INTERNATIONAL CENTER FOR SUSTAINABLE DEVELOPMENT, INC.

Economic Development Potential of Clean Energy Technology in Maryland and Feasibility Study for a Maryland Clean Energy Center

Prepared for
Baltimore Development Corporation

With Funding By:
Maryland Department of Business and Economic Development
Maryland Energy Administration
Abell Foundation

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December 31, 2006

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Acknowledgments

This study was written by John W. Spears and Andre Van Rest of the International Center for Sustainable Development (ICSD) under contract to The Baltimore Development Corporation. Funding was provided by the Maryland Department of Business and Economic Development, Aris Melissaratos, Secretary, Maryland Energy Administration, Frederick Davis, Director, and the Abell Foundation, Robert Embry, President.

The project was administered and managed by the Baltimore Development Corporation. Additional economic and job potential research and analysis were done by RESI Research and Consulting of Towson University and the University of Baltimore Merrick School Of Business. The National Renewable Energy Laboratory conducted a renewable energy resource and cost assessment for Maryland and Peter Lowenthal of the Solar Energy Industries Foundation provided input to the policy section. The project team consisted of Kathy Magruder, DBED, Larisa Salamacha, BDC, Michael Li, MEA, Beth Harber, Abell Foundation, John Fini and Niel Davis with the Emerging Technology Center, John Spears and Andre Van Rest with ICSD.

The International Center for Sustainable Development is a non-profit 501c3 organization located at 111 South Calvert St., Suite 2201, Baltimore, MD. ICSD was established in 2001 with funding from the Abell Foundation and the US Department of Energy. ICSD's mission is to promote sustainable development world wide by undertaking practical development projects around the world that are based on sustainability principles, meet local needs, and are community focused, environment-friendly, financially-healthy, and replicable.

Executive Summary

The International Center for Sustainable Development was contracted by the Baltimore Development Corporation (BDC) with funding provided by DBED, MEA and the Abell Foundation to conduct a study of the economic development potential of clean energy technology in Maryland and the creation of a Maryland Clean Energy Center (MCEC) to act as a focal point for development in the clean energy technology sector. The purpose of the MCEC is to promote economic development and jobs in the clean energy industry sector in Maryland. The study examined the past and future energy use profile in Maryland, the renewable and energy efficiency resource potential, domestic and international clean energy policies, and the economic impacts of energy efficiency improvements and developing the State's renewable energy resources.

In summary, we found that:

- The Clean Energy industry is a $50 billion a year industry world wide, growing at a rate of 30% per year and one of the hottest investment opportunities on Wall Street today.
- A growing number of States are investing aggressively in the Clean Energy industry (over $500 million per year). Maryland, however, is lagging in this sector and is missing out on huge economic development and job growth potentials that the other States are realizing.
- Maryland has vast untapped renewable energy resources that could produce from 30% to 137% of all the State's electricity from solar photovoltaics and on-shore and off-shore wind power at costs often competitive with conventional sources.
- Energy efficiency can significantly reduce energy costs to homeowners, businesses, institutions and government at a cost 60% to 70% cheaper than new generating capacity in Maryland.
- Ethanol can be produced in Maryland at a price competitive with today's gasoline prices.
- Given Maryland's excellent research laboratories and expertise in biotechnology, it is in an excellent position to become a leader in biofuels research and development.
- However, Maryland seems to be moving in the opposite direction by cutting the already slim funding for the Maryland Energy Administration by over 67% in the past two years. ($3.96 million in 2004 to $1.29 million in 2006)
- Over the next 20 years, at the lowest level of effort (20% energy-efficiency improvement, 10% renewable-energy increase, and 10% ethanol production increase), **144,000 jobs** will be created (67,000 in Baltimore), **wages & salaries will go up by $5.7 billion** ($2.4 billion in Baltimore); **state & local tax revenues will increase by $973 million** ($412 million in Baltimore); and gross state product (**GSP) will increase by $16 billion** ($7 billion in Baltimore).
- At the highest level of effort (40% energy-efficiency improvement, 30% renewable-energy increase, and 30% ethanol production increase), the economic impacts more than double.

Given this tremendous potential, the report, therefore, lays out a plan for Maryland to become a national leader in the clean energy industry sector and realize the tremendous economic, social and environmental benefits of clean energy. The proposed plan creates a **Maryland Clean Energy Center** (MCEC) that can act as a focal point for clean energy industry development in Maryland. MCEC will lead a collaborative effort of all of Maryland's existing resources to advocate and promote the clean energy industry in the State and drive development of the State's abundant energy efficiency and renewable energy resources. MCEC will also help identify funding sources to meet the State's needs and tie together all the State institutions- industry, universities, research and State agencies- around a common goal.

The MCEC's mission is to promote the growth of the clean energy industry in Maryland. With most industries, the majority of the economic benefits come from the investment in the companies and the jobs they create. While corporate investment and job creation are also important benefits of the clean energy industry, we found in our study that the vast majority of the economic benefits come from the services the industry provides in Maryland (energy savings and reduction of energy imports). Therefore, in order for us to reap the maximum benefit, Maryland needs to develop a strong clean energy industry and infrastructure that can **effectively deliver** energy efficiency and renewable energy goods and services that maximize the energy efficiency and renewable energy utilization in the State. This means we need to not only build a strong industry in Maryland, but also build a strong market for energy efficiency and renewable energy goods and services.

Energy efficiency and renewable energy are great investments for Maryland. According to our analysis, an investment of $1 million per year by the State in the MCEC over the next 20 years ($20 million) would return $973 million in State and local tax revenues and 144,000 new jobs in the low scenario, and $2,166 million and 327,000 new jobs in the high scenario. If Maryland imposed a very small public benefit tax on consumer's utility bills ($0.0004 cents per kilowatt-hour or less than $0.50 per household per month), as 14 states currently do, and raised $25 million per year (average of the 14 state funds) for Clean Energy investment, the return in increased wages and salaries would be 10 times that ($500 million invested over 20 years returns $5.7 billion in increased wages and salaries).

The report recommends a series of "next steps" to begin the development of a Clean Energy industry in Maryland.

1. Fund the start up of the Maryland Clean Energy Center as an independent non-profit 501c3 corporation not affiliated with any State agency.
2. Set up a Board of Directors and Board of Advisors.
3. Set up offices at the Emerging Technology Center in Baltimore and fill key staff positions.
4. Convene the first meetings of the Maryland Clean Energy Business Council and the Technology Collaboratives.
5. Develop a comprehensive legislative agenda for promoting Clean Energy development in close cooperation with the industry, the legislature and the Governor's office.
6. Develop a funding model for MCEC.
7. Set up the Clean Energy Incubator at ETC and explore setting up additional Clean Energy Incubators in cooperation with the other incubators in the State.
8. Begin networking and developing strategic relationships with all the stake holders and institutions in the State.

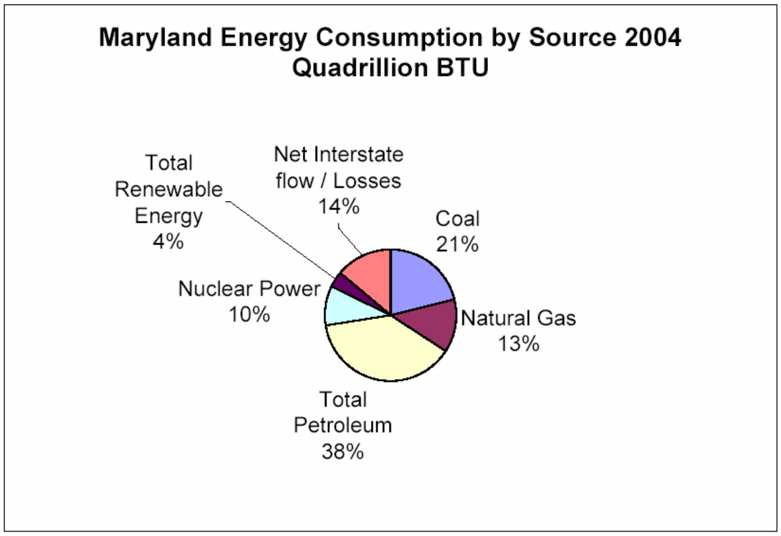
The start up cost of the proposed MCEC is very small and has an excellent return. The report recommends that the State provide $5 million over the next 3 years to fund the start up of the MCEC. During the first three years, MCEC will work with the State to develop a permanent funding mechanism.

