	82.9	228	192	87	248.5	5	67.5			839	590.9
Commercial (Cooling, Low Load Factor)													
43	Post Offices	29	4.4									29	4.4
4581	Airports	8	1.2									8	1.2
6512	Office Buildings - Cooling	1042	78.2	417	156.4	104	130					1563	
7832	Movie Theaters	31	4.7									31	4.7
52,53,56,57	Big Box Retail	543	81.5	128	96	29	72.5					700	250
5411, 5421, 5451, 5461, 5499	Food Sales	770	57.8	102	38.3	2	2.5					874	98.5
5812, 00, 01, 03, 05, 07, 08	Restaurants	850	63.8	8	3	1	1.3					859	68
	Total	3273	291.3	655	293.6	136	206.3					4064	426.7
	Total All Sectors	5394	525.7	1307	700.9	408	864.2	44	448.8	13	637	7166	3177

Table E.4. Maryland Sector Growth Projections Through 2020

SIC Code	Economic Sector	2008-2020 Real Growth
20	Food	8.30%
22	Textiles	-4.60%
24	Lumber and Wood	10.70%
25	Furniture	10.70%
26	Paper	10.70%
27	Printing/Publishing	-4.60%
28	Chemicals	54.00%
29	Petroleum Refining	54.00%
30	Rubber/Misc Plastics	54.00%
32	Stone/Clay/Glass	30.30%
33	Primary Metals	18.40%
34	Fabricated Metals	18.40%
35	Machinery/Computer Equip	58.90%
37	Transportation Equip.	30.40%
38	Instruments	18.60%
39	Misc Manufacturing	10.70%
43	Post Offices	25.00%
4581	Airports	25.00%
6512	Office Buildings - Cooling	0.10%
6513	Apartments	0.10%
7542	Carwashes	4.60%
7832	Movie Theaters	40.70%
8412	Museums	40.70%
4222, 5142	Warehouses	69.80%
4941, 4952	Water Treatment/Sanitary	21.30%
52,53,56,57	Big Box Retail	63.20%
5411, 5421, 5451, 5461, 5499	Food Sales	63.20%
5812, 00, 01, 03, 05, 07, 08	Restaurants	40.70%
7011, 7041	Hotels	40.70%
7011, 7041	Hotels- Cooling	40.70%
7211, 7213, 7218	Laundries	4.60%
7991, 00, 01	Health Clubs	40.70%
7992, 7997-9904, 7997-9906	Golf/Country Clubs	40.70%
8051, 8052, 8059	Nursing Homes	8.10%
8051, 8052, 8059	Nursing Homes- Cooling	8.10%
8062, 8063, 8069	Hospitals	8.10%
8062, 8063, 8069	Hospitals- Cooling	8.10%
8211, 8243, 8249, 8299	Schools	8.10%
8221, 8222	Colleges/Universities	8.10%
9223, 9211, 9224	Prisons	15.00%

Table E.5. CHP Market Segments, Maryland Existing Facilities and Expected Growth 2007-2020

Market	50-500 kW MW	500-1 MW (MW)	1-5 MW (MW)	5-20 MW (MW)	>20 MW (MW)	Total MW
Traditional High Load Factor Market						
Existing Facilities	149	314	573	429	637	2,102
New Facilities	31	59	118	90	294	592
Total	181	372	691	519	931	2,694
Traditional Low Load Factor Market						
Existing Facilities	66	36	10	0	0	112
New Facilities	18	8	1	0	0	26
Total	84	44	11	0	0	138
Cooling CHP High Load Factor Market (partially additive)						
Existing Facilities	83	192	249	68	0	591
New Facilities	24	37	40	13	0	113
Total	107	229	289	80	0	704
Cooling CHP Low Load Factor Market						
Existing Facilities	291	294	206	0	0	791
New Facilities	117	86	46	0	0	249
Total	409	380	253	0	0	1,041
Total Market including Incremental Cooling Load						
Existing Facilities	531	701	864	449	637	3,182
New Facilities	174	163	177	94	294	902
Total	705	864	1,041	543	931	4,084

Note: High load factor cooling market is comprised of a portion of the traditional high load factor market that has both heating and cooling loads. The total high load factor cooling market is shown, but only 30% of it is incremental to the portion already counted in the traditional high load factor market.

