Meeting Maryland's Greenhouse Gas Reduction Goals:

Manufacturing Costs, Employment & Economic Effects from Maryland's Climate Action Plan

A Study Commissioned by
The Maryland Department of the Environment

Center for Integrative Environmental Research

October 2011

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We wish to thank the Maryland Department of the Environment for support of this research.

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When citing this report, please include the following information: Ruth, M., Williamson, S., Frye, R., Irani, D., Ebersole, R., Zhu, J., Emelianoff. A., Hobbs, B., and Shim, Y. Meeting Maryland's Greenhouse Gas Reduction Goals: Manufacturing Costs, Employment and Economic Effects from Maryland's Climate Action Plan, 2011. Center for Integrative Environmental Research, University of Maryland, College Park, Maryland.

Project Overview

This report is the second of a two-part study evaluating the anticipated impacts from Maryland's Climate Action Plan on the state's electricity reliability and manufacturing sector. Here, we present findings from an analysis of manufacturing costs and employment. A previous study presents findings from our electricity reliability analysis.

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Acknowledgments

The authors wish to thank all of those who provided valuable insights and assistance for this study. Specifically, we want to acknowledge guidance and input from Ruth Kiselewich and Bill Wolf at Baltimore Gas and Electric, Calvin Timmerman and Crissy Godfrey at the Maryland Public Service Commission, and Andrea Bohmholdt at the Maryland Department of the Environment. We also wish to thank Anthony Paul, Dr. Karen Palmer and Dr. Dallas Burtraw from Resources for the Future; their previous Haiku modeling and analysis of developments in the Maryland and PJM power markets in response to RGGI were critical for our work. We appreciate the contributions of Mark Olsthoorn, Kim Ross, Andrew Blohm, Jeremy Peichel, Chris Ramig, and Phuong Lien Tran from the Center for Integrative Environmental Research at the University of Maryland; and Katie Radchenko, Regina Asala and Zachary Jones from the Regional Economic Studies Institute of Towson University.

Finally, we thank the Maryland Department of the Environment for the opportunity to work on this important study and for the feedback provided by staff of its Air and Radiation division.

This report is a product of the staff of the Center for Integrative Environmental Research and its collaborators. The findings, analyses, and conclusions expressed in this report do not necessarily reflect the views of the Maryland Department of the Environment.

Acronyms and Abbreviations

ACEEE:	American Council for an Energy Efficient Economy
ACP:	Alternative compliance payment
AEO:	Annual Energy Outlook
ARRA:	American Reinvestment and Recovery Act
ASM:	Annual Survey of Manufacturers
BGE:	Baltimore Gas and Electric
CAP:	Climate Action Plan
CBO:	US Congressional Budget Office
CHP:	Combined heat and power
DG:	Distributed generation
EGU:	Electricity generating unit
EmPowerMD:	EmPower Maryland
GGRA:	Greenhouse Gas Emissions Reduction Act of 2009
GHG:	Greenhouse gases
HVAC:	Heating, ventilation, and air conditioning
IPL:	Industrial process load
LC&I:	Large commercial and industrial
LEED:	Leadership in Energy and Environmental Design
LPG:	Liquefied petroleum gas
LSE:	Load serving entity
MAPP:	Mid-Atlantic Power Pathway
MCCC:	Maryland Commission on Climate Change
MDE:	Maryland Department of the Environment
MEA:	Maryland Energy Administration
MDGA:	Maryland General Assembly
MECS:	Manufacturing Energy Consumption Survey
MMEM:	Maryland manufacturing energy model
NAICS:	North American Industry Classification System
PATH:	Potomac-Appalachian Transmission Highline

PIRG: Public Interest Research Group

PJM: Pennsylvania-New Jersey-Maryland Interconnection

PPRP: Power Plant Research Program

PSC: Public Service Commission

REC: Renewable energy credit

RPS: Renewable Energy Portfolio Standard

RGGI: Regional Greenhouse Gas Initiative

SEDS: State Energy Database System

SEIF: Strategic Energy Investment Fund

SOC: Standard Occupational Classification

Executive Summary

This project investigates potential impacts from climate mitigation policies listed in Maryland's draft 2012 GGRA Plan on four interest areas, including: (1) costs in the manufacturing sector, (2) jobs in the manufacturing sector, (3) state-wide economy, and (4) new employment opportunities. The executive summary covers pertinent background, research approach, major findings, study limitations and applications.

ES.1 Study Background and Approach

Under the Greenhouse Gas Emissions Reductions Act of 2009 (GGRA), the Maryland Department of the Environment (MDE) is charged with submitting a draft plan by December 31, 2011, to the Governor and General Assembly that demonstrates the following: (1) containment of costs in the manufacturing sector, (2) no net loss of jobs in the manufacturing sector, (3) no adverse impact on the state's economy, and (4) generation of new employment opportunities. This report is intended to help MDE meet these GGRA requirements. Furthermore, modified mitigation policies from the 2008 Climate Action Plan (CAP) are anticipated to represent central components of the draft 2012 GGRA Plan to be submitted to the Governor in December 2011. We choose for our analyses a select set of 2008 CAP policies that have a high-likelihood of significantly influencing manufacturing costs, employment and the Maryland economy.

The objectives of this report must be understood within the context of all GGRA requirements. First, the GGRA states, "unless required by Federal law or regulations or existing State law, regulations adopted by State agencies to implement the final plan may not require greenhouse gas emissions reductions from the State's manufacturing sector" (MDGA, 2009, pg. 7). Second, the GGRA requires that by October 2015, an institution of higher education complete an independent study, with oversight from an industry-represented task force, evaluating the economic impact of requiring greenhouse gas emissions reductions from the state's manufacturing sector (MDGA, 2009, pg. 9). In turn, it is expected that new GHG regulations in the manufacturing sector, if any at all, would be deferred until after a legislative review of CAP progress and the 2015 independent study.

As a result, this study does not evaluate costs resulting from new or non-existing greenhouse gas (GHG) regulations in the manufacturing sector. We defer that analysis to the 2015 study, although we expect our present study to provide valuable insights in preparation for the 2015 study.

The purpose of our present study is to evaluate manufacturing cost, employment and economic impacts resulting from execution of the Maryland GHG mitigation plan. Our study addresses the GGRA requirements through consideration of existing climate mitigation policies. Namely, we quantify the impact to manufacturing costs, employment and the Maryland economy that result from implementation of the Renewable Energy Portfolio Standard (RPS), the Regional Greenhouse Gas Initiative (RGGI) and Empower Maryland

(EmPowerMD). Additionally, we present some qualitative analysis of potential impacts on the manufacturing sector that may result from other existing GHG mitigation policies.

MDE selected the University of Maryland's Center for Integrative Environmental Research (CIER) to conduct studies to meet GGRA requirements. In Fall 2009, CIER formed a team that included its own experts of economic and policy analysts, as well as colleagues from Johns Hopkins University and Towson University. Over the past 20 months, we collaborated with government, business, and academic entities and utilized the best available resources to complete the studies.

Given the wide range of mitigation policies identified in the state's 2008 CAP, for the development of this study we adopted the following three guiding principles:

1. Apply a consistent scope of analysis and definitions;
2. Provide in-depth analysis on climate mitigation policies that have a high-likelihood to significantly influence manufacturing costs and employment including RGGI, RPS and EmPowerMD;
3. Verify and document methods thoroughly, including critical assumptions and/or conditions that will influence results.

The analysis in this study relies on modeling to distinguish among impacts under a baseline scenario (without implementation of policies identified in the 2008 CAP) and alternative policy scenarios (with implementation of policies identified in the 2008 CAP). The models evaluate impacts for a period extending to 2020. Both the direction and magnitude of impacts are estimated. The Maryland manufacturing energy model (MMEM) is an industry-disaggregated model of energy profiles and production costs in the Maryland manufacturing sector. The IMPLAN model, run by the Regional Economic Studies Institute (RESI) of Towson University, considers employment and economic changes resulting from production cost impacts. Also, Towson University developed a methodology for forecasting green job opportunities in the state by using the Occupational Network (O*Net) database.

The study is organized in three chapters. Chapter 1 presents a literature review of Maryland's manufacturing sector including its energy profile and economic status; select CAP policies and expected direct and indirect impacts; and potential responses from manufacturing firms as a result of CAP-induced impacts. Next, Chapter 2 presents production costs to be incurred in Maryland's manufacturing sector as a result of select CAP policies and includes a description of the study design, methods, results and applications. Chapter 3 presents manufacturing employment impacts, statewide economic impacts and job creation opportunities as a result of select CAP policies as well as study design, methods, results and applications for respective components. Results from the manufacturing costs analysis (discussed in Chapter 2) serve as direct inputs for quantifying CAP-induced manufacturing employment and economic impacts. Analysis of green job opportunities uses recent Maryland employment data and adopts GGRA employment classifications in the following fields: "energy conservation," "alternative energy supply," and "greenhouse gas emissions reduction technology" (MDGA, 2009, pg. 9).

ES.2 Major Findings

We present four related studies corresponding with individual requirements of the GGRA. GGRA language, report organization and findings can be found in Table ES.1.

Table ES.1 GGRA requirements, corresponding studies and findings

GGRA Language (Section and Paraphrased Requirement)	**Study Title (Chapter)**	**Findings**
Section 2-1205(F)(1): "*Unless required by law, regulations adopted by state agencies to implement the final plan may not: (I) Require GHG emissions reductions from manufacturing sector; or (II) Cause a significant increase in costs to manufacturing sector.*"	Manufacturing Costs (Chapter 2)	No significant increase in capital or energy costs for manufacturing sector. Energy-intensive subsectors experience greatest impact, but costs remain minimal.
Section 2-1206(8): *"Ensure GHG emission reduction measures implemented in accordance with the plan: (V) directly cause no loss of existing jobs in the manufacturing sector."*	Manufacturing Employment (Chapter 3, Section 3.2)	No significant loss of jobs in the manufacturing sector attributable to CAP.
Section 2-1206(8): *"Ensure GHG emissions reduction measures implemented in accordance with the plan: (VI) produce a net economic benefit to the State's economy."*	Economic and Fiscal Impacts (Chapter 3, Section 3.3)	Impacts to economic activity, wages, and employment resulting from CAP-induced manufacturing costs are minimal.
Section 2-1206(8): *Ensure that the greenhouse gas emissions reduction measures implemented in accordance with the plan: (VI) …produce a net increase in jobs in the state; (VII) encourage new employment opportunities in the State related to energy conservation, alternative energy supply, and greenhouse gas emissions reduction technologies."*	Potential Green Job Opportunities, (Chapter 3, Section 3.4)	New job opportunities in each of the GGRA categories exist and are expected to grow. The state's workforce is currently made up of about 3 percent green jobs. Most new green jobs will be in the areas of skill enhancement.

Findings: Manufacturing Costs Study

We consider production cost impacts – including energy and capital costs – resulting from the RGGI, the RPS, and EmPowerMD as well as repercussions from other climate policies in the manufacturing sector. Cost impacts resulting from the RGGI, the RPS, and EmPowerMD are quantified through development of a baseline (without CAP policies) and three alternative policy scenarios (with CAP policies). The policy scenario titles – high, middle and low cost – are derived from their relative anticipated production cost impacts. In other words, the high cost policy scenario results in the greatest increase in production costs relative to the baseline. The assumptions adopted for the middle policy scenario reflect a continuation of historical policy implementation (e.g., limited EmPowerMD participation) and anticipation of average market trends (e.g., cost of renewable energy credits) (Table ES.2). The high and low scenarios represent reasonable bounds under alternative market and policy assumptions.

Table ES.2 Baseline and three alternative scenarios design for manufacturing costs analysis

Scenario	**Manufacturing Economic Output**	**Production Efficiency Trends**	**Renewable Energy Requirements**	**RGGI Implementation**
Baseline	Dollar value of shipments same in all scenarios	Natural efficiency gains; no utility energy efficiency programs in place	Regional RPS met without Maryland's participation; Maryland utilities not subject to the RPS	Regional RGGI compliance; Maryland generating units not subject to the RGGI
Middle	See above	Natural efficiency gains + low EmPowerMD efficiency gains	Maryland RPS (w/ SB 277)[1]; utilities pay for middle value RECs and high value solar REC (Tier 1 only)	Maryland generating units subject to the RGGI; 25% of auction proceeds go towards energy efficiency
High	See above	Natural efficiency gains + low EmPowerMD efficiency gains	Maryland RPS (w/ SB 277); utilities pay for high value RECs and solar alternative compliance payment (Tier 1 only)	Maryland generating units subject to the RGGI; 25% of auction proceeds go towards energy efficiency
Low	See above	Natural efficiency gains + high EmPowerMD efficiency gains	Maryland RPS (w/ SB 277); utilities pay for low value RECs and high value solar REC (Tier 1 only)	Maryland generating units subject to the RGGI; 75% of auction proceeds go towards energy efficiency

On the basis of our analyses, we expect that Maryland's CAP will not create a significant increase in production costs to the state's manufacturing sector. Capital cost impacts associated with energy efficiency improvements in the manufacturing sector will peak and end in 2015; relative to the baseline, capital costs will increase by approximately 0.2 percent. Under our middle scenario, energy costs decrease relative to the baseline in early years (Table ES.3). In 2020, energy cost impacts peak at 0.6 percent above the baseline as a result of:

- a 1.2 percent decrease in purchased electricity via EmPowerMD participation in the manufacturing sector;
- a 2.3 percent increase in average retail industrial electricity rates via the RGGI and the RPS interactions in the electricity market.

Table ES.3 Manufacturing energy costs in millions of 2006$ and percent change relative to baseline under 3 scenarios

	2010	**2012**	**2014**	**2016**	**2018**	**2020**
Middle	739.78	830.27	864.34	893.61	931.73	967.66
% change	*-0.06%*	*-0.32%*	*-0.26%*	*-0.27%*	*-0.05%*	*0.59%*
Low	738.15	823.52	852.09	875.31	909.69	938.92
% change	*-0.28%*	*-1.13%*	*-1.67%*	*-2.31%*	*-2.42%*	*-2.40%*
High	739.86	832.13	869.05	901.80	946.48	995.85
% change	*-0.05%*	*-0.10%*	*0.28%*	*0.64%*	*1.53%*	*3.52%*

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[1] Senate Bill 277, "Renewable Energy Portfolio Standard - Solar Energy." The spring 2010 bill alters the solar RPS requirement for specific years.

We also find that impacts will vary across manufacturing subsectors:

- Large, electricity-intensive industries will see the greatest energy cost increase of between 1-2 percent relative to the baseline (e.g., primary metals, chemicals);
- Small, less electricity-intensive industries with high participation in EmPowerMD programs could see cost savings relative to the baseline (e.g., printing and related, miscellaneous industries);
- Due to mitigation of electricity rate impacts, firms with electricity self-generation capacity will see lower cost impacts than firms without self-generation capacity;
- The factors most likely to influence cost impacts across manufacturing firms include total electricity demand, electricity intensity, and technology attributes such as age of equipment and presence of self-generation capacity.

Additional climate mitigation policies included in the CAP, such as improved building codes, appliance efficiency standards, and promotion of clean distributed energy and combined heat and power, will not create significant adverse impacts in the manufacturing sector. Several policies are market-based and expected to help manufacturing firms overcome investment hurdles. Specific opportunities and challenges include:

- State incentives will lower initial capital costs for otherwise cost-effective investments (e.g., lighting and equipment upgrades);
- Due to the limited size and financial state of most manufacturing firms, as well as economic uncertainties, firms will be constrained in their ability to capitalize on incentives; also, some regulatory policies could create compliance costs for select subsectors (e.g., appliance standards).

Findings: Manufacturing Employment, Economic Impacts, and Employment Opportunities

Our analyses of manufacturing employment and economic impacts depend on the methodology and results from the Manufacturing Costs Study (see above or Chapter 2). We use production cost impacts in the manufacturing sector resulting from the RGGI, the RPS, and EmPowerMD as an input to the IMPLAN model to calculate employment and economic impacts. Similar to the Manufacturing Costs Study analysis, the Employment and Economic Studies present results from three alternative policy scenarios (see Table ES.2).

Job losses in the manufacturing sector attributable to select CAP policies will be minimal and may not occur at all. Specific findings include:

- The trend of employment losses in Maryland manufacturing has been ongoing since the 1970s and is expected to continue through 2020 – with or without the CAP;
- Given time and policies that promote green job growth, employment losses could be offset by green job creation in manufacturing;
- The net employment impact for the manufacturing sector, 2009-2020, is as follows:
    - Under the middle cost scenario (see Table ES.2), approximately 18 manufacturing jobs will be gained as a direct result of climate policies while the high cost scenario will yield a small loss of jobs.
    - These gains and losses are too small to be considered meaningful given the accuracy of the data and models, and long time frames under investigation, suggesting that the CAP will not noticeably influence employment in the state.

Next, we find the economy-wide impacts associated with CAP-induced manufacturing production costs will be minimal. The total economic and fiscal impacts (direct, indirect and induced) for each scenario from 2009 through 2020 are presented in table ES.4. It is important to emphasize that the economic impacts study looks specifically at interactions between the manufacturing sector and CAP policies as opposed to interactions between the entire economy and CAP policies. In turn, the findings of this study will contribute to the dialogue of the CAP and economic feasibility, and should be seen within the context of the broader portfolio of analyses on Maryland's various CAP policies (e.g., Ruth et al., 2007 and 2008; ACEEE, 2008; PPRP, 2006).

Table ES.4 Economic impacts (change in value) resulting from production costs, 2009-2020

Scenario	Economic Activity	Employment	Wages	Fiscal Impact
Middle	-$3,629,105	17.7	$1,138,325	-$2,977
Low	$133,051,839	595.3	$31,953,428	$3,734,194
High	-$162,714,528	-650.0	-$34,461,921	-$4,241,905

Maryland stands to benefit from new employment opportunities that will support mitigation policies associated with the state's CAP. Maryland must ensure that it continues to capitalize on its talented and skilled workforce and that policies and strategies are in place to support growth and attract new "green jobs." We follow the methodology used by the Maryland Green Jobs & Industry Task Force to evaluate the current and past status of green jobs in the state. Using appropriate data, RESI calculates the current amount of green jobs in the state for both 2008 and 2009. Out of the 2.4 million jobs in Maryland, we estimate that 72,293 or approximately 3 percent of the total workforce can be classified as green jobs in 2008. In 2009, employment fell to approximately 2.3 million jobs and the number of green jobs dropped in parallel to 69,865; however, as a percentage of the total workforce, green jobs remained the same.

In order to better understand the types of jobs that will result from new climate policies, a profile of relevant green occupations is compiled. We collected employment information from O*Net's investigation into the impact of green economy activities and technologies on occupation requirements and the development of new and emerging occupations. Due to the nature of Maryland's varied occupational profile, most new green jobs will be in the areas of skill enhancement, or adding skills to existing careers.

ES.3 Key Assumptions and Study Constraints

The results presented in this report are dependent upon a number of assumptions, which, in part, have been necessitated by limitations in data at the firm and state level. We consider a range of scenarios and conduct sensitivity analyses to demonstrate how altering critical assumptions influences results. Key study elements and assumptions include:

1. Direct quantitative analysis applies to only three climate mitigation policies including the RGGI, the RPS, and EmPowerMD; although we anticipate these policies will have the greatest impact on manufacturing costs, jobs and the economy, the possibility exists for other mitigation policies to have impacts.

2. The baseline scenarios adopted in this analysis assume trends that could likely deviate, including: economic growth, energy efficiency improvements in manufacturing firms and declining employment in the manufacturing sector.
3. The policy scenarios assume varying implementation success and market dynamics that may prove different in reality such as the price of renewable energy credits, in-state development of renewable energy capacity, and participation in EmPowerMD programs from manufacturing firms.

ES.4 Lessons

1. Maryland's manufacturing sector is diverse with firms having distinct energy profiles. The energy profile of a firm is a strong determinant for how it will be impacted by climate policies as well as an indicator of how it might respond to policy-induced costs.
2. With some exceptions, electricity intensive firms and firms with a significant share of energy coming in the form of purchased electricity will experience relatively greater impacts from climate policies compared to other firms.
3. Achieving the goals of the GGRA and doing so with the cooperation of the Maryland manufacturing community can be achieved through careful, customized program design. Comprehensive understanding of manufacturing subsectors, locations, energy profiles and business practices should be considered in policy formulation to maximize cost-effectiveness.
4. Specific energy-intensive industries in the manufacturing sector will likely lose a small number of jobs as a result of climate mitigation policies, but overall job loss – beyond existing trends associated with a restructuring of the state's manufacturing sector – may not occur, and job impacts under all scenarios will, in essence, be unnoticeable.
5. Impacts in the statewide economy resulting from manufacturing production costs will be minimal.
6. Successful acquisition and retention of new employment opportunities and green jobs in particular will require policies that drive both workforce supply and demand; utilizing existing partnerships between state and local government, as well as between the public and private sector, will facilitate this effort.

Some policies in Maryland's CAP have direct impacts on manufacturing businesses – such as the three policies analyzed here (the RGGI, the RPS and EmPowerMD) – largely because they change the costs of essential inputs, such as energy and capital equipment. Other CAP policies – for instance those targeted towards the transportation sector or land use – are likely to indirectly influence the broader economic context within which businesses operate. We expect manufacturing in Maryland, and its economy as a whole, to be agile enough to make the necessary changes in technologies and business practices to absorb what has been portrayed as a policy-induced shock on the economy. At worst, the CAP will become an indistinguishable part of a larger and longer-term trend of declining manufacturing employment in the state. At best, the CAP will generate new business opportunities and jobs.

Chapter 1: Review of Manufacturing, Policy Impacts and Responses

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1.1 Introduction

This chapter describes existing literature and insights in four areas, including: (1) background information on Maryland manufacturing, (2) key factors that distinguish energy consumption and production costs among manufacturing firms, (3) observed and expected impacts from three select Maryland climate policies, and (4) potential responses to policy-induced impacts in the manufacturing sector. The information presented in this chapter serves as important context to subsequent chapters dealing specifically with the Maryland manufacturing sector.

Section 1.2 defines manufacturing and presents subsector level historical trends. Also, Section 1.2 outlines briefly the energy patterns in the Maryland manufacturing sector.

A central focus of this research is non-uniformity among manufacturing firms with regards to energy profiles – defined here as the purpose, quantity, type and cost of energy used by a firm. A firm's energy profile is influenced by the good it produces (e.g., food packaging vs. steel), geographic location (e.g., Northeast vs. South US), and plant-level technological characteristics (e.g., on-site generation capacity). In Section 1.3 we review the factors that determine energy profiles in order to establish a basis for modeling Maryland's manufacturing sector.

Next, in Section 1.4 we discuss the Regional Greenhouse Gas Initiative (RGGI), the Maryland Renewable Portfolio Standard (RPS), and EmPower Maryland (EmPowerMD). We review and analyze these climate policies and evaluate both direct regulatory or participatory impacts as well as indirect energy price and investment impacts. We consider analysis of similar policies throughout the US, previous studies forecasting Maryland-specific impacts, and state agency implementation reports. The methods and results of previous work (Ruth et al., 2007; Ruth et al., 2008; ACEEE, 2008; L&A, 2008) are used extensively in the present research to confirm the direction and magnitude of cost impacts.

Finally, we review manufacturing responses to cost impacts in Section 1.5. Realized impacts depend on firms' capacities to respond. Firms with a wide range of feasible response options (e.g., fuel switching, adjustments to production levels, cost recovery, investment in efficiency, relocation) will realize lower impacts relative to firms with limited options. We describe how and why firms respond differently to changes in energy costs and investment opportunities. Chapter 3 discusses employment impacts as a response to changing production costs.

The material presented in this chapter is used to frame and justify the methods adopted for the analysis of manufacturing cost impacts, which is discussed in Chapter 2.

1.2 Overview of Maryland Manufacturing

In 2008, Maryland's manufacturing sector consisted of approximately 3,700 establishments, most of which are small as measured by the number of employees or annual sales.[2] The sector is diverse, ranging from multi-national corporations to local businesses, and spanning a multitude of goods. This section highlights economic and energy trends in these Maryland-based manufacturing businesses and also places them into the broader US manufacturing context.

Definition of Manufacturing in Maryland

The GGRA defines manufacturing as "the process of substantially transforming tangible personal property into a new and different article of tangible personal property by the use of labor or machinery and includes the operation of saw mills, grain mills, feed mills and mining" (MDGA, 2009, pg. 4). Under our analysis, we use the US Census Bureau's North American industry classification system (NAICS), which uniformly classifies all business activities in North America, including goods and services, on a numeric basis. The industrial sector as a whole is defined as agriculture (11), mining (21), construction (23), manufacturing (31), wood manufacturing (32), and primary metal manufacturing (33) (USCB, 2010a). *We define manufacturing as NAICS codes 21 and 31-33 based on the NAICS definitions and the GGRA language above.* Due to data constraints, however, much of the quantitative analysis in this report pertains to NAICS 31-33 only.

Economic State of Maryland's Manufacturing Sector

In 2008, Maryland's manufacturing sector (NAICS 31-33 only) ranked 31st for total number of paid employees and 33rd for total value of shipments among all other states (USCB, 2010b). When considering the cost-efficiency of the state's overall manufacturing output, roughly 68 cents of every one-dollar in value of goods shipped from Maryland's manufacturing sector goes towards costs of production while the national average is approximately 73 cents of every one-dollar (USCB, 2010b).[3] Mining in Maryland is below the average of all other states for both total value of shipments and number of employees (USCB, 2010c). Maryland's manufacturing establishments fall predominantly in the central portion of the state (Map 1.1).

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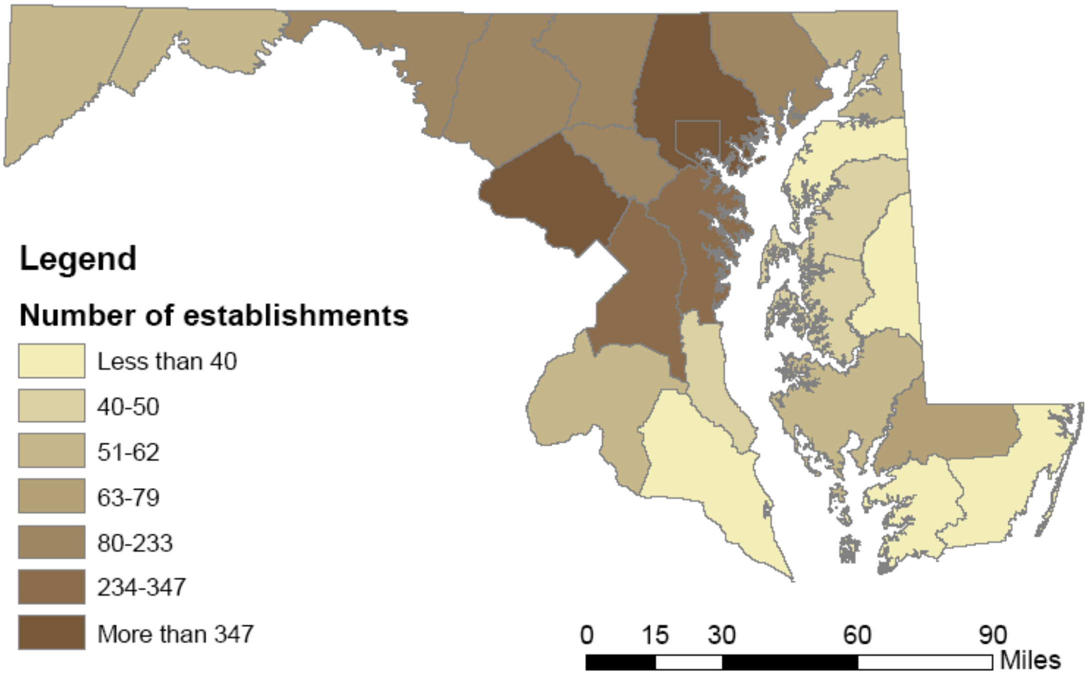
[2] 72 percent of manufacturing establishments have fewer than 20 employees and nearly 2/3 have annual sales between $5-25 million; a very small percentage earn >$25 million/yr (USCB, 2009; MEA, 2003).

[3] Measured as the ratio of total annual manufacturing costs in 2008, including payroll, capital expenditures, and material costs (e.g., energy costs), to the value of shipments in the same year.

Map 1.1 Maryland manufacturing establishments (NAICS 31-33), by county (USCB, 2010c)



By dollar value of shipments, the largest manufacturing subsectors in Maryland are computer and electronic product manufacturing, food products, and chemicals, respectively. By total employment, the largest manufacturing subsectors in Maryland are computer and electronic product manufacturing, food products, and printing & related supporting activities, respectively. Appendix 1.A provides a snapshot of manufacturing in Maryland by 3-digit NAICS codes, subsector name, and corresponding metrics including number of employees, number of establishments, and value of shipments.[4]

Between 2003 and 2008, Maryland's manufacturing sector (NAICS 31-33 only) experienced a decrease in the dollar value of shipments (4.5 percent in real dollars) while the US as a whole experienced an increase in the dollar value of shipments (USCB, 2010b). Volatile and increasing energy prices (e.g., natural gas and electricity) have been cited as a cause of decreased output in Maryland manufacturing (ACEEE, 2008). For example, an Alcoa Corporation aluminum smelter located near Buckeystown, suspended production in 2005 and moved production overseas partly due to high electricity rates (ACEEE, 2008). Chapter 3 discusses manufacturing employment trends in depth.

Aggregate patterns in the manufacturing sector are not indicative of subsectors or firms. Trends in manufacturing output among individual subsectors for Maryland and the US are contrasted below (Table 1.1). Between 2002 and 2008, several Maryland subsectors increased the dollar value of shipments while US subsectors did not, including beverage and tobacco products, textile mills, computer and electronic manufacturing, and furniture and related products. Conversely, some Maryland subsectors saw a drop in output while US

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[4] NAICS is a nested system whereby all 3-digit data (e.g., NAICS 311-339, value of shipments) will sum to 2-digit data (e.g., 31-33, value of shipments); likewise, 4-digit data will sum to 3-digit data. In general, we use the term *sector* to describe NAICS 31-33 and *subsector* for 3-digit NAICS.

subsectors saw an increase. These include primary metal manufacturing and machinery manufacturing.

Table 1.1 Changes in real dollar value of shipments between 2002-2008 (USCB, 2010b) [5]

Industry	**MD**	**US**
Food mfg	8.22%	18.16%
Beverage & tobacco product mfg	48.88%	-1.00%
Textile mills	23.13%	-41.74%
Textile product mills	*	-31.09%
Apparel mfg	*	-63.24%
Leather & allied product mfg	*	-27.74%
Wood product mfg	-45.55%	-17.51%
Paper mfg	-26.97%	-2.91%
Printing & related support activities	-21.59%	-13.50%
Petroleum & coal products mfg	*	198.64%
Chemical mfg other	4.96%	36.15%
Plastics & rubber products mfg	-23.38%	-1.96%
Nonmetallic mineral product mfg	14.75%	1.53%
Primary metal mfg	-60.55%	69.02%
Fabricated metal product mfg	18.26%	21.08%
Machinery mfg	-12.09%	18.09%
Computer & electronic product mfg	1.83%	-8.04%
Electrical equipment, appliance, & component mfg	70.25%	7.00%
Transportation equipment mfg	-62.35%	-12.56%
Furniture & related product mfg	5.35%	-11.53%
Miscellaneous mfg	12.38%	1.57%

* Inconclusive trends due to missing data

Energy Overview of Maryland Manufacturing

Maryland's manufacturing sector has an energy profile reflective of the US as a whole. Relative to the total dollar value of goods shipped, Maryland's electricity consumption within the manufacturing sector (NAICS 31-33 only) resembles the US average – roughly 20 percent of each kWh is needed to produce one dollar of goods shipped in the manufacturing sector (USCB, 2010b). Natural gas consumption is approximately equal to electricity consumption in Maryland's overall industrial sector (NAICS 11, 21, 23, 31-33) and most natural gas consumed in the industrial sector occurs specifically in NAICS 31-33 (EIA, 2009; EIA, 2010b).

A major difference between Maryland and the rest of the US is asymmetrical electricity sales across economic sectors. Whereas the US as a whole and most states have industrial sales equivalent to commercial and residential sales, Maryland's retail electricity sales are dominated by the commercial and residential sectors (90 percent of sales) with industry

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[5] The 2008 annual survey of manufacturers (ASM) shows no value of shipments in Maryland from petroleum and coal, textile products and mills, apparel manufacturing, and leather and allied goods. However, it is common for small industries or industries in flux to not be represented in the survey at the state level (USCB, 2010b). A parallel survey, the county business patterns survey, indicates that each of these industries had establishments and employees in Maryland in 2007 (USCB, 2009).

accounting for less than 10 percent of sales (EIA, 2010b). Since 2005, the quantity of purchased electricity in Maryland's manufacturing sector has decreased (Table 1.2).

Table 1.2 Maryland NAICS 31-33, electricity consumption, energy costs and production (USCB, 2010b)

Year	Generated Electricity (Mil. kWh)	Purchased Electricity (Mil. kWh)	Cost of Purchased Electricity (Mil. of $)	Cost of Purchased Fuels (Mil. of $)	Value of Shipments (Bil. of $)
2002	N/A	9300.8	404.8	394.9	36.36
2003	880.3*	9350.1	456.2	516.4	35.46
2004	972.3	9147.7	456.1	390.8	36.49
2005	946.1	9822.6	566.4	487.3	39.77
2006	1000.6	7118.6	529.2	501.1	42.12
2007	N/A	6446.5	496.2	684.7	41.46
2008	N/A	5649.1	464.7	448.1	39.59

* 2003 equals generated minus sold electricity

Industrial electricity and fuel prices in Maryland have historically followed US average prices (EIA, 2010b). Recently, however, industrial electricity prices have been greater in Maryland relative to the US, and that difference has been increasing (Figure 1.1). The American Council for an Energy Efficient Economy (ACEEE) credits the rise in electricity costs to the expiration of retail rate caps, which were a component of Maryland's 1999 electricity restructuring; caps began to expire in 2004 (ACEEE, 2008). Likewise, natural gas, which often sets wholesale electricity clearing prices, became increasingly expensive between 2002 and 2006 and resulted in higher electricity prices for all consumers in Maryland and the Pennsylvania-New Jersey-Maryland (PJM) electricity region (ACEEE, 2008).

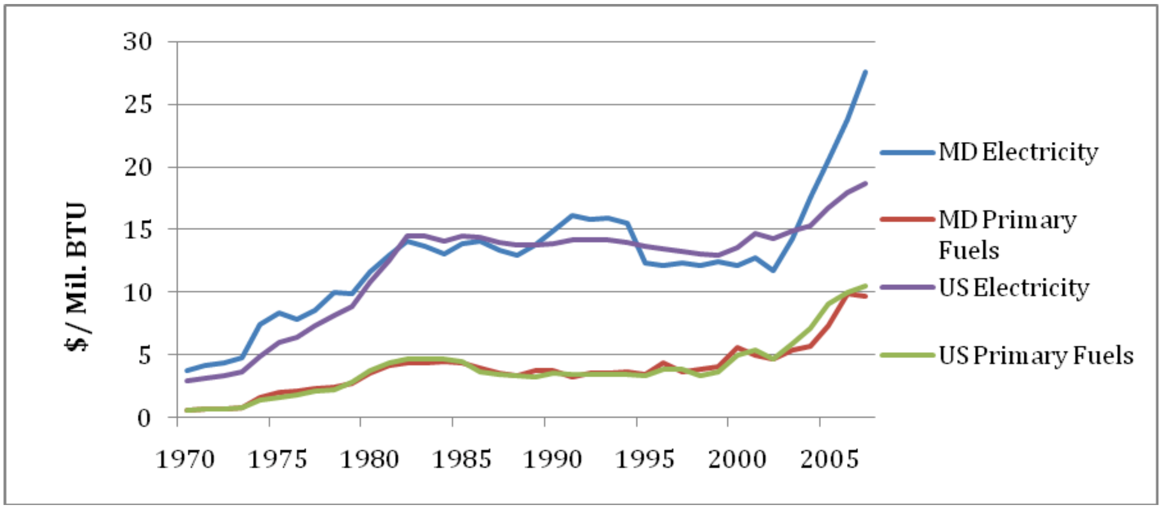

Figure 1.1 Industrial electricity and fuel prices in Maryland and US, 1970-2007 (EIA, 2010b)

Furthermore, it is important to recognize that specific manufacturing subsectors stand out as highly energy-intensive and as a consequence, may be more sensitive to energy price increases. These industries include nonmetallic minerals (e.g., glass and cement), primary metals (e.g., aluminum, iron and steel), paper, and chemicals (e.g., fertilizer production). Some subsectors are energy intensive because of their reliance on energy for non-fuel purposes (e.g., plastics production uses petroleum as a feedstock), while other subsectors simply require large quantities of energy to transform raw materials into products (e.g., aluminum production uses electrolysis, necessitating large quantities of electricity). Yet, some are able to generate a considerable share of their heat, steam and electricity requirements from their own waste and by-products (e.g., pulp and paper) and thus may insulate themselves somewhat from rising market prices. A 2003 survey commissioned by the Maryland Energy Administration estimated that 20 percent of industrial firms accounted for 75 percent of total industrial energy consumption in the state (MEA, 2003).

Disparate energy profiles across manufacturing subsectors and firms will likely result in non-uniform impacts from policy-induced changes in energy prices and consumption. Maryland has a number of energy-intensive manufacturing facilities including paper production, iron and steel and non-metallic metal manufacturing. Similar to previous studies, we expect energy intensive industries to endure relatively greater impacts from climate policy-induced energy price changes (Ruth et al., 2000; Ruth et al., 2002).

1.3 Determinants of Manufacturing Energy Profiles

The energy profile of a manufacturing firm is influenced by what goods are being produced, the geographic location, and technology characteristics, among other factors.

Subsector Determinants

Energy profiles vary across manufacturing subsectors (3-digit NAICS) as well as at more disaggregate levels such as specific industries (6-digit NAICS). Each manufacturing plant consumes different total amounts of energy per unit of output, uses energy for different purposes (e.g., feedstock/nonfuel vs. fuel), and relies on a different fuel mix (e.g., electricity vs. natural gas vs. biomass) to produce goods (Table 1.3).