Summary of Study Results

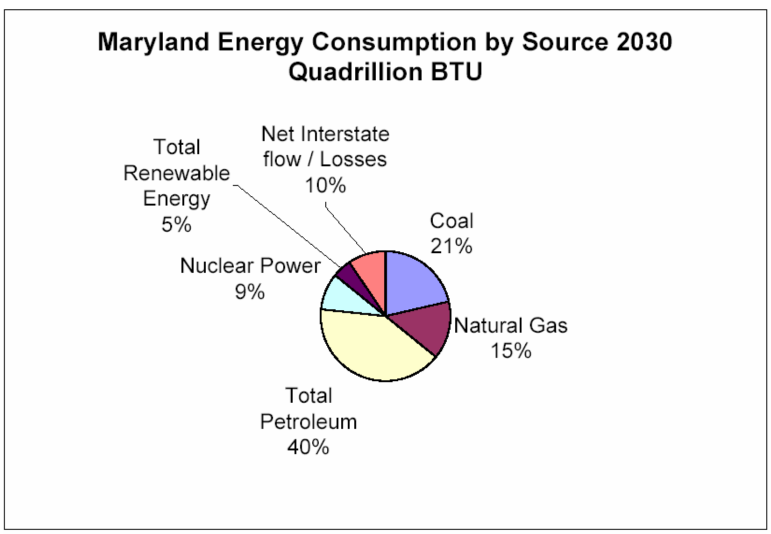
Nationally, the clean energy sector is poised for a new period of growth and activity based on increasing energy prices, falling renewable energy costs, concerns over national energy security and environmental impacts. The accelerated market growth has created a favorable environment for investors, with opportunities for substantial profits in this now $50-billion-a-year industry. There is the potential for significant business, employment and economic development benefits accruing to states that have or can develop a competitive advantage in this sector. For example, the solar industry has shown explosive growth in California and New Jersey, where they have aggressive tax incentives, buy down programs, good interconnection policy and aggressive Renewable Portfolio Standards (RPS). New Jersey's solar industry has experienced a 500 percent growth rate in the past three years as a result of its aggressive policies. Maryland needs to assess its strengths, weaknesses and interest in participating in the expected growth of this sector, and if it decides to participate, how to best capture this growth. ICSD is suggesting that the best way for this assessment to take place is to (1) give Maryland's clean energy industry an identity and a voice in the process of identifying how to best grow the clean energy sector in Maryland, and (2) establish a Maryland Clean Energy Center to help identify, organize, and grow this industry, and bring all of Maryland's private and public resources into play in a coordinated way so that the State can avail itself of the economic benefits of clean energy growth in the most cost-effective way.

Energy Use in Maryland:
In this study, ICSD looks at the feasibility of creating a Clean Energy Center in Maryland designed to stimulate economic development and create jobs in the clean energy technology sector by supporting the existing clean energy businesses, growing new businesses, and attracting companies to move to Maryland. In order to identify the economic impacts of fully developing a clean energy sector in Maryland, an up-to-date scenario of current and future energy consumption in Maryland was needed, by end-use sector and energy source. Because this was not available, ICSD developed such a scenario as presented in Chapter 2. It is estimated that, in 2005, Maryland consumed the equivalent of around 1.55 quadrillion Btu of energy, including over 100 million barrels of petroleum, over 13 million tons of coal, over 197 billion cubic feet of natural gas, over 13 billion kWh of nuclear electric power, and over 2,640 million kWh of hydroelectric power. Almost all of the coal is used to generate electricity. In 2005, Maryland consumed over 69 billion kWh of electricity. In 2003, Maryland was ranked the 24th highest among the States in terms of total energy use. With regard to coal, natural gas, petroleum, and electricity consumption in the same year, Maryland was ranked 27th, 33rd, 23rd, and 21st respectively. And with regard to energy prices, total energy expenditures, and energy expenditures per person, Maryland ranked 13th, 22nd, and 42nd. In 2003, Marylanders spent about $12.6 billion for the energy they consumed.

The results of our analysis also show that in Maryland, the percentage breakout of energy consumption in Btu by source is slightly different from the national level energy use. In 2004, Maryland consumed about 1.54 quadrillion Btu in primary energy. The percentage breakout of Maryland energy consumption by source for 2004 is given in the figure below.   As is the case at the national level, on a Btu-basis, petroleum is the largest energy source consumed in Maryland, at a level of 588.7 trillion Btu. Coal is the second largest energy source, providing 326.7 trillion Btu, and natural gas is third at 198.7 trillion Btu. In 2004, Maryland also consumed 151.9



trillion Btu in nuclear power and 59.3 trillion Btu in renewable energy. By 2030, the forecasted level of energy consumption for Maryland is 2.092 Quads in primary energy. As shown in the figure below, the percentage breakout of this level of energy consumption by source for 2030 is not drastically different than the breakout in 2004. The largest energy source in 2030 is still petroleum, with coal in second place and natural gas in third.



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Clean Energy Technologies:
In order to provide a better understanding of what is meant by clean energy technologies and to characterize the industry, the report provides technical and market information on the various technologies in Chapter 3. The primary technologies considered for Maryland are energy efficiency and green buildings, solar electric (PV), solar thermal, wind power, ethanol, biodiesel and hydrogen. For each technology, the report examines the technology and its applications, the economics and markets, the resource potential for Maryland and Maryland's competitiveness in the field.

Energy efficiency and renewable energy are the fastest growing technology sectors in the world today with major investments being made world wide in wind power, ethanol plants and solar energy, just to name a few. Increasing energy end-use efficiency, or technologically providing more desired service per unit of delivered energy consumed, is generally the largest, least expensive, most benign, most quickly deployable, least visible, least understood, and most neglected way to provide energy services. Simply put, energy efficiency is doing more with less energy input. Productive applications exist in industrial processes, electric generation and distribution, buildings, lighting, heating and cooling, motors, etc. Energy efficiency can also include better energy management like turning off lights and equipment when not in use or automatic controls that optimize the performance cycle. Major energy efficiency opportunities exist in improving the performance of building envelopes and HVAC systems, high efficiency lighting, high efficiency motors, particularly in large pumping systems, variable speed controls on fans and pumps and building energy management systems. At the utility scale, major improvements can be made by decentralizing the power production to reduce transmission losses and capture the waste heat in cogeneration systems. Cogeneration systems make power, and waste heat from the system is used for heating and/or air conditioning. Distributed cogeneration systems also have additional benefits.

Most homes in Maryland could reduce energy cost by 30 percent and savings of 60 percent or greater are possible through measures such as:

- Air tightening the building envelope and ducts
- Better insulation
- Better windows
- Energy efficient appliances and lighting
- Passive solar heating and solar control strategies for summer
- Solar water heating
- High efficiency heat pumps

In most commercial, industrial, and institutional facilities, there are abundant opportunities to save including:

- 70–90 percent of the energy and cost for lighting, fan, and pump systems
- 50 percent for electric motors
- 60 percent in areas such as heating, cooling, office equipment, and appliances

Green buildings incorporate and address renewable energy, energy efficiency, indoor air quality, water consumption, waste, and landscape and site issues. Green buildings popularity is due in large part to the US Green Building Council's (USGBC) LEED green building rating system for commercial buildings. USGBC includes 6,300 member companies and organizations.