Energy Price Projections

The expected future relationship between purchased natural gas and electricity prices, called the *spark spread* in this context, is one major determinant of the ability of a facility with electric and thermal energy requirements to cost-effectively utilize CHP. For this screening analysis, a fairly simple methodology was used:

Electric Price Estimation

- Retail electric price forecasts based on EIA's Annual Energy Forecast for 2007 were used as the starting point for the analysis. ACEEE provided state by state estimates. The annual price forecasts provided were converted to 5 year averages for use in the market penetration model. These prices are shown in Table E-6.
- The electricity price assumptions for the high load factor CHP applications were as

follows
- 50-500 kW – Commercial average price
- 500-1000 kW – Industrial average price
- 1-5 MW – 90% of industrial average price (to reflect higher voltages and lower prices as customer size increases above the average industrial size used by EIA)
- 5-20 MW – 81% of industrial average price
- >20 MW – 81% of industrial average price 1%

- Price adjustments for customer load factor were defined as follows:
  - High load factor – 100% of the estimated value
  - Low load factor – 120% of the estimated value
  - Peak cooling load – 150% of the estimated value
- For a customer generating a portion of his own power with CHP, standby charges[17] are estimated at 15% of the defined average electric rate. Therefore, when considering CHP, only 85% of a customer's rate can be avoided.

Natural Gas Price Estimation

- The natural gas price assumptions are not based on the EIA retail prices because CHP customers use much more gas and are typically able to negotiate discounted commodity and delivery rates. Therefore, the gas prices assumed were based on mark-ups to the Henry Hub wellhead price forecast provided
  - Delivery to Maryland from Henry Hub – $1.80/MMBtu
  - Commercial Customer from City Gate -- $1.50/MMBtu (boiler fuel)
  - Industrial Customer from City Gate -- $1.00/MMbtu (boiler fuel)
  - Electric Utility/CHP discounted rate from City Gate -- $0.40

Table E.6. Input Price Forecast (EIA 2007c) and Maryland Industrial Electric Price Estimation

Maryland Energy Prices	**Avg. 2005-2009**	**Avg. 2010-2014**	**Avg. 2015-2019**	**Avg. 2019-2020**
Maryland Retail Electricity Prices (2006$/kWh)				
Residential	$0.100	$0.115	$0.128	$0.134
Commercial	$0.106	$0.116	$0.131	$0.138
Industrial	$0.082	$0.073	$0.080	$0.085
Transportation	$0.087	$0.098	$0.109	$0.115
Maryland Retail Natural Gas Prices (2006$/MMbtu)				
Residential	$15.609	$14.247	$14.532	$15.078
Commercial	$12.561	$11.085	$11.208	$11.586
Industrial	$11.988	$10.028	$10.209	$10.711
Transportation	$12.334	$13.064	$12.900	$13.087
Wellhead Gas Price (2003$/MMBtu)				
Henry Hub (2003$/MMBtu)	$6.787	$5.635	$5.841	$6.232

[17] While the concept of standby charges is not directly applicable in a retail open access market, we use this value to reflect the cost of procuring power to cover outages.

CHP Technology Cost and Performance

The CHP system itself is the engine that drives the economic savings. The cost and performance characteristics of CHP systems determine the economics of meeting the site's electric and thermal loads. A representative sample of commercially and emerging CHP systems was selected to profile performance and cost characteristics in combined heat and power (CHP) applications. The selected systems range in capacity from approximately 100 – 20,000 kW. The technologies include gas-fired reciprocating engines, gas turbines, microturbines and fuel cells. The appropriate technologies were allowed to compete for market share in the penetration model. In the smaller market sizes, reciprocating engines competed with microturbines and fuel cells. In intermediate sizes (1 to 20 MW), reciprocating engines competed with gas turbines.