Table 1.3 US manufacturing energy intensity in BTUs/Dollar value shipped and electricity share (EIA, 2009)

NAICS Code	**Industry**	**Total Energy Intensity (BTU/$VS)**	**Nonfuel Energy Intensity (BTU/$VS)**	**Electric Energy Intensity (BTU/$VS)**	**Electric Energy Share**
311	Food	2209	6	467	21.14%
312	Beverage and Tobacco	863	*	242	28.04%
313	Textile Mills	4584	0	1700	37.09%
314	Textile Product Mills	2164	0	601	27.77%
315	Apparel	462	0	231	50.00%
316	Leather and Allied Products	505	0	168	33.27%
321	Wood Products	4012	62	810	20.19%
322	Paper	13926	6	1461	10.49%
323	Printing and Related Support	852	*	451	52.93%
324	Petroleum and Coal Products	12553	6532	251	2.00%
325	Chemicals	7836	4280	787	10.04%

3254	Pharmaceuticals and Medicines	508	6	171	33.66%
326	Plastics and Rubber Products	1595	*	861	53.98%
327	Nonmetallic Mineral Products	8823	95	1164	13.19%
3273	Cements	5926	*	636	10.73%
331	Primary Metals	7407	2257	1954	26.38%
331111	Iron and Steel Mills	11144	4618	1875	16.83%
3313	Alumina and Aluminum	7256	827	3592	49.50%
332	Fabricated Metal Products	1248	3	451	36.14%
333	Machinery	625	*	340	54.40%
334	Computers and Electronics	363	3	241	66.39%
335	Electrical Equip., and Components	863	176	369	42.76%
336	Transportation Equipment	682	3	279	40.91%
337	Furniture and Related Products	712	*	374	52.53%
339	Miscellaneous	439	0	219	49.89%

* Inconclusive or missing data

For the purposes of this report, energy intensity is defined as the amount of energy consumed (BTUs) per Dollar value of shipments ($VS). The energy intensity is highest among chemical, non-metallic mineral, primary metal and paper manufacturing. Energy intensive industries account for approximately 50 percent of the total energy consumed in US manufacturing and are more sensitive to energy prices (EIA, 2009; Bohi & Zimmerman, 1984).

Three characteristics distinguish the energy profiles of energy-intensive subsectors. First, both fuel and nonfuel energy sources may be used in production. For example, in the fertilizer industry, natural gas is used as a feedstock to make ammonia, but it may also be used to power boilers. Nonfuel energy demand stands out because these forms of energy are associated with desirable features such as unique chemical properties, which may be non-substitutable. Fuel energy on the other hand is often substitutable with appropriate technology modifications. Second, energy-intensive firms rely heavily on primary fuels relative to electricity and electricity requirements are often met by on-site generation of heat and power (EIA, 2009; Bassi et al., 2009).[6] In Maryland, there are eight combined heat and power facilities with manufacturing applications including chemical, food, paper, and iron and steel facilities (EIA, 2010c). Third, chemicals, primary metals, and paper production are among the most globalized subsectors in manufacturing (Bassi et al., 2009). Consolidation within subsectors is not uncommon and plants are frequently owned by large, international companies holding multiple production facilities and possessing the economies of scale to shift production locations at low costs (Smale et al., 2006).

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[6] Primary fuels include oil, natural gas, coal, biomass and any other substance that is combusted while electricity, although considered a fuel, is secondary in that it is a source of energy, but is not combusted.

As the most energy intensive industries, chemicals, nonmetallic minerals, primary metals and paper manufacturing are vulnerable to increased energy costs. However, Maryland's climate policies focus largely on electricity supply and demand, which necessitates a focus on electricity intensity and share. Electricity intensity is a measure of how much electric energy is needed to generate output. Iron and steel, aluminum production, textile mills, and paper each have comparatively high values for electricity intensity. Electricity share on the other hand is a measure of how much electricity is needed, relative to other fuels, to generate output. By this measure, a different set of industries has high values, including computers and electronics, printing, and plastics and rubber production (Table 1.3). The practical implication of this distinction is that while electricity intensive industries use significant amounts of electricity, industries with large electricity shares use electricity almost exclusively (Bjorner et al., 2001).

Sensitivity to Changes in the Electricity Market
Maryland's climate policies interact directly with the electricity market. Industries with a high electricity intensity and share will be most sensitive to policy-induced electricity market changes (MCCC, 2008; Bjorner et al., 2001).

Electricity end-uses in manufacturing include non-process and process purposes. Non-process uses include heating, ventilation, and air conditioning (HVAC), lighting and other building support functions; process uses are directed specifically at production and include heating, cooling and refrigeration, machine drive and electro-chemical processes (EIA, 2009). Most electricity used in the US manufacturing sector goes towards processes such as motor operation or machine drive (Figure 1.2).

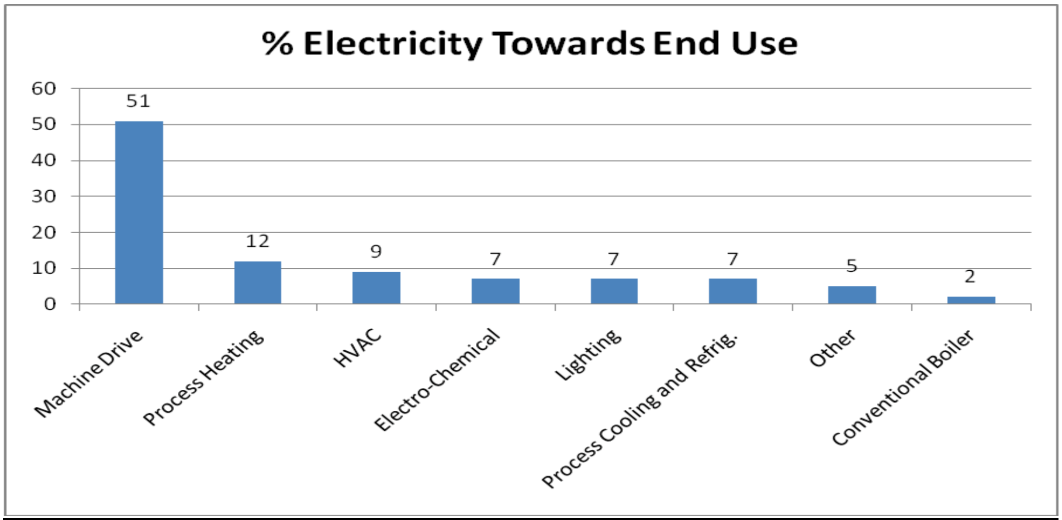

Figure 1.2 Electricity end uses by percentage in US manufacturing (EIA, 2009)

Geographic Determinants

Within a subsector and among manufacturing plants that produce similar goods, firms may have contrasting energy profiles because of geographic differences including access to resources and other factors of production, or climate. Geographic factors influence energy prices, which drives decisions about fuel mix, technology investment and location of production (Bae, 2008). For example, access to hydroelectricity in the northwest US, natural gas in the southern US, and coal in the Great Plains states lead to a majority share of electricity being generated by these fuels in these localities (Bae, 2008).

States and census regions differ from the US as a whole and simple extrapolation of national energy profiles to Maryland would mischaracterize manufacturing energy patterns and policy impacts. As determined by the US Census Bureau, Maryland falls in the South census region, but has similarities to the Northeast census region with regards to climate and energy markets (e.g., natural gas and electricity attributes shared with Pennsylvania and New Jersey). Thus, one challenge of this research is pairing the specifics of Maryland with regionally appropriate energy patterns and available data.

All else being equal, energy prices in the industrial sector are lowest where energy supply is high and demand is low. Manufacturing firms, in turn, concentrate in regions with low-cost fuel and electricity. The South census region, for example, accounts for more than 50 percent of all natural gas used in the US manufacturing sector and liquefied petroleum gas (LPG) intensive industries (e.g., petrochemical industries) produce at high volumes (EIA, 2009).[7] Lower priced natural gas in the South largely explains why the region is so natural gas intensive relative to the Northeast (~1600 BTU/$VS in South compared to ~700 BTU/$VS in Northeast) (EIA, 2009; EIA, 2010a; USCB, 2010b).[8] Also, the South census region is slightly more electricity intensive relative to the Northeast census region (~650 BTU/$VS in South compared to 450 BTU/$VS in Northeast). One reason for this difference is greater demand for cooling in the South (EIA, 2009; USCB, 2010b). The northeast census region, in contrast, has relatively inexpensive coal, which is a necessary input for iron and steel and cement manufacturing; the Northeast census region is more coal-intensive than the South census region (EIA, 2009).

In 2007, Maryland industrial natural gas prices averaged $11.19/Million BTU – the 7th highest in the US; industrial retail electricity was $27.59/Million BTU – the 10th highest in the US; and average industrial petroleum prices were below the average of other states at $14.09/Million BTU (EIA, 2010a).[9] Over the past 40 years, Maryland has not had a comparative advantage in natural gas or electricity prices (EIA, 2010a). Since 1998, Maryland has arguably had a disadvantage as industrial natural gas prices have often been

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[7] The South Census region includes Maryland, Delaware, Washington, D.C., Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Tennessee, Kentucky, Alabama, Mississippi, Louisiana, Arkansas, Texas and Oklahoma.

[8] The Northeast Census region includes Connecticut, Maine, Massachusetts, New Hampshire, Vermont, Rhode Island, New Jersey, New York and Pennsylvania.

[9] Includes distillate fuel oil, residual fuel oil, motor gasoline, liquefied petroleum gas, and other petroleum-based fuels.

at least one standard deviation above the US average (Figure 1.3). Likewise, Maryland industrial electricity prices have been significantly higher than the US average since 2004 (Figure 1.1). Maryland has not had a regional energy price advantage either. Among 12 Northeast and Mid-Atlantic states, Maryland average industrial natural gas prices are 2nd highest (after Massachusetts) and 25 percent higher than the regional average (ACEEE, 2003).

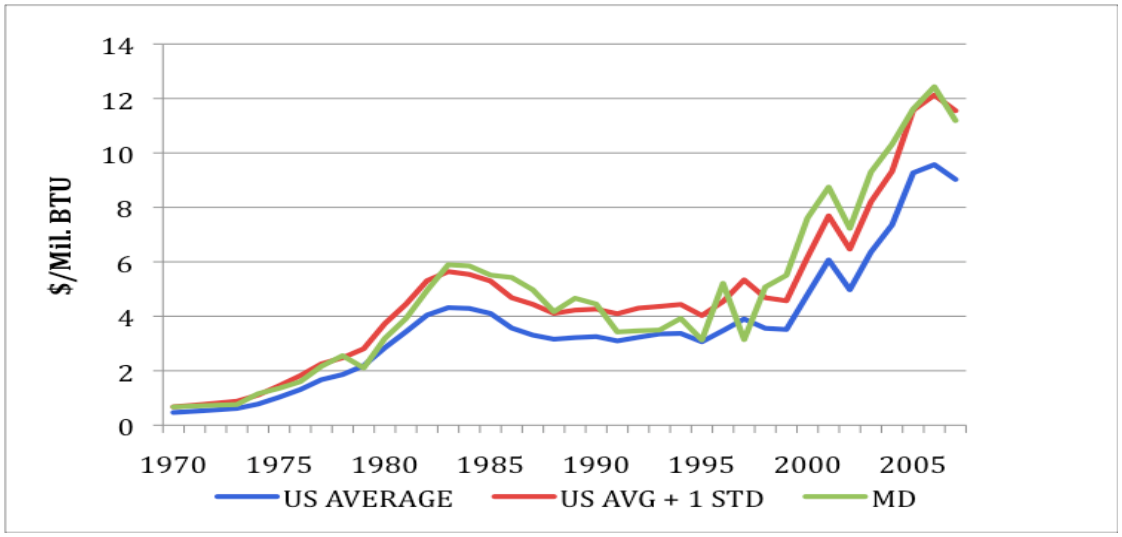

Figure 1.3 Industrial natural gas prices (nominal $) in Maryland and US, 1970-2007 (EIA, 2010a)

Technology Determinants

In addition to broad characteristics such as subsector classification and geography, plant-specific features determine energy profiles. Key among these is technology, which we broadly define as the type of equipment or processes employed at a plant. Equipment age, on-site heat and power capacity, and industry-specific processes all influence energy profiles.

Technology changes over time. For example, in response to the oil crisis of the 1970s the energy intensity of the US economy decreased considerably. While the decreasing energy intensity can be partly attributed to displaced activity from energy intensive actors, including manufacturing, the predominant factor is adoption of increasingly energy efficient technology throughout the economy (Metcalf, 2008; Sue Wing, 2008).

At a smaller scale, such as an individual plant, technology change is complex and may fall behind or exceed broader, economy-wide trends. In general, the older the technology, the lower the energy efficiency. Different industries have different speed and rigor with which they adopt and retire technologies, which may be driven by any number of factors such as industry competition and growth (Bassi et al., 2009). Improved energy efficiency is acquired through two forms of technology change: (1) installation of new capital and retirement of existing, less efficient equipment, and (2) modifying existing capital (e.g., through improved housekeeping practices) (Davidsdottir et al., 2005) (see Section 1.5 for more information). In Maryland, the primary metals subsector, which includes iron and steel, has the oldest equipment among major manufacturing sectors (MEA, 2003).

The presence of specific technologies will impact plant level energy profiles. For example, computerized energy management systems can more precisely control process and non-process energy needs and significantly reduce unnecessary energy consumption. In Maryland, less than 20 percent of manufacturing establishments employ computerized energy management systems (MEA, 2003). Also, there are plants that utilize process waste or byproducts to cut down on energy demand. For example, most manufacturing facilities reuse waste heat as building heat. Several manufacturing facilities in the state have combined heat and power (CHP) capacity on-site and are able to cut down on purchased fuel and electricity costs (EIA, 2010c). Moreover, some CHP facilities use byproducts of processes as a fuel input, further reducing fuel costs (Table 1.4).

Table 1.4 Self-generating electricity capacity at Maryland manufacturing facilities, 10+ MW (EIA, 2010c)

Facility	**Subsector**	**Capacity (MW)**	**Primary Fuels (In Order)**	**Qualified Renewable**
Sparrows Point	Primary Metals (Iron and Steel)	120	Blast Furnace Gas[10], Natural Gas & Residual Fuel Oil	Yes (Tier 2, Blast Furnace Gas)
New Page, Luke Mill	Pulp and Paper	65	Coal & Black Liquor[11]	Yes (Tier 1, Black Liquor)
Domino Sugar	Food	17.5	Natural Gas & Residual Fuel Oil	No
Solo Cup	Pulp and Paper	11.2	Natural Gas	No

Furthermore, within subsectors there are distinct processes for manufacturing similar products. These processes influence the type and quantity of energy used. Two prominent examples include iron and steel production and cement production. The iron and steel industry employs, in essence, one of two processes: (1) integrated steel mills or (2) electric arc furnace (EAF) steel mills, each requiring a different set of materials and infrastructure.[12] The integrated process is more fuel intensive while EAF steelmaking is more electricity intensive. Energy costs account for 20 percent of the total cost of manufacturing steel and cost control is critical to maintaining global competition (ICF, 2007). In cement manufacturing, kilns can employ either wet or dry process technology, with wet process operations using on average 34 percent more energy per ton of production compared to dry process operations (ICF, 2007).[13] With a shift from wet to dry processes over the past 50 years, although decreasing the total energy consumption, total electricity use has increased because the dry process is more electricity-intensive (US EPA, 2004).

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[10] Blast furnace gas is a waste byproduct of iron production and qualifies as a waste-to-energy renewable fuel.

[11] Black liquor is a waste product of pulp and paper manufacturing and qualifies as a renewable fuel.

[12] Integrated steel mills use a blast furnace and a basic oxygen furnace to produce refined steel from raw materials while EAF steel mills use steel scrap to produce carbon steel, alloy, and specialty steels.

[13] In dry cement processing, materials are ground into a flowable powder in horizontal ball mills or in vertical roller mills and there is very little water content. In the wet process, raw materials are ground with the addition of water to produce slurry typically containing 24-48 percent water (USEPA, 2004).

1.4 Three Select Climate Mitigation Policies

In 2008, the Maryland Commission on Climate Change released the state's climate action plan (CAP). The CAP consists of both climate mitigation and adaptation policies. Mitigation policies outlined in the CAP are anticipated to represent central components of the plan to be submitted to the General Assembly before 2012. It is from the CAP that we identify policies to examine.

Maryland's CAP covers five broad mitigation policy areas including: (1) cross-cutting policies, (2) residential, commercial, and industrial energy consumption, (3) energy supply, (4) agriculture, forestry, and waste, and (5) transportation and land use. These policy areas may be further disaggregated into 42 independent policies, which together are expected to meet or exceed the emissions reductions goal for 2020 (MCCC, 2008).

The policies outlined in the CAP are not uniformly designed and each utilizes a different mechanism to achieve a portion of the reduction goal. Some policies focus on technology-adoption (e.g., energy efficiency resource standard) while others rely on market mechanisms (e.g., cap and trade under the regional greenhouse gas initiative). Also, policies vary in anticipated GHG reductions, start-date, implementation progress, and specificity of program design. Some policies are regulatory and exist under legislative authority with several years of implementation (e.g., renewable energy portfolio standards); other policies are incentive-based and retain dedicated funding (e.g., incentives for energy efficient lighting). Likewise, some policies are expected to result in significant direct GHG emissions reductions (e.g., regional greenhouse gas initiative) while other policies function solely as a platform upon which other mitigation efforts might be evaluated (e.g., regular GHG inventories and forecasting) (MCCC, 2008).

Due to the broad scope and range of the CAP, the present research focuses on specific policies with a strong likelihood of impacting manufacturing costs. We select three policies for in-depth quantitative analysis, including: (1) the RGGI, (2) the RPS, and (3) EmPowerMD mandate, which aligns closely with the energy efficiency resource standard policy (Table 1.5). Criteria for selecting these policies include:

1. Significant relative estimates for GHG reductions.
2. Potential for production cost impacts based on previous research.
3. Currently authorized with ongoing implementation.
4. Implementation has resulted in known direct cost impacts for manufacturing facilities.

Table 1.5 CAP mitigation policies, highlight of three select policies (MCCC, 2008)

Policy	**Est. GHG Reduction by 2020 (Million MTCO2e)**	**Description/ Research Task**
Improved Building Codes and Trade Codes	2.4	Energy Demand: Improvement and enforcement of building codes will reduce energy consumption in new or renovated buildings (i.e., Maryland building performance standards, updated in 2010).
Energy Efficiency Resource Standard	11.9	Energy Demand: Mandatory utility demand-side management targets to meet electricity demand and energy consumption reduction goals (i.e., EmPower Maryland Energy Efficiency Act, 2008).
More Stringent Appliance/Equipment Standards	0.2	Energy Demand: Appliance efficiency standards at the state level can be improved to cover appliances not covered by federal standards or where higher-than-federal standard efficiency requirements are appropriate (i.e., Energy Efficiency Standards Act, updated in 2007).
GHG Cap-and-Trade	7.0	Energy Supply: Continue active participation in the Regional Greenhouse Gas Initiative (RGGI), which requires most Maryland electricity generating units to meet decreasing annual GHG emissions targets (i.e., Maryland joins RGGI, 2007).
Clean Distributed Generation/ Combined Heat and Power	1.1 Distributed Generation 1.0 Combined Heat/Power	Energy Supply: Encourage investment in distributed energy and combined heat and power systems such that by 2020, 1% of all electricity sales are from distributed renewable generation and 15% of CHP technical potential is recognized at commercial and industrial facilities.
Renewable Portfolio Standard	13.8	Energy Supply: Requires electricity providers to obtain a minimum percentage of electricity sales from renewable energy sources, escalating annually to a standard of 20% by 2022 (i.e., Renewable Energy Portfolio Standard, last updated 2010).
Waste Management and Advanced Recycling	1.0	Ag. Waste and Forestry: Reduce waste stream through reductions in waste production, expansion of recycling and “up-cycling,” and enhancement re-use of components and manufacturers’ lifetime warranty responsibility.

Cap-and-trade programs, renewable portfolio standards, and energy efficiency programs have the potential to directly impact energy prices, energy consumption, and investment decisions in manufacturing. Following is a review of industry-relevant literature related to the RGGI, the RPS and EmPowerMD.

1.4.1 The Regional Greenhouse Gas Initiative (RGGI)

The RGGI is an energy supply policy within the state’s CAP. The RGGI is a regional cap-and-trade program with ten participating states in the Northeast and Mid-Atlantic designed to mitigate greenhouse emissions. The RGGI regulates only the power sector, and does not address industrial process-based emissions or other categories of GHG emissions. Maryland joined the RGGI in 2007 and began implementing the Maryland CO_2 Budget Trading Program in 2008 (COMAR, 2008).

Direct Regulatory Impacts

Only electricity generating units (EGUs) with 25 MW or greater capacity are required to comply with RGGI (COMAR, 2008). Two facilities within the Maryland manufacturing sector have self-generating capacity that meet this criterion including the New Page, Luke Mill plant (paper manufacturing) and the Severstal Sparrow’s Point plant (iron and steel manufacturing). Both the Luke Mill and Sparrow’s Point plants have attained a limited industrial generator exemption under the Maryland CO_2 Budget Trading Program, as of 2010 (COMAR, 2008). The limited industrial generator exemption applies to facilities with less than 10 percent of electrical generation being directed to the grid for sale. Eligible facilities must also develop a site specific Climate Action Plan for reducing carbon dioxide emissions (COMAR, 2008). The exemption allows a portion of Maryland's allocated emission allowances to be retired on behalf of current averaged emissions from these facilities. Due to the limited industrial generation exemption of the Sparrow's Point and Luke Mill facilities, direct regulatory costs from participation in the Maryland CO_2 Budget Trading Program in the manufacturing sector will be negligible.

Electricity Rate Impacts

RGGI Influences Electricity Supply and Demand

All Maryland manufacturing facilities will be impacted by the electricity rate impacts induced by the Maryland CO2 Budget Trading Program. This program penalizes electricity generation from high-GHG fuels, which constrains electricity supply options and causes an increase in bulk electricity costs (NETL, 2008). However, with the injection of energy efficiency funding from RGGI auction proceeds, electricity demand will relax and cause a decrease in bulk electricity costs (Ruth et al., 2007). The net impact on electricity rates from Maryland participating in the RGGI is a function of these two factors.

Under RGGI, the marginal cost of supplying electricity is expected to increase because EGUs must internalize the cost of GHG emissions. The additional cost of electricity provision incurred by EGUs is passed along to purchasers of wholesale electricity and subsequently to utilities selling at the retail level. In Maryland, this has the repercussion of making low-cost electricity imports more attractive. As a result, imported electricity is able to temper the RGGI rate impact in Maryland (Ruth et al., 2007).

A minimum of 25 percent of proceeds from Maryland's allowance auctions must be directed towards public benefit (RGGI, 2005). In Maryland, interpretation of this requirement generates funds for the Strategic Energy Investment Fund (SEIF). The SEIF will distribute Maryland's auction proceeds towards energy efficiency spending, low-income energy assistance and residential rate relief. A portion of the SEIF funds will be directed to energy efficiency investments at industrial facilities, which has the effect of decreasing energy consumption at participating facilities (MEA, 2009; ACEEE, 2008).[14] The specific role of demand side management and energy efficiency improvements is addressed in more detail in the EmPowerMD segment below.

As the SEIF funds are invested in energy efficiency improvements across residential, commercial and industrial sectors, electricity demand reductions will place downward pressure on electricity rates for all consumers. Moreover, if greater quantities of funding are dedicated to energy efficiency spending, reductions in electricity demand and rates will be greater (Ruth et al., 2008). The Strategic Energy Investment Act of 2008 commits a minimum of 46 percent of SEIF investment to energy efficiency annually (MEA, 2009).

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[14] Customized industrial energy assessments are one such investment. MEA is implementing this program outside of EmPowerMD utility service territories (MEA, 2009).

The overall electricity rate impact resulting from Maryland's participation in RGGI will be a function of the supply-side EGU costs and the demand-side consumer electricity reductions. A 2007 electricity rate study found that, "Maryland's participation in RGGI would have virtually no impact on electricity rates paid by all customer classes" (Ruth et al., 2007, pg. 64). Estimates critical to the 2007 study have proven inexact in actual implementation, in part because program design was originally envisioned differently from the end product. Below we review some of the critical 2007 study assumptions and implementation realities as a basis for recalibrating study results.

First, under the 2007 impact study, the baseline case assumes 25 percent of allowances would be auctioned (the remainder would be freely allocated) while 100 percent of the revenue from the auction of allowances would be directed towards efficiency spending (Ruth et al., 2007). In implementation, 85 percent of allowances are auctioned annually (the remainder are freely allocated) while 100 percent of the revenue from the auction of allowances is directed towards the SEIF (COMAR, 2008).

A second difference lies in the absolute amount of annual RGGI allowances apportioned to Maryland (2009-2015), which is slightly lower than forecasted in the impact study (RGGI, 2010b). Also, in RGGI auctions to-date, allowances have been about half the price forecasted in the impact study (RGGI, 2010a).

Third, the 2007 impact study assumes that 100 percent of allowance revenue goes towards energy efficiency spending. In reality, the SEIF has not allocated this level of funds to energy efficiency spending because a share has gone towards rate relief and education/awareness programs (Table 1.6). A total of 46 percent of the SEIF goes towards energy efficiency and conservation annually (MEA, 2009).

Fourth, given the importance of electricity importation, it should be noted that both the Mid-Atlantic Power Pathway (MAPP) and the Potomac Appalachian Transmission Highline (PATH) transmission projects, which were both assumed to be constructed on schedule in the 2007 study, have been delayed, and their project completion remains at present uncertain (PHI, 2010; AEP & AE, 2010).

Table 1.6 2010 RGGI implementation, 2007 projections vs. actual implementation (Ruth et al., 2007)

	Allowance Allocation	**Quantity of Allowances Auctioned**	**Average Allowance Price**	**EGU Expenditure/ State Revenue**	**Commitment to SEIF**	**Commitment to Energy Efficiency Spending**
2007 RGGI-CIER Study Forecasts	38.3 million tons	9.6 million tons (25%)	$4.05/ton	$38.8 million	$38.8 million (100 %)	$38.8 million (100% of SEIF)
Actual RGGI Results	37.5 million tons	32 million tons (85.3%)	$2.05/ton*	$65.6 million	$65.6 million (100 %)	$18.9 million (46 % of SEIF)**

* Based on average of 4 most recent auctions, current allowances as of May 2010; ** 46 percent of SEIF to go towards energy efficiency and conservation spending (RGGI, 2010a; MEA, 2009)

Under Maryland's participation in the RGGI, the premium on carbon-intensive electricity generation will shift the supply cost for electricity upwards; at the same time, efficiency investments will shift the demand for electricity downwards (Ruth et al., 2007). In the early stages of actual implementation the level of energy efficiency spending is reduced relative to estimates from the 2007 study. Similarly, the cost to EGUs is higher under actual implementation compared to the 2007 study. As a result, the electricity rate impact warrants re-calibration. Methods and assumptions for calculating industrial electricity rate impacts induced by Maryland's participation in the RGGI are discussed in Chapter 2.

1.4.2 Renewable Energy Portfolio Standard (RPS)

Maryland's RPS is an energy supply policy identified in the state's CAP, although Maryland's RPS law was in place for several years prior to the development of the CAP. The current RPS mandates that electricity suppliers or load serving entities (LSEs) provide a minimum of 20 percent of electricity from renewable sources by 2022. LSEs meet the RPS through attainment of renewable energy credits (RECs) equal to 1 MWh of electricity generated from a qualified source; LSEs must also meet tier-specific RPS requirements including the tier 1 solar carve-out.[15] All RPS shortfalls are subject to an alternative compliance payment (ACP) (COMAR, 2010a). Senate Bill 277, which passed the General Assembly in May 2010, accelerated the solar compliance schedule and modified alternative compliance payments (MDGA, 2010). The current schedule for RPS requirements under all tiers and ACPs appear in table 1.7.

Table 1.7 Annual RPS requirements and ACP, by tier; (MDGA, 2010; PSC, 2010; PPRP, 2010b)

Year	Tier 1 Non-solar RPS	Tier 1 ACP (Cents/kWh)	Tier 1 Solar RPS	Tier 1 ACP (Cents/kWh)	Tier 2 RPS	Tier 2 ACP (Cents/kWh)
2010	3.00%	2.0	0.025%	40.0	2.5%	1.5
2011	4.95%	4.0	0.05%	40.0	2.5%	1.5
2012	6.40%	4.0	0.10%	40.0	2.5%	1.5
2013	8.00%	4.0	0.20%	40.0	2.5%	1.5
2014	10.00%	4.0	0.30%	40.0	2.5%	1.5
2015	10.10%	4.0	0.40%	35.0	2.5%	1.5
2016	12.20%	4.0	0.50%	35.0	2.5%	1.5
2017	12.55%	4.0	0.55%	20.0	2.5%	1.5
2018	14.90%	4.0	0.90%	20.0	2.5%	1.5
2019	16.20%	4.0	1.20%	15.0	0.0%	-
2020	16.50%	4.0	1.50%	15.0	0.0%	-
2021	16.85%	4.0	1.85%	10.0	0.0%	-
2022	18.00%	4.0	2.00%	10.0	0.0%	-

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[15] Maryland's RPS is broken into two tiers and each tier must be satisfied (Tier 1 RECs may be used to meet the Tier 2 RPS). Tier 1 resources include solar, wind, certain biomass, and others; tier 2 resources include hydroelectric power facilities. The Tier 1 solar RPS must be met exclusively by in-state solar. Beginning October 1, 2011, waste-to-energy facilities will qualify as Tier 1 resources.

Direct Regulatory and Participatory Impacts

Manufacturing facilities generating and selling electricity may qualify as a LSE and then would be subject to the RPS. If the LSE has industrial process load (IPL) sales in excess of 300 million kWh to a single customer, then those additional sales are exempt from the RPS.[16] All sales below the 300 million kWh threshold must meet the RPS obligation. However, there is a separate, lower-cost alternative compliance payment schedule for LSEs with IPL status (COMAR, 2010a). Moreover, for LSE's with IPL status there is no alternative compliance payment for tier 2 RPS shortfalls and tier 1 non-solar and solar ACPs are equal (COMAR, 2010a). In other words, compliance requirements for LSE's with IPL status are relaxed relative to counterparts without IPL status. If the price of RECs exceeds the IPL ACP, the low-cost RPS compliance option is through the IPL ACP.[17]

A review of Maryland Public Service Commission files reveals one manufacturing LSE with IPL status in 2008 and 2009: Severstal Sparrows Point. During these two years, sales over 300 million kWh were excluded from the RPS. Electricity sales equal to the 300 million kWh threshold were subject to the RPS and REC shortfalls eligible for the IPL ACP (SSP, 2010).

Aside from regulatory impacts, Maryland and regional RPS mandates will result in additional revenue for certified renewable energy facilities in the manufacturing sector. At present, only two manufacturing plants in Maryland are certified as renewable energy facilities: (1) Luke Mill (via black liquor, tier 1) and (2) Severstal Sparrows Point (Waste-to-heat via blast furnace gas, tier 2) (PSC, 2010a). Each plant has significant self-generation capacity and the ability to create and sell RECs (see Table 1.4). The Luke Mill facility will see additional revenue through sale of RECs. The Severstal Sparrows Point facility will be able to offset compliance costs through the sale of RECs, although tier 2 RPS requirements sunset in Maryland in 2018.

The value of RECs as driven by Maryland and regional renewable energy mandates could stimulate renewable capacity development in the manufacturing sector. Depending on capital costs, incentives for installation and/or generation, and market dynamics, facilities may see the potential for profit and choose to construct renewable generation capacity (see Chapter 2 for more discussion of potential benefits).

The direct cost impact from Maryland's RPS on manufacturing facilities is a combination of participatory impacts (i.e., revenue from RECs) and compliance impacts applied to facilities doubling as LSEs (i.e., cost of RECs and/or ACPs). The former category of impacts creates benefits to manufacturing facilities, which are either considering installing renewable capacity or already have renewable generation capacity. Impacts in the latter category

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[16] IPL is defined as "the total consumption of electricity by a facility of a company classified in the manufacturing sector under the NAICS, Codes 31 through 33 (COMAR, 2010a)."

[17] There are a number of exceptions which may mitigate costs to LSEs including: (1) a waiver for LSEs under extreme economic hardship or (2) RPS payment caps (COMAR, 2010a).

create a cost. The Maryland RPS compliance requirement applies to a single manufacturing facility. Nearly all manufacturers in the state will avoid direct cost impacts from the RPS.

Electricity Rate Impacts

RPS Influences Electricity Rates, Fuel Prices

Maryland manufacturing facilities will be indirectly impacted by RPS-induced electricity and fuel price changes. Industrial electricity rates will be influenced by changes in the supply of generating capacity as well as the premium capital costs associated with renewable capacity. Additionally, as renewable capacity competes with existing supply, demand for conventional fuels may change and influence fuel prices.

Multiple studies forecast electricity rate impacts from state RPS programs with varying results including both anticipated rate increases and decreases. Wholesale electricity markets, federal incentives and renewable technology costs are a few uncertainties that influence rate impact estimates. Most studies find that electricity rates will increase less than 1 percent (or about .0005 $/kWh) relative to the baseline during the peak RPS target (i.e., 2022 in Maryland) (Chen et al., 2009). A 2008 study from Levitan and Associates found that to meet Maryland's RPS, the ratepayer impact could be positive or negative, depending on whether onshore or offshore wind capacity is developed, respectively.[18]

Expansion of renewable capacity, or electricity generation resources powered by renewable energy, influences electricity rates through at least two mechanisms: (1) the premium associated with renewable capacity relative to conventional capacity will increase rates, and (2) increased generating capacity and low renewable fuel costs will decrease rates (EIA, 2007; Wiser et al., 2005). A combination of these two cost impacts approximates the total RPS electricity rate impact.

The first cost impact places upward pressure on retail electricity prices because construction and installation of renewable generation facilities, on average, costs more than conventional facilities. For example, the US average levelized costs for a new renewable generation facility entering service in 2016, regardless of fuel-type, will be higher than either conventional natural gas-fired or coal-fired facilities (EIA, 2010a).

The premium costs associated with renewable electricity capacity may be represented by the price of RECs because revenue from REC sales compensates in large part for the excess cost over conventional capacity. Moreover, RECs are a valued commodity that must be acquired by load serving entities to comply with the RPS. Subsequently, assuming utilities will fully recover RPS compliance costs (i.e., cost of RECs or ACPs), an estimate of the electricity rate impact from the RPS can be calculated by the known RPS requirements and a forecast of REC prices. In 2010, Maryland tier-1, non-solar RECs sold at between $0.75

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[18] Assumes entry of renewable capacity occurs in Maryland (L&A, 2008).

and \$1.50/MWh while solar RECs averaged 337.23 \$/MWh or about 85 percent of the solar ACP (PPRP, 2010b; PJM, 2011).[19]

The price of RECs will respond to changing RPS mandates among other factors. The tier 2 RPS mandate is constant at 2.5 percent of retail sales per year and sunsets in 2018. On the other hand, both the tier 1 solar and non-solar RPS mandates will increase steadily until 2022 (Table 1.7). In turn, tier 2 REC prices are expected to remain relatively stable while tier 1 solar and non-solar prices should escalate with rising demand, although LSEs would not be expected to pay more than the ACP, which decreases over time for both solar and non-solar tier 1 RECs. Non-solar tier 1 REC price forecasts range from 5-30 \$/MWh by 2022 and previous analysis suggests that Maryland non-solar tier 1 REC prices will not exceed the ACP price (L&A, 2008).

The second RPS cost impact places downward pressure on retail electricity rates because additional renewable electricity capacity, which has low variable costs (e.g., fuels costs), will reduce the average marginal cost of supplying electricity. This effect is highly variable and depends upon a number of factors including the quantity of renewable capacity added, where capacity is added, and when capacity is available; additionally, demand growth and fuel prices can influence the cost impact (Fischer, 2006; Wiser et al., 2005; Milligan and Kirby, 2009). In general, as availability of renewable capacity increases in a specific time and place, wholesale electricity prices will decrease (Lewis, 2010; Kha, 2008). With lower wholesale electricity prices, industrial retail rates will follow. Between 2006 and 2008, Maryland weighted average wholesale electricity prices, or locational marginal prices, were approximately 80 percent of Maryland industrial electricity retail rates (PJM, 2008; PJM, 2009; EIA, 2010c).

The benefits of adding more renewable capacity to the existing electricity supply must not be exaggerated. Adding low-cost generation capacity of any sort – renewable or conventional – will displace the highest cost generators and lower the clearing price for wholesale electricity. However, because of the intermittency of renewable energy sources, which precludes renewable capacity from being dispatched at a moment's notice, the potential for new capacity to displace high cost generators is limited. For instance, if a wind farm generates at only a small fraction of its total capacity during peak hours, then the farm will minimally displace high-cost peak generators (Milligan & Kirby, 2009). Also, a quantity of conventional capacity or spinning reserve is necessary to follow intermittent renewable generation and ensure electricity reliability (Milligan and Kirby, 2009).

The siting of locations of new renewable capacity will influence wholesale electricity prices because of factors such as congestion in the transmission grid and line losses. In general, as new capacity is located in or near Maryland, the impact on local wholesale electricity prices will be significant; conversely, as new supply is built further from Maryland, the impact on Maryland wholesale electricity prices will be lessened (Kha, 2008; Lewis, 2010). Maryland's RPS law includes language that will promote renewable capacity development

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[19] More than 90 percent of solar RPS obligation was met through alternative compliance payments in 2008 (MD PSC, 2010a).

in Maryland and the PJM region including a requirement that in 2012 and beyond, solar REC facilities must be located in Maryland (MDGA, 2008b).

Currently, both Maryland and the PJM region lack the renewable capacity necessary to meet future RPS requirements (PPRP, 2010b). In 2008, Maryland had 168 MW of total tier 1 electricity capacity. To meet the non-solar tier 1 RPS requirement of 1.18 million MWh in 2008, an absolute minimum of 136 MW of capacity is needed (PSC, 2010a).[20] To meet the forecasted 2022 non-solar tier 1 requirement of 13.4 million MWh, an absolute minimum of 1,529 MW of capacity is needed (PPRP, 2010b). The PJM queue for new capacity projects suggests approximately 266 MW of additional non-solar tier 1 summer capacity will be in-service by 2016 in Maryland service areas (PJM, 2010). Table 1.8 estimates required additional tier 1 non-solar renewable capacity for the period 2009-2022.