Energy efficiency is the least cost strategy for reducing energy cost and the use of fossil fuels. A recent study by the North East Energy Efficiency Partnership showed that energy efficiency is 60-70 percent cheaper than new generating capacity. Many energy efficiency opportunities have very low or no implementation costs. Economical energy efficiency opportunities are available to all customers, sectors, end uses and markets. There is very little market research in the energy efficiency market sector because it is so diverse. Trends however are clear from the green building sector. In the past four years alone, USGBC's membership has tripled and over half a billion square feet of building space is participating in the LEED Rating System, and the annual U.S. market in green building products and services has grown to $7 billion. The exploding market has accelerated green building's acceptance rate by home builders. By the end of 2007, more than half of the members of the National Association of Home Builders, who build more than 80 percent of the homes in this country, will be incorporating green practices into the development, design and construction of new homes. In 2006, the growth in green home building is expected to rise by 20% over 2005, and in 2007, there is a projected a growth of 30% over 2006.

The potential of increasing the efficiency of energy use with currently available technology is vast. Two-thirds of U.S. energy use per unit of economic output could be eliminated using available technology, while still maintaining all the functions that present-day fuel use brings with it. Through a modest set of programs to help Marylanders improve their energy efficiency, Maryland could reduce anticipated total electricity demand by 6 percent by 2010. Studies have shown that a broader set of measures could yield cost-effective savings of five times this amount in a similar timeframe. Maryland's existing capacity to capture energy efficiency savings suffers from a lack of businesses that deliver energy efficiency services, such as Energy Service Companies (ESCOs) or home weatherization contractors that serve the general public. Only one ESCO was identified in the region and the existing weatherization contractors serve only the small subsidized low income market. There is, however, a potential to capture efficiency improvements in new construction given the surge in architects and engineers being accredited by the US Green Building Council's LEED program. There are over 700 LEED Accredited Professionals in Maryland who are qualified to design energy efficient green buildings. The potential for developing energy efficiency companies in Maryland is good and will depend largely on government policy and support.

Wind power is the leader in wholesale renewable electricity production in the United States. The wind industry has been growing at 28 percent a year for the past five years, and if growth trends continue at this pace as is expected, wind capacity will double about every three or four years. Onshore wind power can produce power at good wind sites for 3¢ /kWh today, without incentives and exposure to traditional fuel price volatility. This cost compares favorably to the all-in cost of electricity from a new gas-fired combined cycle gas turbine of about 3-4¢/kWh (depending on the cost fuel), or from a new coal plant of about 4¢/kWh. Offshore wind has the greatest potential for Maryland and major projects are being planned all along the East coast. The Long Island Power Authority is pursuing a 100-MW offshore wind power initiative, and Cape Wind has proposed a 400+MW offshore wind project for Nantucket Sound. Several offshore projects are in operation globally, and 4800 MW of additional offshore wind are planned for Europe over the next five years.

PV is on of the fastest growing sectors in the clean energy market. Global sales for the photovoltaic industry are rising about 30 percent per year. Solar PV is a $12 billion global industry and the leading renewable power source for distributed power generation world wide. The PV equipment market is projected to be $30.8 billion by 2013. California is currently the third largest market for PV in the world and will drive the market for years to come. Renewable energy policy at the state and federal level is a significant driver of the industry growth.

Domestic solar hot water (SHW) and solar pool heaters are cost effective today in Maryland and the economics will continue to improve as the price of gas, oil and electricity increases. A typical home solar water heating system costs approximately $4,000-$5,000, produces up to 80 percent of a family's hot water and pays back in 4-5 years at today's rates. Payback will be faster as rates increase. Over 400,000 homes in Maryland are well-suited for solar hot water. That represents a market potential of $2 billion in potential retrofit applications alone. With 4 to 5 times the energy density of solar photovoltaic (PV), solar water heating produces the most solar power for the least cost. The Los Angeles Air Quality Control Management Board has stated, "next to car pooling, solar water heating is the most cost-effective way to reduce air pollution." The potential market for SWHs is huge. Europe provides a healthy example, as annual growth has been 18 percent in the last 10 years. Annual growth for the next 10 years has been estimated to be 23 percent.

Maryland is home to BP Solar, one of the largest solar cell producers in the world. This one company alone accounts for 8 percent of clean energy sector employment in Maryland. The presence of one of the leading solar companies in the world in the State presents an opportunity to develop an industry cluster around this new and growing technology. The Renewable Energy Policy Project lists Maryland as having 105 businesses with 5,120 employees that could potentially benefit from expanded manufacturing of solar cells. As a result of California's policies, it is home to 15 manufacturers of solar PV technology and more than 62 companies doing retail solar sales. Besides BP Solar, Maryland has two smaller manufacturers of solar components. However, Maryland has less than a hand full (3-5) small solar installers in the state. The solar water heater industry in Maryland also consists of a hand full (3-5) small solar contractors and there are no solar water heater manufacturers. Solar thermal collector manufacturing is a fairly low-tech industry and could take advantage of much of the unused light-industrial space available in Baltimore.

The Table below, from the study done by the National Renewable Energy Laboratory (NREL) for this report, summarizes the renewable energy potential in Maryland. The full NREL report is in Appendix 2. The Table shows the electric sales in Maryland for 2004, and the renewable energy potential with a low and high estimate. As we can see, renewable energy technology can provide 30 percent to over 136 percent of the State's electric energy needs, with offshore wind and solar PV having the greatest potential. PV could provide 17-25 percent and offshore wind could provide 8 percent to almost 100 percent of the power needs of the State. Solar thermal and new hydro are not included.

Technology	MD Electric Sales 2004 MWh	RE Potential Low MWh	RE Potential High MWh
Wind on shore		560,640	5,606,400
Wind off shore		5,212,200	66,576,000
Solar PV		11,650,800	16,644,000
Biomass direct		2,472,072	2,472,072
MSW landfill gas		275,940	275,940
Total	**66,892,000**	**20,171,652**	**91,574,412**
% of 2004 Electric Sales		30.16%	136.90%

Biofuels, principally corn-based ethanol, present the biggest investment opportunity in renewable energy in the United States for the next several years. Recent evidence assembled by Lawrence Berkeley Laboratory rebuts outdated beliefs from the 1970s that, because of the energy-intensive production, environmental benefits from corn-based ethanol are non-existent. It now appears that producing corn-based ethanol requires much less petroleum than producing gasoline and that greenhouse gas emissions from ethanol are about 15 percent to 20 percent lower than from gasoline. New cellulosic ethanol technology reduces both greenhouse gas emissions and petroleum inputs even more substantially. With ethanol replacing methyl tertiary-butyl ether (MTBE), a chemical compound used as a fuel component in gasoline that has been banned in 22 states, demand has grown rapidly. In 2006, more than 4.7 billion gallons (17.9 billion liters) of ethanol will be produced, and there are 2 billion gallons (7.6 billion liters) per year of new processing capacity under construction in the United States. The U.S. auto manufacturers have taken notice of the recent interest in biofuels. General Motors, for example, currently produces nine models that can run on E85, a mixture of 85 percent ethanol and 15 percent gasoline.