Cost and performance estimates for the CHP systems were based on work being undertaken for the EPA (2007g). The foundation for these updates is based on work previously conducted for NYSERDA (EEA 2002), on peer-reviewed technology characterizations that Energy and Environmental Analysis (EEA) developed for the National Renewable Energy Laboratory (NREL 2003) and on follow-on work conducted by DE Solutions for Oak Ridge National Laboratory (DE Solutions 2004). Additional emissions characteristics and cost and performance estimates for emissions control technologies were based on ongoing work EEA is conducting for EPRI (2005). Data is presented for a range of sizes that include basic electrical performance characteristics, CHP performance characteristics (power to heat ratio), equipment cost estimates, maintenance cost estimates, emission profiles with and without after-treatment control, and emissions control cost estimates. The technology characteristics are presented for three years: 2005, 2010, 2020. The 2007-2010 estimates are based on current commercially available and emerging technologies. The cost and performance estimates for 2010-2015 and 2015-2020 reflect current technology development paths and currently planned government and industry funding. These projections were based on estimates included in the three references mentioned above. NOx, CO and VOC emissions estimates in lb/MWh are presented for each technology both with and without aftertreatment control (AT). For this analysis, aftertreatment was only included for the 800 kW and 3000 kW engines. The installed costs in the following technology performance summary tables are based on typical national averages.

Table E.7. Reciprocating Engine Cost and Performance Characteristics

CHP System	Characteristic/Year Available	2007-2010	2010-2015	2016-2020
100 kW	Installed Costs, $/kW	$2,210	$1,925	$1,568
	Heat Rate, Btu/kWh	12,000	10,830	10,500
	Electric Efficiency, %	28.4%	31.5%	32.5%
	Thermal Output, Btu/kWh	6100	5093	4874
	O&M Costs, $/kWh	0.022	0.013	0.012
	NOx Emissions, lbs/MWh (w/ AT)	0.10	0.15	0.15
	CO Emissions w/AT, lb/MWh	0.32	0.60	0.30
	VOC Emissions w/AT, lb/MWh	0.10	0.09	0.05
	PMT 10 Emissions, lb/MWh	0.11	0.11	0.11
	SO2 Emissions, lb/MWh	0.0068	0.0064	0.0062
	After-treatment Cost, $/kW	incl.	incl.	incl.
800 kW	Installed Costs, $/kW	$1,640	$1,443	$1,246
	Heat Rate, Btu/kWh	9,760	9,750	9,225
	Electric Efficiency, %	35.0%	35.0%	37.0%
	Thermal Output, Btu/kWh	2313	3791	3250
	O&M Costs, $/kWh	0.013	0.01	0.009
	NOx Emissions, lbs/MWh (w/ AT)	0.5	1.24	0.93
	CO Emissions w/AT, lb/MWh	1.87	0.45	0.31
	VOC Emissions w/AT, lb/MWh	0.47	0.05	0.05
	PMT 10 Emissions, lb/MWh	0.10	0.01	0.01
	SO2 Emissions, lb/MWh	0.0068	0.0057	0.0054
	After-treatment Cost, $/kW	300	190	140
3000 kW	Installed Costs, $/kW	$1,130	$1,100	$1,041
	Heat Rate, Btu/kWh	9,492	8,750	8,325
	Electric Efficiency, %	35.9%	39.0%	41.0%
	Thermal Output, Btu/kWh	3510	3189	2982
	O&M Costs, $/kWh	0.011	0.0083	0.008
	NOx Emissions, lbs/MWh (w/ AT)	1.52	1.24	0.775
	CO Emissions w/AT, lb/MWh	0.78	0.31	0.31
	VOC Emissions w/AT, lb/MWh	0.34	0.10	0.10
	PMT 10 Emissions, lb/MWh	0.01	0.01	0.01
	SO2 Emissions, lb/MWh	0.0057	0.0051	0.0049
	After-treatment Cost, $/kW	200	130	100
5000 kW	Installed Costs, $/kW	$1,130	$1,099	$1,038
	Heat Rate, Btu/kWh	8,758	8,325	7,935
	Electric Efficiency, %	39.0%	41.0%	43.0%
	Thermal Output, Btu/kWh	3046	2797	2605
	O&M Costs, $/kWh	0.009	0.008	0.008
	NOx Emissions, lbs/MWh (w/ AT)	1.55	1.24	0.775
	CO Emissions w/AT, lb/MWh	0.75	0.31	0.31
	VOC Emissions w/AT, lb/MWh	0.22	0.10	0.10
	PMT 10 Emissions, lb/MWh	0.01	0.01	0.01
	SO2 Emissions, lb/MWh	0.0054	0.0049	0.0047
	After-treatment Cost, $/kW	150	115	80