Table 1.8 Forecast of Maryland RPS requirements and needed renewable capacity

Year	**Tier 1, Non-solar Estimated RPS Requirement (GWh)***	**Tier 1, Non-solar Minimum Capacity (MW)****	**Tier 1, Non-solar Net Additional Capacity (MW)*****
2009	1,272.7	145.3	0.0
2010	1,284.9	146.7	0.0
2011	1,944.2	221.9	53.9
2012	3,255.1	371.6	203.6
2013	4,250.0	485.2	317.2
2014	5,358.5	611.7	443.7
2015	6,745.7	770.1	602.1
2016	6,903.6	788.1	620.1
2017	8,451.2	964.7	796.7
2018	8,810.5	1,005.8	837.8
2019	10,604.9	1,210.6	1,042.6
2020	11,692.8	1,334.8	1,166.8
2021	12,070.9	1,378.0	1,210.0
2022	12,500.5	1,427.0	1,259.0

* MD retail sales based on PSC forecast and current RPS mandate (PSC, 2010a; PSC, 2010c); ** Minimum capacity equals RPS requirement/8760; *** Net additional capacity = minimum less 168 MW of existing total tier 1 capacity in Maryland (PSC, 2010a)

RPS electricity rate impacts are subject to multiple uncertainties and assumptions. State and regional RPS mandates will drive REC prices up, but it is unclear how the economy, technology costs, and fuel prices will play out. Wholesale electricity prices could be partially depressed in Maryland as significant renewable capacity penetrates local supply. The direction and magnitude of electricity rate impacts under Maryland's RPS is uncertain and estimates should be performed under multiple scenarios (see Chapter 2).

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[20] Assumes 100 percent capacity factor and generation equal to 8760 hours/year. This assumption does not reflect actual electricity generation from renewable sources, but rather serves to provide a minimum figure for necessary capacity additions.

Natural Gas Price Impacts

Manufacturing, Natural Gas and RPS
Manufacturing is natural gas intensive and would be impacted by any changes in the natural gas market. With greater state and regional renewable capacity, demand for natural gas in the power sector may decrease resulting in fuel price effects in the industrial sector (ACEEE, 2003).

A 2003 study coordinated by the Maryland Public Interest Research Group (PIRG) found that electricity rates would increase as a result of an RPS, although the magnitude of change would be minimal (Chen et al., 2003). Since the study was performed, Maryland's RPS has evolved considerably. However, the study conducted insightful scenario analyses concerning the relationship between renewable energy and natural gas in Maryland. The 2003 study found that if Maryland's RPS were able to reduce PJM natural gas prices by 4 percent, then Maryland electricity rates would in fact be lower under an RPS (Chen et al., 2003). Regional natural gas price changes from Maryland's RPS would indirectly impact the state's manufacturing sector. It should be emphasized that the natural gas market is global and any influence of Maryland policy on prices would be minimal.

In its analysis of a national RPS, the US Energy Information Administration found that consumer expenditures on electricity are marginally different between an RPS and a reference scenario because, "the reduction in fuel prices caused by lower fossil fuel use for electric power generation outweighs the increased capital cost of new renewable generation capacity" (EIA, 2007, pg. xi). The effect of displaced natural gas is pronounced in early years because a small reduction at the upper end of the demand curve can have a disproportionately greater rate impact. In later years, the displacement effect is less pronounced and a national RPS would create higher electricity rates (EIA, 2007).

Regional or state-level renewable expansion could have a similar effect of reducing natural gas demand among electric utilities (ACEEE, 2003).[21] Natural gas demand reductions within the electricity market will stimulate price decreases in corresponding industrial, commercial and residential natural gas markets. Low industrial fuel prices will impact energy costs among manufacturers and result in broader consumption changes within the regional manufacturing sector. In the Northeast/PJM region, a natural gas demand reduction within the electricity market may actually result in an increase in industrial natural gas consumption relative to a scenario without renewable expansion (and energy efficiency improvements) (ACEEE, 2003). This situation would occur through avoided "demand destruction," or lower electricity demand resulting from a closure/production cut at industrial facilities. For example, as the price of natural gas decreases, industrial facilities operating at the margin of profitability will see cost savings and remain in operation instead of closing thereby creating a relative increase in total industrial natural gas

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[21] Due to a homogenous national natural gas market, regional or state natural gas demand reductions would impact national prices and vice versa (ACEEE, 2003).

consumption. Maryland and Pennsylvania are two Northeast states identified as locations where this might occur (ACEEE, 2003).

It is questionable whether Maryland's RPS alone could result in enough renewable generation expansion to create a significant displacement of natural gas demand in the PJM region (i.e., Chen et al., 2003). Nonetheless, because the electricity market is regional and most PJM states are expanding renewable capacity, it is more reasonable to assume that region-wide renewable generation expansion is capable of significant displacement of natural gas demand. In the PJM region, the magnitude of natural gas demand reductions and subsequent price reductions (in both the utility market and industrial market) may be substantial. Nationally, research estimates that a 1 percent decline in natural gas demand will result in a 4 percent drop in natural gas prices for all users (NCEP, 2003). The manufacturing cost impacts of a natural gas price decrease are explored in Chapter 2.

1.4.3 EmPower Maryland (EmPowerMD)

An energy efficiency resource standard establishes mandatory electricity and natural gas targets of achieving at least 15 percent per capita energy reductions by 2015 (MCCC, 2008). This demand-side CAP policy is embodied in the EmPowerMD programs. The EmPower Maryland Energy Efficiency Act of 2008 establishes two targets: (1) reduce per capita electricity consumption 15 percent (relative to 2007 levels) by 2015, and (2) reduce per capita peak electricity demand 15 percent (relative to 2007 levels) by 2015 (MDGA, 2008a). Responsibility for meeting these obligations is shared among all of Maryland's electric utilities with the five major utilities in the state expected to make the largest contribution.[22]

Background and Implementation

The EmPowerMD legislation requires that utilities develop plans to meet the stated targets through demand response, energy efficiency and conservation programs, which must be cost-effective (MDGA, 2008a). Demand response programs target peak electricity demand through voluntary curtailment or other means. Reductions in electricity demand via demand response programs are essential for mitigating high peak electricity costs and improving system reliability. Energy efficiency and conservation programs target electricity consumption through investment in more efficient lighting, building systems, and appliances. Figures 1.4 and 1.5 show the expected results from EmPowerMD demand response and energy efficiency and conservation programs, respectively. Across Maryland utilities, most demand response reductions are expected to occur through residential programs while most of the consumption reductions are expected to occur through non-residential programs (PSC, 2009).

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[22] Utilities include Pepco Holdings Inc., Delmarva Power & Light (DP), Baltimore Gas & Electric (BGE), Southern Maryland Energy Co-operative (SMECO), and Allegheny Power (AP).

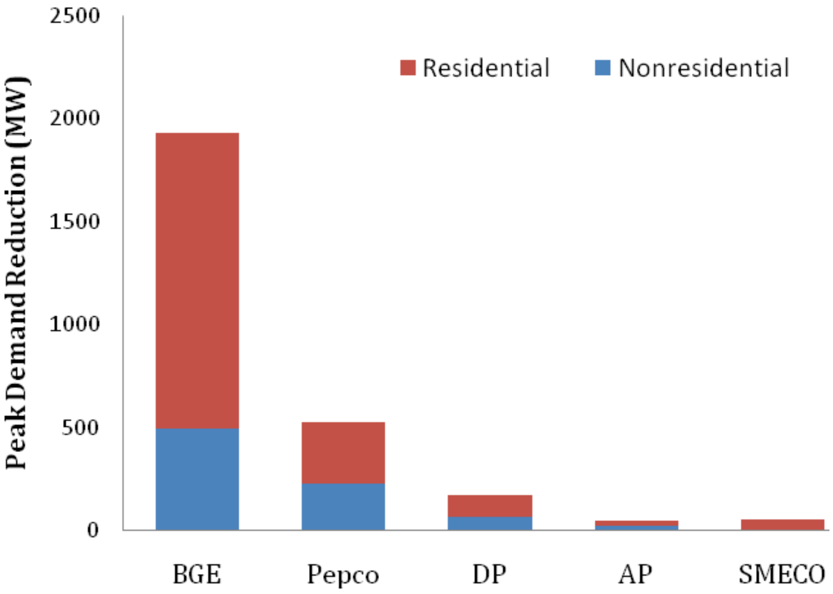

Figure 1.4 Aggregate electricity demand reduction target, by utility and residential and nonresidential (BGE, 2008; DP, 2008; Pepco, 2008; AP, 2008; SMECO, 2008)

The industrial sector has great potential for energy efficiency improvements. This is due to the fact that total national industrial energy consumption is approximately equal to residential or commercial consumption and because industrial consumption is concentrated in fewer buildings. Efficiency investments in the US industrial sector have focused on energy management measures, replacement of equipment, and process evaluation and modification (Glatt & Schwentker, 2010). In Maryland, although energy consumption in the industrial sector is about half of either the residential or commercial sectors, there is significant efficiency potential (EIA, 2010b). Installing cost-effective, non-process specific energy efficient measures within Maryland's industrial sector could save an estimated 20 percent of industrial electricity use by 2025; by addressing process-specific energy consumption and targeting large facilities, that estimate could increase to 25-30 percent. This reduction would total between 12-15 percent of total electricity consumption in Maryland (ACEEE, 2008).

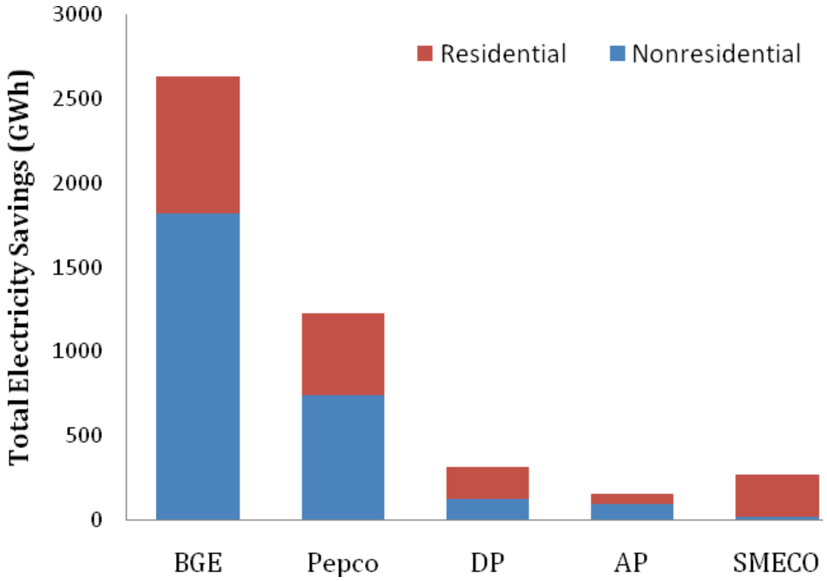

Figure 1.5 Aggregate electricity savings target, by utility and residential and nonresidential customers (BGE, 2008; DP, 2008; Pepco, 2008; AP, 2008; SMECO, 2008)

As Maryland's largest electric utility, Baltimore Gas and Electric (BGE) is responsible for most of the electricity consumption and demand response reductions under EmPowerMD. Also of significance, BGE serves a majority of the state's manufacturing customers including several large plants such as Severstal Sparrows Point and chemical production facilities (ACEEE, 2008) (Figure 1.6).

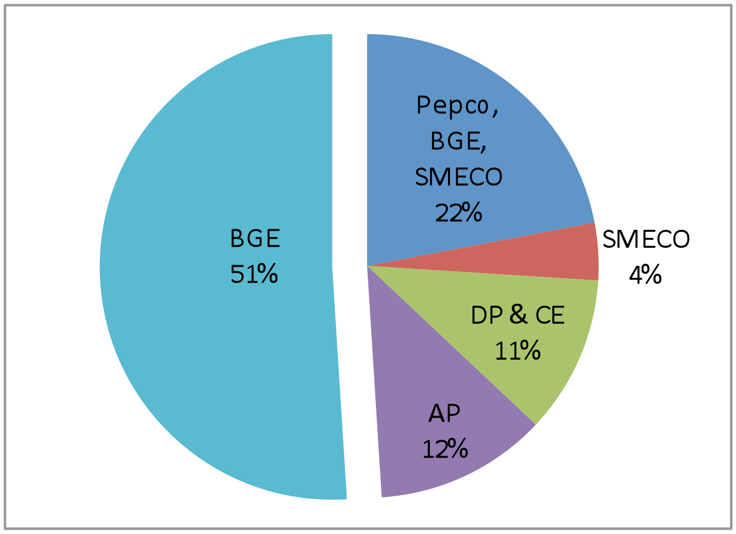

Figure 1.6 Proportion of manufacturing establishments in each utility's territory (USCB, 2009)

Implementation of EmPowerMD utility programs has fallen short, particularly concerning electricity consumption targets (PSC, 2010b; PIRG, 2010; Itron, 2010).[23] A study released by Maryland PIRG in early 2010 estimates that the total electricity savings from all utilities is just 58 percent of the 2011 target (2010). The shortfall is attributed to slow program implementation and poor economic conditions (PIRG, 2010; PSC, 2010b). The PSC estimates the 2011 goal will be achieved due to the economic downturn and resulting reductions in electricity demand (2010b).

BGE has delivered its programs faster and has had more success in its large commercial and industrial (LC&I) programs relative to other major utilities (PIRG, 2010; BGE, 2010; Itron, 2010).[24] BGE has three LC&I program categories, including: (1) prescriptive program, (2) custom measure program, and (3) retro-commissioning program. The first two programs have had the highest participation (BGE, 2010).[25] The BGE 2010 2nd quarter EmPowerMD report indicates that since the programs began, approximately 72,000 LC&I efficiency measures have been adopted at a gross annual energy savings of about 41,000 MWh of electricity. Despite the relative success of the programs, LC&I participation is only about 42 percent of expected levels for this stage of implementation (BGE, 2010). Only electricity savings have been reported by BGE in its LC&I programs (i.e., no reported gas savings) (BGE, 2010).

An inquiry with BGE's demand side management personnel in October 2010, revealed manufacturers have participated in its EmPowerMD programs. Between May 2009 and September 2010, approximately 100 efficiency measures were adopted among 40 different manufacturing firms. Prescriptive lighting, motors, and variable frequency drives were the most popular equipment upgrades, respectively. As a result of the efficiency improvements made at industrial businesses during this sample period, an estimated 6.1 million kWh of electricity will be saved annually with the support of close to $500,000 in incentives (Wolf, 2010).

Finally, it should be noted that EmPowerMD plans will be revised by utilities (MDGA, 2008). As of summer 2010, utilities were still gaining approval from the PSC for implementation of smart grid and advanced metering infrastructure technology within their service territories (Cho, 2010). Furthermore, the EmPowerMD requirements are set to expire after 2015. Whether or not the programs will continue past 2015 remains to be seen. Efficiency savings, based on the lifetime of technology, will extend past 2015 and likely, 2020.

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[23] Each of five major utilities have energy efficiency and conservation programs in place while only four utilities have demand response programs (PSC, 2010b).

[24] Manufacturing firms may qualify for other programs (small C&I, fast track lighting and appliances).

[25] The prescriptive program is broad in its applications and offers defined incentives for energy efficient technology; the custom measure program is site-specific and offers incentives for audits and technology among other means to energy efficiency improvements (BGE, 2008).

Direct Participatory Impacts

Demand-side management programs such as EmPowerMD are unable to service each and every electricity customer. Only a fraction of customers will be aware of the program and only a fraction will actually participate. However, it is possible to generalize which types of manufacturing facilities may participate based on characteristics such as age, size, electricity intensity and capital available for investment. Also, program design will impact participation.

Plants preparing to retire equipment or expand/modify processes will invest in new equipment. In deciding how to invest, firms should seek out cost-effective, energy efficient technology and optimal payment options including utility-sponsored incentive programs. Second, firms with more employees are more likely to participate because governments or utilities usually market to large companies (DeCanio & Watkins, 1998). Third, electricity intensive firms are more sensitive to electricity prices, and would be expected to invest in efficiency improvements to reduce costs (Bjorner et al., 2001). Fourth, because energy efficiency investments are capital intensive and require out-of-pocket expenses, firms with stable historical profits (as well as a positive outlook) are more likely to participate. Firms with a higher price-to-earnings ratio and historical earnings growth rates are more likely to participate in energy efficiency programs (DeCanio & Watkins, 1998). Last, if programs are broad and support widely used equipment (e.g., lighting) participation will be more diverse than programs targeting highly specific equipment (e.g., basic oxygen furnace in steel production) (Arora and Cason, 1995).

Among manufacturing firms that choose to participate in EmPowerMD programs, there will be both costs and benefits. Firms investing in new equipment or services (e.g., energy audits) will pay a one-time cost upfront. For process-specific technology (e.g., variable frequency drive for motors), efficiency upgrades may come at the additional cost of suspending production. Benefits from improved electricity efficiency in the form of reduced electricity costs will accrue over the lifetime of the technology. Because the lifetime of technology varies, as well as the potential for efficiency gains, the electricity cost savings accrued differs by technology and firm.

Select EmPowerMD Benefits, Costs Accrue for Participants Only
EmPowerMD programs are voluntary for customers and there will be no direct compliance costs to Maryland's manufacturing sector. Participatory costs (e.g., technology investment) and benefits (e.g., electricity savings) will only accrue for participating firms.

The payback periods among industrial and commercial (I&C) energy efficient equipment differ; variable frequency drives and lighting retrofits typically have the lowest average payback period. Each of the EmPowerMD programs put forth by Maryland utilities demonstrates a return on energy efficiency investments. In other words, the long-term electricity cost savings will be greater than one-time capital costs. At BGE, for example, each dollar spent on commercial efficiency programs will result in $3.60 in electricity cost savings for the consumer (PIRG, 2010). Table 1.9 shows the average annual electricity savings, capital costs, and payback period for seven categories of commercial and industrial efficiency measures.

Table 1.9 Electricity savings, capital costs, and payback period for typical manufacturing efficiency measures (Wolf, 2010)

	I&C Commercial Refrigeration	**I&C Custom**	**I&C HVAC**	**I&C Motors**	**I&C Prescriptive Lighting - Retrofit**	**I&C Variable Frequency Drives**	**Small Business Lighting Solutions**
Average elect. savings (kWh/yr)	4,261	70,952	649	865	72,357	152,939	17,210
Average cost ($/measure)	2,700	45,923	3,000	720	15,782	30,000	28,404
Payback period (Years)*	5.8	5.9	42.0**	7.6	2.0	1.8	15.0

* Assumes $.11/kWh; ** does not include savings from reductions in heating fuel demand

Electricity Rate Impacts

EmPowerMD will impact electricity rates in at least two distinct ways: (1) EmPowerMD surcharges will apply to all manufacturing firms regardless of program participation, and (2) in the long-term, decreased electricity demand from all residential and non-residential EmPowerMD participants as well as avoided capacity expansion costs will put downward pressure on electricity rates (Figure 1.7).

Utilities will recover program costs through a surcharge applied to all electricity customers. All regulated utilities have adopted a surcharge to recover costs and surcharges will be amortized over a period to distribute cost impacts.[26] It should be noted that the surcharge for large electricity customers is considerably smaller than residential surcharges for all regulated utilities; also, these surcharges only exist in regulated utility service areas (Godfrey, 2010; PSC, 2009). The 2010 EmPowerMD industrial surcharge ranges between .02 and .5 $/MWh depending on rate class and service area (Godfrey, 2010).

In addition to the rate impact from EmPowerMD surcharges, secondary policy impacts in the electricity market are worth considering. Namely, peak demand reductions will mitigate the highest wholesale electricity prices and decreased demand can lead to deferment/avoidance of new generation, transmission and distribution capacity (EnerNOC, 2009). Energy efficiency and conservation measures will influence electricity rates to a lesser extent relative to demand response measures (L&A, 2008).

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[26] "Expenses associated with conservation and energy efficiency programs should be amortized over a five-year period," and, "program costs should be appropriately allocated to rate classes based on their eligibility to participate in each program and benefited derived" (PSC, 2007, pg.6).

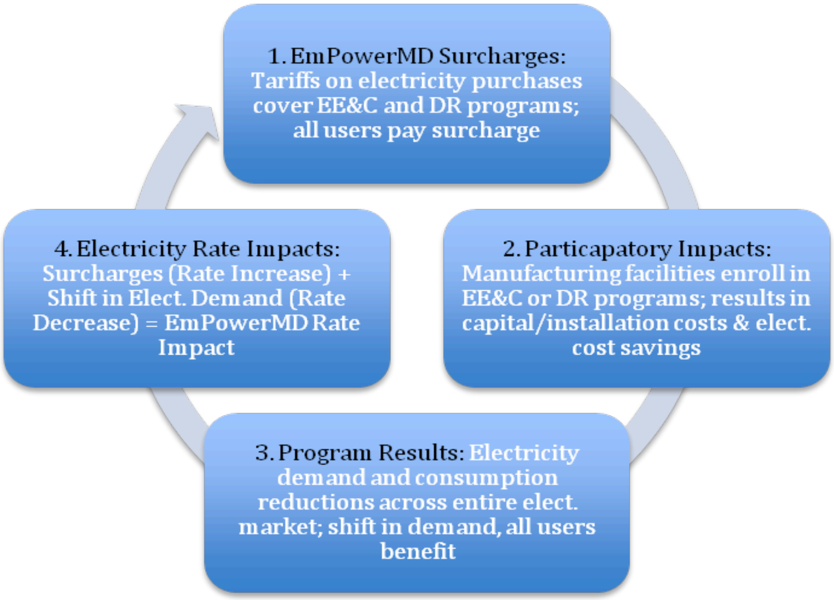

Figure 1.7 Indirect (participatory) and direct (electricity rate) impacts from EmPowerMD

A number of studies have identified the significant benefits to ratepayers resulting from demand-side management investment (ACEEE, 2008; L&A, 2008; EnerNOC, 2009; Ruth et al., 2007, 2008; PIRG, 2010). However, these studies generally capture the collective decrease in electricity costs paid by ratepayers, which occurs mostly through decreased electricity consumption and not necessarily decreased electricity rates. In other words, the electricity cost savings being measured fall primarily upon participants of programs through reduced electricity consumption. For electricity consumers not participating in EmPowerMD programs, the true test of EmPowerMD cost impacts lies in electricity rate impacts and related consequences such as enhanced grid reliability. Chapter 2 below discusses in more depth the assumptions and methods adopted to quantify the impact from EmPowerMD programs on the manufacturing sector.

1.5 Manufacturing Responses to Policy

The manner in which manufacturing firms respond to policy-induced changes differs between the short and long term. Likewise, the range of reasonable responses varies by subsector, plant technology, and other characteristics. Potential responses include decreasing energy demand through production cuts, fuel switching, investing in more energy efficient technology, cost recovery (via cost pass-through to consumers) and a host of other options. Of course, non-response is possible and likely with imperceptible or negligible policy impacts. Below is a review of potential responses to policy impacts.

Short-Term Energy Demand Responses

Manufacturing firms respond to changes in energy prices by adjusting consumption patterns. Industrial firms are more responsive to energy prices in the long run than the short run (Bohi & Zimmerman, 1984). Firms are typically more responsive to natural gas prices than electricity prices in the short term; in the long run, however, the relationship is reversed and firms become more responsive to electricity prices (Beierlein et al., 1981). Short-term substitutability of natural gas relative to purchased electricity contributes to this pattern (EIA, 2005).

Three Lessons of Energy Consumption Response in Manufacturing
(1) Manufacturing firms are more responsive to energy prices in the long term than the short term, (2) firms are more responsive to natural gas prices in the short term, and (3) electricity intensive industries are more responsive to purchased electricity prices than less intensive firms.

Manufacturing firms with either a high electricity intensity or share are usually more sensitive to the price of electricity than their low-intensity counterparts. On average, these facilities will reduce electricity demand by a greater quantity than other, less electricity-intensive facilities as a response to electricity rate increases (Bjorner et al., 2001).[27] All things being equal, high electricity intensity firms demonstrate a stronger response to electricity rate increases than high electricity share firms (Bjorner et al., 2001). In considering how electricity end-use might be modified, firms tend to reduce greater quantities of demand from process end-use (process heating and motor drive) than non-process end use (lighting and space conditioning) (Kenney & Kershner, 1980).

Short-term reductions in energy consumption suggest that a firm is probably decreasing production. This is because energy efficiency improvements are time and capital intensive and infeasible in the short term. In the long term, reduced energy demand is attributable to efficiency gains, although decreased production remains a factor. Trends reveal that decreased energy demand in the US, particularly energy demand per unit of production, has largely come through energy efficiency improvements and less through decreased or outsourced production (Metcalf, 2008).

Firms may cut production and energy consumption as part of their efforts to increase profit independent of changes in energy prices. Production might be steadily reduced over time, which would correspond with steadily increasing energy prices. Also, production might be cut temporarily and quickly returned to normal activity, which would correspond with temporarily elevated energy prices. Broad-level production, cost, and employment trends will be distinctive between firms choosing the former and latter options.

Firms may be unable to make incremental reductions in production if technology shut-down/boot-up is cost prohibitive. For firms with the option to incrementally cut production, there are advantages. Short-notice production cuts provide firms curtailment benefits in the event of high electricity prices (e.g., during peak hours, summer days) or high natural gas prices (e.g., during winter months). The motive for this decision may be

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[27] Bjorner et al. find that companies with *very high* electricity intensity are slightly less responsive to electricity prices relative to companies with *high* electricity intensity. This may be a product of the economies of scale associated with very intensive plants including fuel switching capacity and leverage for favorable electricity contracts (2001).

strictly cost-savings or under some energy contracts, curtailment may actually provide a source of revenue (PJM, 2009).

Energy Quality/Fuel Switching Responses

For manufacturing facilities with self-generating electric capacity or on-site boilers, an additional set of response options is available. Facilities with these technologies may be able to shift fuel types to meet either process or non-process end-use demand. Because of the ability to switch fuels, a price change in one fuel may influence demand for a substitute fuel. For example, an increase in the price of natural gas may contribute to increased demand and use of fuel oil (Halverson, 1977).

Response Option: Fuel-Switching
Fuel-switching capacity adds another option by which to respond to policy-induced changes in the price of energy. In fact, fuel switching is usually the first option, before demand reductions, for some manufacturing subsectors (e.g., pulp and paper facilities) (Chern & Just, 1980).

Most manufacturing facilities in the US rely on natural gas and electricity as energy inputs to production, but not all facilities have the ability to switch among fuels in response to energy price changes (Table 1.10). Of manufacturing facilities relying on natural gas as a fuel source, depending on the subsector, between 11 and 45 percent are capable of switching away from natural gas in a relatively short period of time. In contrast, only 2-7 percent of facilities are capable of switching away from purchased electricity, which probably indicates on-site generation capacity (EIA, 2005).

There is also a geographic component to fuel switching. In regions with similarly priced fuels, even for part of the year, fuel-switching capability is more likely to exist. Conversely, in regions where one fuel is consistently the low-cost option, most manufacturing facilities will be locked into a fuel-specific technology (Doms, 1993). Economies of scale are a critical factor in determining fuel-switching capacity too. Industrial boilers and electricity generators require significant capital and fuel investment, so large facilities in energy intensive industries are more likely to benefit from and thus own technology that allows fuel-switching (Doms et al., 1993). Each of the four Maryland manufacturing facilities with significant self-generation capacity is able to switch among fuels (Table 1.5) (EIA, 2010c).

Fuel switching does not occur without additional costs. Facilities may have to negotiate new energy contracts or disrupt production to modify equipment. Still, facilities with the ability to switch among fuels are less susceptible to price volatility and supply disruption. Also, fuel-switching technology provides leverage in negotiations for energy contracts (Doms, 1993).

Table 1.10 US manufacturing establishments, fuel dependence and fuel switching (EIA, 2005)

Industry	**Percent of Establish. using natural gas**	**Percent w/ capability to switch away from natural gas**	**Most common natural gas alternative (In order)***	**Percent w/ capability to switch away from purchased electricity**	**Most common purchased electricity alternative (In order)**
Food	80%	18%	Dist, LPG	4%	Dist., NG
Beverage and Tobacco Products	71%	21%	Dist, Elect.	4%	NG, Dist.
Textile Mills	62%	45%	Dist, Res.	2%	Dist.
Textile Product Mills	65%	13%	Elect., LPG	4%	NG
Apparel	55%	11%	Elect., Dist.	3%	NG, Dist.
Leather and Allied Products	83%	28%	Elect., Dist.	7%	Dist.
Wood Products	44%	18%	Elect., LPG	4%	NG, Dist.
Paper	82%	18%	Elect., Dist.	2%	NG, Dist.
Printing and Related Support	66%	12%	Elect., LPG	3%	NG, Coal
Petroleum and Coal Products	74%	21%	Dist., LPG	7%	Dist.
Chemicals	76%	20%	Elect., Dist.	4%	NG, Dist.
Plastics and Rubber Products	76%	20%	Elect., LPG	3%	NG, Dist.
Nonmetallic Mineral Products	63%	18%	Elect., LPG	5%	Dist., NG
Primary Metals	86%	15%	LPG, Elect.	4%	Dist., NG
Fabricated Metal Products	76%	17%	Elect., LPG	4%	NG, Dist.
Machinery	81%	15%	Elect., LPG	3%	NG, Dist.
Computer and Electronic Products	72%	11%	Elect., LPG	4%	NG, Dist.
Electrical Equip., Appliances, and Components	86%	14%	LPG, Elect.	5%	NG, LPG
Transportation Equipment	78%	14%	LPG, Elect.	5%	Dist., NG
Furniture and Related Products	56%	11%	Elect., LPG	3%	NG, Dist.
Miscellaneous	72%	11%	Elect., LPG	4%	Coal, Coke and Breeze

* Dist = Distillate Oil, Res = Residual Oil, NG = Natural Gas, LPG = Liquefied Petroleum Gas, Elect. = Electricity

Efficiency Responses

Improving technological performance, specifically the energy efficiency of equipment and processes, is a common response to increasing energy prices across all sectors of the economy. Of course, other technological responses exist such as adding electric self-generation capacity or installing a boiler as insulation against volatile energy prices. This segment looks at technological responses that improve the energy efficiency of existing technology. Technological responses are more likely to occur over the long-term.

Autonomous efficiency improvements occur regardless of policy-induced price changes or incentives/rebates and are represented by natural turnover of capital stock, which is usually replaced with newer, more energy efficient technology (Grubb et al., 1995). New capital investment is expected to secure the most cost-efficient technology available and not necessarily the most energy efficient technology available. Moreover, facilities must ensure that new capital aligns with existing infrastructure, processes, and knowledge, which constrains options and contributes to technology lock-in (Unruh, 2000). As a result, investment in seemingly cost-effective, highly efficient technologies frequently falls short of expectations and investment is instead directed towards less efficient technologies. This gap in potential investment is known as the efficiency gap (Golove et al., 1996).

Induced and Autonomous Energy Efficiency Improvements
Climate policies may induce energy efficiency investments (e.g., firms capitalizing on utility rebates) while autonomous efficiency improvements will occur independent of climate policies (e.g., through natural retirement and replacement of equipment).

Induced efficiency improvements occur in response to external changes (e.g., availability of rebates) that alter the economics of remaining with the current technology and drive early equipment retirement or modification. The most prominent example of induced technical change follows from the oil price shocks of the 1970s when sudden and substantial energy price increases discourage firms to hold on to existing technology (Sue Wing, 2007). Since this period, manufacturing firms in the United States have invested in more energy efficient technology to lower costs (Sue Wing, 2007; Metcalf, 2008).

There are multiple examples of programs designed to change the economics of remaining with existing technology, induce adoption of energy efficient technology, and close the energy efficiency gap. EmPowerMD utility rebate programs are intended to induce efficiency investments and should create efficiency gains at a rate faster than autonomous efficiency improvements (ACEEE, 2008; PIRG, 2010).

Embodied and Disembodied Efficiency Improvements
The costs associated with energy efficiency improvements vary by embodied and disembodied technological change. Disembodied change doesn't require capital investments or capital replacement and is associated with lower costs relative to embodied changes (Solow, 1957; Berndt et al., 1993).

Technological change may be classified as either embodied or disembodied. The former represents changes to capital (e.g., a new motor) and the latter represents changes around existing capital (e.g., calibrating or tuning a motor) (Solow, 1957; Berndt et al., 1993). The distinction is important because embodied technological change is associated with higher capital investment and longer payback periods. Also, disembodied technological change can apply to all capital of varying characteristics while embodied change may be limited to specific equipment (Davidsdottir et al., 2005). Furthermore, creating embodied technological change can be difficult as it frequently represents radical deviation in equipment of processes compared to the relatively incremental steps associated with disembodied change (Unruh, 2000; Davidsdottier et al., 2005).

Finally, firms investing in energy efficiency improvements may succumb to the rebound effect. In the context of manufacturing, the rebound effect may be defined by an economic choice to increase production because the availability of more efficient operations justifies such activity; the net effect is that realized efficiency gains are minimized or totally offset (Berkhout et al., 2000).

Cost Recovery, Relocation, Job Cuts and Electricity Delivery Contracts

Competition – actual or perceived – between Maryland firms and regional or global firms will deter significant pass-through of additional costs to consumers unless competitors are forced to do so as well or unless consumers otherwise value the actions that led to higher costs. If pass-through is possible, it can occur in several ways. At manufacturing firms with narrow profit margins, internalizing increasing energy costs is unacceptable – the best short-term option is usually to pass along costs to consumers. Alternatively, some industries have a wider profit margin and may be able to partially cover higher energy prices while minimally increasing the price of products. Another facet of cost recovery is substitutability of goods. Some subsectors are able to increase prices with little consequence because of the necessity of goods (e.g., food and pharmaceutical goods). Last, companies may be able to increase prices for a period of time without significant reductions in sales. As price differences among competitors persist, higher-priced items will be selected less frequently (Katz et al., 1997).

A useful example of energy price increases and cost recovery comes from fertilizer production and natural gas price escalation between 1998 and 2001. During this time, natural gas, a feedstock to fertilizer/ammonia production, reached $10/Million BTU in the US. Because natural gas accounts for as much as 90 percent of the material costs in fertilizer production, domestic fertilizer prices doubled and farmer consumption dropped. Ultimately, several fertilizer manufacturing facilities in the US closed and fertilizer imports from abroad increased (ACEEE, 2003).

Passing Costs onto Consumers
Firms have varying abilities to pass on costs to consumers and factors such as availability of substitutes, necessity of goods, and duration of the price change all influence cost recovery options. In globally competitive industries such as basic chemicals and iron and steel, there is very little room to increase the price of goods without significant sales reductions (Katz et al., 1997).

Relocation of manufacturing processes is a potential response to higher energy prices. Among companies owning multiple production sites, it is feasible to shift output among production locations. Primary metal and basic chemical production are two such subsectors characterized by dominance from a small number of large companies, which frequently have production facilities throughout the world (Bassi et al., 2009). In contrast, smaller firms are tied to a particular location because they lack the resources to relocate and may depend exclusively on a local retail market. Natural resource dependent industries such as mining/quarrying, wood production, and cement manufacturing vis-à-vis coal dependence are often tied to regionally advantageous resources (Bae, 2008). The corollary to this dependence on regional assets is immobility relative to other manufacturing subsectors and a resulting disadvantage to relocation. Relocation of production is always a more feasible option in the long term rather than the short term, and there are numerous costs associated with relocation including production stoppage and renegotiating of material contracts. The Eastalco Aluminum Company, a division of Alcoa, formerly produced aluminum products at a smelter in Buckeytown, Maryland. Around 2005, production shifted to Trinidad and other global locations with lower electricity prices (ACEEE, 2008).

Additionally, as energy and capital costs increase and production becomes less profitable, firms may reduce employment levels as a means of either aligning with lower productivity or becoming more efficient. This response would follow recent trends in US manufacturing, which show decreasing employment levels. Chapter 3, Section 3.2 discusses in more detail potential job losses in Maryland's manufacturing sector as a direct result from CAP policies.

Next, there is significant dispersion in the price paid by manufacturing plants for electricity. In fact, the spread of electricity rates across manufacturing plants is at least as great as the spread of average hourly employee wages across manufacturing (Davis et al., 2007). This dispersion is a result of geography, technology, and most importantly, plant size and quantity of electricity procurement. Larger plants typically benefit from quantity discounts such as block pricing (Davis et al., 2007). Some plants have high voltage lines connecting directly to the transmission grid or locate nearby generation capacity, both of which reduce transmission and distribution costs (Davis et al., 2007). Also, electricity congestion and cost recovery for new generation, transmission and distribution capacity can result in different rates. Most industrial customers are charged separately for demand or the maximum requirements for power. Utilities adopt a pricing scheme that discourages erratic power consumption through this additional cost (Davis et al., 2007).

In a deregulated electricity market, there are opportunities for manufacturing facilities to take advantage of favorable pricing schemes through contract negotiation. Industrial firms may enter a contract with real time pricing and load curtailment elements, which have demonstrated significant interest among manufacturing firms. For example, a study of real time pricing found that when firms are exposed to high electricity rates for only a portion of the year (10 percent of the time or less), they usually respond by shifting load to off-peak hours (Boisvert et al., 2004).

1.6 Summary

This chapter presented context to be used in the studies that follow. Information regarding Maryland's manufacturing sector, energy profiles, observed and expected policy impacts, and potential responses to cost impacts were all presented. A number of lessons, which will be applied and reiterated in the studies that follow, can be drawn from this chapter, including:

- Manufacturing is energy-intensive and Maryland firms must control energy costs to remain globally competitive;
- Firms have diverse energy profiles influenced by the goods they produce, their geographic location, and technology characteristics;
- Policy impacts associated with RGGI and RPS will be both direct (e.g., regulatory costs) and indirect (e.g., costs associated with electricity rates);
- Policy impacts associated with EmPowerMD will be direct, but voluntary (e.g., participation in utility programs and reductions in energy consumption) and indirect (e.g., surcharges associated with program cost recovery);
- Firms vary in their capacities to respond to any change in production costs (e.g., relocation, pass on costs to consumers, fuel-switching).