Driven by the stable policy environment provided by the Energy Policy Act of 2005 (EPACT) and passage of the Volumetric Ethanol Excise Tax Credit (VEETC), as well as high margins for producers, ethanol production and usage are expected to grow rapidly through 2008 at approximately 27 percent per year. In 2008, ethanol production is forecast to be 7.9 billion gallons, which exceeds the 7.5-billion-gallon level of the RFS in 2012. According to the USDOE, the economics of cellulosic ethanol production can be enhanced by producing ethanol in a biorefinery in combination with electric power and biochemicals. By integrating the production of higher value bioproducts into the biorefinery’s fuel and power output, the overall profitability and productivity of all energy related products will be improved. With regard to being able to produce cellulosic ethanol on a large scale, USDOE also believes this will require transformational breakthroughs in science and technology and that incremental improvements in current bioenergy-production methods will not suffice. Several developments have converged in recent years to suggest that systems biology research into microbes and plants promises solutions that will overcome critical roadblocks on the path to cost-effective, large-scale production of cellulosic ethanol and other renewable energy from biomass.

In Maryland, ethanol can be produced from corn for less than $1.30 per gallon and for even less in the Corn Belt. A recent feasibility study done for ethanol production in Maryland shows an equity internal rate of return of 27-34 percent. As a result of its Renewable Fuels Promotion Act of 2005, Maryland has a $0.20 per gallon producer credit for ethanol produced from small grains (winter grain) and a $0.05 per gallon producer credit for ethanol from other agricultural products. Maryland's maximum total payment is $3 million/year for all ethanol produced. To reach this maximum would require at least 15mgy of ethanol from small grains in a facility that began operating or expanded after 12/31/04. Maryland's program Sunsets on 12/31/2017. There are currently no ethanol plants in operation on the East-coast of the U.S. Maryland currently uses about 2.5 billion gallons of gasoline per year. At E-10 levels, the State could use about 250 million gallons of ethanol per year. At E-85 levels, the utilization will be over 2 billion gallons of ethanol. Similarly, the State of Virginia uses about 4 billion gallons of gasoline per year. Virginia's E-10 requirement would be 400 million gallons of ethanol, and its E-85 requirement would be almost 3.5 billion gallons of ethanol. In Maryland, there are currently at least five organizations that are in either the planning or permitting stage for building an ethanol plant:

- Atlantic Ethanol, $100 million, 54-100 mgpy plant in Baltimore City;
- Chesapeake Renewable Energy, LLC, $120 million, 50 mgpy facility in Somerset County;
- Ecron, $150 million, 100 mgpy facility in Baltimore City;
- Greenstock , 30 mgpy facility in Dorchester County; and
- Maryland Grain Producers Board, 50 mgpy facility

Biodiesel is a domestically produced, renewable fuel that can be manufactured from vegetable oils, animal fats, or recycled restaurant greases. Biodiesel is safe and biodegradable. Blends of 20 percent biodiesel with 80 percent petroleum diesel (B20) can generally be used in unmodified diesel engines. Biodiesel can also be used in its pure form (B100), but it may require certain engine modifications to avoid maintenance and performance problems and may not be suitable for wintertime use. The use of biodiesel has grown dramatically during the last few years. In 2005, the estimated U.S. biodiesel production was 75 million gallons, triple the production of 2003. There are presently 86 companies producing biodiesel with a total capacity of 581 million gallons per year. Sixty-five companies are building biodiesel plants that will be completed in the next 14 months and 13 plants are expanding their existing operations. Their combined capacity, if realized, would result in another 1.4 billion gallons per year of biodiesel production capacity.
The American Jobs Creation Act that created the VEETC also includes a tax credit for biodiesel of $1.00/gallon for agri-biodiesel (from virgin oils) and renewable diesel (from biomass), and 50 cents/gallon for biodiesel made from recycled oil and grease. EPACT 2005 extended the tax credit through 2008 and created a new credit for small agri-biodiesel producers equal to 10 cents/gallon of agri-biodiesel produced at facilities with annual capacity not exceeding 60 million gallons. In Maryland, under the Renewable Fuels Promotion Act of 2005, ethanol and biodiesel producers may apply to the Renewable Fuels Incentive Board for biodiesel and ethanol production credits. At least 50 percent of Maryland state vehicles must use a minimum biodiesel blend of B5 beginning

in fiscal year 2008. This requirement does not apply to any state vehicles for which mechanical failure due to the use of biodiesel will void the manufacturer's warranty for that vehicle.

Without the $1/gallon tax incentives, biodiesel is expensive to produce because it requires a high-value feedstock – vegetable oil or animal fats. Also, without the incentive, biodiesel production will not be profitable, unless crude oil prices are in excess of $70-75/barrel, assuming average crude soybean oil prices are in the 22-24 cents/gallon range. Only yellow grease-based biodiesel shows a positive margin of 6 cents/gallon before the tax incentive is included. Fats and greases cost less and produce less expensive biodiesel, sometimes as low as $1.00 per gallon. The quality of the fuel is equivalent to soy biodiesel fuel. In 2004, with the tax incentive and soybean oil prices of 19 cents/lb and diesel prices of $1.75/gallon, the gross margin per gallon was about $0.77/gallon. This implied that a 30 mgpy facility could have a gross profit of $23.1 million; that is equivalent to 75-80 percent of the capital equipment costs required to build a new biodiesel plant. Today, with diesel prices in the $2.50+ range, the current environment offers significant economic incentives to expand biodiesel production.

Maryland's first biodiesel plant opened in Berlin on June 19, 2006. It planned to produce 1.5 million gallons per year by September 2006. There are also at least four other organizations that are in either the planning or permitting stage for building a biodiesel plant in Maryland:

- Cropper/Maryland Biodiesel, $1.2 million 5 mgpy facility in Worcester County;
- Windridge Farms/Chesapeake Green Fuels $4 million, 30 mgpy facility;
- Valley Proteins project under consideration in Curtis Bay; and
- Perdue, $15-18 million, 15 mgpy facility

Most current plants in the U.S. are in the 60 thousand gpy to 30 mgpy range. Currently, the largest plant produces about 38 mgpy. Approximately 83 percent of the biodiesel produced today is made from soybean. Yellow grease accounts for about 9 percent, animal fats (tallow, lard, byproducts from the production of Omega-3 fatty acids from fish oil) for 6 percent and other vegetable oils for 2 percent. Other crops show promise, because their oil yield per acre is much larger than that of soybeans, which yields 46 gallons of oil per acre per year. Safflower, for example, yields 80, rapeseed 122, Jatropha 194, and oil palm 610 gallons per acre per year.

There is no doubt that biodiesel has the potential to be a very large agriculturally produced commodity. However, biodiesel produced from vegetable oils can never displace a significant portion of our petroleum diesel, because of the limited capacity we have to produce vegetable oil, and because there are other important food uses for the major portion of our edible fats and oils. The U.S. currently consumes roughly 60 billion gallons of petroleum diesel and 120 billion gallons of gasoline per year. According to a study by the University of Idaho, it would be very ambitious to produce the annual amount of diesel used on the farm – 3.1 billion gallons. This would require all of the vegetable oil produced in the U.S. and would require about 15 percent of our total production land area. According to the same study, it would in fact be very ambitious to have a 0.5 billion gallons per year biodiesel industry. This would require all of the surplus vegetable oil (0.13 billion gallons), half of the used oil (0.17 billion gallons), and all of the oil which would be produced on the 37 million acres of idle crop land (about 0.3 billion gallons) or the equivalent by displacing current crops.