Table E.8. Microturbine Cost and Performance Characteristics

CHP System	Characteristic/Year Available	2007-2010	2010-2015	2016-2020
60 kW	Installed Costs, $/kW	$2,739	$2,037	$1,743
	Heat Rate, Btu/kWh	13,891	12,500	11,375
	Electric Efficiency, %	24.6%	27.3%	30.0%
	Thermal Output, Btu/kWh	6308	3791	3102
	O&M Costs, $/kWh	0.022	0.016	0.012
	NOx Emissions, lbs/MWh (w/ AT)	0.15	0.14	0.13
	CO Emissions w/AT, lb/MWh	0.24	0.22	0.20
	VOC Emissions w/AT, lb/MWh	0.03	0.03	0.02
	PMT 10 Emissions, lb/MWh	0.22	0.20	0.19
	SO2 Emissions, lb/MWh	0.0079	0.0074	0.0067
	After-treatment Cost, $/kW			
250 KW	Installed Costs, $/kW	$2,684	$2,147	$1,610
	Heat Rate, Btu/kWh	13,080	11,750	10,825
	Electric Efficiency, %	2.6%	29.0%	31.5%
	Thermal Output, Btu/kWh	4800	3412	2625
	O&M Costs, $/kWh	0.015	0.013	0.012
	NOx Emissions, lbs/MWh (w/ AT)	0.43	0.24	0.13
	CO Emissions w/AT, lb/MWh	0.26	0.26	0.24
	VOC Emissions w/AT, lb/MWh	0.03	0.03	0.02
	PMT 10 Emissions, lb/MWh	0.18	0.18	0.16
	SO2 Emissions, lb/MWh	0.0070	0.0069	0.0064
	After-treatment Cost, $/kW	500	200	90

Table E.9.Fuel Cell Cost and Performance Characteristics

CHP System	Characteristic/Year Available	2007-2010	2010-2015	2016-2020
200 kW PAFC in 2005 150 kW PEMFC in outyears	Installed Costs, $/kW	$6,310	$4,782	$3,587
	Heat Rate, Btu/kWh	9,480	9,480	8,980
	Electric Efficiency, %	36.0%	36.0%	38.0%
	Thermal Output, Btu/kWh	4250	3482	3281
	O&M Costs, $/kWh	0.038	0.017	0.015
	NOx Emissions, lbs/MWh (w/ AT)	0.06	0.05	0.04
	CO Emissions w/AT, lb/MWh	0.07	0.07	0.07
	VOC Emissions w/AT, lb/MWh	0.01	0.01	0.01
	PMT 10 Emissions, lb/MWh	0.00	0.00	0.00
	SO2 Emissions, lb/MWh	0.0057	0.0056	0.0053
	After-treatment Cost, $/kW	n.a.	n.a.	n.a.
300 kW MCFC	Installed Costs, $/kW	$5,580	$4,699	$3,671
	Heat Rate, Btu/kWh	8,022	7,125	6,920
	Electric Efficiency, %	42.5%	47.9%	49.3%
	Thermal Output, Btu/kWh	1600	1723	1602
	O&M Costs, $/kWh	0.035	0.02	0.015
	NOx Emissions, lbs/MWh (w/ AT)	0.1	0.05	0.04
	CO Emissions w/AT, lb/MWh	0.07	0.05	0.04
	VOC Emissions w/AT, lb/MWh	0.01	0.01	0.01
	PMT 10 Emissions, lb/MWh	0.00	0.00	0.00
	SO2 Emissions, lb/MWh	0.0057	0.0042	0.0041
	After-treatment Cost, $/kW	n.a.	n.a.	n.a.
1200 kW MCFC	Installed Costs, $/kW	$5,250	$4,523	$3,554
	Heat Rate, Btu/kWh	8,022	7,110	6,820
	Electric Efficiency, %	42.5%	48.0%	50.0%
	Thermal Output, Btu/kWh	1583	1706	1503
	O&M Costs, $/kWh	0.032	0.019	0.015
	NOx Emissions, lbs/MWh (w/ AT)	0.05	0.05	0.04
	CO Emissions w/AT, lb/MWh	0.04	0.04	0.03
	VOC Emissions w/AT, lb/MWh	0.01	0.01	0.01
	PMT 10 Emissions, lb/MWh	0.00	0.00	0.00
	SO2 Emissions, lb/MWh	0.0044	0.0042	0.0040
	After-treatment Cost, $/kW	n.a.	n.a.	n.a.