It should also be underscored at this point that based on our review of the literature, we expect direct costs to manufacturing firms in the form of regulatory or compliance costs to be small and relevant for only a few select firms. Namely, we find that direct impacts associated with the RGGI and the RPS, which were in place prior to the GGRA, will have minimal impacts on the manufacturing sector as a whole. Among the firms impacted directly by these policies, options exist for mitigating cost impacts (e.g., IPL status under RPS and the limited industrial generator exemption under RGGI). No manufacturing firms will be adversely impacted as a direct result of EmPowerMD.

Indirect effects related to electricity rate impacts are covered in greater detail in the following chapter. Ultimately, because of the variability in firm's energy profiles and the range of response options available to firms, we do not expect the cost impacts to be uniform across the manufacturing sector. An emphasis on the diversity within the manufacturing sector is conveyed in the following studies.

1.7 Appendices

Appendix 1.A Maryland Manufacturing by 3-Digit NAICS Codes, 2008

NAICS-based code	Meaning of NAICS-based code	Number of employees (March 2008)	Annual payroll ($1,000)	Number of Establishments	Value of Shipments ($1,000)	Percent of MD to US Value of Shipments
311	Food mfg	14,164	492,214	313	6,894,999	1.062%
312	Beverage & tobacco product mfg	1,627	78,783	32	1,562,904	1.247%
313	Textile mills	1,153	64,203	29	395,308	1.241%
314*	Textile product mills	943	31,638	119	N/A	N/A
315*	Apparel manufacturing	988	27,252	72	N/A	N/A
316*	Leather and allied products	182	5,587	7	N/A	N/A
321	Wood product mfg	2,981	103,866	140	589,341	0.670%
322	Paper mfg	4,198	179,986	42	1,063,471	0.595%
323	Printing & related support activities	12,777	573,235	606	2,119,286	2.138%
324*	Petroleum and coal products	779	51,268	40	N/A	N/A
325	Chemical mfg	9,812	586,344	186	5,810,800	0.774%
326	Plastics & rubber products mfg	5,894	265,499	118	1,527,990	0.747%
327	Nonmetallic mineral product mfg	5,055	242,901	202	1,515,467	1.309%
331	Primary metal mfg	2,840	87,641	35	772,259	0.274%
332	Fabricated metal product mfg	12,202	553,800	466	3,011,159	0.841%
333	Machinery mfg	7,921	466,749	159	2,747,948	0.770%
334	Computer & electronic product mfg	21,352	1,740,765	224	7,172,177	1.817%
335	Electrical equipment, appliance, & component mfg	2,187	97,505	49	447,275	0.339%
336	Transportation equipment mfg	4,816	267,111	109	1,300,554	0.195%
337	Furniture & related product mfg	4,931	175,155	267	756,098	0.940%
339	Miscellaneous mfg	5,077	217,251	411	933,846	0.609%
21	Mining, quarrying and gas extraction	1,601	78,357	88	521,516**	0.038%

Sources: USCB, 2010b; *NAICS 21, mining and quarrying from* USCB, 2010c; *NAICS 314, 315, 316, 324 from* USCB, 2009; All establishment counts from USCB, 2009; * = Data from CBP Survey and missing data for value of shipments from ASM ** = Total value of shipments and receipts

Chapter 2: Manufacturing Costs Study

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2.1 Introduction and Background

Global climate change is expected to have adverse economic and social consequences unless concerted action is taken to reduce the emission of greenhouse gases (GHG) into the atmosphere. A noted leader in environmental and natural resource fields, Maryland has committed to reducing harmful emissions under the Greenhouse Gas Emissions Reduction Act of 2009 (GGRA). Meeting this goal must occur in parallel with other economic, environmental, and social priorities. Our research explores the intersection of two Maryland priorities – environmental protection and economic welfare – through an analysis of GHG mitigation policies and associated impacts on the state's manufacturing sector.

Concerns over how Maryland's diverse manufacturing sector will be influenced by GHG mitigation policies are warranted because economic prosperity in the state has, to some extent, been generated by its manufacturing businesses. Since effective mitigation of GHGs will address the quantity and quality of energy consumption patterns, energy-intensive industries may incur a disproportionate impact. Manufacturing processes are highly energy-intensive and exposed to global competition, which makes them sensitive to any increase in energy prices (Baron et al., 2008). While the potentially negative impacts on production costs and competitiveness are readily recognized, the potential for positive impacts in the region that come from more energy efficient production and the creation of new "green collar jobs" are less well understood.

Manufacturing is globally competitive. Firms are constantly seeking opportunities to reduce costs, generate quality products and remain ahead of competition. In turn, to avoid leakage of carbon emissions, jobs, and wealth, the Maryland General Assembly suggests that regulating GHG emissions in the manufacturing sector will be most effective at a national or international level (MDGA, 2009). In this context, the State of Maryland has chosen to lead the charge.

The General Assembly has approached climate legislation in a manner that recognizes the sensitivity of Maryland's manufacturing sector to any potential policy-induced cost impacts. Specifically, the Maryland Department of the Environment must submit a plan by December 31, 2012, for achieving the GHG reduction target with the following obligations:

- No requirement to reduce GHG emissions from the state's manufacturing sector unless from existing state or federal law;
- No significant increase in costs to the state's manufacturing sector.

In addition to the 2012 obligations to not create new regulatory requirements or significant cost increases for Maryland manufacturers, the GGRA also addresses the prospect of future GHG regulation in the manufacturing sector. Specifically, in 2015, an independent institution of higher education will conduct a study of the economic impacts of requiring GHG emissions reductions from Maryland's manufacturing sector though additional (not currently existing) regulations. We expect any new GHG regulations in the manufacturing sector to be deferred until at least 2016, after a legislative review of CAP progress and completion of the 2015 independent study (MDGA, 2009).

The purpose of this chapter is to evaluate cost impacts in the manufacturing sector resulting from execution of the Maryland GHG mitigation plan. Our study primarily evaluates existing climate mitigation policies although cursory analysis of potential new or revised policies is conducted.

2.1.1 Scope of Analysis

Due to the broad scope and range of the CAP, this research focuses on three select policies: (1) the Regional Greenhouse Gas Initiative (RGGI), (2) the Renewable Energy Portfolio Standard (RPS), and (3) the EmPower Maryland (EmPowerMD) mandate (see Table 1.5, Chapter 1). We seek to quantify the collective production cost impacts resulting from these three select policies in Maryland’s manufacturing sector.

We believe the three select policies capture the magnitude of the 2008 Maryland Climate Action Plan (CAP) as it impacts the manufacturing sector, and analysis of these policies will provide conclusive results. We also recognize the opportunities for the range of policies in the CAP to directly or indirectly influence the manufacturing sector, although these are not necessarily quantified in their impact in this report. Instead, we review the additional CAP policies in varying depth to arrive at a more comprehensive portrait of potential impacts. We review additional CAP policies, including: Improved Building Codes and Trade Codes, More Stringent Appliance/Equipment Standards, Clean Distributed Energy/ Combined Heat and Power, and Waste Management and Recycling (see Table 1.5, Chapter 1).

2.1.2 Research Questions

The overarching research questions of this chapter include:

Question 1. What is the magnitude and direction of cost impacts on the manufacturing sector for select CAP policies including the RGGI, the RPS, and EmPowerMD?

Question 2. What are the general impacts to be incurred in the manufacturing sector resulting from other CAP policies?

In addition to these overarching questions, second tier questions, many of which were explored in Chapter 1, are considered to provide better resolution on individual issues and a broader context within which to judge impacts of CAP policies on Maryland's manufacturing sector. These questions include:

A. What is the energy profile of Maryland manufacturing subsectors?
B. What are the findings of previous studies regarding the cost impacts of climate policies and how should that research be applied to the manufacturing sector?
C. How will cost impacts differ depending on the specific manufacturing subsector or firm characteristics (e.g., available technology, energy profile)?
D. How might manufacturing firms respond to changes in the costs of production and what are the key differences across subsectors concerning response options?
E. Which policy/market scenarios and modeling assumptions need to be explicitly addressed as having a significant influence on cost impacts?

2.1.3 Research Approach

To answer the research questions above, we use both quantitative and qualitative methods and rely upon primary and secondary sources. We review academic papers, policy implementation reports, market forecasts, and utility-provided data as well as consult with experts to address the questions at hand.

First, to evaluate Question 1 above, we develop a detailed model to estimate baseline manufacturing production costs in the absence of the GGRA. We then contrast this baseline against alternative policy scenarios, which account for the range of expected electricity consumption, electricity rate, and capital cost impacts from each of the select policies. We present three policy scenarios (see Table ES.2 as well as Table 2.6 below). Policy scenarios are designed to highlight policy implementation or market elements with the greatest uncertainty and capacity for influencing cost impacts. To evaluate Question 2 above, we review appropriate literature and case studies from within Maryland and elsewhere.

Electricity characteristics in the manufacturing sector are particularly important to this research because climate policies under review (e.g., the RPS) directly influence the electricity market from both the supply and demand side. Our research focuses on electricity price, electricity consumption, and capital cost changes that would impact manufacturing energy and capital costs. Furthermore, we conduct sensitivity analyses where assumptions about economic growth and natural energy efficiency gains are adjusted as well as evaluate how policy-induced natural gas price changes might influence manufacturing costs (see Chapter 1).

Our analysis focuses on the years 2006-2020, which follows the timetable of the GGRA. Results are presented on an annual scale representing reasonable average or aggregate figures. The analytical scope of this report includes the manufacturing sector (North American Industry Classification System (NAICS) codes 31-33 only) and considers capital and energy production costs. Manufacturing employment and policy impacts are discussed in Chapter 3. Analysis occurs at a fine resolution isolating all 3-digit NAICS subsectors in Maryland and certain 4 and 6-digit NAICS industries with unique characteristics meriting disaggregation. Moreover, the analysis accounts for specific fuel consumption by fuel type (e.g., natural gas, distillate fuel, residual fuel), purpose of fuel use (e.g., fuel vs. non-fuel), and on-site electricity generation capacity.

There are a number of advantages and disadvantages to using these conceptual bounds on our analysis, which are discussed in more depth in Section 2.4. While the detail of our analysis may be difficult to apply to policy-making, it merits emphasizing that attributes of Maryland manufacturing, specifically its energy profile, differ considerably from facility to facility (small scale) as well as subsector to subsector (large scale). Assuming a uniform manufacturing sector would considerably simplify the analysis, but seriously fail to account for this diversity and discount the potential for climate policies to have ranging impacts. Moreover, Maryland climate policies will impact firms differently depending on specific facility features– namely, the electricity intensity of production and the presence of on-site electricity generation capacity.

This chapter relies upon the literature review of manufacturing and policy material presented in Chapter 1, which serves as justification for adopted methods discussed in the following Section 2.2. Findings of our methods are presented in Section 2.3 and finally discussed in terms of applications, limitations and future work in Section 2.4.

2.2 Methods: Estimating Production Costs and Policy Impacts

In this section we describe the research approach adopted to quantify the cost impacts from select Maryland climate policies. The first Subsection (2.2.1) outlines the methods for building a subsector-level model of Maryland manufacturing energy patterns and production costs. The second Subsection (2.2.2) outlines methods and assumptions to forecast expected electricity rate, electricity consumption, and capital cost impacts resulting from the RGGI, the RPS and EmPowerMD.

In order to quantify cost impacts from the RGGI, the RPS and EmPowerMD, we first develop a model, the Maryland manufacturing energy model (MMEM), and estimate baseline energy consumption and production costs (Subsection 2.2.1). The baseline represents Maryland manufacturing in an environment free of state climate policy impacts (see Table ES.2 in Executive Summary and Table 2.6). The MMEM is a static economic model that calculates energy consumption and energy costs, as well as capital costs, at the level of manufacturing subsectors based upon projections of economic productivity. The MMEM, which is constructed to consider the period 2006-2020, is tailored to Maryland because it includes energy profiles (e.g., energy intensity of production) and fuel prices specific to or of best fit to the state. For standardization with available data, the MMEM is based on NAICS codes. Twenty-one manufacturing subsectors (3-digit NAICS) are included as well as select 4 and 6-digit NAICS industry groups, including cement, pharmaceuticals, and iron and steel. Criteria for isolating these industries include: (1) an industry group contributes a significant portion of the total dollar value of shipments to a 3-digit subsector, or (2) the industry group has an energy profile contrasting drastically from the 3-digit subsector. In addition to arranging the model by subsectors and industry groups, we also account for geographically appropriate fuel intensities, autonomous energy intensity improvements, and technology-specific impacts from on-site electricity generation.

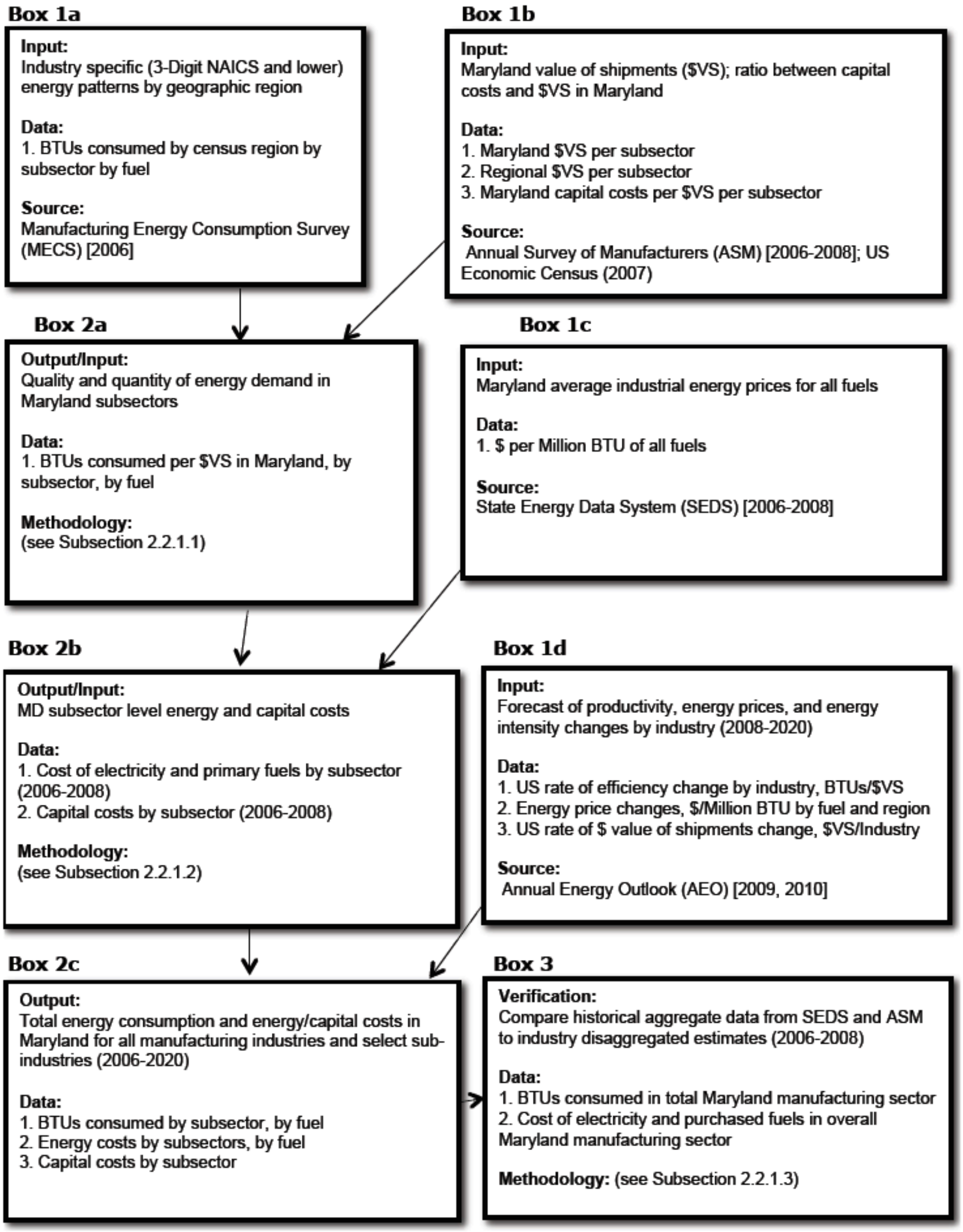
Upon establishing a baseline, we forecast the cost impacts associated with each of the select Maryland climate policies in Subsection 2.2.2. The factors influenced by policy include electricity rates, electricity demand and capital costs. Regulatory cost impacts are discussed in Chapter 1. Chapter 3 discusses potential labor and economic impacts. The methods adopted rely extensively on previous research, policy implementation reports and communications with experts. In evaluating policy impacts, we identify uncertainties and present results under a range of market and implementation assumptions. This analysis forms the basis for our three policy scenarios: (1) a middle cost scenario, (2) a low cost scenario, and (3) a high cost scenario (see Tables ES.2 and 2.6). Our middle cost policy scenario reflects a continuation of historical policy implementation (e.g., limited EmPowerMD participation) and applies average market trends (e.g., cost of renewable energy credits). The high and low scenarios represent reasonable bounds under alternative market and policy assumptions. The results of our methods are presented in Section 2.3.

2.2.1 Methods for Estimating Energy Profiles and Baseline Costs

We construct a model of energy profiles and production costs (i.e., energy and capital costs) for all 3-digit NAICS subsectors and select industry groups in Maryland. The MMEM is designed with insight from previous work (see Chapter 1) and built from multiple data sources. Additional assumptions are adopted as a means of aligning the model with the project scope and overcoming data limitations. By comparing model results against historical data (2006-2008), we are able to test assumptions, calibrate and select a method of best fit (see Subsection 2.2.1.3 below). Once the baseline results are confirmed against historical data, the methodology is extended through 2020 using forecasts of economic trends, energy intensity trends, and regional energy price forecasts. Figure 2.1 below presents an overview of the methods.

<u>Data Sources</u>

Available data differ in scope, age, and level of aggregation. Moreover, some datasets provide historical information while others provide forecasts. No single data source is capable of portraying a disaggregate picture of Maryland manufacturing and multiple datasets contribute to the design of the MMEM. This research relies on data from the Manufacturing Energy Consumption Survey (MECS), Annual Survey of Manufacturers (ASM), State Energy Database System (SEDS), US Economic Census, Electric Power Annual, and Annual Energy Outlook (AEO). Appendix 2.A describes data sources in greater detail.



Box 1a

Input:
Industry specific (3-Digit NAICS and lower) energy patterns by geographic region

Data:
1. BTUs consumed by census region by subsector by fuel

Source:
Manufacturing Energy Consumption Survey (MECS) [2006]

Box 1b

Input:
Maryland value of shipments ($VS); ratio between capital costs and $VS in Maryland

Data:
1. Maryland $VS per subsector
2. Regional $VS per subsector
3. Maryland capital costs per $VS per subsector

Source:
Annual Survey of Manufacturers (ASM) [2006-2008]; US Economic Census (2007)

Box 2a

Output/Input:
Quality and quantity of energy demand in Maryland subsectors

Data:
1. BTUs consumed per $VS in Maryland, by subsector, by fuel

Methodology:
(see Subsection 2.2.1.1)

Box 1c

Input:
Maryland average industrial energy prices for all fuels

Data:
1. $ per Million BTU of all fuels

Source:
State Energy Data System (SEDS) [2006-2008]

Box 2b

Output/Input:
MD subsector level energy and capital costs

Data:
1. Cost of electricity and primary fuels by subsector (2006-2008)
2. Capital costs by subsector (2006-2008)

Methodology:
(see Subsection 2.2.1.2)

Box 1d

Input:
Forecast of productivity, energy prices, and energy intensity changes by industry (2008-2020)

Data:
1. US rate of efficiency change by industry, BTUs/$VS
2. Energy price changes, $/Million BTU by fuel and region
3. US rate of $ value of shipments change, $VS/Industry

Source:
Annual Energy Outlook (AEO) [2009, 2010]

Box 2c

Output:
Total energy consumption and energy/capital costs in Maryland for all manufacturing industries and select sub-industries (2006-2020)

Data:
1. BTUs consumed by subsector, by fuel
2. Energy costs by subsectors, by fuel
3. Capital costs by subsector

Box 3

Verification:
Compare historical aggregate data from SEDS and ASM to industry disaggregated estimates (2006-2008)

Data:
1. BTUs consumed in total Maryland manufacturing sector
2. Cost of electricity and purchased fuels in overall Maryland manufacturing sector

Methodology: (see Subsection 2.2.1.3)

Figure 2.1 Overview of Maryland manufacturing energy analysis

2.2.1.1 Energy Profiles

We estimate energy consumption in each manufacturing subsector and select industry groups by fuel type over a period from 2006 to 2020. First, we apply geographically appropriate energy intensities to each industry and each fuel (BTUs/$ value shipped, abbreviated here as $VS). Second, we estimate total energy consumption based on economic activity and derived energy intensities. Third, we distinguish between purchased electricity and on-site electricity consumption by accounting for significant self-generation capacity.

Subsector/Industry Group Energy Intensities

We first quantify the energy intensity of subsectors and industry groups in Maryland using the 2006 MECS regional data on first energy use (EIA, 2009).[28] The general formula for estimating energy intensity of production in Maryland subsectors is as follows:

$$E_{I,F(MD2006)} = C_{I,F(Region2006)} / \$VS_{I(Region2006)}$$

Where *E* is energy intensity (BTUs/$VS), *C* is BTUs of energy consumed, $*VS* is the dollar value of shipments, *I* is a given subsector or industry group, and *F* is a given fuel. *MD* indicates it is the Maryland specific value. The *Region* variable represents census regions in the Northeast, the South, or the US as a whole. The following specific regional-fuel pairings are used to estimate energy intensity in Maryland manufacturing:

Energy Intensity of Electricity, Residual Fuel, Distillate Fuel, Coal, Coke $_{I(MD2006)}$

$$= C_{I,F(South2006)} / VS_{I(South2006)}$$

Natural Gas Intensity, Liquefied Petroleum Gas, Other Fuels $_{I(MD2006)}$

$$= C_{I,F(Northeast2006)} / VS_{I,F(Northeast,2006)}$$

Based on comparisons with aggregate-level Maryland manufacturing energy data (see Subsection 2.2.1.3 below), we find that Maryland subsectors and industry groups are as energy intensive (BTU/$VS) as the South census region for electricity, residual fuel, distillate fuel, coal, and coke. Alternatively, Maryland subsectors and industry groups are as energy intensive as the Northeast census region for natural gas, LPG and other fuels.[29] A few explanations exist for these particular region-fuel pairings. First, Maryland industries do not consume natural gas at rates as high as the South census region because fuel prices

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[28] First energy use is all energy (electricity and primary fuels) used for fuel and nonfuel purposes alike in respective subsectors and industry groups (EIA, 2009).

[29] Other fuels are defined as petroleum byproducts, wood products and byproducts, or any energy source not specified (EIA, 2009); also the energy intensity of other fuels in production is assumed to be constant through time.

are historically higher in Maryland.[30] Also, Maryland does not have industries of the same scale or type as the South census region. Namely, the petrochemical, petroleum, and wood product industries in the South census region consume natural gas, LPG and other fuels at high rates not shared by Maryland. Last, Maryland industry should be approximately as electric intensive as the South census region due to similar cooling requirements – this is especially true for Maryland's large food industry (EIA, 2009).

Energy intensities are not constant through time in this analysis. Beginning with 2006 estimates from the MECS, we assume Maryland manufacturing energy intensities change at an annual rate equal to US subsectors (EIA, 2009). Forecasts of this data can be calculated from the AEO (EIA, 2010a). If industry specific rates of change are available, then we apply these to Maryland industries. If industry specific rates are not available, then we apply a rate equal to the "US balance of manufacturing," or the remainder of subsectors not analyzed (EIA, 2010a).[31] The generally decreasing energy intensity of production accounts for autonomous efficiency gains we expect to observe over time regardless of climate mitigation policies. The implications of this efficiency assumption are explored in sensitivity analysis (see Section 2.4).

Economic Output and Energy Consumption

Energy consumption by year, industry, and fuel type is the product of the energy intensity (described above) and the economic output or dollar value of shipments by industry. For 2006-2008, economic output data are available through the US Economic Census and ASM. In instances where data are not available, we extrapolate or interpolate from years with existing data. Due to significant changes in the Maryland primary metals subsector over the past several years, data are withheld and we develop a separate methodology to estimate economic output in this subsector drawing on older data (e.g., 1997 US Economic Census).[32] Finally, to avoid double counting in instances where industry groups are disaggregated (e.g., pharmaceuticals is separate from chemicals), we subtract economic output in industries from larger subsectors.

For future projections of economic output, we assume Maryland industries change output at a rate equal to US industries. Corresponding data are available in the AEO (EIA, 2010a). Each subsector or industry group grows or shrinks output at a different rate and rates fluctuate over time. Forecasts for subsector and industry level economic growth in Maryland, which are direct inputs to the MMEM, are presented in Table 2.1. The implications of this economic growth assumption are explored in sensitivity analysis (see Section 2.4).

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[30] Due to greater demand for heating purposes during winter and lower supply from hub/transportation distances, natural gas prices are generally lower in the South than the Northeast (EIA, 2010b).

[31] Industries include NAICS 312, 313, 314, 315, 316, 337, and 339.

[32] We assume the ratio between iron and steel and primary metals $VS at the national level is equal to Maryland for the period from 1997-2008 (USCB, 2006; USCB 2010b).

Table 2.1 Maryland value of goods shipped, in 1000s of $2006, by subsector; highlight demonstrates average annual growth rate during period in real dollars, by subsector

Subsector and NAICS Code	**2010**	**2015**	**2020**
Period of Analysis	*2008-2010*	*2011-2015*	*2016-2020*
TOTAL (NAICS 31-33)	34,724,290	42,447,197	48,190,933
	-3.62%	*4.01%*	*2.67%*
Food (311)	6,352,840	7,243,138	7,966,955
	-0.80%	*2.55%*	*1.99%*
Beverage and tobacco (312)	1,323,188	1,359,396	1,455,990
	-4.79%	*0.66%*	*1.40%*
Textile mills (313)	281,275	269,089	268,709
	-12.00%	*-1.03%*	*0.01%*
Textile product mills (314)	269,954	258,258	257,893
	-12.00%	*-1.03%*	*0.01%*
Apparel (315)	73,385	59,932	46,582
	-13.19%	*-5.39%*	*-4.45%*
Leather & allied products (316)	24,769	20,985	18,706
	-10.74%	*-3.47%*	*-2.08%*
Wood products (321)	448,405	582,652	604,332
	-9.37%	*3.46%*	*0.61%*
Paper (322)	862,025	1,015,187	1,084,389
	-6.72%	*3.53%*	*1.26%*
Printing & related (323)	1,592,654	1,583,230	1,623,796
	-9.87%	*0.03%*	*0.45%*
Petroleum & coal products (324)	777,109	819,849	834,381
	-0.06%	*0.61%*	*0.42%*
Chemical (*Includes Pharmaceuticals*) (325)	5,137,801	6,175,379	7,146,722
	-2.78%	*3.95%*	*3.04%*
Pharmaceuticals (3254)	1,498,451	1,876,132	2,336,235
	-1.40%	*5.15%*	*4.69%*
Plastics & rubber products (326)	1,202,582	1,543,781	1,730,198
	-7.97%	*5.25%*	*2.32%*
Nonmetallic mineral (*Includes Cement*) (327)	1,144,335	1,498,251	1,637,919
	-9.68%	*4.78%*	*1.80%*
Cement and concrete products (3273)	632,554	860,039	941,258
	-13.19%	*6.04%*	*1.81%*
Primary metal (*Includes Iron and Steel*) (331)	447,698	739,698	838,828
	-19.14%	*9.33%*	*2.51%*
Iron and Steel (331111)	177,056	364,821	426,180
	-25.87%	*15.52%*	*3.00%*
Fabricated metal products (332)	2,243,343	2,757,522	2,996,769
	-10.22%	*3.87%*	*1.79%*
Machinery (333)	2,059,367	2,653,853	2,981,498
	-9.98%	*4.45%*	*2.51%*
Computer products (334)	7,752,329	10,180,512	12,578,911
	7.72%	*6.15%*	*4.52%*
Electrical equipment (335)	359,692	431,055	491,003
	-7.16%	*3.49%*	*2.77%*
Transportation equipment (336)	974,750	1,427,938	1,448,059
	-10.12%	*5.54%*	*0.80%*
Furniture & related (337)	551,415	728,408	798,942
	-11.06%	*5.87%*	*1.81%*
Miscellaneous (339)	845,375	1,099,084	1,380,351
	-1.66%	*5.75%*	*5.10%*

On-Site Electricity Generation

For the purpose of accurately estimating electricity purchases, we account for significant on-site power generation capacity defined as capacity above 10 MW. As a default, we assume that all electricity necessary for production is purchased from an electric utility unless on-site generation is available. On-site generation capacity in turn reduces the need for purchased electricity and creates a need for fuels. There are only four on-site electric generation facilities with capacity over 10 MW in Maryland owned by manufacturing firms, which we define here as self-generators (EIA, 2010c; PPRP, 2009). For the purpose of estimating on-site power generation and the corollary of reduced demand for purchased electricity, we include only self-generators (see Table 1.4, Chapter 1).[33]

Total electricity generation is estimated for four self-generators using capacity data from the US Energy Information Administration (EIA, 2010c). In order to calculate annual on-site electricity generation at each facility, we adopt three assumptions: (1) generators run every hour of the year, (2) generators operate at a 53 percent capacity factor, and (3) all electricity is used on-site (no electricity is sold).[34] This level of generation is assumed to represent the maximum from each facility. However, if total electricity demand decreases as a result of lowered production, then we expect electricity generation to decrease in parallel.[35] To adjust electricity generation in years with decreased economic output, we first calculate the ratio of electricity generation to total electricity demand in 2006 for each subsector/industry group with significant capacity.[36] In subsequent years we multiply subsector electricity demand by this ratio – this method assumes that self-generators reduce generation proportionally to total electricity demand. In years where this calculation yields total generation above the presumed 2006 maximum, the maximum generation is applied. The implication of this final assumption is that estimates of purchased electricity in the applicable industries may be inflated in the case of growth in electricity generation (kWh/year) surpassing production growth ($VS).

2.2.1.2 Baseline Production Costs

Production costs include energy and capital costs as we expect these two cost components to be impacted by climate policies. Other costs (e.g., non-energy material costs) are not estimated in this analysis. All cost data are presented in constant 2006 dollars.

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[33] There are eight combined heat and power facilities in Maryland with heat and power contributions towards manufacturing processes (EIA, 2010c).

[34] Shutdown and restart costs are high for manufacturing facilities and it is common practice to continually run production; capacity factor based on nameplate capacity and generation from US industrial combined heat and power plants, 3-year average (EIA, 2010c).

[35] Production creates byproducts such as waste gases or black liquor, which double as fuel. With less byproduct being generated as a result of decreased output, electricity generation may require purchase of substitute fuels or decreased on-site generation altogether.

[36] 2006 Maryland level data represents an economic high point and the most recent year reflecting total value of dollar shipments among subsectors and industries groups with generating capacity (USCB, 2010b).

Energy Costs

Energy costs are defined as the dollar value paid for all energy consumed (for fuel and non-fuel purposes) by manufacturers. Energy costs are a function of the total energy consumption and the price of respective fuels (methods for estimating energy consumption described above). Historical energy prices paid by Maryland manufacturers, which are presented as yearly aggregate averages, are attained from the SEDS (EIA, 2010b). Maryland industrial prices are organized by fuel including electricity and are available for years 2006-2008. Beyond 2008, for the period 2009 to 2020, we assume industrial fuel prices change at a rate equal to the 2010 AEO for the Mid-Atlantic region (EIA, 2010a). We assume that the regional RGGI and the RPS effects, which are included in the AEO modeling system, have a negligible influence on regional industrial fuel prices, including electricity (Martin, 2010). For fuels classified as "other," we assume the annual price is equal to the average of all primary fuels in a given year. Electricity costs are a function of the total quantity of electricity consumption minus self-generation and the electricity rate in a given year. Total energy costs are equal to the sum of all primary fuel and purchased electricity costs. Subsection 2.2.2 explains methods for estimating changes to the baseline industrial electricity rate resulting from GHG mitigation policies.

Capital Costs

We define capital costs as the dollar value paid for equipment and buildings necessary to conduct manufacturing processes; capital costs do not include material or labor costs, nor do they explicitly include the opportunity costs of capital or the lost benefits of the foregone investment opportunity. All baseline capital expenditures encompass out-of-pocket as well as principal and interest payments on loans in a given year. Capital costs, which are derived for each subsector and industry group, are calculated using data from the ASM (USCB, 2010b). A 3-year average of the ratio of capital costs to economic output (dollar value of shipments) is calculated for each subsector and industry group at the national level for the period of 2006-2008. This ratio is multiplied by the Maryland dollar value of shipment for each subsector to represent capital costs in all years.

2.2.1.3 Model Calibration

We test the baseline outcome of the MMEM against other data sources to calibrate results. Namely, SEDS and the ASM each provide estimates of costs and energy consumption in the Maryland manufacturing sector (EIA, 2010b; USCB, 2010b).[37]

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[37] The ASM has the advantage of providing manufacturing-specific data (NAICS 2-digit only), but the ASM does not disaggregate energy consumption and costs by fuel type (USCB, 2010b). In contrast, SEDS uses a more robust method of estimation and disaggregates data by fuel type. However, SEDS data is at the level of industrial users, which includes manufacturing in addition to agriculture, mining, and construction (EIA, 2010b).

Despite the fact that these datasets are compiled by different means and measure different segments of the economy, the data provide a valuable reference point for MMEM results. For example, in matching census region MECS data with Maryland to calculate energy intensities, we compare consumption and expenditure outcomes and select the method of best fit. The final MMEM baseline results for energy consumption and costs are compared to SEDS and ASM below (Table 2.2).

Table 2.2 Energy consumption and expenditures, MMEM (highlighted) vs. ASM & SEDS: columns (1-4), energy consumption in trillions of BTU; *columns (5-6), energy costs, millions of 2006$*

	(1) Purchased Elect. Consumption (TBTU)	**(2) Self - Generated Elect. Consumption (TBTU)**	**(3) Total Elect. Consumption (TBTU)**	**(4) Natural Gas Consumption (TBTU)**	***(5) Elect. Costs (M$)***	***(6) Natural Gas Costs (M$)***
2006 MMEM	22.1	3.7	25.8	25.0	*527*	*310*
*2006 SEDS**	20.7	-	-	23.8	*493*	*296*
*2006 ASM***	24.3	-	-	-	*529*	-
2007 MMEM	21.0	2.7	23.7	22.9	*564*	*249*
2007 SEDS	20.4	-	-	21.2	*548*	*230*
2007 ASM	22.0	-	-	-	*483*	-
2008 MMEM	19.5	1.6	21.1	20.7	*554*	*252*
2008 SEDS	19.3	-	-	21.9	*549*	*267*
2008 ASM	19.3	-	-	-	*435*	-

* SEDS data represents all of industry (NAICS 31-33, 11, 21, 23); ** ASM is NAICS 31-33 only

A study performed by the American Council for an Energy Efficient Economy (ACEEE) in 2008 provides a subsector reference point for the MMEM results. The ACEEE study confirms the distribution of Maryland subsector electricity demand; electricity consumption is dominated by a few subsectors including chemicals, food, primary metals, and computers and electronics. However, ACEEE also estimates that in 2007, more than half of the electricity consumed in the manufacturing sector occurred in the chemical subsector (ACEEE, 2008; Trombley, 2010). As a result of this finding, we explore disaggregation of the chemical sector into smaller industry groups and find that the pharmaceutical industry in Maryland accounts for approximately one-third of the total chemical subsector economic output, yet pharmaceutical production is considerably less electricity intensive than the total subsector. In turn, we disaggregate the chemical sector into pharmaceuticals and all other chemical industries. We estimate that the entire chemicals subsector accounts for only 18 percent of total electricity consumption in Maryland's manufacturing sector (Table 2.3).

Table 2.3 Share of total manufacturing electricity consumption in Maryland, by subsector, 2007

Subsector	ACEEE	MMEM
Chemicals	51%	18%
Food	13%	14%
Primary Metals	6%	13%
Paper	N/A	8%
Computers and Electronics	9%	6%
Plastics and Rubber	4%	6%
Printing	N/A	6%
Durable Metals	N/A	6%
Nonmetallic	N/A	6%
Other	17%	17%

2.2.2 Methods for Estimating Policy Impacts

In this subsection we describe the methods used in quantifying how individual policies impact electricity rates, energy demand, capital costs and, ultimately, production costs. In our analysis we demonstrate only the first order effects of policy and assume no adjustment to production levels in response to production cost changes. Chapter 3 considers employment impacts resulting from production cost changes. We also demonstrate how a range of alternative policy scenarios will impact manufacturing production costs. Under this framework we develop a set of three policy scenarios including middle, high, and low (see Tables ES.2 and 2.6). In designing scenarios we focus on factors that have the potential to significantly change cost outcomes including: (1) the price of REC s, (2) development of renewable capacity in Maryland, (3) implementation and participation in EmPowerMD programs, and (4) energy efficiency spending under the RGGI.

Data Sources

We estimate policy impacts with assistance from multiple data sources and documents. We use results from earlier modeling exercises and modify to reflect current implementation or application in the manufacturing sector where appropriate (Ruth et al., 2007; L&A, 2008). We explore policy implementation status reports from the Maryland Public Service Commission (PSC), RGGI, Inc., and electric utilities (PSC, 2010a and 2010b; RGGI 2010a and 2010b; BGE, 2010). Finally, we contacted experts working directly with policies or markets to acquire data and refine assumptions. Key among these communications was an inquiry with Baltimore Gas and Electric (BGE) regarding penetration of their EmPowerMD programs in the manufacturing sector. BGE provided the researchers with primary data including installation of specific efficiency measures, expected electricity savings and utility incentive contributions (Wolf, 2010). We state data sources used in the detailed methods below.

2.2.2.1 Overview of Policy Impacts

Previous research suggests the RGGI, the RPS and EmPowerMD will have impacts of varying direction and magnitude on energy prices and demand (see Section 1.4, Chapter 1). The RGGI is expected to result in minimal electricity rate impacts in Maryland. The reason for this outcome is that higher costs of electricity supply will be offset by decreased electricity demand from efficiency improvements. As more RGGI auction proceeds go towards efficiency investment, the demand-side impact of drawing electricity rates down will be greater. Electricity rates are not expected to increase as a result of the RGGI until 2020 and rate changes would be very small, particularly for industrial customers (Ruth et al., 2007, 2008).