Making biodiesel from algae appears to be a different story. Algae have been estimated to theoretically yield 15, 000 gallons of oil per acre per year. Based on adequate research and proof of concept, biodiesel produced from algae may, in the not to distant future, become a feasible solution for replacing petro-diesel ***completely***. As of today, no other feedstock has the oil yield high enough for it to be in a position to produce such a large volume of oil. As mentioned above, in order for a crop such as soybean or palm to yield enough oil capable of replacing petro-diesel completely, a very large percentage of the current land available needs to be utilized only for biodiesel crop production, which is quite infeasible. If the feedstock were to be algae, owing to its very high yield of oil per acre of cultivation, it has been found that about 10 million acres of land would need to be used for biodiesel cultivation in order to produce enough biodiesel to replace not only all the petrodiesel used currently in the U.S., but also all petroleum transport fuels, if all gasoline vehicles were replaced with diesels This is just 1% of the total land used today for farming and grazing together (about 1 billion acres). In practice, biodiesel has not yet been produced on a wide scale from algae, though large scale algae cultivation and biodiesel production appear feasible in the near future. Finding algae strains to grow is not too difficult. Cultivating specific strains of algae for biodiesel is more difficult, as they require high maintenance and could get easily contaminated by undesirable species. Species of algae that have the highest oil content are not necessarily the quickest to reproduce, thereby allowing other species to take over the growing process. For several years, scientists at the University of Maryland Biotechnology Institute (UMBI) and the University of Maryland in College Park (UMCP) have been looking at these issues and working on the use of algae as a feedstock in biodiesel and biofuels production. To date, the results of their research are very promising. There is also renewed interest at the U.S. Department of Energy in algae-based biodiesel. The Department's Sandia National Laboratory recently announced that it is teaming up with a California company, LiveFuels Inc, with the intent of producing algal oil on marginal lands, unsuitable for foods crops. The company estimates that, by using algal-based oil production, all U.S. oil imports could be replaced by biocrude grown on 20 to 40 million acres of marginal lands that exist across the country.

The University of Missouri estimates that 100 million gallons of biodiesel production could generate an approximate $8.34 million increase in personal income and more than 6,000 temporary or permanent jobs in a metropolitan region. Another study predicts a 100 million-gallon biofuels plant could generate a one-time economic boost of $250 to $359 million during the construction phase. Additionally, the local economic base is projected to expand by $250 million through annual direct spending of $140 million. More than 100 new full-time jobs would be created at the plant and more than 1,500 indirect jobs in the state, and annual community household income in the area would increase by $50 million. Another dimension to job creation from biodiesel production is the additional income and employment that can be created by producing biodiesel as part of a biorefinery, along the same lines as ethanol biorefinery production. This could be the most economically sustainable means of larger-scale biodiesel production. Within this production design, the crude vegetable oil pressed from bioenergy crops, potentially including algae, is the base for all sorts of products, ranging from relatively lower-value biodiesel to higher-value biolubricants for motors. Other potential high-value byproducts include nutritional supplements, biopesticides/bioherbicides, glycerin-derived alcohols and specialty chemicals, and animal feed.

The best way to reduce our Nation's dependence on imported oil in the short-term—over the next 5 to 10 years — is through the increased use of gasoline hybrid-electric vehicles, which are available to consumers today, and through the increased use of alternative fuels, like ethanol and biodiesel. In the longer-term, however, 15 to 20 years from now, increases in fuel efficiency and the use of biofuels can begin to be significantly supplemented by the use of hydrogen and fuel cell technologies. According to the U.S. Department of Energy, hydrogen fuel cell vehicles will begin to reach the mass consumer market in 2020. At the present time, the cost of producing, delivering and storing hydrogen is too high for hydrogen to be competitive with gasoline and other fossil fuels. Also, the cost of fuel cells in stationary and transportation applications are too high compared to traditional electricity-generation technologies and internal combustion engines. Improving fuel cell durability is also a major challenge to fuel cell commercialization. Researchers and engineers are hard at work to resolve these performance issues and, in the meantime, it is becoming more and more apparent, that in the long run no other energy generation technology offers the combination of benefits that hydrogen and fuel cells do. Currently, there are 11 companies operating in Maryland in the hydrogen and fuel cell field and Maryland is also home to the Mid-Atlantic Hydrogen Coalition (MAHC). MAHC is an initiative under the International Center for Sustainable Development to promote the deployment of hydrogen energy and fuel cell technologies in the mid-Atlantic region. This region includes the States of Delaware, Maryland, New Jersey, Pennsylvania, Virginia, and West-Virginia, and the District of Columbia.

Clean Energy Policy:

Chapter 4 is a general introduction to the policy issues for clean energy with some examples of model policies in other states and countries. The clean energy sector is very diverse, creating policy issues that are very complex and often unique to each industry, such as solar, wind, and biofuels. Some policy issues cut across industries, as in the case of electric generation technologies and grid interconnection issues. While we have cited examples of policy and policy concepts that have worked in other places and may be good models for Maryland, we have not made specific policy recommendations for Maryland in this study. States that have developed the most successful policies have done so through a collaborative effort with the clean energy industry and all the stake holders in the clean energy sector. As can be seen in the business plan for the Center in Chapter 6, we are proposing a process of industry collaboration in setting industry specific policy.

At least 28 countries and regions offer government-sponsored incentives for clean energy, as well as most of the U.S. states and Canadian provinces. But there has been little cross-fertilization of ideas and even less scientific evaluation of the results of these programs. This lack of dialogue and evaluation has led to disproportionate reliance on the simplest solutions, which generally base incentives on costs. A recent study examined economic incentives for clean energy programs around the world. It showed that purely cost-based incentives mostly resulted in excessive levels of free ridership and failed to transform markets. It also found scarce anecdotal evidence that mixed performance and cost-based incentives did work. These results were contrasted to the experience with performance-based programs, which have proven to be effective both at actually delivering efficiency improvements and transforming markets. As also pointed out in this study, one of the best programs for market transformation has been the Washington State feed-in tariff program. This program, which is similar to a program implemented in Germany, pays producers of renewable electricity a feed-in tariff of up to $0.15 kWh or up to $2000 per year for nine years. Larger tariffs are paid if products are produced in-state. If, for example, the inverter was made locally, the rate jumps to 18 cents. If the system uses a locally-made inverter and modules, the rate jumps to 54 cents. The customer also receives the net metered value of the power and the renewable energy credits. This is the first state end-user incentive program to encourage local growth of renewable manufacturing.

Economic Development Potential of a Maryland Clean Energy Center:
The economic impact analysis discussed in Chapter 5 shows that the largest job-creation impacts and other economic benefits for both Maryland and Baltimore, resulting from the operation of a Maryland Clean Energy Center, will be derived from the Center's promotion of electricity energy efficiency improvements (20, 30, or 40 percent). The second largest opportunity involves an increase in renewable energy utilization (10, 20, or 30 percent). The third largest impacts are associated with promoting the operations of ethanol facilities with the capacity to produce enough fuel to replace select proportions (10, 20, or 30 percent) of current and projected gasoline consumption in Maryland and the Baltimore metropolitan area. The fourth largest impacts involve improvements in natural gas utilization (10, 15, or 20 percent). Other economic impacts identified were those associated with the attraction, expansion and start-up activities of clean energy companies in Maryland, and with the incubation-related activities for these companies. Finally, the construction of a 50 mgpy ethanol plant was estimated to have about 5 times the economic impact of building a 50 MW wind facility.

As shown in the Table below, the cumulative economic impacts of the promotion of energy efficiency, renewable energy and alternative fuels in the State of Maryland, over a twenty-year period, are huge. At the lowest level of effort (20 percent energy-efficiency improvement, 10 percent renewable-energy increase, and 10 percent ethanol production increase), the employment benefits over twenty years are approximately 144 thousand jobs for Maryland, of which approximately 67 thousand will be created in Baltimore. At the same level of effort, and over a twenty-year time period, wages & salaries will go up by $5.7 billion in Maryland and over $2.4 billion in Baltimore; state & local tax revenues will increase by $973 million in Maryland and $412 million in Baltimore; and gross state product (GSP) will increase by $16 billion in Maryland and almost $7 billion in Baltimore. At the highest level of effort (40 percent energy-efficiency improvement, 30 percent renewable-energy increase, and 30 percent ethanol production increase), the economic impacts more than double.

Cumulative Economic Impacts (Efficiency, Renewable & Alternative Fuels Scenarios), 2006-2025, for Maryland and Baltimore.