Table E.10. Gas Turbine Cost and Performance Characteristics

CHP System	Characteristic/Year Available	2007-2010	2010-2015	2016-2020
3000 KW GT	Installed Costs, $/kW	$1,690	$1,560	$1,300
	Heat Rate, Btu/kWh	13,100	12,650	11,200
	Electric Efficiency, %	26.0%	27.0%	30.5%
	Thermal Output, Btu/kWh	5018	4489	4062
	O&M Costs, $/kWh	0.0074	0.0065	0.006
	NOx Emissions, lbs/MWh (w/ AT)	0.68	0.38	0.2
	CO Emissions w/AT, lb/MWh	0.55	0.53	0.47
	VOC Emissions w/AT, lb/MWh	0.03	0.03	0.02
	PMT 10 Emissions, lb/MWh	0.21	0.20	0.18
	SO2 Emissions, lb/MWh	0.0070	0.0069	0.0069
	After-treatment Cost, $/kW	210	175	150
10 MW GT	Installed Costs, $/kW	$1,298	$1,342	$1,200
	Heat Rate, Btu/kWh	11,765	10,800	9,950
	Electric Efficiency, %	29.0%	31.6%	34.3%
	Thermal Output, Btu/kWh	4674	4062	3630
	O&M Costs, $/kWh	0.007	0.006	0.005
	NOx Emissions, lbs/MWh (w/ AT)	0.67	0.37	0.2
	CO Emissions w/AT, lb/MWh	0.50	0.46	0.42
	VOC Emissions w/AT, lb/MWh	0.02	0.02	0.02
	PMT 10 Emissions, lb/MWh	0.20	0.18	0.17
	SO2 Emissions, lb/MWh	0.0069	0.0064	0.0059
	After-treatment Cost, $/kW	140	125	100
40 MW GT	Installed Costs, $/kW	$972	$944	$916
	Heat Rate, Btu/kWh	9,220	8,865	8,595
	Electric Efficiency, %	37.0%	38.5%	39.7%
	Thermal Output, Btu/kWh	3189	3019	2892
	O&M Costs, $/kWh	0.004	0.004	0.004
	NOx Emissions, lbs/MWh (w/ AT)	0.55	0.2	0.1
	CO Emissions w/AT, lb/MWh	0.04	0.04	0.04
	VOC Emissions w/AT, lb/MWh	0.01	0.01	0.01
	PMT 10 Emissions, lb/MWh	0.16	0.15	0.15
	SO2 Emissions, lb/MWh	0.0054	0.0052	0.0051
	After-treatment Cost, $/kW	90	75	40

In the cooling markets, an additional cost was added to reflect the costs of adding chiller capacity to the CHP system. These costs depend on the sizing of the absorption chiller which in turn depends on the amount of usable waste heat that the CHP system produces. A curve fitting approach was used and the values by size bin are as follows:

- 50-500 kW -- $390 530/kW
- 500-1,000 kW --$275-500/kW
- 1-5 MW – $110-270/kW

- 5-20 MW – $65-110/kW
- >20 MW – $45/kW

Market Penetration Analysis

EEA has developed a CHP market penetration model that estimates cumulative CHP market penetration in 5-yrar increments. For this analysis, the forecast periods are 2010, 2015, and 2020. The target market is comprised of the facilities that make up the technical market potential as defined in Appendix A. Thee economic competition module in the market penetration model compares CHP technologies (Appendix C) to purchased fuel and power (Appendix B) in 5 different sizes and 4 different CHP application types. The calculated payback determines the potential pool of customers that would consider accepting the CHP investment as economic. Additional, non economic screening factors are applied that limit the pool of customers that can accept CHP in any given market/size. Based on this calculated economic potential, a market diffusion model is used to determine the cumulative market penetration for each 5-year time period. The cumulative market penetration, economic potential and technical potential are defined as follows:

- *Technical potential* represents the total capacity potential from existing and new facilities that are likely to have the appropriate physical electric and thermal load characteristics that would support a CHP system with high levels of thermal utilization during business operating hours.
- *Economic potential*, as shown in the table, reflects the share of the technical potential capacity (and associated number of customers) that would consider the CHP investment economically acceptable according to a procedure that is described in more detail below.
- *Cumulative market penetration* represents an estimate of CHP capacity that will actually enter the market between 2006 and 2020. This value discounts the economic potential to reflect non-economic screening factors and the rate that CHP is likely to actually enter the market.

In addition to segmenting the market by size, as shown in the table, the analysis is conducted in four separate CHP market applications (high load and low load factor traditional CHP and high and low load factor CHP with cooling.) These markets are considered individually because both the annual load factor and the installation and operation of thermally activated cooling has an impact on the system economics.

Economic potential is determined by an evaluation of the competitiveness of CHP versus purchased fuel and electricity. The projected future fuel and electricity prices and the cost and performance of CHP technologies determine the economic competitiveness of CHP in each market. CHP technology and performance assumptions appropriate to each size category and region were selected to represent the competition in that size range (**Table E-11)**. Additional assumptions were made for the competitive analysis. Technologies below 1 MW in electrical capacity are assumed to have an economic life of 10 years. Larger systems are assumed to have an economic life of 15 years. Capital related amortization costs were based on a 10% discount rate. Based on their operating characteristics (each category and each size bin within the category have specific assumptions about the annual hours of CHP operation (80-90% for the high load factor cases with appropriate adjustments for low load factor facilities), the share of recoverable thermal energy that gets utilized (80%-90%), and the share of useful thermal energy that is used for cooling compared to traditional heating. The economic figure-of-merit chosen to reflect this competition in the market penetration model is simple payback.[18] While not the most sophisticated measure of a project's performance, it is nevertheless widely understood by all classes of customers.

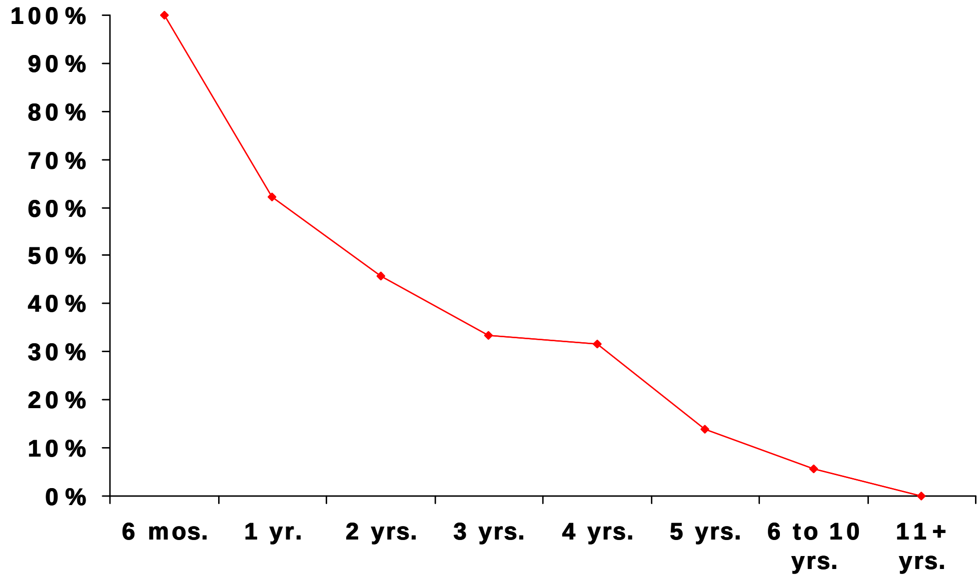
Table E.11. Technology Competition Assumed within Each Size Category