Maryland's RPS will require new electricity capacity to be built, which will come at a premium relative to conventional electricity capacity (EIA, 2007). However, additional renewable electricity capacity increases supply and displaces high cost generation capacity, which has the potential to lower the clearing price for wholesale electricity (EIA, 2007; Kha, 2008; Chen et al., 2009). A first order estimate of electricity rate impacts resulting from Maryland's RPS may be expressed as a function of these two effects. Most state-level RPS studies demonstrate a small net increase in electricity rates with the greatest impact occurring in peak mandate years (Chen et al., 2009).

EmPowerMD will have multiple impacts including long-term reductions in electricity consumption and initial capital costs (PSC, 2010b; Wolf, 2010). Capital costs for efficiency improvements under utility programs will end in 2015 while electricity savings will persist through the life of the installed technology. Also, electricity prices will increase as a result of utility surcharges designed to recover programs costs. Current surcharges do not increase the effective rate for industrial electricity by more than 1 percent (Godfrey, 2010).

2.2.2.2 RGGI Impact

Our analysis concerns only electricity rate impacts resulting from the RGGI. We do not account for the regulatory costs associated with the RGGI compliance demonstration (see Section 1.4, Chapter 1) nor do we account for the electricity consumption reductions that will occur in the manufacturing sector as a result of SEIF-funded efficiency improvements. We estimate the electricity rate impact under two scenarios: (1) 25 percent of the RGGI allowance auction proceeds go towards energy efficiency investments, and (2) 75 percent of the RGGI allowance auction proceeds go towards energy efficiency investments.[38]

RGGI Electricity Rate Impact

Our analysis reiterates and revises the findings of the 2007 electricity rate study, a component of *The Economic and Energy Impacts from Maryland's Potential Participation in*

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[38] Energy efficiency spending is defined here as the portion of Maryland RGGI auction proceeds dedicated to the Strategic Energy Investment Fund (SEIF).

the Regional Greenhouse Gas Initiative (Ruth et al., 2007). The 2007 study used a sophisticated general equilibrium model, the Haiku model, designed over more than a decade and calibrated over the course of an 18-month project to estimate aggregate average industrial electricity rates under a “baseline scenario” and a “Maryland joins RGGI scenario.” The difference between these two scenarios represents the change in electricity rates resulting from Maryland’s participation in RGGI. For application to the present study, we build on this prior work, rather than replicate the associated efforts, and explicitly consider model-implementation discrepancies. Specifically, we acknowledge that relative to the 2007 study, early stages of the RGGI implementation have resulted in greater than forecasted total costs to Maryland electricity generating units (EGUs) as well as lower than forecasted energy efficiency spending. In implementation, energy efficiency spending has been about half the amount forecasted in the 2007 study (Ruth et al., 2007; RGGI, 2010a and 2010b) (see Table 1.6, Chapter 1).

The 2007 study demonstrates that additional EGU costs will shift the supply curve for electricity provision upward, raising rates; concurrently, energy efficiency investments will result in less electricity consumption, effectively shifting the demand curve downward and lowering rates (Ruth et al., 2007). Under the 2007 study, the industrial electricity rate minimally decreases every year for the period 2010-2019 as a result of Maryland joining RGGI; in 2020, as the RGGI cap tightens, the electricity rate increases by a very small magnitude relative to the baseline as a result of Maryland joining RGGI (Ruth et al., 2007). We expect supply and demand to shift in the same direction in implementation, although the magnitude of the shifts will be altered as a result of comparatively greater costs to EGUs and less energy efficiency spending (Ruth et al., 2007; RGGI, 2010a).

To account for these model-implementation discrepancies, we re-scale the effective RGGI industrial electricity rate impact from the 2007 study as follows:

If $MDJR\_ERate - Base\_ERate < 0$

$$MIERI = (MDJR\_ERate - Base\_ERate) *((EGU\_Cost * .25)/(MDJR\_EES));$$

If $MDJR\_ERate - Base\_ERate > 0$

$$MIERI = (MDJR\_ERate - Base\_ERate) /((EGU\_Cost * .25)/(MDJR\_EES))$$

Where *MIERI* is the modified industrial electricity rate impact ($/MWh) as a result of Maryland's participation in RGGI, *MDJR_ERate* is the industrial electricity rate after Maryland joins RGGI (Ruth et al., 2007), *Base_ERate* is the industrial electricity rate before Maryland joins RGGI (Ruth et al., 2007), *EGU_Cost* is the total cost paid by Maryland electricity generating units to comply with RGGI under actual implementation (RGGI, 2010a), and *MDJR_EES* is the total amount of energy efficiency spending occurring in the 2007 study after Maryland joins RGGI (Ruth et al., 2007). The above equation re-scales the magnitude of the electricity rate impact without adjusting the direction (i.e., positive or negative).

The value .25 represents the fraction of total Maryland CO_2 allowance revenue going towards energy efficiency investments. When .25 is multiplied by the total EGU costs in 2010, or 65.6 million dollars, the product is 16.4 million dollars. In turn, the above scenario closely approximates the current level of energy efficiency spending, which totaled 18.9 million in 2010 (see Table 1.6, Chapter 1). This level of energy efficiency spending is a fraction of the total estimated spending under the 2007 study, indicating that electricity demand reductions and the associated downward pressure on electricity rates will be lessened (Ruth et al. 2007, 2008). As a result, under the 25 percent efficiency-spending scenario, we expect electricity rates to increase relative to the 2007 forecasted impacts.

To develop the second scenario, where 75 percent of RGGI proceeds are directed towards energy efficiency spending, we replace .25 with .75 in the above equations. The value .75 represents the fraction of total Maryland CO_2 allowance revenue going towards energy efficiency investments. When .75 is multiplied by the total EGU costs in 2010, or 65.6 million dollars, the product is 49.2 million dollars. This level of energy efficiency spending is greater than the initial estimated spending under the 2007 study, indicating that electricity demand reductions and the associated downward pressure on electricity rates will be amplified. As a result, under the 75 percent efficiency-spending scenario, we expect electricity rates to decrease relative to the 2007 forecasted impacts.

A critical assumption of this method is that the RGGI electricity rate impact is directly proportional to energy efficiency spending under each scenario. Given the multiple factors that influence electricity rates as well as the realized electricity savings from efficiency investments, this relationship only partially explains electricity rate dynamics. Moreover, the above method adjusts the magnitude of the rate impact and not the direction, which we assume to be consistent in both implementation and the 2007 study. The precise rate impact resulting from shifts in electricity supply and demand would be best estimated through a general equilibrium model such as Haiku. Also, because it is difficult in the context of prior modeling work to assess the impacts of a delay in building the MAPP and PATH transmission lines, we assumed development of both lines as originally planned. A consequence of this assumption is the possibility of exaggerating electricity cost containment benefits afforded by electricity importation from non-RGGI states (i.e., Pennsylvania, West Virginia) (Ruth et al., 2007). Furthermore, we assume the annual rate of change for the SEIF contributions and EGU costs will be equal to the annual rate of change presented in the 2007 study, which was relatively constant. In turn, if the state varies its contributions to the SEIF from year-to-year, then actual cost impacts are likely to fluctuate more than indicated in this analysis.

2.2.2.3 RPS Impact

Our analysis of Maryland's RPS considers electricity rate impacts only. In Chapter 1 we consider regulatory costs that might be incurred at manufacturing facilities doubling as load serving entities as well as revenue that might be gained from the sale of RECs by manufacturing firms. These facility-level considerations, however, are not included in our present analysis on electricity rate impacts. Also, we estimate the electricity rate impact from tier 1 (solar and non-solar) RPS mandates only. We model the electricity rate impact under three scenarios based on divergent assumptions (Table 2.4).

Table 2.4 Scenarios for quantifying RPS electricity rate impact (see Subsection 1.4.2, Chapter 1)

Cost Scenario	Tier 1 non-solar REC price annual rate of increase *	Tier 1 solar REC price 2010-2020**	Tier 1, non-solar capacity sited in Maryland***
Low	18% (6 $/MWh by 2020)	Fraction of solar ACP	10% (117 MW by 2020)
Middle	28% (14 $/MWh by 2020)	Fraction of solar ACP	5% (58 MW by 2020)
High	38% (31 $/MWh by 2020)	Equal to solar ACP	1% (12 MW by 2020)

* Based on 2009 average weighted price; **Based on 2009 average weighted SREC price as portion of solar ACP; *** Based on total minimum necessary capacity (see Table 1.8, Chapter 1)

RPS Electricity Rate Impact

We account for both the capital cost premium and the wholesale electricity price impacts (see Subsection 1.4.2, Chapter 1). The premium cost impact is calculated as a function of forecasted REC prices, legislatively established ACP prices, and the most current tier-specific RPS mandate in each year (MDGA, 2010; DSIRE, 2010). We forecast future tier 1 non-solar REC prices through extrapolation from the 2009 average weighted price and three price escalation rates that result in reasonably distributed REC prices (Table 2.4). We assume that tier 1 non-solar REC prices do not reach the ACP in any year (L&A, 2008). Under the high cost scenario, solar ACP prices are equal to the prices in Senate Bill 277 and only the solar ACP is used to meet the solar RPS mandate (see Table 1.7, Chapter 1). In the low and middle cost scenarios the solar RPS mandate is met through only solar RECs priced at a constant fraction of the respective ACP in each year – the rate used is equal to 86 percent, which is set conservatively higher than the 2009 SREC weighted average, equal to 83 percent (PJM, 2011). The cost to load serving entities associated with meeting the tier 1 solar and non-solar RPS through RECs or ACPs is passed through entirely to industrial electricity customers.

The wholesale electricity price impact resulting from additional renewable supply is estimated through four steps. First, the load duration curve of net electricity imports into Maryland is used to demarcate three average import demand categories (base, shoulder, and peak) as well as estimate the frequency of each category (RFF, 2007).[39] Second, we construct the supply cost curve for electricity generation in Maryland integrating all available capacity, current fuel prices, and other known variable costs (RFF, 2007; Hobbs & Chen, 2007; EIA, 2010a). We then apply numerically equivalent definitions of demand

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[39] Net peak demand imports account for 4% of hours annually, net shoulder demand imports account for 18% hours annually, and net base demand imports account for 78% hours annually (RFF, 2007).

categories (see footnote 39) to the electricity generation supply cost curve and identify the range of generation capacity and costs at base, shoulder, and peak periods. The elasticity of supply in the local electricity market is then calculated for each period. Third, we calculate the minimum additional tier 1, non-solar capacity necessary to meet the corresponding RPS requirement in each year from 2010-2020 (Table 1.8) (PSC, 2010c). At this stage the scenario analysis becomes relevant as we weigh the necessary new capacity in each year by values of .01, .05, and .10 to represent the percentage of new renewable capacity actually built in Maryland. These values are selected as conservative estimates that do not exceed the current capacity expansion projections and account for the possibility of project delays/cancellations as well as the fact that our necessary capacity additions represent an absolute minimum (PJM, 2010).[40] Fourth, assuming new renewable capacity is available in full and equivalent amounts during each of the three load periods, we estimate the average weighted price change in wholesale electricity during each period. Wholesale price change is transformed into industrial retail electricity price changes by applying a ratio of Maryland average industrial retails rates to Maryland average wholesale prices (EIA, 2010c; PJM 2009; PJM 2008).

Multiple assumptions are made to estimate the RPS electricity rate impact. First, regarding the premium cost of renewables, we assume that the value of RECs encompass a majority if not all of the capital cost differential between renewable generation capacity and conventional capacity. We also assume that tier 1 non-solar REC prices will increase at constant rates between 2009 and 2020 and will not meet or exceed the ACP in any year. Second, regarding the wholesale electricity price impacts, we assume that no Maryland generation capacity is retired, that renewable capacity constructed outside of Maryland minimally influences industrial electricity rates, that congestion impacts from additional renewable capacity are negligible, that the MAPP line is constructed, average annual distribution across different demand periods remains unchanged, and that only the minimum amount of generation necessary to meet the RPS is added and no more. Last, we assume a constant ratio of retail industrial rates to wholesale electricity rates.

2.2.2.4 EmPowerMD Impact

Our analysis of EmPower Maryland (EmPowerMD) considers electricity rate, electricity consumption, and capital cost impacts in the manufacturing sector. Electricity rate impacts include only surcharges needed for program cost recovery. Electricity savings include reductions in consumption only (i.e., from energy efficiency and conservation measures); demand response impacts are not included. We also forecast the capital costs associated with energy efficiency improvements. EmPowerMD surcharges and capital cost impacts end in 2015 with the expected expiration of EmPowerMD; however, electricity savings persist beyond the scope of this study.[41]

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[40] Calculated as follows: tier 1 non-solar summary capacity in Maryland (266 MW) / minimum necessary capacity to meet RPS (1166 MW in 2020) = 23 percent of capacity in Maryland.

[41] If program cost recovery is amortized or spread over multiple years, then surcharges will not end in 2015; we do not amortize surcharges in our analysis.

We model EmPowerMD impacts under the following two scenarios:
(1) Limited implementation as estimated from historic trends, and
(2) Full implementation commensurate with the goals established in the EmPower Maryland Act of 2008.

The benefits manufacturing firms could see from utility programs include reductions in their utility bills and incentives for capital improvements (paid by the utilities), if they participate in a program. Costs include expenses incurred by capital improvements, plus increases in electricity bills due to utility EmPowerMD surcharges. All manufacturing firms, regardless of participation in a program, will incur the electricity rate surcharge; electricity cost savings and one-time capital costs will apply to participating manufacturing firms only. The total annual impact on a participating manufacturing establishment in the year when efficiency investments are made could be written as:

$$Cost\ Impact = (\Delta E * ERate - S * E) - (C - I)$$

Where ΔE is the reduction in purchased electricity, $ERate$ is the average industrial electricity rate, S is the average industrial EmPowerMD surcharge, E is the total purchased electricity, C is the capital cost of energy efficiency projects, and I is the utility provided capital cost incentive.

Participation Model

We first estimate EmPowerMD participation within the manufacturing sector as an input to cost impacts. Using manufacturing customer participatory data provided by BGE for a sample period from May 2009 to September 2010, we estimate participation in all utility programs (Wolf, 2010) (see Subsection 1.4.3, Chapter 1). Market adoption of efficiency measures through utility-sponsored rebate programs typically follows an S-shaped curve with low participation in the beginning, rapidly growing participation next, and saturation at the end. However, our statistical analysis shows that a logistic model for participation, which produces an S-shaped curve, does not fit the data from the sample period (Figure 2.2). In addition, the S-shaped curve makes an unreasonable prediction that the number of projects will climax in 2012, with no additional projects thereafter.

Compared to the S-shaped curve, a two-stage linear model is a much better fit (Figure 2.2). Like an S-shaped curve, it differentiates early adopters from mid-adopters. The low adoption rate at the first stage reflects the higher cost and risks faced by early adopters as well as customers' lack of information when the programs are first implemented. General awareness programs and examples from early adopters inform other customers of the program benefits and boost the adoption rate in the second stage (i.e., mid-adopters). Unlike an S-shaped curve, however, this model does not differentiate late adoption rate from mid-adoption rate (i.e., a third stage) and instead assumes a constant rate because the adoption rate is too low to reach market saturation.

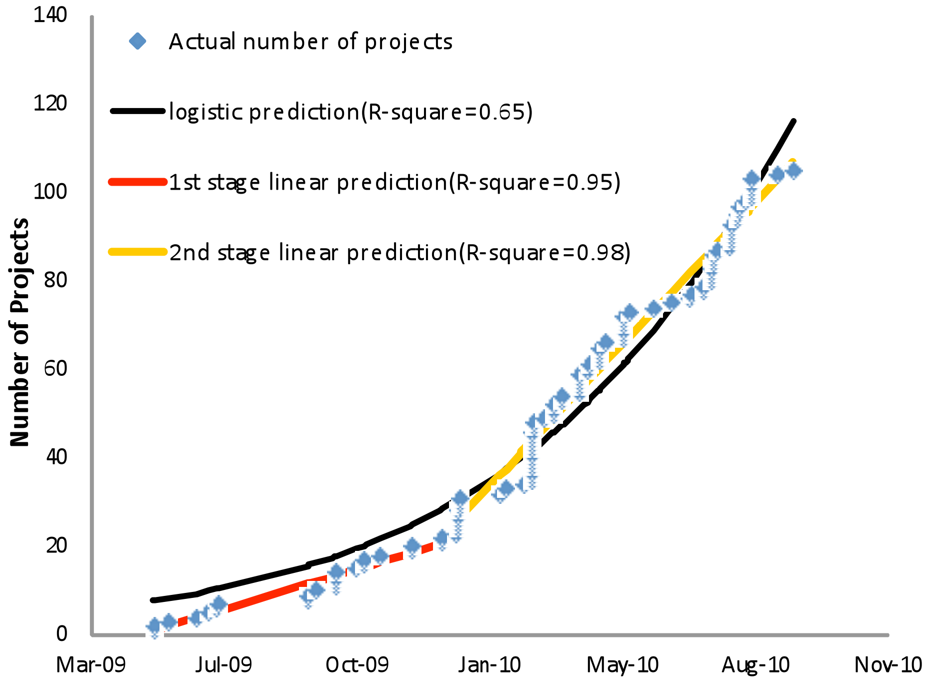

Figure 2.2 Accumulative number of EmPowerMD projects undertaken by MD manufacturers, May 2009-Sept 2010, and models of best fit in BGE territory (Wolf, 2010)

The results of the model, which appear in Appendix 2.B, are used to estimate two EmPowerMD scenarios: (1) participation based on historic trends, and (2) participation commensurate with the goals outlined in the EmPowerMD Energy Efficiency Act of 2008. First, to estimate total manufacturing participation based on historic trends, we scale the trend of BGE projects upwards by a ratio of total Maryland manufacturing customers to BGE service area manufacturing customers (USCB, 2009). We assume that manufacturing firms in other utility service areas will undertake EmPowerMD efficiency projects at the same rate as our model predicts for BGE. This represents our first scenario, which we call "limited implementation."

Our second scenario, "full implementation," is defined as meeting the goals outlined in the EmPowerMD legislation as opposed to the goals outlined in utility EmPowerMD plans, which fall short of the EmPowerMD goals (L&A, 2008; PIRG, 2010; PSC, 2010b). We do not model a situation where the manufacturing sector meets the entire economy-wide EmPowerMD goal under this scenario, but rather model an appropriate share of the EmPowerMD goal in the manufacturing sector. To relate economy-wide EmPowerMD implementation to implementation in the manufacturing sector alone we assume the ratio of utility to mandated electricity savings in all of Maryland is equal to the ratio of utility to mandated electricity savings in the manufacturing sector.[42] To estimate the full implementation scenario, we scale the limited implementation participation rate upwards twice; first, by a margin necessary to close the gap between limited implementation and

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[42] To calculate this ratio, we use the IOU and EmPowerMD electricity savings in 2015 (L&A, 2008, pg. 128).

utility plans and second, by a margin necessary to close the gap between utility plans and full implementation (AP, 2008; BGE, 2008; DPL, 2008; Pepco, 2008; SMECO, 2008; L&A, 2008).

Electricity Consumption Changes

Using our estimated participation rates we then calculate total electricity savings. To do so, we assume (1) a rate of adoption for each efficiency measure (e.g., motors, lighting) proportional to the sample period, (2) an average lifetime for each measure and, (3) average electricity savings for each measure (Wolf, 2010; BGE, 2010b). We believe these assumptions to be reasonable because measures adopted by future participants tend to be similar to the successful measures already in use by current participants. Also, in submitting EmPowerMD plans, utilities committed to specific efficiency technology, which should represent actual installed technology until plans are revised (MDGA, 2008a).

Capital Costs and Incentives

We forecast efficiency measure costs and utility incentives by assuming a constant level of capital costs and incentives corresponding to each project. An analysis by Levitan and Associates, which is based on Delmarva Power's EmPowerMD filing, shows that the relationship between aggregate expense and yearly electricity savings is nearly perfectly linear (L&A, 2008). Therefore, if electricity savings per measure are constant, costs should be as well. Incentives may range between 25 and 75 percent of capital costs (BGE, 2008). In the BGE EmpowerMD plan, incentives are set at a constant 25 percent of customers' expense.[43] We use the same ratio in our estimation and assume it stays unchanged over the period of 2010-2015 so that equal opportunities are afforded to early and late adopters.[44] We assume that capital cost payments for energy efficiency technology are made out-of-pocket, without loans and subsequent interest payments.

EmPowerMD Electricity Rate Impact

Although BGE and Allegheny Power predict surcharges in their EmPowerMD plans, the predicted estimate is much larger than the current rate because of low participation (MD PSC, 2010b; PIRG, 2010). For example, BGE's current EmPowerMD surcharge for Schedule GL customers is 0.017 cents per kWh, while the prediction in BGE's plan is 0.026 cents per kWh – in implementation the surcharge is 35 percent lower (BGE, 2008; Godfrey, 2010). To adjust for this discrepancy, we estimate surcharges from forecasted incentive payouts. The EmPowerMD surcharge is used to recover utility program costs in the same year as incentives are disbursed and customer incentives are a major program cost (BGE, 2008;

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[43] BGE, 2008; filing #006, pg. 201

[44] As mentioned above, we first maintain the proportion of each category of measures unchanged through years, and then assume the incentives per project in each category are constant. Because we do not have the cost information for completed projects, we infer project costs from incentives for each category.

PSC 2010b). Under our full implementation scenario higher surcharges are necessary to recover higher program costs.

BGE lists its estimated share of customer incentive costs as a percentage of total program costs equal to 63, 69 and 70 percent, respectively, for the years 2009, 2010 and 2011 (BGE, 2008). We assume this rate will continuously increase by 0.5 percent annually until the program expires during the years 2012-2015 while the market matures and utilities cut other costs (e.g., administrative cost, marketing cost). To calculate the surcharge, we use forecasted program costs in each year (2009-2015) and for simplicity, do not amortize costs.[45] Based on our estimate of total program costs necessary to implement EmPowerMD programs in the manufacturing sector, we calculate the per kWh surcharge required to fully recover costs.

Distribution of Electricity Savings and Capital Costs

Electricity savings and capital costs are calculated for the entire manufacturing sector. To align with our subsector-level model, we make assumptions about EmPowerMD participation across subsectors. Large industrial subsectors should invest in more projects because they have more potential to reduce electricity consumption and also more financial and managerial assets. Thus, we assume that each subsector will complete a number of electricity saving projects proportional to its scale, which we represent by the number of employees (USCB, 2009).[46] Change in purchased electricity and capital costs is represented by the following formula:

$$\Delta E, \Delta C = (em/EM * ES, ECC)$$

Where ΔE is the reduction in purchased electricity, ΔC is the increase in capital costs, em is the number of employees in the subsector EM is the number of employees in the manufacturing sector, ES is electricity savings in the manufacturing sector from utility programs and ECC is efficiency capital costs in the manufacturing sector from utility programs.

2.3 Results: Climate Policy Impacts on Maryland's Manufacturing Sector

This section presents the results of our analysis for the impacts of three select climate action plan policies. Subsection 2.3.1 presents the combined production cost impacts from select CAP policies under a range of scenarios. This subsection follows directly from the discussion in the above Section 2.2. Subsection 2.3.2 expands the analysis with a review of additional policies and considers the potential influence they might have on Maryland manufacturing businesses.

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[45] Utilities will amortize surcharges as required by the PSC (PSC, 2007).

[46] Due to large employee concentrations and relatively low electricity consumption in select subsectors (e.g., printing, miscellaneous), we observe some unrealistic electricity savings. To adjust, we cap total electricity reductions at 10 percent and reallocate residual electricity savings and capital costs through all subsectors.

We find that Maryland's climate mitigation policies will not result in significant cost impacts to Maryland's manufacturing sector. As a result of the RGGI, the RPS and EmPowerMD, the manufacturing sector will see production costs (i.e., capital and energy costs) increase by less than 0.5 percent in 2020 with smaller cost impacts in all preceding years. This impact is less than the average annual production cost increase of 3.2 percent under our baseline scenario. Other climate policies may assist firms in reducing costs and risk as well as drive production. Section 2.4 summarizes findings as well as applications and limitations.

2.3.1 Cost Impacts from the RGGI, the RPS and EmPowerMD

Baseline Scenario Results

Our results show economic output in Maryland's manufacturing sector (NAICS 31-33) reached a minimum in 2009 and will grow steadily afterwards. As a consequence of increased output, consumption of energy rises first in parallel and then slows down a bit, compared to the increase in value of shipments. Due to natural or autonomous efficiency improvements in all subsectors and industry groups, however, we find less total energy is consumed each year when normalized by output (Figure 2.3).

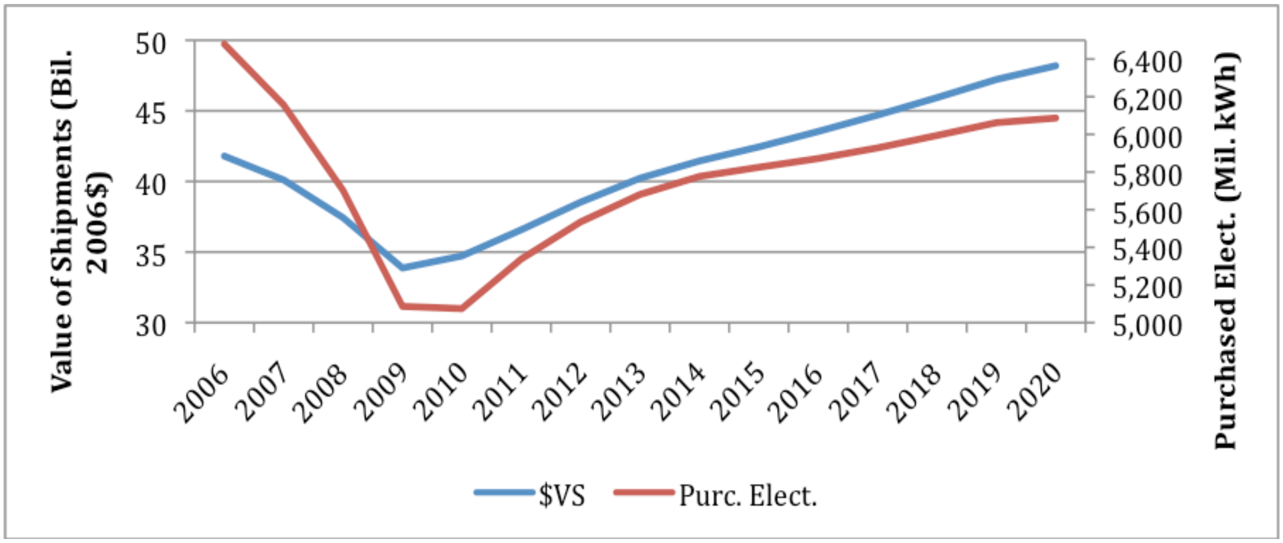

Figure 2.3 Economic output and purchased electricity in MD manufacturing sector, baseline scenario

Under our baseline scenario we find that energy and capital costs will increase for the period 2010-2020. Between 2010 and 2012, as the state's manufacturing sector recovers from the economic recession, production costs will grow at the highest rate. Also, energy costs will be influenced by fluctuations in fuel prices. We see that despite increases in fuel consumption, absolute fuel costs from year-to-year may actually decrease due to suppressed fuel prices – particularly for heavily consumed fuels (e.g., natural gas and electricity) (Table 2.5).

Table 2.5 Manufacturing costs in millions of 2006$, 2-year rate of change, baseline scenario

	2010	2012	2014	2016	2018	2020
All Energy	740.21	832.93	866.59	896.03	932.22	962.02
% change	*N/A*	*12.5%*	*4.0%*	*3.4%*	*4.0%*	*3.2%*
Purchased Electricity	450.24	467.21	465.99	490.82	517.31	533.25
% change	*N/A*	*3.8%*	*-0.3%*	*5.3%*	*5.4%*	*3.1%*
Natural Gas	119.46	163.55	170.82	168.01	170.39	174.03
% change	*N/A*	*36.9%*	*4.5%*	*-1.6%*	*1.4%*	*2.1%*
Capital Costs	1,159.54	1,288.74	1,394.01	1,472.90	1,562.13	1,644.66
% change	*N/A*	*11.1%*	*8.2%*	*5.7%*	*6.1%*	*5.3%*

Total economic output as measured by the dollar value of shipments is expected to increase for most subsectors by about 2 to 4 percent per year. However, some subsectors will see less productivity and others will see decreased production (see Table 2.1). Firms will increase energy consumption to meet production levels, but some subsectors will see greater year-over-year increases in energy costs. Two critical factors include specific energy requirements and fuel price volatility. The chemical subsector, for instance, is reliant on LPG, which is forecasted to increase in price significantly between 2010 and 2020 (EIA, 2010a). Also, the rate of energy intensity reductions across subsectors influences cost trends. For example, computers and electronics become less electricity intensive (BTUs/$VS) at a faster rate than cement, iron and steel, or pulp and paper industries. Figure 2.4 shows subsector-level total energy costs for the period of 2010-2020.

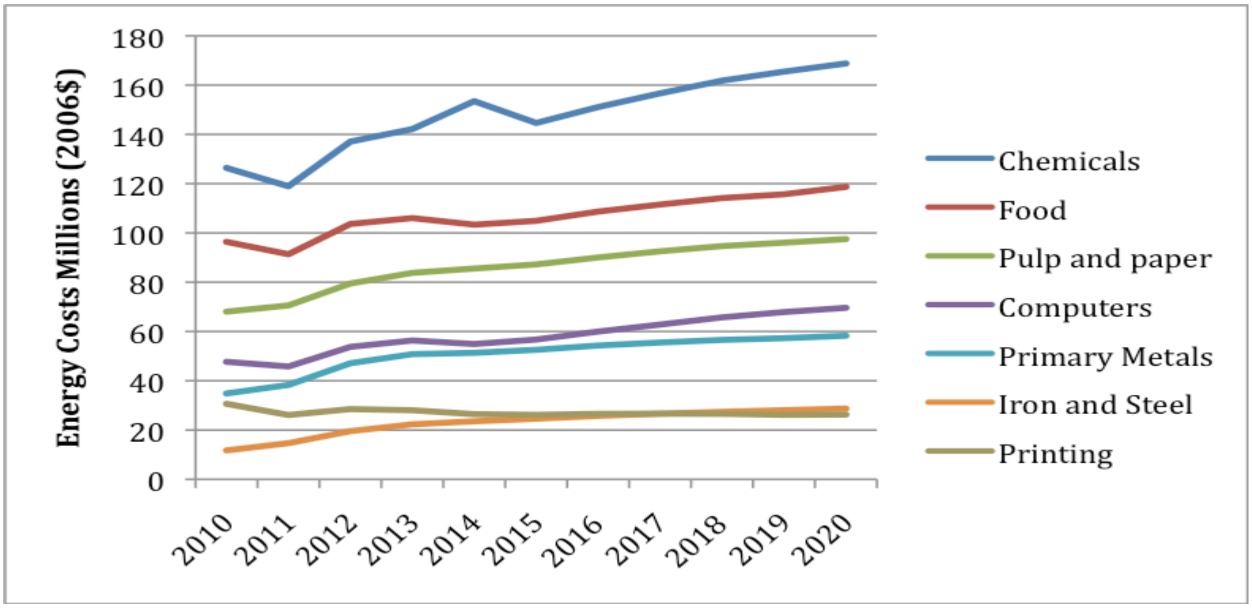

Figure 2.4 Maryland energy costs by subsector, baseline scenario

Policy Scenarios and Impacts

Here, we present production costs under three policy scenarios and contrast against baseline production costs to determine policy impacts (see Table ES.2, Executive

Summary). The policy scenario titles – high, middle and low cost – are derived from their relative anticipated production cost impacts. In other words, the high cost policy scenario results in the greatest increase in production costs relative to the baseline. The assumptions adopted for the middle policy scenario reflect a continuation of historical policy implementation (e.g., limited EmPowerMD participation) and anticipation of average market trends (e.g., cost of renewable energy credits) (Table 2.6). The high and low scenarios represent reasonable bounds under alternative market and policy assumptions.

Table 2.6 Policy and market conditions and relationship with three scenarios; baseline highlighted

Scenario/Policy	**Middle**	**Low**	**High**	**Baseline**
RGGI (See 2.2.2.2 for methods)	25% of RGGI auction proceeds directed to SEIF	75% of RGGI auction proceeds directed to SEIF	25% of RGGI auction proceeds directed to SEIF	Regional RGGI compliance; Maryland generating units not subject to RGGI
RPS (See 2.2.2.3 for methods)	Mid-REC prices; solar RECs at fraction of ACP; 5% of non-solar tier 1 renewable capacity built in MD	Low-REC prices; solar RECs at fraction of ACP; 10% of non-solar tier 1 renewable capacity built in MD	High-REC prices; solar RECs = ACP; 1% of non-solar tier 1 renewable capacity built in MD	Regional RPS met; Maryland utilities do not pay for renewable energy credits (RECs) or alternative compliance
EmPowerMD (See 2.2.2.4 for methods)	Limited implementation with low participation based on historical trend	Full implementation with high participation based on EmPowerMD mandate	Limited implementation with low participation based on historical trend	Natural efficiency gains; no utility energy efficiency programs in place

We find that under our middle scenario, total production cost impacts (energy and capital costs) will be no greater than 0.5 percent in any year relative to the baseline. With climate policies in place, energy costs will fall below baseline energy costs in early years; energy costs will be higher relative to the baseline by 2019 (see Appendix 2.C for year-by-year results). Capital costs, which are influenced solely by EmPowerMD programs, will increase by approximately 0.2 percent each year under the middle scenario until 2016 (Table 2.7 and Table 2.8).

Table 2.7 Energy costs in millions of 2006$, percent change relative to baseline under 3 scenarios

	2010	**2012**	**2014**	**2016**	**2018**	**2020**
Middle	739.78	830.27	864.34	893.61	931.73	967.66
% change	*-0.06%*	*-0.32%*	*-0.26%*	*-0.27%*	*-0.05%*	*0.59%*
Low	738.15	823.52	852.09	875.31	909.69	938.92
% change	*-0.28%*	*-1.13%*	*-1.67%*	*-2.31%*	*-2.42%*	*-2.40%*
High	739.86	832.13	869.05	901.80	946.48	995.85
% change	*-0.05%*	*-0.10%*	*0.28%*	*0.64%*	*1.53%*	*3.52%*

Table 2.8 Capital costs in millions of 2006$, percent change relative to baseline under 3 scenarios

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016***
Middle/High [47]	1,162.29	1,223.86	1,291.49	1,352.53	1,396.76	1,434.34	1,472.90
% change	*0.24%*	*0.23%*	*0.21%*	*0.20%*	*0.20%*	*0.19%*	*0.00%*
Low	1,174.85	1,236.43	1,304.06	1,365.10	1,409.33	1,446.91	1,472.90
% change	*1.32%*	*1.25%*	*1.19%*	*1.14%*	*1.10%*	*1.07%*	*0.00%*

* By 2016, EmPowerMD utility programs assumed to end

Energy costs in the policy scenarios are influenced by both electricity rate and electricity consumption changes. Under the middle scenario, industrial electricity rates will increase; however, rate impacts above 1 percent do not emerge until 2018 as the RGGI and the RPS mandates tighten. The RPS will have the greatest influence on electricity rates accounting for roughly 90 percent of the rate impact in 2020. Also, as a result of the most recent RPS amendments (SB 277), a noticeable decrease in electricity rates occurs between 2016 and 2017 as the solar ACP drops from 0.35$/kWh to 0.20$/kWh. Stated alternatively, SB 277 increased the solar ACP for the period 2011-2016 while leaving 2017 unchanged, which accounts for the noticeable dip in the expected rate impact between 2016 and 2017. We also find that electricity rate impacts will be highest in early years under the low scenario due to program cost recovery under full EmPowerMD implementation and associated surcharges (Figure 2.5).

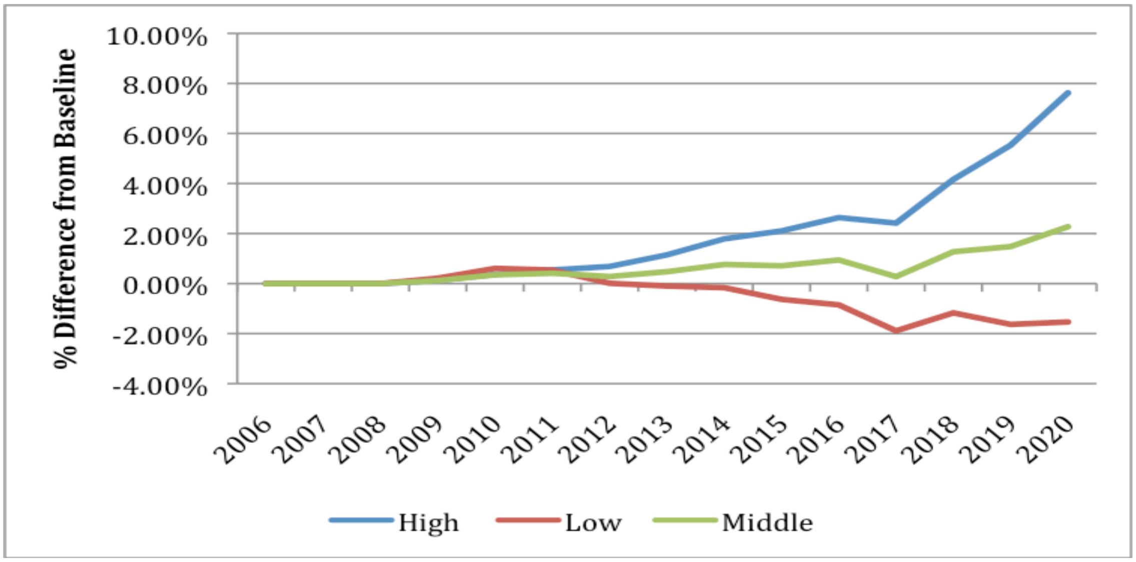

Figure 2.5 Aggregate average industrial electricity rate impacts relative to baseline by scenario

We expect that EmPowerMD programs will reduce the quantity of purchased electricity by no more than 1.5 percent under the middle scenario (Table 2.9). Electricity reductions will peak in 2015 as the effects of current (2015) and previous (2009-2014) efficiency

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[47] Capital cost impacts are equal under the middle and high scenarios as both assume limited EmPowerMD implementation; the low scenario results in higher capital costs than the middle/high scenario, however, total cost impacts (energy and capital) are lowest in low cost scenario.

measures are maximized; beyond 2015 electricity reductions gradually decrease as measures run for their expected lifetime and are retired.