Scenario	Employment	Wages & Salaries*	State & Local Tax Revenues*	Gross State Product (GSP)*
MD Baseline	143,719	$5,729.7	$973.3	$15,980.9
MD High	326,514	$12,944.8	$2,165.9	$36,006.9
BM Baseline	66,546	$2,437.0	$412.6	$6,852.5
BM High	162,177	$5,890.2	$985.0	$16,560.2

*millions of dollars

The numbers associated with the economic impacts of firm attraction, expansion and start-up activities, over a 24 year time period, are lower, but significant. For these activities, total employment impacts for Maryland range from 3,750 to nearly 15,000 jobs. Associated wages and salaries for these jobs range from $177 million to over $708 million, while expected state and local tax revenues exceed $18 million in the low scenario and surpass $72 million in the high scenario. The estimated impact on Maryland's GSP ranges from nearly $455 million to more than $1.8 billion. For Baltimore, employment impacts range from 1,863 to 7,450 jobs, and associated wages and salaries for these jobs range from $81 million to over $325 million. Expected state and local tax revenues range from over $8 million to over $33 million, and the estimated impact on Baltimore GSP ranges from over $209 million to more than $837 million.

In the case of business incubations, for every $10 million spent, the Maryland yearly employment impacts total 159 jobs, while associated wages and salaries for these jobs for a year exceed $7 million. Yearly estimated state and local tax revenues approaches $1 million and the estimated yearly impact on Maryland's GSP exceeds $18 million. These impacts are expected to happen wherever the incubator is located. For Baltimore, the estimated employment impacts total 79 jobs, and the associated wages and salaries for these jobs total to $3.4 million. Annual estimated state and local tax revenues in Baltimore are $320,000, and the estimated annual impact on Baltimore' GSP is over $8.3 million. Over a 20 year time period, these numbers will be several times larger, but nowhere near the cumulative estimated impacts of energy efficiency, renewable energy, and alternative fuel improvements.

Nationally, the alternative and clean energy sector is poised for a new period of growth and activity based on increasing energy prices, scarcity and environmental impacts. There is the potential for significant business, employment and economic development benefits accruing to states that have or can develop a comparative advantage in this sector. Maryland is in a good competitive position to capture the growth of the clean energy sector and avail itself of some of the employment and other benefits identified above. In order to be able to do this, Maryland should consider (1) facilitating the development of an industry involved in the production of renewable energy power components and balance of systems, (2) developing a detailed assessment of its position in clean energy research at its universities, private sector companies, and federal facilities, (3) identifying how to better link its clean energy sector to federal government programs, (4) identifying how to best utilize the strength of its biotechnology sector in clean energy development, (5) identifying how to better use the capabilities of Johns Hopkins Applied Physics Laboratory and other university research facilities in developing its clean energy sector, (6) organizing a Maryland Clean Energy Business Council, (7) how to best promote linkages between existing incubators, research parks and clean energy companies, (8) conducting an accurate assessment of what the clean energy industry in the State looks like and what the industry's priority issues are for expanding its capabilities, and (9) establishing the Maryland Clean Energy Center to undertake these activities.

Maryland Clean Energy Center (MCEC):

The MCEC is modeled after the leading successful clean energy business development programs in the country with the **mission** to promote economic development in the clean energy sector by improving access to energy efficiency and renewable energy technologies and supporting the growth of clean energy businesses in Maryland. MCEC is a public /private partnership that brings together the diverse interests in the clean energy sector to form a clearly defined business sector in

Maryland and a forum for discussions about strategies and policies that will support the growth of the clean energy sector. The MCEC will be formed as a Maryland non profit 501c3 corporation.

Vision:
The MCEC will strive to create the maximum economic, environmental and quality of life improvement in the State through the promotion of business development and growth in the clean energy industry sector. Through its efforts, MCEC will increase the number of businesses in Maryland that manufacture, sell and service energy efficiency and renewable energy technologies. As a result, Marylanders will benefit from reduced energy cost, increased profits and disposable income, improved energy price and supply stability, improved environment, and overall improved quality of life.

Clean Energy:
For the purpose of the MCEC, we define clean energy as any technology that reduces environmental impact of energy generation and use. This includes technologies associated with cleaner sources of energy, more efficient uses of energy, and better management of waste energy. MCEC will focus primarily on energy efficiency, green buildings, and renewable energy sources, such as solar thermal, solar PV, wind, ethanol, biodiesel, land fill gas, hydrogen and biogas.

Core Values:
MCEC is guided by the following set of core values or guiding principals.

1. Public Purpose. MCEC is focused on results that improve the quality of life for all Marylanders. We understand that economic development must benefit not only businesses, but also the poor and disadvantaged by providing access to affordable energy services, new jobs, and economic opportunities in the growing clean energy sector.
2. Innovation. MCEC recognizes the power of ideas and innovation to address our growing energy needs and responsibilities to the public and the environment. MCEC will work to stimulate new ideas and support innovation.
3. Understanding. Good information and informed dialogue leads to good public policy. To be successful in an expanding, diverse, dynamic and highly technical economy, we need timely, accurate, complete and unbiased information. This requires a combination of data collection, data analysis, listening, and an active engagement with a broad range of stake holders. MCEC will work to assure that policy makers have the best and latest data for making informed policy and facilitate short feed back loops on what’s working and what’s not.
4. Collaboration. No single organization can do it all alone. MCEC will establish long-term relationships and public/ private partnerships that generate effective solutions and facilitate communication and collaboration between all stake holders, including citizens, government, industry, researchers and academia.
5. Catalytic Action. Industry can not bring change in Maryland’s clean energy sector fast enough on its own. It needs a dedicated, informed, articulate and credible champion for the cause. MCEC will act as a catalyst providing support to leaders in government, academia, and industry to accelerate economic development and job growth in the clean energy sector.

MCEC and Maryland Energy Administration:

The Maryland Energy Administration (MEA) and the MCEC will work hand in hand in a strategic partnership to promote energy efficiency and renewable energy. They each have a distinct role to play. MEA is charged by the Governor to carry out the energy policy of the Administration. In that role, MEA has a diverse mix of programs to serve that mission. Being a State agency, MEA is limited in its ability to address specific business and industry needs that may support one business over another or take on initiatives without the direction of the legislature and the Governor. MCEC can fill that gap by representing the unique and diverse interests of the clean energy industry in Maryland. MCEC will act in some ways like an industry association or chamber of commerce for the clean energy industry in the State. MCEC will organize the industry and provide a forum for discussions about strategies and policies that will support the growth of clean energy business in the State. Working with MEA and DBED, MCEC can provide advice to the legislature and the governor on policies that would have the highest impact on business growth and provide feed back on the effectiveness of existing policy. MCEC will be a valuable resource to MEA, DBED and the Administration when it comes to stimulating business development in Maryland.

MCEC Goals

The goals of the MCEC are centered around promoting and growing the clean energy industry in Maryland:

1. Organize the clean energy sector in Maryland into a cohesive and recognized entity;
2. Give the clean energy industry a voice to the public and policy makers and be the public advocate for the industry;
3. Increase the number of clean energy companies in Maryland by attracting new companies to locate in Maryland and growing new ones through our clean energy incubators and business support resources;
4. Establish MCEC as the credible source of information on the clean energy industry, energy data, and policy guidance in Maryland;
5. Increase the deployment and application of clean energy technologies in Maryland.