Market Size Bins	*Competing Technologies*
50 - 500 kW	100 kW Recip Engine
	70 kW Microturbine
	150 kW PEM Fuel Cell
500 - 1,000 kW	300 kW Recip Engine (multiple units)
	70 kW Microturbine (multiple units)
	250 kW MC/SO Fuel Cell (multiple units)
1 - 5 MW	3 MW Recip Engine
	3 MW Gas Turbine
	2 MW MC Fuel Cell
5 - 20 MW	5 MW Recip Engine
	5 MW Gas Turbine
20 - 100 MW	40 MW Gas Turbine

Rather than use a single payback value, such as 3-years or 5-years as the determinant of economic potential, we have based the market acceptance rate on a survey of commercial and industrial facility operators concerning the payback required for them to consider installing CHP. Figure E-1 shows the percentage of survey respondents that would accept CHP investments at different payback levels (CEC 2005b). As can be seen from the figure, more than 30% of customers would reject a project that promised to return their initial investment in just one year. A little more than half would reject a project with a payback of 2 years. This type of payback translates into a project with an ROI from 49 to 100%. Potential explanations for rejecting a project with such high returns is that the average customer does not believe that the results are real and is protecting himself from this perceived risk by requiring very high projected returns before a project would be accepted, or that the facility is very capital limited and is rationing its capital raising capability for higher priority projects (market expansion, product improvement, etc.).

[18] Simple payback is the number of years that it takes for the annual operating savings to repay the initial capital investment.

Figure E.1. Customer Payback Acceptance Curve



Source: *Primen's 2003 Distributed Energy Market Survey*

For each market segment, the economic potential represents the technical potential multiplied by the share of customers that would accept the payback calculated in the economic competition module.

The estimation of market penetration includes both a non-economic screening factor and a factor that estimates the rate of market penetration (diffusion.) The non-economic screening factor was applied to reflect the share of each market size category (i.e., applications of 50 to 500 kW, applications of 500 to 1,000 kW, etc) within the economic potential that would be willing and able to consider CHP at all. These factors range from 32% in the smallest size bin (50-500 kW) to 64% in the largest size bin (more than 20 MW.) These factors are intended to take the place of a much more detailed screening that would eliminate customers that do not actually have appropriate electric and thermal loads in spite of being within the target markets, do not use gas or have access to gas, do not have the space to install a system, do not have the capital or credit worthiness to consider investment, or are otherwise unaware, indifferent, or hostile to the idea of adding CHP. The specific value for each size bin was established based on an evaluation of EIA facility survey data and gas use statistics from the iMarket database.

The rate of market penetration is based on a *Bass diffusion curve* with allowance for growth in the maximum market. This function determines cumulative market penetration for each 5-year period. Smaller size systems are assumed to take a longer time to reach maximum market penetration than larger systems. Cumulative market penetration using a Bass diffusion curve takes a typical S-shaped curve. In the generalized form used in this analysis, growth in the number of ultimate adopters is allowed. The curves shape is determined by an initial market penetration estimate, growth rate of the technical market potential, and two factors described as *internal market influence* and *external market influence*.

The cumulative market penetration factors reflect the economic potential multiplied by the non-economic screening factor (maximum market potential) and by the Bass model market cumulative market penetration estimate.

Once the market penetration is determined, the competing technology shares within a size/utility bin are based on a *logit function* calculated on the comparison of the system paybacks. The greatest market share goes to the lowest cost technology, but more expensive technologies receive some market share depending on how close they are to the technology with the lowest payback. (This technology allocation feature is part of the EEA CHP model that is not specifically used for this analysis.)

Two cases were run to show the effects of providing an economic stimulus for CHP market penetration consisting of a capital cost reduction of $600/kW for all CHP systems 20 MW and below. The results of the base case, without incentives, are shown in Table E12 and Table E13. The results of the incentive case are shown in Table E14 and Table E15. The $600/kW incentive payment for CHP 5 MW or less more than doubles total economic potential and increases 2020 market penetration by 87%.