Table 2.9 EmPowerMD electricity reductions (millions of kWh) and percent change from baseline under 3 scenarios

	2010	**2012**	**2014**	**2015**	**2016**	**2018**	**2020**
Middle/High Reductions	22.55	46.97	71.40	83.61	83.61	80.88	72.42
% change	*-0.44%*	*-0.85%*	*-1.24%*	*-1.44%*	*-1.42%*	*-1.35%*	*-1.19%*
Low Reductions	53.83	112.15	170.47	199.62	199.62	193.12	172.92
% change	*-1.06%*	*-2.03%*	*-2.95%*	*-3.43%*	*-3.40%*	*-3.22%*	*-2.84%*

Cost impacts differ across manufacturing subsectors and individual firms. We find that by 2020 some subsectors will experience energy cost increases above 1 percent while other subsectors will actually see a decrease in energy costs. Subsectors with the highest cost impacts are the most electricity-intensive, consume the most electricity, and are heavily dependent on electricity relative to other fuels (i.e., high electricity share). Additionally, EmPowerMD participation influences cost impacts. Because we assume energy efficiency measures will be adopted in proportion to subsector employment, industries with a high concentration of employees implement a significant share of the total EmPowerMD measures and see greater electricity reductions. In turn, some industries with high employment and low electricity intensity/share experience net savings (Figure 2.6).

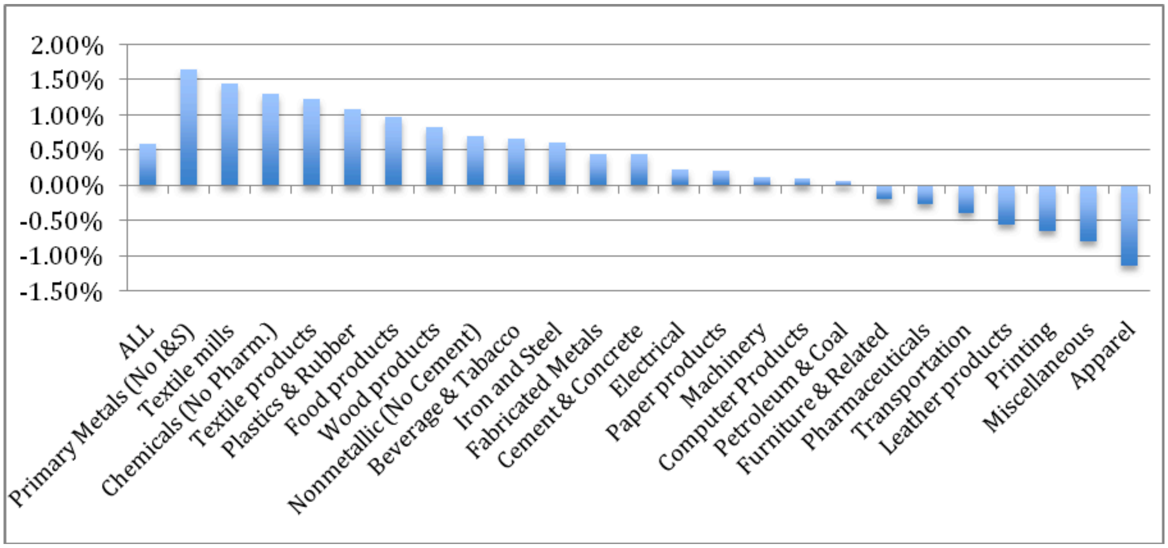

Figure 2.6 Subsector energy cost impacts, percent change relative to baseline under middle scenario, 2020

We also find that cost impacts differ depending on available technology. Specifically, firms with self-generation capacity experience lower electricity cost impacts under the policy scenarios. For example, in our analysis we account for self-generation capacity at two paper facilities. If we remove self-generation capacity in the paper industry and assume instead that facilities are purchasing electricity, we observe that the policy-induced cost difference with the "self-generation" case is consistently below the "purchased electricity case." This analysis excludes fuel costs associated with on-site electricity generation as a result of uncertain fuel demand at individual facilities (Figure 2.7).

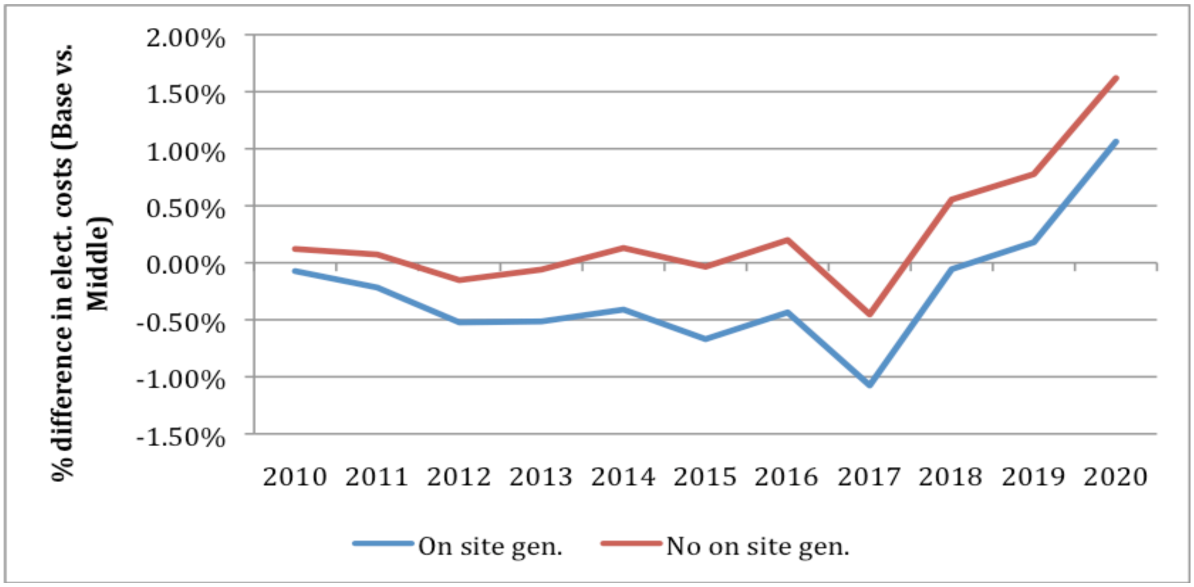

Figure 2.7 Percent change in electricity costs in pulp and paper industry between base and middle scenarios, with and with out on-site generation capacity

Sensitivity Analyses

The results presented above are subject to model design, including assumptions about economic growth, autonomous efficiency change, and policy-market interactions. Here we present insight into the sensitivity of results under alternative assumptions.

Under our model, we assume Maryland subsectors will increase economic output at a rate equal to US subsectors. By assuming an alternative rate of output equal to half the US rate, we find that the baseline dollar value of shipments increases between 2009-2012 and decreases between 2013-2020. Relative to the original model assumption, the alternative assumption has the effect of flattening energy costs over time (Figure 2.8). Regarding policy impacts, we find that the alternative growth rate has minimal influence. By 2020, under the middle scenario, total energy costs increase 0.59 percent above the baseline with the original model growth rate; the alternative growth rate results in a 0.52 percent increase above the baseline. In absolute terms, the difference in policy impact between the two assumptions is less than $1 million in 2020.

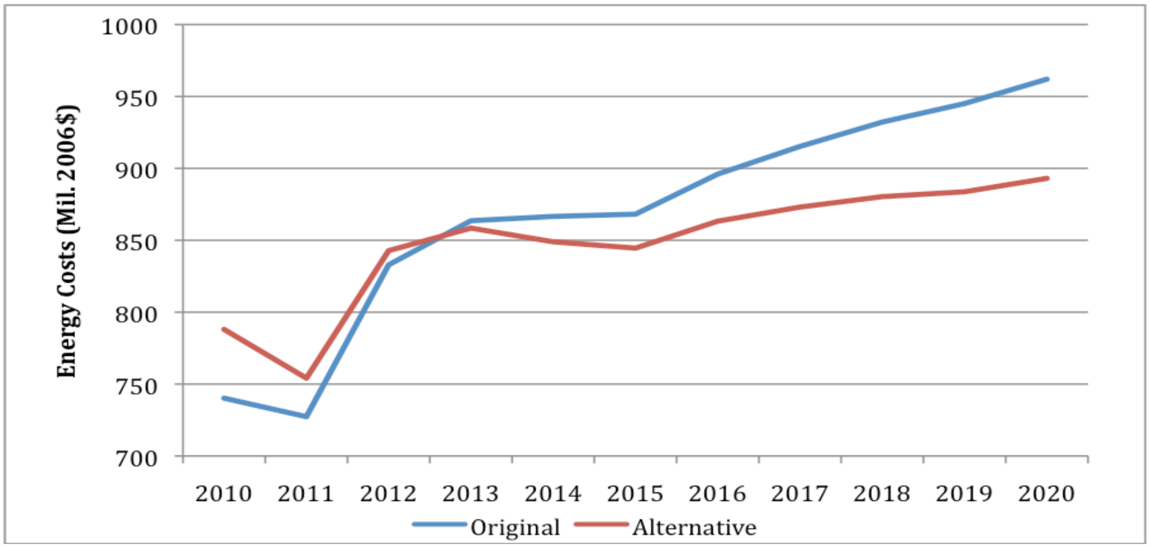

Figure 2.8 Total baseline energy costs under two assumptions; Blue = Original growth rate (=US), Red = Alternative growth rate (=US/2)

Similarly, we find that an alternative assumption about autonomous efficiency improvements has minimal influence over the results. In our original model we assume the electricity intensity (BTUs/$VS) of Maryland manufacturing decreases at a rate equal to the US, or approximately -0.15 to -2.0 percent per year, depending on the subsector (EIA, 2010c). If we instead assume electricity intensity decreases at half the rates initially adopted, then we find baseline energy costs increase due to greater consumption. This assumption has little influence on the overall policy impact. By 2020, under our middle policy scenario, we find that energy costs increase by 0.59 percent with the initial efficiency assumption and by 0.63 percent with the alternative efficiency assumption. In absolute terms, the difference in policy impact between the two assumptions is less than $1 million in 2020.

Finally, policy implementation and market assumptions are critical to the results. Key policy and market variables are represented in the three cost scenarios outlined above. However, we exclude policy impacts in the natural gas market from our results due to significant uncertainty. Considering natural gas prices in the context of manufacturing is essential given forecasts for growing natural gas demand in the industrial sector (EIA, 2010d). As discussed in Subsection 1.4.3 of Chapter 1, there is potential for additional renewable electricity capacity to suppress regional natural gas demand and prices through displacement of natural gas powered generation. We offer supplemental analysis of how modestly decreasing natural gas prices would affect energy costs in the manufacturing sector. Assuming a 2 percent reduction in natural gas prices by 2020 and omitting all other policy impacts, we find that energy costs in the manufacturing sector would be approximately 0.36 percent below the baseline by 2020. There would be divergent impacts depending on the natural gas intensity of a firm’s production. Iron and steel production would be among the subsectors with the greatest cost savings (Table 2.10).

Table 2.10 Percent change in energy costs relative to baseline with alt. natural gas price assumption[48]

	2010	**2012**	**2014**	**2016**	**2018**	**2020**
All Manuf.	-0.05%	-0.13%	-0.20%	-0.25%	-0.30%	-0.36%
Paper	-0.07%	-0.15%	-0.21%	-0.27%	-0.33%	-0.39%
Nonmetallic	-0.07%	-0.15%	-0.21%	-0.26%	-0.31%	-0.35%
Primary Metals	-0.06%	-0.16%	-0.25%	-0.32%	-0.39%	-0.45%
Iron and Steel	-0.09%	-0.22%	-0.32%	-0.42%	-0.51%	-0.61%

Over the coming decades natural gas prices are expected to remain low due to significant supply of US shale gas reserves (EIA, 2010d). Moreover, there is a recognized, but not well-understood, element of codependency between intermittent renewable capacity and easily dispatchable capacity or spinning reserves such as gas-fired turbines. It is possible that additional renewable capacity may support growth in natural gas capacity, which could partially counteract any displacement effect. As a consequence of these factors, the possibility for Maryland or regional renewable capacity development to significantly influence natural gas prices appears unlikely.

2.3.2 Additional Climate Policies and Impacts

In this subsection we evaluate cost impacts in the manufacturing sector resulting from additional climate action policies. Analysis is qualitative and draws on literature and case studies. We focus on specific policy impacts including promotion of combined heat and power and distributed generation, appliance standards, building codes and waste management.

2.3.2.1 Combined Heat and Power and Clean Distributed Generation

Combined heat and power (CHP) systems are designed to capture waste heat from electricity generation to be used for building or process heat. Industrial facilities are compatible with CHP technology because they often have significant heat and power needs as well as physical space to support a system. Also, by siting new locations of CHP supply in close proximity to demand, heat and power transmission losses are minimized. In Maryland, eight CHP plants are classified as having manufacturing applications (EIA, 2010c). There is considerable unrealized potential for CHP in Maryland. An estimated 3,700 sites in the state may have the technical potential to utilize CHP systems and at least 900 commercial or industrial sites could install CHP units of greater than 500 kW in capacity (PPRP, 2006). The goal of Maryland's CHP policy is to achieve 15 percent of in-state CHP technical potential at commercial and industrial facilities by 2020 (MCCC, 2008).

Some distributed generation (DG) systems include on-site renewable energy technologies such as combustion engines, small wind, solar, small hydroelectric, and fuel cells. Maryland

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[48] Assumes a 2% reduction in natural gas prices by 2020; year-over-year reductions in natural gas prices ramp-up beginning in 2009 and are equal in each period.

is presently expanding DG capacity through numerous small renewable electricity installations, primarily solar installations (PSC, 2010a). Due to the physical space and upfront capital required for DG projects, industrial facilities could be critical for expanding DG in Maryland. Similarly, meeting the solar RPS could likely be supported through installation at industrial facilities (L&A, 2008).

Local Job Retention Through Technology Investment

In 2003, the 97-year-old Ethan Allen Furniture factory of Beecher Falls, Vermont planned to close because of energy costs. Instead, they replaced their steam engine with a steam turbine powered by a biomass-fired boiler to save the factory over 10 percent of its energy costs with a three-year payback. With the support and joint funding from the states of Vermont and New Hampshire and the Vermont Electric Cooperative Utility, the new system allowed the factory to remain open, saving 500 jobs (EERE, 2009).

Compared with purchased electricity and onsite-generated heat, CHP and DG systems offer certain benefits (Table 2.11). The primary benefit of these systems is long-term fuel and electricity savings, but secondary benefits are extensive. For example, lower fuel requirements for industrial boilers decrease harmful air pollutants (e.g., NO_x and SO_x) and associated air quality compliance costs. Also, CHP/DG systems protect against disruptions in the electricity grid and serve to hedge against volatile energy prices.

Despite these benefits, high capital costs and long payback periods will deter investments for many firms. Regulations and transaction costs related to interconnection, net metering, and standby rates are also determining factors for cost effectiveness (Table 2.11). In turn, Maryland's CHP/DG policies will likely use economic tools and regulatory revisions to assist would-be developers in overcoming high investment costs or shortening the payback period. For example, in 2009, Maryland expanded its net metering law to include wind, solar, and micro-CHP resources (i.e., under 30 kW) (DSIRE, 2010). Eligibility for net metering will provide industrial sites with an additional cost recovery tool.

Table 2.11 Opportunities and Barriers to DG and CHP systems

Opportunities	Barriers
- Higher fuel use efficiencies and energy savings - Offset capital costs by installing CHP instead of boilers or chillers (new facilities) or when upgrading equipment, i.e. HVAC units (existing facilities) - Revenue from electricity or heat sales - Reliability against system-wide black outs or local disruption; fuel-switching provides insulation against price volatility - Reduced GHG and air pollution emissions (e.g., NOx, SOx) with associated compliance cost savings - DG participation in PJM Demand Response Programs	- High initial capital costs discourage investment and vary greatly - Unfavorable utility tariffs such as standby charges, backup rates, and exit fees - Transaction costs associated with grid interconnection and permitting - Uncertainty associated with fuel and electricity prices

Calculating CHP/DG system costs is complicated and requires a complete analysis of site-specific operational characteristics. For CHP installations, the US Environmental Protection Agency provides a generic analysis of project costs assuming relatively high fuel costs ($8.30/Mill. Btu), a highly efficient system (95%), average capital costs ($1,200/kW turnkey), and an average interest rate (8%). It also assumes that the CHP system is being installed as a retrofit; therefore, no capital cost offset is taken. Given these assumptions, the total operating and capital costs equal $0.0618/kWh or a cost lower than present and forecasted average industrial electricity rates in Maryland, not to mention added fuel savings. As industrial electricity rates increase, the potential for energy cost savings through CHP technology will rise (PPRP, 2010a). Alternative fuel types, system configurations, and contract structures may further overcome cost barriers where there is a strong technical fit (US EPA, 2010). Distributed generation costs vary by technology, fuel and site-specific attributes. For example, solar capacity is eligible for highly valued solar RECs, but has a long average payback period; biomass, on the other hand, can create both heat and power, but depends on an uncertain feedstock.

Policy Impact

To make investments in CHP and DG capacity more attractive for manufacturing facilities, the state could lower initial costs or increase opportunities for recovering costs in a shorter period of time. One policy option is to further expand net metering eligibility by increasing the minimum capacity requirement for micro CHP facilities. This is doubly important because larger CHP systems generally result in a greater return on investment (PPRP, 2010a). Presently, large manufacturing firms with available capital, high-energy demand, and physical space tend to have CHP capacity in-place (EIA, 2010c). The benefits of this technology at firms with the economies of scale are apparent; for smaller firms, which make up a majority of Maryland's manufacturing sector, the economics are less favorable. The state will need to improve the economics for small and medium size firms to stimulate significant investment in CHP and DG technology in the manufacturing sector.

Expansion of CHP and DG under Maryland's CAP will have positive impacts on the manufacturing sector as these facilities are probable beneficiaries of state incentives and regulatory restructuring. If incentives are attractive enough to overcome the barriers and stimulate investment, then energy costs will decrease, energy reliability will increase, and environmental performance will improve. However, due to the economies of scale necessary to warrant current CHP and DG systems, further expansion by Maryland's small firm dominated manufacturing sector may be difficult. Adoption of CHP and DG technology, particularly renewable energy capacity, is dependent upon technology innovation and decreasing capital and transaction costs.

2.3.2.2 Appliance and Lighting Efficiency Standards

Appliance efficiency standards impact manufacturing firms as both producers and consumers of appliances. Maryland, along with several other states, has opted to enforce efficiency standards ahead of the federal schedule or for products not covered by the federal standards (DSIRE, 2010). In 2004, Maryland's Energy Efficiency Standards Act required 16 manufactured products to meet appliance efficiency standards; presently, all but three appliance standards have been preempted by federal standards (ACEEE, 2010).

As a climate action policy, Maryland could further expand appliance efficiency standards to surpass federal standards or create appliance standards where holes exist (MCCC, 2008). For example, California became the first state to establish a minimum efficiency standard for televisions and Maryland could follow suit (ACEEE, 2010).

In Maryland, manufacturers are required to test products in a manner consistent with the standards outlined by the federal government. Manufacturers must also gain certification with the Maryland Energy Administration as well as label products as being compliant with the minimum efficiency standards (COMAR, 2006). To meet these requirements, some firms may need to modify production processes, which could result in additional capital and material costs. It is also possible that compliance with these requirements will necessitate new positions, resulting in a need for more workers to be hired, thus raising labor costs, as well as higher transaction costs associated with realigning contracts for either raw materials and/or finished goods.

Manufacturers could procure more efficient appliances as the standards are enforced and products sold in retail outlets. However, a majority of the appliance standards apply to commercial and residential appliances, which are insufficient for industrial purposes and therefore seldom used in industry (DSIRE, 2010). Lighting standards could be more significant given that lighting accounts for a substantial share of electricity end-use in the manufacturing sector (see Figure 1.2, Chapter 1). Under the Energy Independence and Security Act of 2007, new lighting standards were developed requiring light bulbs to consume 60 percent electricity relative to 2007 by 2020 (DSIRE, 2010). As mandated by the legislation, the new federal lighting standard is both technically feasible and economically justified.

<u>Policy Impact</u>

Maryland's appliance efficiency standards largely align with national standards precluding any national disadvantage to state manufacturers. Moreover, based on recent and scheduled federal appliance standard revisions, the state may find it difficult if not impractical to move ahead of federal standards. Alternatively, if an ambitious portfolio of appliance efficiency standards is adopted, then there is potential for adverse effects in a small segment of the manufacturing sector. Industries subject to appliance standards could struggle if major production modifications are required. Also, some consumers may see energy efficient appliances as inferior products resulting in decreased sales or consumer leakage. Manufacturers and trade associations opposed to new television efficiency standards adopted in California have raised this point as an issue of concern (Woody, 2009). If Maryland moves ahead of the federal government on appliance standards, cost and consumer leakage concerns will need to be resolved.

In the context of manufacturing firms procuring appliances and lights, more efficient products will probably result in significant energy savings at little or no additional upfront cost (ACEEE, 2010). We find that unless appliance standards address industrial grade equipment, lighting efficiency standards will be of primary importance for manufacturing procurement.

2.3.2.3 Building Codes and Green Building Incentives

Maryland aims to reduce building energy consumption through improvement and enforcement of building and trade codes. The policy also encourages constructing high-performance buildings through incentives for achieving third-party efficiency standards and certification. The state's goal is to reduce energy consumption per square foot of floor space by 15 percent by 2010, and 50 percent by 2020 (MCCC, 2008).

Manufacturing plants and their office buildings are subject to Maryland's building codes. At the time of this report, the newest version of the Maryland Building Performance Standards, incorporating the 2009 editions of the International Building Code, the International Residential Code, and the International Energy Conservation Code, became effective on January 1, 2010 (DSIRE, 2010).

Building codes outline minimum energy efficiency requirements for new and renovated buildings. The building codes address energy-related components such as day lighting, electric lighting, building envelope, and integrated building design strategies. Local Maryland jurisdictions may modify these codes to suit local conditions with exception to the 2009 International Energy Conservation Code and the energy efficiency chapter of the 2009 International Building Code, which can be made more stringent but not less by local jurisdictions (COMAR, 2010b). New building codes are developed every three years and the state, with influence from the international codes, may elect to enhance building energy efficiency standards (DSIRE, 2010).

According to the Building Codes Assistance Project, a coalition advocacy group that provides technical and policy assistance on the topic of building energy efficiency, implementation of the 2009 International Energy Conservation Code and Standard 90.1-2007 could save Maryland businesses and residents an estimated $78 million annually by 2020 and $157 million annually by 2030 in energy costs (OCEAN, 2010). These latest codes could also help avoid about 14.7 trillion Btu of primary annual energy use and annual emissions of more than 1.03 million metric tons of CO_2 by 2030. The study considers commercial and residential and makes no mention of industrial facilities (OCEAN, 2010).

In addition to the building code revisions, there are incentives available to help manufacturing firms meet or exceed energy performance standards. The MEA offers a personal income tax credit for buildings, including industrial facilities, which have obtained certification from the Leadership in Energy and Environmental Design (LEED) Green Building Rating System. The credit is worth up to eight percent of the total cost of the building. Buildings must be located in a priority funding area or Brownfield site and be at least 20,000 square feet; renovation projects are eligible if they do not increase the size of the building by 25 percent or if they are located in a priority funding area. Currently, all funds are exhausted for this tax credit and authority for the tax credit expires at the end of 2011 (DSIRE, 2010).

Green Buildings in Industry

In 2005, NRG Systems of Hinesburg, Vermont constructed a 46,000 square foot manufacturing facility and office building that received LEED gold level certification, making it only one of four manufacturing facilities in the world to receive this designation (as of 2005). The $8 million building is powered primarily by renewable energy and uses one-third as much energy as a conventional building, saves more than 100,000 gallons of water annually, and cost about $13.81 per square foot or 8.21 percent more to build, with an estimated five-year payback period (NRG, 2005).

Obtaining LEED certification has not been a prevailing achievement of the industrial sector. A review of Maryland buildings with LEED certification suggests no industrial facilities in the state have achieved LEED certification (USGBC, 2009a). The US Green Building Council will not prevent a building from attempting certification due to its use (USGBC, 2009b). However, anecdotal evidence suggests LEED certification can be a challenge for building designers because of integration of green and production features, which may raise design and construction costs.

Policy Impact

Maryland manufacturing facilities will be minimally impacted by revised building codes because only new or renovated buildings are subject to the new codes. Due to economic and geographic constraints, facility owners lack incentives to develop new or renovated buildings and will remain with existing facilities in the short-term. However, as manufacturing facilities in the state are developed or renovated, the impact from more stringent building codes will be evident. Among manufacturing facilities that might be subject to revised codes, we expect higher initial capital costs, but substantial energy cost savings in the long-term resulting from higher energy performance standards. Given the long life of most manufacturing facilities, the energy savings will very likely offset additional capital costs.

Additionally, we find that the unavailability of funding for LEED certified facilities as well as potential complications associated with industrial LEED certification will be critical. With extension of the Maryland green building income tax credit and additional funding opportunities, we would expect manufacturing firms to benefit; still, industrial participation in LEED will probably remain minor relative to the commercial/residential sectors. As knowledge in LEED industrial expands, costs will come down and we can expect more manufacturing facilities in the state to gain LEED certification.

2.3.2.4 Waste Management and Advanced Recycling

Industries generate significant quantities of waste during production. There are opportunities to reduce waste in manufacturing processes including using recycled materials for feedstock, using waste heat or other byproducts in production, and creating more efficient production lines with less demand for energy and materials. Manufacturers may also actively refine or recycle waste products and subsequently trade with other firms or initiate aftermarket recycling programs.

There are generally three methods for reducing waste in manufacturing: (1) installation of more efficient technology (e.g., retire outdated processes or equipment); (2) installation of new technology that allows for use of waste (e.g., a biomass-powered electricity generator); or (3) collection and sale of waste or recycled materials. Implementing each of these methods comes at a cost and as emphasized in the discussion of CHP/DG technology above, characteristics such as firm size and financial status are correlated with adoption of waste reduction technologies (King et al., 2001). Waste management technologies and practices exist in Maryland manufacturing. For example, the New Page facility is powered by black liquor, a byproduct of pulp and paper production (EIA, 2010c). Further expanding waste management technology to firms lacking economic motives may require additional incentives or information to stimulate investment.

In 2006, there were approximately 122,000 tons of industrial waste accepted for management in Maryland – 26 percent of this waste was recycled and the remainder disposed (MDE, 2007). Maryland's waste management climate policy will "provide incentives for recycling construction materials, develop markets for recycled materials, and increase average participation and recovery rates for all existing recycling programs to encourage upcycling (where the remanufactured product is equal to, or higher in quality, than the original product" (MDCC, 2008, Appendix D, pg.80). To meet this goal Maryland could employ incentives meant to reduce waste generation in manufacturing as well as develop education and training programs (MCCC, 2008). The Industrial Assessment Center, operated by the US Department of Energy, has catalogued waste and energy minimization options for facilities throughout the US. Data available through the Industrial Assessment Center demonstrate an initial investment in a waste reduction can create cost savings in major subsectors represented in Maryland (Table 2.12).

Table 2.12 Waste minimization and pollution prevention measures, by subsector (EERE, 2010)

Subsector	Measure Type and Example	Average Annual Savings ($)	Average Payback (Years)
Food	Recycling (e.g., Purchase baler and sell cardboard to recycler)	29,407	19.7
	Post generation treatment (e.g., use filtration to remove contaminants)	96,998	2.3
Pulp and Paper	Operations (e.g., make a new byproduct)	139,150	.6
	Waste disposal (e.g., use drying oven to reduce sludge volume)	62,881	1.6
Chemicals	Maintenance (e.g., implement a regular audit program to reduce emissions from leaky pipes)	82,295	.1
	Equipment (e.g., closely monitor chemical additions to increase bath life)	39,776	.6
Primary Metals	Water use (e.g., replace city water with recycled water via cooling tower)	35,673	9.4
	Recycling (e.g., recycle scrap metal to foundry)	108,909	.5

Several programs are in place to help educate manufacturers and build knowledge of cost-effective measures for reducing waste. For example, the MDE offers pollution prevention technical assistance for businesses. The program, which is executed with assistance from the University of Maryland Technology Extension Service, is free, voluntary and conducts on-site evaluations. The goals of the program are to, "make more efficient use of raw materials and energy, reduce waste disposal and handling costs, reduce regulatory compliance and liability costs, and decrease worker exposure to pollution (MDE, 2010)."

Policy Impact

It is unlikely that Maryland's waste management policy will negatively impact manufacturers given the non-regulatory approaches emphasized (MCCC, 2008). With availability of financial incentives and educational resources, such a policy would lower the costs of investment and result in technology adoption. A waste management program that accounts for the diversity of Maryland manufacturing will receive participation; specifically, small-sized firms lacking the economies of scale and/or knowledge to install waste reduction technology should be targeted by the state.

2.3.2.5 Other Policies and Economic Development Impacts

All portions of the CAP have the potential to interact with the manufacturing sector including energy supply and demand, transportation and land-use, and agriculture, forestry and waste policies. While the policies analyzed here in great detail directly affect the manufacturing sector's technology choices, cost structure and competitiveness, other policies may have similar such impacts and together they are likely to change the environment within which business operates. Unlike for the impacts that we quantified for the three select policies, the broader range of CAP policies have more diffuse, harder to calculate cost and employment implications.

Promotion of renewable energy resources through removal of regulatory and financial hurdles may encourage investment in the manufacturing sector. State and federal funding such as production tax credits, grants, and low-cost loans afford a greater incentive for renewable development, as does revision of regulations (e.g., expanding eligibility for net metering). Also, state-supported energy service contracts present an option for Maryland to create investment in demand-side energy management that might not occur otherwise. Energy service contracts are most suitable for medium-sized firms because they're small enough to not warrant in-house energy management, but large enough to have high production costs and thus potential for cost savings (Sorrell, 2007). Collectively, we expect that energy supply and demand policies, particularly market-based policies, will garner interest and participation from industry as they represent an opportunity to cut costs and improve environmental performance.

Transportation and land use policies could influence manufacturers. For example, a land use policy designed to capitalize on the energy patterns of manufacturers through district heating and cooling could benefit firms. Locating new industrial facilities in close proximity to residential areas and developing the appropriate infrastructure can lead to shared heat and power at a lower cost for all users. Additionally, any policy that promotes a shift in transportation of goods to more efficient means (e.g., rails instead of roads) could have repercussions on manufacturers shipping costs. While rail freight is typically the lowest cost option per ton of goods shipped, it is not practical for a variety of manufacturers based on location or trip type (Forkenbrock, 2001). Transportation and land use policies will generally benefit manufacturers when (1) policies improve access to materials and markets, and (2) create opportunities for sharing risks (e.g., energy costs) with other businesses or the public.

Agriculture, forestry and waste policies could have implications in Maryland's wood and pulp and paper industries. Incentives for biofuel or biomass production may present a lucrative opportunity for some firms. Alternatively, restricting supply to forests for the purpose of carbon sequestration or increasing demand for biomass through production incentives could raise the local price of wood products and ultimately, production costs. There is also the possibility of earning revenue through carbon offsets gained through preservation of private forests (Adams et al., 2003). The potential impact of agriculture, forestry, and waste policies should be reviewed with manufacturing stakeholders generally, and pulp, paper and wood stakeholders specifically.

The whole of the CAP could have direct and indirect impacts for economic development in Maryland's manufacturing sector. Business assistance programs targeting clean technology companies can build or expand manufacturing in the state. Incentives for investing in renewable energy technology or energy efficiency improvements create demand for products and services. More direct impacts will emerge as firms participate in utility EmPowerMD programs or sell renewable energy credits.

2.4 Discussion: Findings, Constraints and Future Work

Maryland's manufacturing sector is diverse containing primarily small firms, a few very large firms, and significant economic output from select subsectors (e.g., computers, food, and chemicals). Moreover, the state's subsectors exhibit disparity in energy requirements. The quality and quantity of energy necessary to meet production levels as well as technology characteristics, largely explain energy cost differences across subsectors. Non-uniformity within the manufacturing sector is an important premise to measuring and understanding climate policy impacts.

The state's CAP contains a portfolio of policies capable of meeting the goals set out in the GGRA. Large-scale electricity supply and demand elements are key to the CAP including the RGGI, the RPS, and EmPower Maryland (EmPowerMD). While the RGGI and the RPS will create minimal direct regulatory costs for a very small group of manufacturing facilities, we focus our analysis on policy interactions in the electricity market and resultant implications for all Maryland manufacturing facilities.

Relying on a range of data sources, literature, and communication with experts, we develop a methodology to quantify policy-induced production cost impacts. We find that Maryland's manufacturing sector will not experience significant cost impacts from the state's climate action plan. Between 2010 and 2018, energy costs will decrease as firms participate in EmPowerMD utility programs and install efficiency measures; by 2019, tightening of the RPS and the RGGI mandates will result in higher electricity rates and energy costs will increase by less than 1 percent. Based on historical trends of limited EmPowerMD implementation and participation, adoption of electricity efficiency measures will raise capital costs by an estimated 0.2 percent for the remaining duration of the program.

The CAP covers a variety of policies in addition to the RGGI, the RPS, and EmPowerMD. We find that these additional policies will not have broad detrimental or positive effects, but could be critical for firms of a certain size or subsector. Regulatory policies (e.g., establish appliance standards) will create compliance costs for a small number of firms. Market-oriented policies (e.g., promotion of distributed generation) offer incentives for firms to overcome cost barriers to investment and will be beneficial. Depending on firm characteristics, economic trends, and available funding, some firms will participate in incentive programs while others will sit out. The program participation gap can be closed with increased funding and carefully designed programs that account for the diversity of the manufacturing sector, particularly small-sized firms. In this section we review limitations to our findings (2.4.1), implications (2.4.2), and finally, future work to be explored (2.4.3).

2.4.1 Constraints

Available Maryland Manufacturing Data

Limited historical and sector-level data are available for Maryland manufacturing. To parse out further subsector-level detail we use broad geographic information including census region and US-level data to draw connections. In turn, there is the possibility for mischaracterization of Maryland energy profiles and costs to the extent that Maryland is dissimilar to census regions and the US as a whole. Also, due to data gaps in NAICS 21, which comprises the mining sector, we exclude this sector from quantitative analysis. These shortcomings might be addressed in future studies through additional surveys or questionnaires.

Policy Information and Implementation Trends

Maryland's CAP is significant in both breadth and depth and anticipating the interaction of policies in the market is inherently uncertain. As a result, precisely quantifying the policy impacts of the entire CAP is outside the scope of this study. Instead, our goal is to comprehensively evaluate a select group of policies with a probability of influencing energy prices and thus production costs in the manufacturing sector. One limitation of this study is exclusion of quantitative analysis across the entire CAP, which could be accomplished through formulation of policy mechanisms and implementation data.

Additionally, this research relies on earlier policy analysis as well as implementation status reports and data from regulated entities. Interpreting, adjusting, and eventually applying this information to the Maryland manufacturing sector requires multiple assumptions. In turn, our methods for policy analysis have limitations that are tied to earlier analyses and the difficultly of re-interpreting complex models. For example, electricity rate impacts from the RGGI are contingent upon an unlikely assumption that transmission lines (i.e., MAPP and PATH) are built according to a 2007 schedule. Regarding electricity imports and the delay of the MAPP and PATH transmission lines, it is uncertain how exactly Maryland electricity rates will be influenced, though earlier work shows import capacity is likely to suppress RGGI related rate increases (Hobbs, 2010; Ruth et al., 2007). Moreover, our analysis of EmPowerMD uses data from BG&E for a short period of implementation. Data stretching over a longer period of time as well as data from other regulated utilities would improve future analysis.

Manufacturing Responses

We exclude responses to policy-induced changes in the manufacturing sector and account for first order policy impacts only. Taking these responses into consideration could alter results considerably. For example, firms participating in EmPowerMD programs and realizing lower energy costs in the short-term might compensate by expanding production and ultimately nullifying energy savings in the long-term (i.e., rebound effect). By not capturing the responses of manufacturing firms to policy-induced effects, we introduce an additional source of deviation from actual manufacturing and economic patterns.

2.4.2 Findings and Applications

This research presents useful information for the Maryland General Assembly, state agencies, and manufacturing firms. Moreover, we expect this study to be of importance for the independent study of Maryland manufacturing to be completed by 2015 (MDGA, 2009). There are key take away messages pertinent for all stakeholders. The central finding is that production cost impacts on the manufacturing sector will be insignificant as a result of the RGGI, the RPS, and EmPowerMD. Additional CAP policies will not broadly influence the manufacturing sector though select firms and subsectors will be impacted. There are a number of secondary findings that should be taken into consideration. Some of these are detailed here.

Energy Profiles of Manufacturing Firms

The manufacturing sector is diverse with each firm having distinct requirements for energy quality, quantity and purpose. Moreover, firms have ranging technology characteristics including equipment and process attributes that determine energy profiles and costs. However, there are also commonalities across all firms including reliance on electricity, electricity end-uses, and the cost-effectiveness criterion for making electricity efficiency improvements.

Non-Uniform Climate Policy Impacts

The energy profile of a firm is a strong determinant of how it will be impacted by policy as well as an indicator of how it might respond to policy-induced changes. Electricity intensive firms and firms with a significant share of energy coming in the form of electricity will experience relatively greater impacts from Maryland climate policies than less intensive counterparts. In turn, these firms are more likely to respond to changing energy costs through a host of options such as short-term production cuts and long-term efficiency improvements. The energy profile is not the sole determinant of policy impacts, particularly in the context of EmPowerMD or similar participatory programs. Factors such as employee size, equipment age, or financial status will determine participation in EmPowerMD programs.