MCEC Objectives

To reach the above goals, MCEC will achieve the following objectives:

1. Organize a Maryland Clean Energy Business Council that will represent and speak for the Maryland clean energy industry and undertake key activities supportive of the industry's economic growth;
2. Increase the availability of clean energy-related services at all existing incubators throughout the State of Maryland;
3. Undertake outreach and technical assistance activities that will foster a general climate supportive of clean energy technology deployment and application in Maryland;
4. Undertake assessments and analyses to identify Maryland's strengths and weaknesses in growing the clean energy industry in Maryland;
5. Establish and maintain an energy data collection and tracking system in Maryland;

6. Develop procedures for promoting entry into domestic and international markets by Maryland clean energy businesses and organizations;
7. Increase the adoption and sales of clean energy technologies in Maryland
    - Increase use of renewable energy 15 percent by 2016 and 30 percent by 2026
    - Increase energy efficiency of electricity consumption 20 percent by 2016 and 40 percent by 2026
    - Increase energy efficiency of gas consumption 10 percent by 2016 and 20 percent by 2026
    - Increase the use of non-petroleum transportation fuel 20 percent by 2016 and 40 percent by 2026

Key Players and Strategic Partners:

One of MCEC's core values is collaboration. The Center will strive to develop long-term relationships and partnerships that will effectively support the growth of clean energy in Maryland. The MCEC will build public/ private partnerships and facilitate communication and collaboration between all stake holders, including citizens, government, industry, researchers and academia.

Over the past year, ICSD has met with numerous groups in the State to discuss the feasibility and potential for a MCEC. We received unanimous agreement from every organization we met with that there is a tremendous opportunity for economic development in clean energy and the concept of the MCEC is a good one. The following is a partial list of the organizations we met with that voiced their support for the MCEC and a desire to form a strategic relationship with the Center:

- Johns Hopkins University, Dr. Theodore Poehler
- Johns Hopkins Applied Physics Laboratory, Dr. Richard Roca
- University of Maryland College Park, Brian Darmody, Kimberly Ross
- University of Maryland Biotech, Dr. Jennie Hunter-Cevera
- BGE, Kevin D. Ryan, Counsel, Alexander G. Nunez
- PEPCO, Richard Swink, Manager Strategic Planning
- TEDCO, Renee M. Winsky
- Emerging Technology Center, John Fini
- Jacob France Institute, University of Baltimore, Richard Clinch
- RESI, Towson University, Dr. Daraius Irani
- BEACON – Salisbury University: Dr. Memo Diriker
- Chesapeake Bay Region Technical Center (CBRTCE): John General
- Maryland Center for Environmental Training (MCET), College of Southern Maryland: Karen L. Brandt
- Tri County Council for Western Maryland, LeAnne Mazer
- Frederick Innovative technology Center, Inc, Michael Dailey

Activities of the MCEC

The MCEC activities in the short term are focused on pulling together a cohesive and visible clean energy industry in Maryland and giving the industry a voice to the public and policy makers. Based on the feedback from the industry and other stake holders, MCEC will expand its activities as needed to support the growth of the clean energy industry. The primary activities of the Center, for at least the first two years, fall into 4 categories:

(1) **Maryland Clean Energy Incubator.** MCEC will support a Maryland Clean Energy Incubator (MCEI) at the Emerging Technology Center (ETC) in Baltimore and recruit companies to join the MCEI. MCEC will also establish strategic partnerships with the other incubators in Maryland, modeled after the ETC partnership, to create a network of clean energy incubators in the State. MCEC also intends to explore promoting further linkages between existing incubators and research parks and clean energy companies. For example, BP Solar has expressed interest in working with the Frederick County incubator. Also, as further discussed below, MCEC's activities will attract new start-up clean energy businesses to Maryland. This will have the dual impact of enhancing incubator utilization and stimulating new research opportunities and linkages in Maryland.

(2) **Maryland Clean Energy Business Council and Clean Energy Business Development Collaboratives.** MCEC will organize a Clean Energy Business Council. ICSD has already taken the initial step of identifying what companies make up the existing base of the clean energy industry in Maryland. MCEC will further develop and refine this database, so that we have accurate assessment of what the industry looks like from the perspective of each clean energy technology. MCEC will work with the Council to initially establish five Clean Energy Business Development Collaboratives for solar energy, energy efficiency and Green buildings, off- shore wind, biofuels and hydrogen. The Collaboratives are critical to creating a cohesive and visible clean energy industry that can interact with the public and policy makers to grow the industry. MCEC will recruit membership and participation in the Council and organize a series of forums to discuss issues common to the industry. The MCEC through the Council will create an annual assessment of the state of the industry and a legislative agenda to promote the growth and health of the industry in Maryland.

(3) Data Collection, Assessments and Analyses. It was clear in the development of this study that there is a severe lack of good data and useful information on energy use, trends and the state of the energy industry in Maryland. Good information is needed to develop good public policy and to track the effectiveness of our activities. To be successful in its mission, MCEC will need to obtain timely, accurate, complete and unbiased clean energy-related information. MCEC will (1) track energy consumption, energy sources, industry activity, sales of clean energy products and services, and the health of the clean energy industry in Maryland, (2) track these activities in other States, at the Federal level, and in other countries, and (3) work to assure that policy makers have the best and latest data for making informed policy and facilitate short feed back loops on what's working and what's not. Furthermore, in order to assist Maryland in capturing the growth of the clean energy sector and the associated benefits that come with the growth of this sector, MCEC will undertake several assessments and analyses to help identify Maryland's strengths, weaknesses and interests in growing this sector.

(4) Outreach and Technical Support. The clean energy industry needs a dedicated, informed, articulate and credible champion to promote clean energy development and utilization in the State. MCEC will act as a catalyst providing support to leaders in government, academia, and industry to accelerate economic development and job growth in the clean energy sector. Working through the Collaboratives, MCEC will provide regular information to the media and support workshops and seminars for consumers. MCEC will also publish a Newsletter and an annual "State of the Maryland Clean Energy Industry." Furthermore, MCEC will provide technical assistance to the State, institutions and NGOs in Maryland on the application of energy efficiency and renewable energy technologies in their facilities. Through conference participation and its international contacts, MCEC will inform the national and international clean-energy community of Maryland's decision to pursue clean energy-driven economic development in the State and foster a general climate supportive of clean- energy technology deployment and application. This, and the quality of the State's workforce, its locational benefits and atmosphere of creative innovation, will work to attract clean-energy start-up and mature businesses to Maryland.

<u>MCEC Time Line:</u>

MCEC Year 1

The following are the priorities for the first year of the MCEC.

1. Establish the MCEC
    - Set up the MCEC at ETC and recruit and hire staff,
    - Set up bylaws, Board of Directors and Board of Advisors,
    - Apply for 501c3 tax exempt status with the IRS
2. Establish MOUs with Strategic partners
3. Further develop and refine the Maryland Clean-Energy Industry Database
4. Create and manage the Maryland Clean Energy Business Council and establish the above-mentioned Clean Energy Business Development Collaboratives
5. Begin developing other core activities of Center
    - track State and National activities
    - publish a Newsletter and an annual State of the Maryland Clean Energy Industry
    - establish and maintain an energy data collection and tracking systems
    - conduct a Clean Energy Policy Study and develop policy recommendations
    - provide technical assistance to businesses, home owners, state and local governments, NGOs and the Maryland legislature
6. Establish and support the Clean Energy Incubator at ETC
7. Begin developing projects with MCEC Strategic partners

MCEC Year 2

1. Continue working with the Clean Energy Business Council, and supporting the Clean Energy Collaboratives and other core activities
2. Hold the first Annual Clean Energy Conference and Clean Energy Workshops
3. Explore the feasibility of creating a Clean Energy Fund for Maryland
4. Launch projects with MCEC Strategic Partners
5. Launch Green Home Pro Weatherization Program

Potential Projects to be undertaken in year 1 or 2 with MCEC Partners:

- Feasibility study for developing a "Maryland Real-Time Regional Energy Monitoring and Alerting System (RREMAS)"

- Assessment of potential renewable-energy power component and balance-of-systems industrial development in Maryland
- Assessment, inventory, and needs-and-applications analysis of private, university and federal clean-energy technology capabilities, research and activities in the State
- Assessment and inventory of the linkages of the Maryland clean-energy sector to federal agency programs
- Analysis of potential biotechnology applications in the clean energy field in Maryland
- Analysis of available renewable energy production and utilization incentives in Maryland
- Feasibility studies for ethanol and biodiesel plants, and wind farms in Maryland
- Clean energy demonstration projects
- Zero Energy Building for MCEC
- Vocational development projects
- Sustainable Cities Program

Staffing and Management:

The MCEC will be managed and staffed in the beginning by the ICSD, until full-time staff can be hired. MCEC will seek full time staff positions to include:

- Executive Director
- Chief Technology Officer
- Solar, energy efficiency and green-buildings collaboratives manager
- Biofuel and hydrogen collaboratives manager
- Wind collaborative manager
- Outreach manager
- Data and policy analyst
- Project managers (as needed to work with Strategic Partners)

MCEC will have a Board of Directors that will oversee the operations of the Center. The Board of Directors will consist of representatives from DBED, MEA, Abell Foundation, ETC and industry. MCEC will be guided by a Board of Advisors that will be named by the Board of Directors and consist of leaders in industry, research, educators and policy makers.