Table E.12. Summary CHP Base Case Market Values for Maryland: Technical Potential, Economic Potential, Cumulative 2008-2020 Market Penetration

Maryland	50-500 kW MW	500kW-1,000kW MW	1-5 MW MW	5-20 MW MW	>20 MW MW	All Sizes MW
Cumulative Market Penetration						
2010	1	0	0	0	0	1
2015	21	1	0	0	38	60
2020	41	3	3	0	49	97
Economic Potential	168	20	37	0	70	295
Technical Potential	705	864	1,041	543	931	4,084

Table E.13. Summary Base Case CHP Output Values by Year

Year	Market Pen. (MW)	Avoided Elec. for Cooling (MW)	Fuel Cons. (Billion Btu/year)	Avoided Boiler Fuel (billion Btu/year)	Elec. Gen. (million kWh)	Avoided Elec. for Cooling (million kWh)
2010	1	0	85	45	7	0
2015	60	2	4,033	1,629	427	5
2020	97	3	6,237	2,426	660	10

Table E.14. Summary CHP Incentive Case Market Values for Maryland: Technical Potential, Economic Potential, Cumulative 2008-2020 Market Penetration

Maryland	50-500 kW MW	500kW-1,000kW MW	1-5 MW MW	5-20 MW MW	>20 MW MW	All Sizes MW
Cumulative Market Penetration						
2010	4	0	0	0	0	4
2015	32	6	36	29	38	141
2020	60	20	58	37	49	224
Economic Potential	233	131	239	105	70	778
Technical Potential	705	864	1,041	543	931	4,084

Table E.15. Summary Incentive Case CHP Output Values by Year

Year	Market Pen. (MW)	Avoided Elec. for Cooling (MW)	Fuel Cons. (Billion Btu/year)	Avoided Boiler Fuel (billion Btu/year)	Elec. Gen. (million kWh)	Avoided Elec. for Cooling (million kWh)
2010	4	0	240	114	21	0
2015	141	4	8,935	3,412	975	9
2020	224	7	13,690	5,042	1,498	19

Policy Analysis

For this analysis we assume that the results of the CHP policy is the difference between the CHP installed in the base case and the incentive case (Table E-16). Required CHP investments were made by applying size-weighted average costs based on the projected equipment cost by size class (Table E17). Annual values were estimated by interpolation.

Table E.16. Projected Installed CHP Capacity and Output in Policy Case

Projected Cumulative Capacity						
	50-500 kW	**500kW-1,000kW**	**1-5 MW**	**5-20 MW**	**>20 MW**	**All Sizes**
	MW	MW	MW	MW	MW	MW
2010	2	0	0	0	0	2
2015	11	6	36	29	0	81
2020	19	17	54	37	0	128
Output Values						
Year	**Market Pen. (MW)**	**Avoided Elec. for Cooling (MW)**	**Fuel Cons. (Billion Btu/year)**	**Avoided Boiler Fuel (billion Btu/year)**	**Elec. Gen. (million kWh)**	**Avoided Elec. for Cooling (million kWh)**
2010	2	0	155	69	13	0
2015	81	2	4,902	1,783	548	4
2020	128	3	7,453	2,616	838	10

Table E.17. Average CHP Costs by Size Class and Installed Capacity Weighted Costs

	50-500 kW	500kW-1,000kW	1-5 MW	5-20 MW	>20 MW	All Sizes
Installed Capacity Costs						
2010 Cost/kWh	2,700	1,650	1,150	1,300	1,000	1,602
2015 Cost/kWh	2,100	1,450	1,100	1,300	950	1,400
2020 Cost/kWh	1,700	1,250	1,050	1,200	925	1,240
Operating Costs						
2010 O&M/kWh	0.018	0.013	0.011	0.006	0.004	0.011
2015 O&M/kWh	0.015	0.010	0.009	0.005	0.004	0.009
2020 O&M/kWh	0.012	0.009	0.008	0.005	0.004	0.008