Program Design and Implementation

Achieving the goals of the GGRA and doing so with the cooperation and support of the Maryland manufacturing community can be achieved through careful program design. Comprehensive understanding of manufacturing subsectors, locations, energy profiles, and business practices can be integrated into policy design to maximize cost-effectiveness. Of particular importance for policy-makers is reconciling sectoral diversity with policy expectations. For example, a policy designed to improve electricity efficiency in non-process end uses (e.g., lighting) could achieve sector-wide participation; however, a policy designed to improve electricity efficiency in process end-uses (e.g., machine drive) could realize greater electricity savings at the expense of lower participation. An appreciation for the tradeoffs in policy design resulting from sectoral diversity will create opportunities for GHG mitigation and industry growth.

2.4.3 Future Research

Future research into the relationship between GHG mitigation efforts and manufacturing in Maryland could proceed in many directions. First, there are methods adopted in this study that can be improved as programs are implemented and data become available. For example, further examining manufacturing participation in EmPowerMD programs with a detailed review of technology adoption and motivations would be useful for utilities and government officials alike. Second, as elements of the state's CAP are refined and specific policy tools are identified, additional comprehensive analysis can be performed to better understand impacts in the manufacturing sector. Along the same lines, research can be undertaken on how to optimally design climate policies so as to garner high participation and minimal cost impacts in the manufacturing sector. Last, there are broader questions regarding climate change and manufacturing. For example, Maryland's manufacturing sector and particular subsectors may be vulnerable to specific climate-related impacts including uncertain availability (and prices) for raw materials or extreme weather events that may disrupt production processes. Increased knowledge of climate risks and adaptation measures in the state's manufacturing sector could help direct investment and ensure long-term viability.

2.5 Appendices

Appendix 2.A Description of Data Sources

Annual Energy Outlook and National Energy Model System, 2009 and 2010

Each year the US Energy Information Administration forecasts national energy trends via the Annual Energy Outlook (AEO). Of particular relevance to this study, the AEO forecasts economic growth and energy consumption in US manufacturing subsectors. Also, the AEO forecasts regional industrial fuel prices. AEO forecasts are based on the National Energy Modeling System, which is updated annually to include trends in world energy markets and legislative or regulatory changes. The 2010 AEO reference case accounts for state renewable portfolio standards as well the regional greenhouse gas initiative in estimating energy price and consumption trends. State RPS programs and RGGI minimally impact fuel and electricity prices under the current model (Martin, 2010).

Annual Survey of Manufacturers (ASM), 2003-2008; US Economic Census, 2007

The Annual Survey of Manufacturers (ASM) provides economic data related to industrial costs and productivity. The US Census Bureau conducts the ASM yearly with 2008 representing the most recent data used in this analysis. The ASM presents national and state-level data on employment, costs (including capital, primary fuel, and electricity costs), and value of shipments. Select variables (e.g., value of shipments) are available at the subsector-level for states, while other variables (e.g., electricity costs) are only available at the subsector-level nationally. Every 5 years the US Economic Census is conducted and ASM data are not released. For the purposes of this study, the US economic census provides the same data as the ASM.

State level economic data from the Northeast and South Census regions are aggregated to arrive at regional information, which pairs with MECS regional data. Energy and electricity cost data are available for the state of Maryland, though only at the level of the entire manufacturing sector (2-digit NAICS) and not by subsector. Last, these two datasets provide historic value of shipments data in Maryland, which serve as a proxy for productivity and an input for estimating total energy demand.

County Business Patterns (CBP), 2006-2008

The county business patterns survey is an annual survey of county level economic and employment data conducted by the US Census Bureau. The database provides relevant information into the number of establishments and employee size at very detailed industry and geographic levels (e.g., county levels or metropolitan statistical areas). This database is used to construct a distribution of employment in Maryland manufacturing subsectors and industry groups.

Manufacturing Energy Consumption Survey (MECS), 2002 and 2006

The Manufacturing Energy Consumption Survey (MECS) is vital for developing an industry and geographically disaggregated model of Maryland manufacturing. MECS, conducted by the US Energy Information Administration every four years, is a comprehensive survey of US manufacturing establishments and their energy profiles. The most recent MECS data is from 2006, though older data from the 2002 survey is used in this research. MECS data are organized by NAICS codes and are at the national and census region level with Maryland falling in the South census region. All manufacturing industries are represented at the 3-digit NAICS level (e.g., Food Industry, NAICS 311) while some of the more energy-intensive industries are portrayed at the 6-digit NAICS level (e.g., Iron and Steel Plants, NAICS 331111). Critical metrics are available in MECS including energy intensity as measured by BTUs/$ value shipped, energy consumption as broken down by fuel and non-fuel purposes, and the end use of energy within each industry.

State Energy Data System (SEDS), 1970-2008

The US Energy Information Administration organizes the State Energy Database System (SEDS). SEDS offers historical data such as industry energy prices and consumption, which is a tool for verifying the Maryland manufacturing energy model. SEDS data are updated annually and includes data all states and sectors (e.g., residential, commercial, industrial). Because SEDS data are presented at the industrial sector level, which includes industries outside the scope of this study, comparison to the manufacturing-only model constructed for this research is imperfect.

Electric Power Annual, 2006-2008

The Electric Power Annual database, also organized by the US Energy Information Administration, is used to accurately gauge electricity generation in the Maryland manufacturing sector. The Electric Power Annual database details capacity in Maryland's industrial sector as well as national level industrial electricity generation, which is useful in shaping understanding of generation at Maryland facilities.

Appendix 2.B EmPowerMD Participation Model Results

Table 2.B Manufacturing participation model results

	Logistic model	**First stage linear model**	**Second stage linear model**
Model	f(x) = a/(1+b*exp(-c*x))	f(x) = a*x + b	f(x) = a*x + b
a	450 (fixed at bound)	0.09109 (0.0813, 0.1009)	0.3204 (0.3102, 0.3306)
b	57.17 (35.79, 78.55)	0.8633 (-0.4585, 2.185)	-47.63 (-51.26, -44)
c	0.006202 (0.005253, 0.007152)	-	-
SSE	3.379e+004	44.61	966.6
R^2	0.6497	0.9496	0.9797
Adj R^2	0.6463	0.9471	0.9795
RMSE	18.11	1.494	3.454

Note: numbers in parentheses are the 95% confidence bounds.

Appendix 2.C Energy Costs, Baseline and Middle Scenarios

Table 2.C Total energy costs ($2006), in 1000s of dollars, base and middle scenarios, by subsector; highlight of percent difference

NAICS CODE	**2012**	**2014**	**2016**	**2018**	**2020**
31-33 (Base)	832,929	866,588	896,028	932,220	962,020
31-33 (Middle)	**830,272**	**864,343**	**893,606**	**931,730**	**967,655**
	-0.32%	*-0.26%*	*-0.27%*	*-0.05%*	*0.59%*
311 (Base)	103,640	103,353	108,672	114,143	118,690
311 (Middle)	**103,375**	**103,219**	**108,560**	**114,341**	**119,848**
	-0.26%	*-0.13%*	*-0.10%*	*0.17%*	*0.98%*
312 (Base)	13,031	12,023	11,895	11,793	11,629
312 (Middle)	**13,001**	**12,000**	**11,870**	**11,792**	**11,706**
	-0.23%	*-0.19%*	*-0.21%*	*-0.01%*	*0.66%*
313 (Base)	18,372	16,472	16,051	15,839	15,455
313 (Middle)	**18,369**	**16,508**	**16,095**	**15,927**	**15,679**
	-0.02%	*0.22%*	*0.28%*	*0.56%*	*1.45%*
314 (Base)	6,020	5,406	5,303	5,267	5,161
314 (Middle)	**6,008**	**5,404**	**5,301**	**5,280**	**5,224**
	-0.20%	*-0.04%*	*-0.05%*	*0.25%*	*1.23%*
315 (Base)	1,179	954	841	763	672

NAICS CODE	**2012**	**2014**	**2016**	**2018**	**2020**
315 (Middle)	**1,169**	**941**	**825**	**748**	**664**
	-0.88%	*-1.35%*	*-1.95%*	*-1.94%*	*-1.15%*
316 (Base)	139	118	109	104	97
316 (Middle)	**138**	**116**	**107**	**102**	**97**
	-0.79%	*-1.15%*	*-1.54%*	*-1.40%*	*-0.55%*
321 (Base)	27,111	27,646	29,206	30,320	30,872
321 (Middle)	**27,055**	**27,624**	**29,190**	**30,371**	**31,130**
	-0.20%	*-0.08%*	*-0.06%*	*0.17%*	*0.84%*
322 (Base)	79,477	85,555	90,039	94,665	97,492
322 (Middle)	**79,384**	**85,482**	**89,959**	**94,655**	**97,696**
	-0.12%	-0.09%	-0.09%	-0.01%	0.21%
323 (Base)	28,508	26,447	26,577	26,576	26,280
323 (Middle)	**28,142**	**25,989**	**26,027**	**26,105**	**26,110**
	-1.28%	*-1.73%*	*-2.07%*	*-1.77%*	*-0.65%*
324 (Base)	104,787	111,798	117,231	116,157	120,548
324 (Middle)	**104,776**	**111,798**	**117,235**	**116,179**	**120,631**
	-0.01%	*0.00%*	*0.00%*	*0.02%*	*0.07%*
325 (Excludes 3254) (Base)	122,982	139,176	135,793	145,391	151,602
325 (Excludes 3254) (Middle)	**123,045**	**139,566**	**136,332**	**146,301**	**153,571**
	0.05%	*0.28%*	*0.40%*	*0.63%*	*1.30%*
3254 (Base)	14,080	14,295	15,290	16,424	17,179
3254 (Middle)	**13,922**	**14,096**	**15,056**	**16,233**	**17,133**
	-1.12%	*-1.40%*	*-1.53%*	*-1.16%*	*-0.27%*
326 (Base)	38,893	39,310	41,331	42,849	44,081
326 (Middle)	**38,778**	**39,253**	**41,284**	**42,928**	**44,557**
	-0.29%	*-0.15%*	*-0.12%*	*0.18%*	*1.08%*
327 (Excludes 3273) (Base)	47,093	46,659	47,095	47,988	48,411
327 (Excludes 3273) (Middle)	**47,081**	**46,703**	**47,155**	**48,119**	**48,752**
	-0.03%	*0.09%*	*0.13%*	*0.27%*	*0.71%*
331 (Excludes 331111) (Base)	27,562	27,772	28,541	29,187	29,574
331 (Excludes 331111) (Middle)	**27,586**	**27,884**	**28,690**	**29,421**	**30,064**
	0.09%	*0.40%*	*0.52%*	*0.80%*	*1.66%*
331111 (Base)	19,549	23,558	25,763	27,397	28,709
331111 (Middle)	**19,508**	**23,539**	**25,753**	**27,432**	**28,884**

NAICS CODE	**2012**	**2014**	**2016**	**2018**	**2020**
	-0.21%	*-0.08%*	*-0.04%*	*0.13%*	*0.61%*
332 (Base)	43,047	43,658	45,143	46,523	47,475
332 (Middle)	**42,762**	**43,358**	**44,796**	**46,305**	**47,691**
	-0.66%	*-0.69%*	*-0.77%*	*-0.47%*	*0.45%*
333 (Base)	22,378	22,706	23,430	24,610	25,358
333 (Middle)	**22,165**	**22,457**	**23,137**	**24,391**	**25,388**
	-0.95%	*-1.10%*	*-1.25%*	*-0.89%*	*0.12%*
334 (Base)	53,763	54,914	59,973	65,726	69,614
334 (Middle)	**53,205**	**54,247**	**59,201**	**65,150**	**69,684**
	-1.04%	*-1.22%*	*-1.29%*	*-0.88%*	*0.10%*
335 (Base)	5,285	5,257	5,492	5,812	6,066
335 (Middle)	**5,229**	**5,193**	**5,417**	**5,757**	**6,079**
	-1.05%	-1.22%	-1.37%	-0.95%	0.23%
336 (Base)	12,826	13,229	13,113	12,982	13,210
336 (Middle)	**12,688**	**13,061**	**12,911**	**12,809**	**13,158**
	-1.07%	*-1.27%*	*-1.54%*	*-1.33%*	*-0.40%*
337 (Base)	9,481	9,582	9,975	10,203	10,407
337 (Middle)	**9,360**	**9,435**	**9,802**	**10,062**	**10,386**
	-1.28%	*-1.53%*	*-1.74%*	*-1.38%*	*-0.20%*
339 (Base)	7,176	7,271	7,804	8,443	9,068
339 (Middle)	**7,040**	**7,094**	**7,595**	**8,264**	**8,997**
	-1.90%	*-2.43%*	*-2.68%*	*-2.13%*	*-0.78%*

Chapter 3: Manufacturing Employment, Economic Impact and Green Jobs Studies

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3.1 Introduction

As Maryland's manufacturing sector experiences energy and capital cost impacts from the 2008 Climate Action Plan (CAP), firms will adjust production. Among the production responses are adjustments to employment, which may be cut or increased depending on firm level cost impacts. Additionally, as Maryland's manufacturing sector is impacted by and responds to the CAP, repercussions will ripple through the state's economy. While some economic and social changes will be a direct result of what occurs in the manufacturing sector, other changes will extend beyond manufacturing and affect the whole economy. Namely, the CAP has the potential to influence the type and amount of employment opportunities available in Maryland by establishing the basis and motivation for a green economy. Chapter 2, which considers specific Greenhouse Gas Emissions Reduction Act of 2009 (GGRA) obligations (Table ES.1 in the Executive Summary), analyzes a range of employment and economic issues that stem from manufacturing specifically but apply to the economy at large.

This chapter reviews employment impacts in the manufacturing sector resulting from CAP-induced production costs. Section 3.2 explores whether production cost impacts will "result in a loss of existing jobs in the manufacturing sector" (MDGA, 2009, pg. 8). This analysis uses results from Chapter 2 including specific scenarios and assumptions (Table ES.2). Moreover, we define manufacturing in a consistent manner using the North American Industry Classification System (NAICS) to distinguish subsectors. We utilize the IMPLAN model to determine how changes in energy and capital costs translate to employment impacts.

After reviewing direct employment impacts in the manufacturing sector, we present broader economic impacts resulting from CAP-induced production cost impacts. Section 3.3 considers the "net economic impact to the state's economy" (MDGA, 2009, pg. 9). This study investigates effects on employment, wages, economic activity, and fiscal trends in Maryland deriving from manufacturing costs. Similar to Section 3.2, this study depends on Chapter 2 assumptions and scenario design and uses these within the IMPLAN model.

Last, we evaluate economy-wide green jobs potential as it relates to the CAP. Section 3.4 investigates whether the CAP will "produce a net increase of jobs in the state" and "encourage new employment opportunities related to energy conservation, alternative energy supply, and greenhouse gas emissions reduction technologies" (MDGA, 2009, pg. 9).

We review the green jobs concept, estimate existing green jobs in Maryland, and identify a set of occupations that correspond to the description above from the GGRA.

3.2 Manufacturing Employment

This section presents background information and analysis of manufacturing employment impacts resulting from Maryland CAP policies. Subsection 3.2.1 provides context for employment trends in Maryland manufacturing and outlines literature relating climate policies to job impacts. Subsection 3.2.2 presents methods of analysis, which rely on data and assumptions discussed in Chapter 2 (Tables ES.2 and 2.6), and findings for potential loss of jobs in Maryland's manufacturing sector resulting from CAP policies.

3.2.1 Background: Manufacturing Employment Trends and Climate Policy Impacts

Maryland's manufacturing sector has experienced a recent trend of declining employment. Most employment fluctuations have occurred during or around national economic recessions or expansions. The most notable periods of job loss occurred between 1990-1991 and 2001-2003 (BLS, 2011) (Figure 3.1). An economic slowdown in 1995 and certain statewide factors have also affected employment in various industrial sectors. The latest national recession, declared by the Business Cycle Dating Committee of the National Bureau of Economic Research, began in December of 2007 and ended in June, 2009 (NBER, 2010). Leading up to the recent recession was a prolonged period of overall employment expansion in Maryland.

The manufacturing sector experienced a decline of 5.4 percent (or more than 6,600 jobs) between the first quarters of 2009 and 2010, according to the Bureau of Labor Statistics. This was the 37th consecutive quarter of employment decline for Maryland manufacturing. Since 1990, quarters during which the manufacturing sector experienced year-over-year growth are few; the overall trend is one of decline (BLS, 2011). Our baseline employment projections through 2020 show similar rates of decline, albeit at a somewhat slower pace. Data showing historical and projected employment levels and annual employment growth for Maryland's manufacturing sector (NAICS 31-33) are provided below (Figure 3.1).

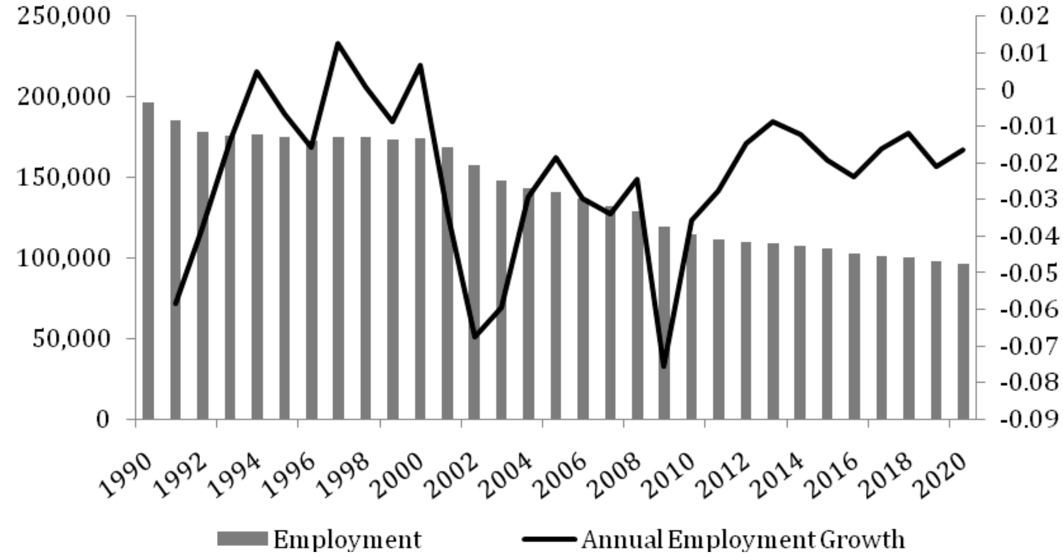

Figure 3.1 MD manufacturing employment (NAICS 31-33) (BLS, 2011); forecast by RESI

Manufacturing in the US has mostly experienced year-over-year declines in employment, with the greatest decrease occurring between the third quarters of 2008 and 2009 or 8.7 percent. There have been a few periods of employment gains, but these have been relatively minor and have not occurred in the entire sector since the fourth quarter of 2000 (BLS, 2011). Factors influencing cuts in U.S. manufacturing jobs include decreased consumer spending on goods (more on services) and increasing global competition (CBO, 2004).

Climate Policies and Employment Effects

A number of recent studies and publications have examined the effects of greenhouse gas (GHG) emissions reduction policies on employment. Of particular concern is carbon leakage, or a movement of manufacturing production to unregulated regions/countries resulting in equal or greater net GHG emissions, and employment declines in energy-intensive industries (e.g., iron and steel).

The Waxman-Markey bill (H.R. 2454) – landmark climate legislation in the U.S. that attempted to establish a national cap and trade system – has been at the center of recent debates over jobs and climate policy. In a 2009 article from *Seeking Alpha*, a finance journal, the author suggests cap and trade legislation would harm the steel industry (Chu, 2009). The article claims the cap and trade system established in the European Union resulted in job losses totaling 110,000, “or 2.2 jobs for every job created” (Chu, 2009). Similar concerns have been raised regarding a U.S. cap and trade system and the steel industry is seen as one of the most vulnerable subsectors due to its energy intensity and the potential for carbon leakage (Baron et al., 2008).

Additionally, a 2009 report from the Specialty Steel Industry of North America (SSINA) posited that the Waxman-Markey bill (H.R. 2454) could result in the loss of, "almost one-third of specialty steel and superalloy productive capacity in the United States and the highly paid and skilled jobs associated with that production." The report cites carbon leakage as a driving factor for job loss. SSINA estimates potential job loss in the U.S. specialty steel industry of 6 to 9 percent by 2020 and 23 to 29 percent by 2030 if federal legislation goes into effect (SSINA, 2009).

Higher energy costs associated with climate change policies, "could impose new economic burdens…and hurt competitiveness of U.S. businesses, resulting in the loss of jobs" (Yudken et al., 2009). Although there are job loss concerns, "most analyses have shown that climate policies would have only modest effects on manufacturing costs, profits, and outputs" (Yudken et al., 2009). Basic materials manufacturing, which are more energy-intensive, would feel a more significant impact from rising energy prices and competition from non-U.S. firms.

Despite these cautionary reports, it is difficult to accurately predict specific job growth or loss directly attributable to climate policies due to uncertain market trends and policy implementation. Moreover, studies such as those discussed above are generally concerned with direct employment impacts, which may contrast with total (direct, indirect and induced) employment impacts across all sectors. Economists typically measure three types of impacts: direct, indirect and induced. The direct economic effects are generated as new businesses create jobs and hire workers to fill new positions. The indirect economic impacts occur as new firms purchase goods and services from other firms. In either case the increases in employment generate an increase in household income, as new job opportunities are created and income levels rise. This drives the induced economic impacts that result from households increasing their purchases at local businesses. In this study, we apply a framework of analysis that includes these three distinct economic impacts.

The Congressional Budget Office (CBO) issued an economic and budget brief regarding this topic in 2010. The brief states that a variety of industries would be affected by GHG emissions reduction policies. Most notably, coal mining, "would probably see the largest percentage decline in employment," due to decreases in coal-fired electricity generation (Arnold et al., 2010). The CBO also predicts job losses in oil and gas extraction, natural gas utilities, mining for materials other than coal, construction, metal, nonmetallic, chemical manufacturing, and transportation services. However, job growth would be seen in low-emission industries as well as renewable energy and energy efficiency-related manufacturing industries (e.g., nuclear, solar, wind, etc.) (Arnold et al., 2010).

The CBO report also suggests total employment impacts could be minimized as long as businesses and workers adapt to changes quickly and efficiently–something the employment market has been able to do in response to changes in economic patterns. If quick and efficient adaptation occurs, then overall impacts would be minimal and short-term. Regardless of the time-scale, workers will have to transition to industries with higher productivity, which will likely require new training. Unfortunately, even after reemployment, many workers are likely to experience decreased earnings (Arnold et al., 2010). According to the CBO, "most laid-off workers would find employment in other industries whose products are less emission-intensive and produce fewer emissions when used and in industries that manufacture equipment for the production of energy using low-emission technologies" (Arnold et al., 2010). As a result, the economy would eventually return to normal employment levels.

Employees in manufacturing industries at risk for job cuts could potentially transition to occupations with similar skill requirements in a green industry, or industry that promotes energy efficiency, renewable energy supply or pollution control. Many existing skills can be applied to green jobs and job-training services are available. For more information regarding job training, green jobs and green industry, please refer to Section 3.4.

3.2.2 Methods and Findings: CAP Policy Impacts on Maryland Manufacturing Jobs

This subsection explains the methods used to quantify potential impacts on Maryland's manufacturing jobs and presents the findings.

Methods

To calculate direct job impacts in Maryland's manufacturing sector resulting from CAP policies, we rely upon analysis and findings discussed in Chapter 2. Specifically, we consider expected collective energy and capital cost changes resulting from the Regional Greenhouse Gas Initiative (RGGI), Renewable Portfolio Standard (RPS), and EmPower Maryland (EmPowerMD). The baseline case (without CAP) and three policy scenarios (with CAP) presented in Chapter 2 are used in the present employment analysis (see Tables ES.2 in the Executive Summary and 2.6 in Chapter 2 above). Our middle scenario aligns closest with historical trends and anticipated future projections. The high and low scenarios represent reasonable bounds under alternative market and policy assumptions.

Based on changes in production costs under each policy scenario we estimate subsequent direct employment impacts. This is accomplished through use of the IMPLAN model, an input/output tool designed to balance changes in expenditures or savings (e.g., capital or energy) with other factors of production, including labor. For more information regarding IMPLAN and RESI's methodology, please refer to Appendix 3.A. This analysis does not quantify green job growth in Maryland's manufacturing sector resulting from CAP policies. Given time and policies to promote green job growth, any CAP-related manufacturing employment losses could be offset by green-related manufacturing job creation. Green job opportunities are discussed in more depth in Section 3.4.

Findings

Under the middle scenario (see Tables ES.2 and 2.6), employment in the entire manufacturing sector will increase, though at an insignificant margin, as a result of CAP policies. Considering the trend of employment losses in Maryland manufacturing since the

1970s, job impacts associated with CAP policies under any scenario are comparatively low. The net direct job impacts in the manufacturing sector from 2009-2020 are presented in Table 3.1 below.

Table 3.1 Manufacturers job change (total number of jobs) relative to baseline under three scenarios, 2009-2020

Scenario	**Change in Employment, 2009-2020**
Middle	18.7
Low	267.5
High	-267.8

As shown in Table 3.1, the high scenario will result in the greatest net direct job loss for manufacturing, at approximately 267.8 jobs over the period between 2009 and 2020. Such employment declines are minimal when compared against general job loss trends in manufacturing. During the same period, the middle scenario results in a net direct gain of 18.7 jobs and the low scenario results in net direct gain of approximately 268 jobs. Net job gains occur mostly as a result of energy cost savings in early years (e.g., 2010-2015) in less energy-intensive industries (Table 3.2).

Table 3.2 Job changes for period 2009-2020 relative to baseline by subsector*

Subsector and NAICS Code	**Change in Employment, 2009-2020**		
	Middle	**Low**	**High**
TOTAL (NAICS 31-33)	18.7	267.5	-267.8
Food Manufacturing (311)	-4.4	22.9	-36.9
Beverage and Tobacco Product Manufacturing (312)	-0.1	1.6	-2.1
Textile Mills (313)	-3.6	6.6	-15.9
Textile Product Mills (314)	-0.8	3.4	-5.8
Apparel Manufacturing (315)	0.7	1.8	-0.5
Leather and Allied Product Manufacturing (316)	0.0	0.1	0.0
Wood Product Manufacturing (321)	-2.8	13.6	-22.1
Paper Manufacturing (322)	-0.3	6.3	-8.0
Printing and Related Support Activities (323)	18.6	49.1	-14.4
Petroleum and Coal Products Manufacturing (324)	-0.2	0.6	-1.1
Chemical Manufacturing (325)	-6.6	14.6	-32.1
Plastics and Rubber Products Manufacturing (326)	-2.8	15.3	-24.2
Nonmetallic Mineral Product Manufacturing (327)	-4.5	14.9	-27.5
Primary Metal Manufacturing (331)	-3.9	5.8	-15.6
Fabricated Metal Product Manufacturing (332)	3.7	27.4	-23.2
Machinery Manufacturing (333)	3.9	15.0	-8.5
Computer and Electronic Product Manufacturing (334)	9.3	34.4	-18.5
Electrical Equipment, Appliance, and Component Manufacturing (335)	0.8	3.3	-2.1
Transportation Equipment Manufacturing (336)	2.2	6.0	-1.9
Furniture and Related Product Manufacturing (337)	4.2	13.0	-5.5
Miscellaneous Manufacturing (339)	5.4	12.1	-1.7

* Figures in may not add up to totals due to rounding

Overall, we find that employment impacts in Maryland's manufacturing sector as a result of CAP policies will be small. Employment data from the U.S. Bureau of Labor Statistics and projections from RESI predict a loss of approximately 22,608 jobs in Maryland's manufacturing sector between 2009 and 2020 under a baseline scenario (BLS, 2011). Considering these background trends, the greatest additional loss of jobs resulting from CAP policies (in the high scenario) would result in an increase of employment losses of approximately 1 percent during the same period. Employment losses of this magnitude would be well within the range of employment declines expected to occur without the CAP and consistent with trends over the last decade.

3.3 Economic and Fiscal Impacts

This section analyzes total impacts (e.g., direct, indirect, induced) on Maryland's economy resulting from manufacturing production cost changes. The section presents methodology, which relies on assumptions and data presented in Chapter 2, and findings including changes in economic activity and economy-wide employment.

3.3.1 Methods and Findings: Impacts on Economy Resulting from Manufacturing Costs

Methods

To calculate economic and fiscal impacts in Maryland resulting from CAP policies, we rely upon analysis and findings discussed in Chapter 2. Specifically, we consider energy and capital cost changes resulting from the RGGI, the RPS, and EmPowerMD. The baseline case (without CAP) and three policy scenarios (with CAP) presented in Chapter 2 are used in the present employment analysis (see Tables ES.2 in the Executive Summary and 2.6 in Chapter 2 above). Similar to the manufacturing jobs analysis, collective changes in production costs under each policy scenario are used as an input to estimate direct, indirect, and induced impacts in Maryland's economy. Our middle scenario aligns closest with historical trends and anticipated future projections. The high and low scenarios represent reasonable bounds under alternative market and policy assumptions.

In order to best coordinate with and relate to data presented in previous chapters, we considered only the energy cost and capital cost implications of the aforementioned policies. Our analysis of economic impacts considers CAP effects on the manufacturing sector only and does not involve potential green manufacturing growth. For example, any economic activity resulting from increased demand for renewable energy technology and subsequent production is not included. Furthermore, we do not account for economic activity resulting from disbursement of Strategic Energy Investment Fund (SEIF) monies (e.g., for energy efficiency spending) nor do we consider fiscal benefits accruing to the state via sale of RGGI allowances.

In order to quantify the economic impact of Maryland's CAP policies, RESI utilized the IMPLAN input/output model. This model enumerates the employment and fiscal impact of each dollar earned and spent by the following: employees of the new business, other supporting vendors (business services, retail, etc.), each dollar spent by these vendors on other firms and each dollar spent by the households of the new business' employees, other vendors' employees, and other businesses' employees. To quantify the economic impact of a new policy, economists measure three types of economic impacts: direct, indirect, and induced impacts. For more information regarding IMPLAN and RESI's methodology, please refer to Appendix 3.A.

Findings

Under the middle scenario, economic impacts will be mixed including net employment gains and net loss of economic activity. Total impacts, encompassing direct, indirect and induced effects, can be found below in Table 3.3.

Table 3.3 Total economic impacts relative to baseline under three policy scenarios, 2009-2020 ($2006)

Scenario	Economic Activity	Employment	Wages	Fiscal Impact*
Middle	-$3,629,105	17.7	$1,138,325	-$2,977
Low	$133,051,839	595.3	$31,953,428	$3,734,194
High	-$162,714,528	-650.0	-$34,461,921	-$4,241,905

* The fiscal impact includes state and local property, income, sales and payroll tax revenues

The total (direct, indirect and induced) economic and fiscal impacts associated with the change in production costs (energy and capital costs) for all sectors in the state are small compared to long-term trends. Under the middle scenario, there is a total loss of $3.6 million in economic activity and a gain of about 17 jobs and $1.2 million in wages. The presence of both employment (and wage) gains and economic activity losses follows from the split between energy-intensive and less energy-intensive industries. Less energy-intensive subsectors may see energy savings as a result of CAP policies and subsequent growth in employment and output. Conversely, energy-intensive industries will see greater energy costs and decreases in output and employment. However, industries generate output per employee at different rates. Specifically, energy-intensive industries (e.g., primary metals, nonmetallic products) tend to have fewer employees and greater output per person, so each employee lost results in relatively larger output losses. The net effect is that output losses in energy-intensive industries outweigh the output gains in less energy-intensive industries while employment gains in less energy-intensive industries outweigh employment losses in energy-intensive industries.

The two other scenarios analyzed do not create this effect. The high scenario creates negative impacts across all categories (i.e., economic activity, wages, employment, fiscal activity), whereas the low scenario produces positive impacts across all categories. Table 3.4 breaks impacts down into direct, indirect and induced impacts for each scenario (see Appendix 3.B for annual economic impacts by scenario).

Table 3.4 Economic impacts by type and policy scenario relative to baseline scenario, 2009-2020 (2006$)

Impact Type	**Direct**	**Indirect**	**Induced**	**Total***
Middle Scenario				
Economic Activity	-$2,599,043	-$1,708,472	$678,411	-$3,629,105
Employment	18.7	-6.4	5.3	17.7
Wages	$1,233,597	-$305,181	$209,909	$1,138,325
Fiscal Impact**				-$2,977
Low Scenario				
Economic Activity	$82,632,288	$29,517,362	$20,902,189	$133,051,839
Employment	267.5	163.1	164.6	595.3
Wages	$16,711,892	$8,774,355	$6,467,181	$31,953,428
Fiscal Impact				$3,734,194
High Scenario				
Economic Activity	-$101,903,624	-$38,188,176	-$22,622,728	-$162,714,528
Employment	-267.8	-204.0	-178.2	-650.0
Wages	-$16,574,864	-$10,887,554	-$6,999,503	-$34,461,921
Fiscal Impact				-$4,241,905

* Figures may not add up to totals due to rounding; **Fiscal impacts as produced by IMPLAN cannot be broken down into impact types

Although the net economic and fiscal impacts are negative in two of the three scenarios, it is important to note that the magnitude of these impacts is relatively minor compared to Maryland’s overall economy. For example, according to the U.S. Bureau of Economic Analysis, between 2005 and 2009, the latest year for which data is available, Maryland's real state GDP increased by an average of $10.3 billion per year (BEA, 2011). Average annual economic losses under the high scenario, or approximately $13.6 million per year, would be a very small fraction (about a tenth of a percent) of typical annual changes in Maryland's economy. Additionally, the total number of jobs in Maryland in 2009 was approximately 2.3 million (BLS, 2011). The high scenario, which had the greatest employment loss for 2009 among the three scenarios, would account for a fraction of 1 percent of overall employment in the state. Finally, it is important to recognize the limited scope of this analysis and to place the findings in context with previous research. Section 3.5 discusses study limitations and applications in more depth.

3.4 Potential Green Job Opportunities

This section reviews green job opportunities in Maryland in light of the state’s GHG mitigation policies. Subsection 3.4.1 defines green jobs in a manner consistent with other entities. Then, with a definition in place, Subsection 3.4.2 provides figures of Maryland’s current green jobs. Subsection 3.4.3 considers the future of green jobs in the state given occupational demand and industry growth trends. Subsection3.4.4 presents methods and findings for potential green occupations in energy conservation, renewable energy, and GHG reduction fields. Finally, Subsection 3.4.5 covers the transition to a green economy through a review of Maryland’s existing green job opportunities and a sampling of model programs and best practices from other states.

3.4.1 Defining Green Jobs and a Green Economy

In September 2010, the Bureau of Labor Statistics (BLS) released their definition of green jobs for two surveys that will be used to collect data on jobs associated with producing green goods and services. Data collection is planned to begin in early 2011 with a publication slated for spring 2012 (BLS, 2011). Following this definition, a two-pronged approach is used, including:

- *Output approach*: Jobs in businesses that produce goods or provide services that benefit the environment or conserve natural resources;
- *Process approach*: Jobs in which workers' duties involve making their establishment's production processes more environmentally friendly or use fewer resources.

Prior to the definition released by the BLS there was no official definition, let alone a standard method for quantifying green jobs. However, an extensive literature review points to several categories of common green job characteristics. For example, definitions tend to categorize green jobs as part of industries and businesses engaged in improving energy efficiency, producing renewable energy, or preventing and cleaning up pollution. Due to the current lack of green-job data from the BLS, for the purposes of this study, we will use the general guidelines outlined in our literature review as a method for analyzing green job activity.

The U.S. green economy has grown significantly over the last several years. In fact, recent studies suggest green jobs are growing at a faster rate than traditional jobs. According to a 2009 report published by the Pew Charitable Trusts, the number of jobs in America's emerging clean energy economy grew nearly two and a half times faster than all jobs between 1998 and 2007. During this growth period, the green economy flourished with minimal government funding or investment. Funding received as a result of the American Reinvestment and Recovery Act (ARRA) in 2010 is arguably the first, comprehensive government initiative to fund and promote clean energy and the green economy. ARRA funds included $92 billion for clean technology; nearly $33 billion in clean energy and $27 billion in energy efficiency nationwide (Pew, 2009).

A green economy is based on using energy efficiently, limiting pollution and developing renewable sources of power. To understand the current state of Maryland's green economy, we focus on quantifying green jobs. RESI follows the methodology used by the Maryland Green Jobs and Industry Task Force, which was developed using survey data from the *Greening of Oregon's Workforce Report* (OED, 2009). In Oregon, the top three industries with a significant share of green jobs include natural resources and mining (11% of jobs are green), construction (9%), and utilities (8%). Approximately 2 percent of the manufacturing jobs in Oregon are considered green (OED, 2009).

The *Greening of Oregon's Workforce Report* asked private firms and state and local government agencies to provide information about their employees who worked in any of the green activity categories. The report defined a green job as one that provides a service or produces a product in:

- Increasing energy efficiency
- Producing renewable energy
- Preventing, reducing, or mitigating environmental degradation
- Cleaning up and restoring the natural environment
- Providing education, consulting, policy promotion, accreditation, trading and offsets, or similar services that support the previous four categories (OED, 2009).

3.4.2 Green Jobs in Maryland

To estimate current green jobs in Maryland, we apply the percentage of green jobs in *Greening of Oregon's Workforce Report* to Maryland (OED, 2009). Using Quarterly Census of Employment and Wage data from the BLS, RESI calculated the current amount of green jobs in Maryland for 2008 and 2009 (BLS, 2011). Based on the 2.4 million jobs in Maryland in 2008 and applying industry appropriate green job percentages, we estimate that roughly 72,000 or approximately 3.0 percent of the total workforce could be classified as a green job in 2008. In 2009, employment fell to 2.3 million jobs and the number of green jobs estimated dropped to 70,000; as a percentage of the total workforce, the number of green jobs remained the same between 2008 and 2009 (Table 3.5).

Table 3.5 Green jobs in Maryland, 2008-2009, by major sectors (BLS, 2011)

Sector	Maryland Jobs in 2008	Estimated Green Jobs in 2008	Maryland Jobs in 2009	Estimated Green Jobs in 2009	Absolute Change in Green Employment, 2008-2009
All Jobs	**2,409,776**	**72,293**	**2,328,832**	**69,865**	**(2,428)**
Natural Resources and Mining	6,511	716	6,424	707	(10)
Construction	178,072	16,026	153,091	13,778	(2,248)
Utilities	10,274	822	10,101	808	(14)
Administrative and Waste Services	151,601	12,128	139,807	11,185	(944)
Professional Technical Services	226,066	15,825	224,240	15,697	(128)
Wholesale and Retail Trade	386,247	11,587	364,526	10,936	(652)
Other Services	90,106	1,802	87,727	1,755	(48)
Manufacturing	128,415	2,568	118,658	2,373	(195)
State and Local Government	343,395	6,868	345,745	6,915	47
Leisure and Hospitality	236,183	2,362	230,245	2,302	(59)
Transportation and Warehousing	64,585	646	61,723	617	(29)
Information	49,800	498	46,240	462	(36)
Management of Companies and Enterprises	21,282	213	20,001	200	(13)
Education and Health Services	367,961	3,680	378,434	3,784	105
Financial Activities	149,278	149	141,870	142	(7)

3.4.3 Future of Green Jobs in Maryland

Clean energy and energy efficiency industries have the potential to create a significant number of new jobs. National estimates calculated by the Political Economy Research Institute and Center for American Progress indicate that each $1 million invested in clean energy and energy efficiency will create 16.7 jobs compared with 5.3 created through spending on oil, gas and coal (CAP, 2009). Another study estimates renewable energy and energy efficiency industries could create 37 million new jobs in the U.S. by 2030 (Bezdek, 2009).

While the green economy plays an important role in Maryland, Pew's 2009 clean energy report suggests Maryland plays a small part in the national clean energy economy. Unlike the U.S. as a whole, Maryland total job growth outpaced green job growth between 1998 and 2007 (Pew, 2009). That is not to say, however, that Maryland does not have the foundation to expand its' share of the green economy. The Pew report points out that

Maryland ranks sixth in the nation in clean technology and venture capital investments. This is a positive sign for growth potential as investment in Maryland's green businesses today could position them for long-term success.

Job Growth Projections

A study compiled by RESI, in conjunction with the International Center for Sustainable Development, Inc., enumerated the economic development potential of clean energy technologies in Maryland (Spears et al., 2008). According to study findings, in 2006, clean energy was a $50 billion per year industry worldwide growing at a rate of 30 percent per year. As is stands, Maryland is expected to be a participant in worldwide green economy growth. Depending on growth in energy efficiency, renewable energy and alternative fuel industries, green job creation in Maryland will vary. At the lowest clean energy industry growth level, Maryland will gain approximately 144,000 jobs over a 20-year period. At the highest growth level, approximately 326,500 jobs could be created (Spears et al., 2008). It should be noted that these growth projections were estimated prior to ARRA funding and could underestimate short-term gains associated with the stimulus

ARRA Job Impacts

Funding from the ARRA could prove to be an integral part of developing Maryland's green workforce. The White House Council of Economic Advisors estimates it takes approximately $92,000 in government spending to create one job-year or one job for one year. To estimate the number of jobs attributable to the ARRA, we add up the average number of jobs created per year by the stimulus funding directed to Maryland. Using this approach, the $117 million allocation of ARRA funds to Maryland under the "Energy" category is expected to generate approximately 1,272 job-years. ARRA funding should be fully allocated by FY 2010 and needs to be spent within two years of allocation or by FY 2012. While ARRA funding plays a factor in the short-term green job composition of Maryland, it is not instrumental to the state's overall job composition. For instance, if 1,272 jobs were created in one year, it would amount to just 2.0 percent of 2009 green jobs in Maryland (CEA, 2009)

Occupational Demand

The emerging clean energy economy is creating well-paying jobs in every state for people of all skill levels and educational backgrounds (Pew, 2009). GHG mitigation policies in Maryland will inevitably have an impact on the employment climate of the state. As evidenced by prior studies on job creation, the initiatives to stimulate energy efficiency investments, alternative energy expansion and GHG emission reduction technologies will spur job market opportunities in the coming years (Ruth et al., 2007 and 2008).

As the green economy in Maryland matures, there is potential for creation and development of new occupations. However, most growth in green jobs will occur in areas of employment existing today. For example, as activities associated with green building construction and retrofitting grow, so will demand for construction jobs and manufacturing jobs that supply green-building products. Construction jobs transition to the green economy as skills possessed by roofers, insulators and building inspectors are easily adaptable. Within manufacturing, energy efficient products such as compact fluorescent lights (CFLs), water filtration systems, insulation, solar water heaters, and wind turbines will all be in greater demand (EDF, 2008).

Inevitably, growth of alternative energy sources will impact the manufacturing sector. Maryland has opportunities to be a player in this growing industry by utilizing its existing infrastructure and workforce. For example, wind turbine equipment will require a manufacturing base similar to what currently exists. As a result, blade, turbine and gearbox component manufacturing will be necessary. A complete overhaul of existing infrastructure and processes is not necessary as most jobs associated with the wind industry (about 70 percent) are in the manufacturing of components rather than complete turbine systems (AA and UH, 2007). Examples of using existing manufacturing infrastructure to transition into green product development are abundant. For instance, mills that are struggling because of a shrinking wood pulp and paper industry can make modifications to existing infrastructure in order to process wood waste into biofuels such as biobutanol (Galbraith, 2009). Likewise, old photographic film factories have been retrofitted to produce photovoltaic film used in solar power (Arnold et al., 2010). Even car manufacturing plants are being retooled to produce solar panels by using existing glass, sheet metal and motor supply chains (Energy Business Daily, 2009). In other words, the existing manufacturing infrastructure will greatly benefit the transition to manufacturing of green products. Manufacturers may find that by changing small aspects of their production, for example by making their products more energy efficient or supplying materials to other green projects, they can achieve growth in the green sector.

3.4.4 Green Jobs and Maryland's CAP

To better understand the types of jobs that will result from new policies and mandates under Maryland's CAP, we compiled a profile of relevant green occupations. Employment information was collected from the U.S. Labor Department's occupational network (O*Net), including: green economy activities and technologies, occupational requirements, and profiles of new and emerging occupations (ONET, 2011). RESI compiled occupational data most relevant to Maryland in light of the GGRA and CAP policies. We find that due to the nature of Maryland's varied occupational profile, most new green jobs will be in the areas of skill enhancement, or adding skills to existing careers.

Methods

O*Net investigates the impact of green economy activities and technologies on occupational requirements and the development of new and emerging occupations. Using data from O*Net, green occupations are identified (ONET, 2011). O*Net's methodology for identifying and classifying occupational information is divided into three portions: (1) the content model, (2) O*Net-SOC taxonomy, and (3) data collection. The content model defines every occupation with a collection of specific variables called "descriptors," which define the qualification and skills needed in each occupation. O*Net has incorporated 277 "descriptors" with more values added by research from federal agency sources such as the BLS. The content model allows descriptors to correspond with job traits across different occupations and industries to analyze similarities between two unrelated jobs. To update the system, which places and defines occupations across all industries, O*Net defines its SOC (Standard Occupational Classification) through data collected from recent job incumbents and occupational experts. To aid in the classification of these positions, O*Net added the SOC taxonomy. This ensures that 840 detailed occupations are combined into 461 broad occupations, 97 minor groups, and 26 major groups. O*Net annually polls populations and consults occupational experts to collect statistics. Each polled population is selected from a random sampling of businesses expected to employ particular occupations. (ONET, 2011).

O*Net's data led to the identification of green economic sectors, green increased demand occupations, green enhanced skills occupations, and green new and emerging occupations. These occupations are now reflected in the O*NET-SOC system. Since activities related to the green economy can be varied, to efficiently and effectively determine the potential occupational implications of green technology, workplace activities are categorized under different green economy sectors (ONET, 2011). These sectors include:

- Renewable Energy Generation
- Transportation
- Energy Efficiency
- Green Construction
- Energy Trading
- Energy and Carbon Capture and Storage
- Research, Design, and Consulting Services
- Environmental Protection
- Agriculture and Forestry
- Manufacturing
- Recycling and Waste Reductions
- Governmental and Regulatory Administration

Findings

RESI compared and contrasted these sectors with GGRA language and the Environmental Defense Fund's Green Job Guidebook (EDF, 2009). Specifically, under the GGRA, emission reduction measures in the state's pending climate action plan should encourage new employment opportunities related to energy conservation, alternative energy supply, and GHG reduction technologies (MDGA, 2009). Accordingly, using O*Net occupational information, RESI developed a comprehensive list of green occupations under each of these categories (See Appendix 3.C).

3.4.5 Transitioning to a Green Economy

Transitioning an economy towards supporting and cultivating green-collared jobs will be facilitated by training and educational opportunities. Displaced workers across all sectors are susceptible to overlooking career opportunities in science and technology and may not realize only minor training is necessary to transition into growth industries like high-tech manufacturing or renewable energy. Maryland has multiple training programs that can prepare workers for the green economy. Below is a sampling of existing resources across the state (Table 3.6).

Table 3.6 Educational, training and employment placement services in Maryland (MDGWIB, 2009; DLLR, 2011)

Programs	**Program Description**
Baltimore Regional Green Tech Workers Program	• Improve manufacturing sustainability practices • Waste steam management and "lean to green" practices in manufacturing sector
Manufacturing Skill Standards Council (MSSC)	• Certificate recognized nationwide • Focuses on the core skills and knowledge by the nation's production workers
Maryland One Stop Workforce Centers	• Designed to serve Maryland's business and dislocated workers • Trains workers in skills related to industrial manufacturing of green technology and energy efficient manufacturing
Maryland Business Green Worker Training (MGWT)	• Designed for employers who wish to provide their incumbent workers with green training within the scope of the MESP grant • Increase sustainability and energy efficiency competencies for Maryland's manufacturing workforce • Incumbent or skilled worker Green Workforce Certification
Maryland Energy Sector Partnership (MESP)	• Promote skills attainment and career pathway development in green jobs in the fields of manufacturing and construction
Building Trades & Construction-The Green Training for Energy Efficiency Achievement (Green TEEA)	• To provide training in green construction including energy-efficiency, insulation training, building information and modeling, electrical generation/Smart Grid Technology; green building maintenance, residential retrofitting and deconstruction
Renewable Technology-Go Solar! Consortia	• To provide electricity basics and PV installation training for entry-level workers, and incumbent worker certification in North American Board of Certified Energy Practitioners (NABCEP's). • Entry Level Certificate of Knowledge of Solar Photovoltaic (PV) Systems and Solar PV Installer Certification examination.
Environmental Technology-CACHE Institute for Environmental Careers	• To provide environmental tech training that meets the needs of industries, government agencies, land management companies, developers and other firms.

Model Programs

Maryland can ease its transition to a green economy by adopting best practices and looking to other states for examples of successful programs. RESI's research uncovered strategies that may help attract green jobs and create a green-collar workforce. Due to the emerging quality of the green economy, and relatively recent implementation of these strategies, many of the practices have no recorded results, making a measure of their success limited.

The three programs outlined below represent current thinking and may serve as models, which Maryland should consider emulating to meet its green economy aspirations.

New Hampshire—Green Incubation and Start-Up Support
The University of New Hampshire (UNH) in partnership with the State of New Hampshire and the Governor designed and implemented a plan on February 9th, 2010 to create a self-sustaining fund called the Green Launching Pad. The hope is that this fund will bring new green technologies to the marketplace, help innovative clean technology companies succeed and support the creation of green economy jobs. Established and startup companies will receive extensive financial, operational, technical, and managerial support to launch new green products and services. $750,000 will be originally funded through the state and the ARRA for two years and will then become self-sustaining through industry, private foundations, public investments, and funds that revolve back into the program via successful ventures. Businesses compete to present the most innovative and highest potential plans in order to receive a share of funding or aid. Aid comes in the form of marketing and managerial support, but also as help from UNH providing research and student interns. Each business is given the summer to develop its business plan and strategies before aid is lifted and it enters the market looking for its own backing and profits (UNH, 2010).

California—Tracking Emerging Occupations
On September 8th, 2008, the Green Workforce Coalition was tasked with growing California's green-collar workforce. The main objective of the coalition and its members is to identify new and emerging green occupations and to cooperate with training and education providers to fill the new positions in these fields. The coalition is partnered with middle and high schools to encourage student interest and participation in STEM (Science, Technology, Engineering, and Mathematics) programs, which naturally tie in with future green technology fields. Also, through a partnership with California colleges, namely California community colleges, the world's largest higher education system with over 2.9 million students, the coalition can match green-workforce demand with graduating students (CGWC, 2010).

Florida—Skill Development and Training
In June 2008, Florida created a green workforce readiness system called Greenforce Florida. By January 2009, Greenforce Florida determined the occupations that are in need of immediate training in specific regions and will take action to put those training needs–especially two and four year degrees–on the fast-track. Several teams have been created to work on different initiatives; teams have assessed a region's needs, developed training programs and expedited graduates into green fields. Through cooperation with institutions of higher education, Greenforce Florida will help the education systems adapt to what they perceive as up-and-coming green workforce demands (FDE, 2010).

Future of the Green Economy in Maryland

Green jobs in Maryland have received attention from partnerships between state and local government, as well as between the public and private sector. The effectiveness of these partnerships in advancing the green economy remains to be seen, but their presence has stimulated important dialogue. For example, the Governor's Workforce Investment Board's energy industry steering committee (the Steering Committee) set out to define the number and types of green jobs as well as refine existing education and training programs (MDGWIB, 2009). In the end, the Steering Committee, composed of a variety of stakeholders from all sectors of the economy and branches of Maryland government, provided the Governor with a report and recommendations designed to nurture the growth and development of green jobs in the state.

The *Green Job and Industry Task Force* (the Task Force) is another example of a private-public partnership (DBED, 2010). The Task Force, consisting of a diverse group of individuals in government and the private sector, compiled a set of recommendations designed to improve green industry and employment opportunities in Maryland. The Task Force recommended strengthening communication across different partners and stakeholders, capitalizing on existing opportunities, and promoting sustainable development practices that create jobs (DBED, 2010). Public-private partnerships are a valuable starting point for establishing the foundation of a green economy. However, it is up to individual stakeholders to champion the adoption and implementation of recommendations and action plans.

Finally, it is important to note that developing and preparing a workforce is only half of the challenge. There must also be demand for green jobs, which will be driven by the private sector through a realization of the economic value of green industries. If the public sector facilitates demand for green jobs through technology and process innovation, for example, Maryland will be strongly positioned to emerge as a green economy leader.

3.5 Discussion: Findings and Constraints

The findings presented in Chapter 2 demonstrate that Maryland's CAP, and specifically the RGGI, the RPS and EmPowerMD, which are part of the CAP, will create insignificant production cost impacts for Maryland's manufacturing sector. In the analyses of Chapter 3 we quantified the existing trends of decreasing employment in the state and extracted information on potential CAP-related impacts on jobs. Findings from Section 3.2 show that the state can expect small job gains relative to existing manufacturing jobs or annual changes in employment. Under alternative policy scenarios those manufacturing job impacts may be positive or negative, but compared to underlying employment trends in manufacturing, these changes will be minimal. Moreover, we find that job impacts will vary across subsectors with energy-intensive firms (e.g., metals, chemicals) experiencing comparatively greater impacts relative to less energy-intensive industries (e.g., printing, computer and appliances).

In Section 3.3 we evaluated the effects of manufacturing cost impacts on the Maryland economy. Based upon our best estimate of policy implementation and market trends, economic activity in the state will decrease by a small magnitude as a result of CAP-induced manufacturing costs. Under alternative scenarios, net economic impacts including wages, jobs, and fiscal activity may be positive or negative. These findings contribute important information to the ongoing discussion of Maryland's climate policies and economic feasibility. The results reveal where the state can improve policy to be more cost-effective and responsive to the manufacturing sector. Moreover, the narrow-scope of the study suggests consideration of previous research on the impacts of EmPowerMD (PIRG, 2010; ACEEE, 2008) and RGGI (Ruth et al., 2007 and 2008), as well as supplemental CAP policies such as expansion of combined heat and power resources (PPRP, 2006). These studies present valuable context that should be included in the broader discussion of Maryland's CAP and the net economic impact.

Finally, we discuss the present and future state of Maryland's employment opportunities in the context of the CAP. In Section 3.4, we adopt a definition of green jobs that is consistent with a number of different studies conducted for other states. We use this definition to estimate green jobs in Maryland. Lack of supporting data for the U.S. Bureau of Labor Statistics "green job" definition led us to rely on a broad categorization of green jobs. In 2008 and 2009, green jobs in Maryland accounted for 3 percent of the workforce, or approximately 70,000 jobs. The green jobs outlook in the state is positive. Green jobs in Maryland will be created in part by the ARRA and similar government support, but most green jobs will be created by emerging green industries in both service and goods sectors. Using O*Net data, we develop a set of occupations related to energy conservation, alternative energy supply, and greenhouse gas emissions reduction technologies that may emerge as Maryland transitions to a green economy. Finally, we examine Maryland's existing educational and career tools as well as look at case studies from other states as a means for informing the transition to a green economy.

Constraints and Assumptions

There are some constraints to the methodology, specifically limitations associated with the IMPLAN model, which should be noted. First, all monetary impacts are measured in 2006 dollars, as IMPLAN requires the selection of a default year. IMPLAN analyzes the default year and generates linear impacts based on that single year. As a result, IMPLAN impacts were determined for 2009 (measured in $2006) and scaled according to the difference between the capital cost and energy cost inputs for 2009 and cost inputs for other years. In addition, capital cost and energy cost inputs were modeled together as negative industry sales.

Also, while the IMPLAN model provides a comprehensive economic impact analysis, one shortcoming is that the model assumes an infinite supply curve and as a result, there are no price effects feeding back into the analysis. By incorporating price effects, a more complete analysis can be undertaken. One such modeling tool is the Regional Economic Model, Inc.

(REMI) model, which tends to be cost prohibitive for smaller scale studies but could be considered for further extensions of the current analysis.

Last, it is important to emphasize two design constraints associated with the analysis presented in this chapter. First, the employment and economic studies presented in Sections 3.2 and 3.3 depend on methodology, assumptions, and results discussed in Chapter 2. As a consequence, these limitations also apply to the findings of studies presented in this chapter. Second, analysis of manufacturing employment and economic impacts is performed strictly through a lens of production cost impacts incurred in the manufacturing sector as a result of CAP policies. Our analysis does not consider the "benefits" side of the equation or the potential emergence of green manufacturing (e.g., renewable energy supply, energy efficiency technology) more likely to occur under CAP policies. Likewise, CAP interactions in the broader industrial sector, as well as commercial and residential sectors, are not included in our analysis. Thus, this research should contribute to the discussion of GGRA requirements and overall economic feasibility of Maryland's climate action plan, while also being supplemented by ongoing analyses and previous studies.

3.6 Appendices

Appendix 3.A – IMPLAN Model Overview

In order to quantify the economic impact of Maryland's GGRA considered in this analysis, RESI utilized the IMPLAN input/output model. This model enumerates the employment and fiscal impact of each dollar earned and spent by the following: employees of the new business, other supporting vendors (business services, retail, etc.), each dollar spent by these vendors on other firms and each dollar spent by the households of the new business' employees, other vendors' employees, and other businesses' employees.

To quantify the economic impact of a new policy, economists measure three types of economic impacts: direct, indirect, and induced impacts. The direct economic effects are generated as new businesses create jobs and hire workers to fill new positions. The indirect economic impacts occur as new firms purchase goods and services from other firms. In either case the increases in employment generate an increase in household income, as new job opportunities are created and income levels rise. This drives the induced economic impacts that result from households increasing their purchases at local businesses.

Consider the following example. A new firm opens in a region and directly employs 100 workers. The firm purchases supplies, both from outside the region as well as from local suppliers, which leads to increased business for local firms, thereby creating jobs for say, another 100 workers. This is called the indirect effect. The workers at the firm and at suppliers spend their income mostly in the local area, creating jobs for hypothetically another 50 workers. This is the induced effect. The direct, indirect, and induced effects add up to 250 jobs created from the original 100 jobs. Thus, in terms of employment, the total economic impact of the hypothetical firm in our example is 250. Total economic impact is defined as the sum of direct, indirect and induced effects.

What is IMPLAN?

IMPLAN is an economic impact assessment software system. The system was originally developed and is now maintained by the Minnesota IMPLAN Group (MIG). It combines a set of extensive databases concerning economic factors, multipliers and demographic statistics with a highly refined and detailed system of modeling software. IMPLAN allows the user to develop local-level input-output models that can estimate the economic impact of new firms moving into an area as well as the impacts of professional sports teams, recreation and tourism, and residential development. The model accomplishes this by identifying direct impacts by sector, then developing a set of indirect and induced impacts by sector through the use of industry-specific multipliers, local purchase coefficients, income-to-output ratios, and other factors and relationships.

There are two major components to IMPLAN: data files and software. An impact analysis using IMPLAN starts by identifying expenditures in terms of the sectoring scheme for the model. Each spending category becomes a “group” of “events” in IMPLAN, where each event specifies the portion of price allocated to a specific IMPLAN sector. Groups of events can then be used to run impact analysis individually or can be combined into a project consisting of several groups.

The overall movement of jobs into Maryland is defined as the direct economic impact. Once the direct economic impacts have been identified, IMPLAN can calculate the indirect and induced impacts based on a set of multipliers and additional factors.

The hallmark of IMPLAN is the specificity of its economic datasets. The database includes information for 528 different industries (generally at the four or five digit North American Industrial Classification level), and twenty-one different economic variables. Along with these data files, national input-output structural matrices detail the interrelationships between and among these sectors. The database also contains a full schedule of Social Accounting Matrix (SAM) data. All of this data is available at the national, state, and county level.

Another strength of the IMPLAN system is its flexibility. It allows the user to augment any of the data or algorithmic relationships within each model in order to more precisely account for regional relationships. This includes inputting different output-to-income ratios for a given industry, different wage rates, and different multipliers where appropriate. IMPLAN also provides the user with a choice of trade-flow assumptions, including the modification of regional purchase coefficients, which determine the mix of goods and services purchased locally with each dollar in each sector. Moreover, the system also allows the user to create custom impact analyses by entering changes in final demand. This flexibility is a critically important feature in terms of the RESI proposed approach.

RESI is uniquely qualified to develop data and factors tailored to this project, and, where appropriate, overwrite the default data contained in the IMPLAN database.

Another major advantage of IMPLAN is its credibility and acceptance within the profession. There are over five hundred active users of IMPLAN databases and software within the federal and state governments, universities, and among private sector consultants. Table 3.A provides a sampling of IMPLAN users.

Table 3.A Sampling of IMPLAN Users

Academic Institutions	**State Governments**
Alabama A&M University	MD Dep't of Natural Resources
Albany State University	Missouri Dep't of Economic Dev.
Auburn University	California Energy Commission
Cornell University	Florida Division of Forestry
Duke University	Illinois Dep't of Natural Resources
Iowa State University	New Mexico Dep't of Tourism
Michigan Tech University	South Carolina Empl. Security
Ohio State	Utah Dep't of Natural Resources
Penn State University	Wisconsin Dep't of Transportation
Portland State University	
Purdue University	**Private Consulting Firms**
Stanford University	Coopers & Lybrand
Texas A&M University	Batelle Pacific NW Laboratories
University of California – Berkeley	Boise Cascade Corporation
University of Wisconsin	Charles River Associates
University of Minnesota	CIC Research
Virginia Tech	BTG/Delta Research Division
West Virginia University	Crestar Bank
Marshall University College of Business	Deloitte & Touche
	Ernst & Young
Federal Government	Jack Faucett Associates
Argonne National Lab	KPMG Peat Marwick
Federal Emergency Management Agency (FEMA)	Price Waterhouse LLP
US Dep't of Agriculture, Forest Service	SMS Research
US Dep't of Agriculture, Econ Research Service	Economic Research Associates
US Dep't of Interior, Bureau of Land Mgmt	American Economics Group, Inc.
US Dep't of Interior, Fish and Wildlife Service	L.E. Peabody Associates, Inc.
US Dep't of Interior, National Parks Service	The Kalorama Consulting Group
US Army Corps of Engineers	West Virginia Research League

The paradigmatic centerpiece of an economic impact study is the classification of impacts. The economic impacts of a given event or circumstance (such as new jobs) are classified into three general groups: direct impacts, indirect impacts, and induced impacts. The direct impacts include the creation of jobs in specific industries and businesses. Indirect impacts measure the positive effect on the economy resulting from businesses selling goods and services to the households. Induced impacts include the effects of increased household spending resulting from direct and indirect effects. Put another way, direct impacts are the immediate impacts of the incoming jobs. Indirect and induced impacts are derivative, flowing from direct impacts.

Indirect and induced impacts are estimated by applying multipliers to direct impacts. Multipliers are factors that are applied to a dollar expended toward a particular use. These factors estimate the total value of that dollar as it propagates through the economy. For instance, suppose that a dollar is spent in a certain industry. That dollar will increase the number of jobs in that industry by a certain amount. Furthermore, some of that dollar will go to pay the increased earnings in that industry, resulting in higher personal income. In turn, consumers will spend some share of that increase in personal income. The ultimate impact of that dollar initially spent in that certain industry, therefore, is greater than its direct impact on the earnings of that industry. Multipliers are industry-specific factors that estimate the value of a dollar spent in an industry, including not only its direct impacts, but also its indirect and induced impacts.

Appendix 3.B – Economic and Fiscal Impacts by Year and Scenario

RESI broke out total economic and fiscal impacts by year to show the change in impacts, which contributed to the net totals. The three tables below demonstrate annual economic impacts under three scenarios relative to the baseline.

Table 3.B.1 Middle scenario, annual economic impacts relative to baseline ($2006)

Year	Economic Activity	Employment	Wages	Fiscal Impact
2009	-$1,441,574	-6.4	-$339,059	-$40,481
2010	-$3,702,232	-16.3	-$868,763	-$103,884
2011	-$2,862,926	-12.3	-$653,976	-$79,480
2012	-$122,599	0.3	$24,260	-$1,198
2013	$55,722	1.8	$110,790	$6,019
2014	-$748,399	-1.0	-$35,334	-$14,224
2015	$1,218,230	8.1	$452,267	$41,959
2016	$3,995,653	22.1	$1,209,207	$124,919
2017	$9,246,548	44.3	$2,391,126	$268,733
2018	$898,263	9.2	$518,601	$40,686
2019	-$1,248,680	0.1	$30,706	-$18,102
2020	-$8,917,112	-32.3	-$1,701,499	-$227,925
Total	**-$3,629,105**	**17.7**	**$1,138,325**	**-$2,977**

Table 3.B.2 Low scenario, annual economic impacts relative to baseline ($2006)

Year	Economic Activity	Employment	Wages	Fiscal Impact
2009	-$6,166,739	-28.2	-$1,510,217	-$175,656
2010	-$21,343,978	-98.1	-$5,264,882	-$609,592
2011	-$18,156,231	-83.5	-$4,485,203	-$518,811
2012	-$9,548,660	-44.6	-$2,402,722	-$275,365
2013	-$4,661,174	-22.1	-$1,194,305	-$136,037
2014	-$1,351,947	-6.9	-$373,434	-$41,600
2015	$5,923,169	25.6	$1,362,848	$162,607
2016	$33,408,704	153.2	$8,232,053	$950,679
2017	$42,128,205	189.9	$10,189,773	$1,189,050
2018	$36,304,159	165.2	$8,875,016	$1,029,299
2019	$39,323,267	177.3	$9,523,750	$1,110,124
2020	$37,193,064	167.6	$9,000,752	$1,049,495
Total	**$133,051,839**	**595.3**	**$31,953,428**	**$3,734,194**

Table 3.B.3 High scenario, annual economic impacts relative to baseline ($2006)

Year	Economic Activity	Employment	Wages	Fiscal Impact
2009	-$1,484,281	-6.6	-$348,733	-$41,668
2010	-$3,829,475	-16.9	-$897,612	-$108,145
2011	-$3,689,665	-15.9	-$840,852	-$102,892
2012	-$3,090,906	-12.3	-$644,923	-$83,269
2013	-$5,064,443	-19.9	-$1,041,370	-$133,327
2014	-$8,263,822	-32.7	-$1,722,882	-$216,480
2015	-$9,123,789	-35.5	-$1,866,864	-$236,234
2016	-$9,084,988	-33.0	-$1,721,417	-$224,764
2017	-$7,778,254	-27.2	-$1,419,886	-$188,913
2018	-$22,674,716	-89.6	-$4,753,772	-$585,435
2019	-$34,640,466	-139.6	-$7,432,395	-$903,157
2020	-$53,989,723	-220.8	-$11,771,215	-$1,417,620
Total	**-$162,714,528**	**-650.0**	**-$34,461,921**	**-$4,241,905**

Appendix 3.C Occupations in energy conservation, alternative energy and GHG emissions reductions

Below are three tables with green job occupations classified as being responsible for energy conservation (Table 3.C.1), alternative energy promotion (Table 3.C.2), and GHG emissions reduction (Table 3.C.3). Additionally, each occupation is further defined as one of the three following options:

> **New and Emerging:** The impact of green economy activities and technologies is sufficient to create the need for unique work and worker requirements, which resulted in the generation of a new occupation relative to the O*NET taxonomy.
>
> **Enhanced Skills:** The impact of green economy activities and technologies is a significant change to the work and worker requirements of an existing occupation. This impact may or may not result in an increase in employment demand for the occupation.

Expanding Demand: The impact of green economy activities and technologies is an increase in employment demand of an existing occupation; however, this impact does not entail significant changes in the work and worker requirements of the occupation.

Table 3.C.1 Energy conservation related occupations

New and Emerging	Expanding Demand	Enhanced Skills
Commercial Energy Field Auditor	Bus Drivers, Transit and Intercity	Auditing service sales consultant
Commercial Green Building & Retrofit Architect	Electrical and Electronic Equipment Assemblers	Boilermakers
Conservation of resources commission	Electrical and Electronics Repairers, Commercial and Industrial Equipment	Building Maintenance Engineer
Electrical Engineer (Green Construction)	Electrical Power-Line Installers and Repairers	Carpenter
Electrical Engineering Technologists	Electrical System Installer	Civil Engineer (Green Construction)
Energy Analyst	Electricians	Construction Carpenters
Energy Auditors	Electromechanical Engineering Technologists	Engine and Other Machine Assemblers
Energy Brokers	Electronics Engineering Technicians	Green plumber and pipefitter
Energy Conservation Representative	Electronics Engineering Technologists	Home improvement retrofit trainee
Energy efficiency consultant	Freight Forwarders	Industrial Engineering Technologists
Energy Efficiency Finance Manager	HVAC Engineer	Industrial Engineers
Energy Engineer	HVAC maintenance/repair trainee	Industrial Machinery Mechanics
Energy Infrastructure Engineer	HVAC Service Technician	Industrial Production Managers
Energy manager and analyst	Indoor and outdoor landscape architect	Machinist
Energy Procurement Manager	Industrial Safety and Health Engineers	Market and rate analyst
Energy trading specialist	Insulation Installer	Roofing Installer
Environmental Construction Engineer	Lighting & HVAC Energy Engineer	Welder
Environmental Economists	Locomotive Engineers	
Environmental Engineering Manager	Manufacturing Engineering Technologists	
Field Energy Consultant	Manufacturing Engineers	
Field Technician	Manufacturing Production Technicians	
Fuel Cell Engineers	Mechanical Engineering Technologists	
Fuel Cell Technicians	Railroad Conductors and Yardmasters	
Industrial Energy Field Auditor	Refrigeration Engineer	

Industrial Green Systems & Retrofit Designer	Refrigeration Mechanics and Installers
Logistics Analysts	Residential air sealing technician
Logistics Engineers	Senior HVAC engineer
Logistics Managers	Structural design engineer
Materials Scientists	Urban planner
Mechatronics Engineers	Urban renewal planner
Nanosystems Engineers	
Nanotechnology Engineering Technicians	
Residential Energy Field Auditor	
Residential Green Building & Retrofit Architect	
Site supervising technical operator	
Smart Grid Engineer	
Solar Hot Water Heater Manufacturing Technician	
Sustainability Specialists	
Water resource engineer	
Water systems designer and engineer	
Weatherization operations manager	

Table 3.C.2 Alternative energy related occupations

New and Emerging	Expanding Demand	Enhanced Skills
Alternative fueling station operations	Chemical Engineers	Automotive Engineering Technicians
Alternative Fuels Policy Analyst	Chemical Equipment Operators and Tenders	Automotive plant assembly
Animal Waste Biomethane Gas Collection System Technician	Chemical Plant and System Operators	Geothermal Heat Pump Machinist
Battery design engineer	Chemists	Geothermal Sheet Metal Worker
Battery manufacturing technician	Fisheries biologist	Hydro-electric operations maintenance worker
Battery testing technician	Marine and fish biologist	Hydrogen pipeline construction
Biochemical Engineers	Plant safety engineer	Powertrain control systems and software engineer
Biodiesel/Biofuel Plant Field Technician	Plant supervising technical operator	Solar Sales Representatives and Assessors
Biodiesel/Biofuel Technology & Product Development Manager	Plant technical specialist-instrument repair technician	Hazardous Materials Removal Workers
Biofuel Plant Operations Engineer	Power Distributors and Dispatchers	
Biofuels Processing Technicians	Safety investigator/ cause analyst	
Biofuels Production Managers		
Biofuels/Biodiesel Technology and Product Development Managers		
Biomass Collection, Separation Sorting		
Biomass Plant Operations, Engineering Maintenance		
Biomass Plant Technicians		
Biomass Production Managers		
Chief Sustainability Officers		
Commercial Solar Sales Consultant		
Diesel Retrofit Designer		
Diesel retrofit manufacturer plant labor		
Director of Wind Development		
Electro-Mechanical Wind Turbine Technician		
Energy Commission Specialist		
Environmental health and safety lead		

Environmental, health and safety engineering manager
Geothermal Electrical Engineer
Geothermal Mechanical Engineer
Geothermal Operations Engineer
Geothermal Plant Efficiency Operator
Geothermal Plant Installation Technician
Geothermal Production Managers
Hydro Geologist
Hydro-Electric Component Machinist
Hydro-Electric Electrical Engineer
Hydro-Electric Mechanical Engineer
Hydro-electric plant efficiency operator
Hydro-electric plant electrical engineer
Hydro-Electric Plant Installation Technician
Hydro-electric Plant Technicians
Hydro-Electric Power Generation Engineer
Hydroelectric Production Managers
Hydro-electric structural engineer
Hydrogen Plant Operator and operations manager
Hydrogen Power Plant Installation, Operations Engineering & Management Staff
Instrumentation Controls Technician
Landfill Gas Collection System Operator
Landfill gas system technician
Landfill Gas to Energy LGE Plant Installation, Operations, Engineering and Management
Methane/Landfill Gas Collection System

Operators
Methane/Landfill Gas Generation System Technicians
Power system operator
Power system operator and instructor
PV fabrication and testing technician
PV Power Systems Engineer
PV Solar Cell Designer
Renewable Energy Consultant
Residential Solar Sales Consultant
Senior automotive power electronics engineer
Solar and PV installation: Roofer
Solar Commercial installation engineer
Solar Commercial installation engineering technician
Solar energy engineer
Solar Energy Industry Analyst
Solar Energy Installation Managers
Solar energy system installer helper
Solar energy systems designer
Solar Energy Systems Engineers
Solar Fabrication Technician
Solar Installation Electrician
Solar lab technician
Solar operations engineer
Solar Photovoltaic Installers
Solar Thermal Installers and Technicians
Solar thermoelectric plant manager
Wind Energy Engineers
Wind Energy Operations Manager
Wind Energy Project

Managers
Wind Farm Electrical Systems Designer
Wind Field Technician
Wind Turbine Service Technicians

Table 3.C.3 Greenhouse gas emissions reductions occupations

New and Emerging	Expanding Demand	Enhanced Skills
Air Emissions Permit Engineer	Agricultural Inspectors	Atmospheric and Space Scientists
Air Pollution Specialist	Agriculture/irrigation/water supplier	Automotive Specialty Technicians
Air Quality Control Engineer	Bus system operator	Electric shipyard operator
Air Quality Program	Fish and Game Wardens	Electric Vehicle Electrician
Air Quality Specialist	Forest and Conservation Technicians	Geological Sample Test Technicians
Air Resource Engineer	Forest and Conservation Workers	Hybrid Powertrain Development Engineer
Associated engineer - wastewater treatment	Forestry Supervisor	Soil and Water Conservationists
Carbon Capture Power Plant Installation, Operations, Engineering Management	Fuel transporter - trucker	Transportation Managers
Carbon emissions specialist	Geographic Information Systems Technicians	
Carbon Sequestration Plant Installation, Operations, Engineering Management	Geologist /Hydrogeologist	
Climate Change Analysts	Hazardous materials removal worker	
Climate change and energy policy specialist and advocate	Hazardous waste management specialist	
Climatologist	Hydrologists	
Compliance Managers	Operations maintenance worker for water services	
Conservation forestry consultant	Recycling and Reclamation Workers	
Conservation policy analyst and advocate	Recycling center operator	
Emission reduction credit marketer and market analyst	Recycling collections driver	
Emission reduction credit portfolio manager	Recycling Coordinators	
Emissions accounting and reporting consultant	Wastewater engineer in refinery	
Engineering geologist	Wastewater plant civil engineer	
Environmental Compliance Specialist	Water resource consultant	
Environmental engineer	Water resource engineer	
Environmental engineer/scientist intern	Water Resource Specialists	
Environmental health and safety lead	Water/Wastewater Engineers	

Environmental planner	Water/wastewater quality consultant
Environmental Research Manager	Zoologists and Wildlife Biologists
Environmental Restoration Planners	
Environmental Sampling Technician	
Environmental Scientist	
Environmental Technician	
Environmental, health and safety engineering manager	
Fueling station designer and project engineer	
Geospatial Information Scientists and Technologists	
GIS Specialist	
Greenhouse Gas Emissions Permitting Consultant	
Greenhouse gas emissions report verifier	
Industrial Ecologists	
Power marketing specialist	
Precision Agriculture Technicians	
Program manager, environmental construction	
Regulatory Affairs Managers	
Regulatory Affairs Specialists	
Senior environment consultant	
Soil conservation technician	
Soil conservationist	
Train system operator	
Transportation Engineers	
Transportation Planners	
Waste Reduction Consultant	
Weatherization Installers and Technicians	

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