Potential funding methods:

The majority of State Clean Energy Centers are funded by the State or local government with additional support from foundations. The most effective clean-energy economic development programs are funded by a very small public benefit surcharge on consumer's electric bills. These funds currently collect more than $500 million per year in 14 States in support of renewables and efficiency. The Massachusetts Renewable Energy Trust Fund is supported through a system benefits charge with total funding of roughly $150 million over the initial five-year period, with approximately $25 million per year for each year thereafter. The New Jersey fund is about $18 million per year, New York $25.5 million per year, and Pennsylvania $27.3 million per year. States that have made this kind of investment have seen significant economic development benefits for the State. Clearly, Maryland needs to look at how the State can fund clean energy investments at a level of at least $25 million per year in order to see significant growth in the clean energy sector. MCEC expects to start small and build statewide support for a more aggressive program. If Maryland chooses to impose a very small public benefit tax on consumers' utility bills of $0.0004 cents per kilowatt-hour or less than $0.50 per household per month, as 14 states currently do, this would raise $25 million per year for clean energy programs.

At least for the first two years, we think an annual operating budget of approximately $1 million can be funded by a combination of State funds and foundation support, with the majority of the funds coming from the State. As the MCEC starts to develop projects, these projects will seek project specific funding that can come from a variety of sources, including the Federal government, foundations, industry and private investment. MCEC will always seek to leverage existing programs and funding whenever possible. During the first two years of the MCEC, we will work closely with the State, utilities and others to find a way to fund a Maryland Clean Energy Fund.

Conclusions

The overall conclusion of the study is that creating a Clean Energy Center for Maryland would have tremendous benefits to the State in terms of economic development, stable energy prices and supply, and environmental improvement. Additional conclusions are as follows:

1. **The economic development potential of clean energy development in Maryland is very significant in terms of jobs, wages and salaries, state and local tax revenues, and gross state product.** The estimated cumulative economic impacts of the promotion of energy efficiency, renewable energy and alternative fuels to the State of Maryland, over a twenty year period, are huge. At the lowest level of effort (20 percent energy-efficiency improvement, 10 percent renewable-energy increase, and 10 percent ethanol production increase), the employment benefits over 20 years are approximately 144 thousand jobs for Maryland, of which approximately 67 thousand will be created in Baltimore. At the same level of effort, and over a twenty-year time period, wages & salaries will go up by $5.7 billion in Maryland and over $2.4 billion in Baltimore; state & local tax revenues will increase by $973 million in Maryland and $412 million in Baltimore; and gross state product (GSP) will increase by $16 billion in Maryland and almost $7 billion in Baltimore. At the highest level of effort (40 percent energy-efficiency improvement, 30 percent renewable-energy increase, and 30 percent ethanol production increase), the economic impacts more than double.
2. **The estimated economic development potential of attracting, expanding and starting-up clean-energy companies, over a 24 year time period, is lower, but still significant.** For these activities, estimated total jobs impacts for Maryland range from 3,750 to nearly 15,000. Associated wages and salaries for these jobs range from $177 to over $708 million, while expected state and local tax revenues exceed $18 million in the low scenario and surpass $72 million in the high scenario. The estimated impact on Maryland's GSP ranges from nearly $455 million to more than $1.8 billion. For Baltimore, job impacts range from 1,863 to 7,450, and associated wages and salaries for these jobs range from $81 million to over $325 million. Expected state and local tax revenues range from over $8 million to over $33 million, and the estimated impact on Baltimore's GSP ranges from over $209 million to more than $837 million.
3. **The estimated economic development potential of clean energy business incubation is also significant.** For every $10 million spent on business incubation, the Maryland yearly employment impacts total 159 jobs, while associated wages and salaries for these jobs for a

year exceed $7 million. Yearly estimated state and local tax revenues approaches $1 million and the estimated yearly impact on Maryland's GSP exceeds $18 million. These impacts are expected to happen wherever the incubator is located. For Baltimore, the estimated employment impacts total 79 jobs, and the associated wages and salaries for these jobs total to $3.4 million. Annual estimated state and local tax revenues in Baltimore are $320,000 and the estimated annual impact on Baltimore' GSP is over $8.3 million. Over a 20 year time period, these numbers will be several times larger, but nowhere near the cumulative estimated impacts of energy efficiency, renewable energy, and alternative fuel improvements.

4. **The greatest economic benefit from growing the clean energy business sector comes not just from the jobs created and economic investment in the companies, but from the energy services they provide to Marylanders.** The greatest economic benefit comes from the energy savings to people and businesses, which increases disposable income and increases profit, stimulating economic activity in all sectors. In addition, every dollar not spent on imported energy (all Maryland's energy is imported), stays in the community and generates approximately $3 in economic activity locally.
5. **Maryland needs to assess its strengths, weaknesses and interest in participating in the expected growth of this sector, and if it decides to participate, how to best capture this growth.** ICSD is suggesting that the best way for this assessment to take place is to (1) give Maryland's clean energy industry an identity and a voice in the process of identifying how to best grow the clean energy sector in Maryland, and (2) establish a Maryland Clean Energy Center to help identify, organize, and grow this industry, and bring all of Maryland's private and public resources into play in a coordinated way so that the State can avail itself of the economic benefits of clean energy growth in the most cost-effective way.
6. **There is strong support for promoting clean energy in Maryland.** We received unanimous agreement from every organization we met with that there is a tremendous opportunity for economic development in clean energy and the concept of the MCEC is a good one. As a result, we have begun to develop strong collaborative relationships with the major institutions in the State, including TEDCO, UMBI, UMD, JHU, JHU-APL, ETC, PEPCO, BGE and many others.
7. **Energy costs are rising and we need a more stable energy supply and costs.** Energy efficiency and renewable costs and supplies are much more stable and entail lower costs in the long term than conventional energy. In addition, we need to provide better access to stable affordable energy services for the low income and disadvantaged segment of the population in Maryland.
8. **Maryland has good to excellent renewable energy resources in wind, solar, and biomass with off-shore wind and solar PV having the greatest potential.** Renewable energy resource potential exceeds current electric sales. Renewable energy technology can provide 30 percent to over 136 percent of the State's electric energy needs**.** PV could provide 17-25 percent and off-shore wind could provide 8 percent to almost 100 percent of the power needs of the State.
9. **The potential clean energy market is large and growing rapidly, over 30 percent per year.** In 2006, the growth in green home building is expected to rise by 20 percent over 2005, and in 2007, there is a projected a growth of 30 percent over 2006 numbers. This means that more than two-thirds of all the home builders will be building green homes. The sheer number of participants in the green-home building market will pull the rest of the

market up to green-building standards in order to remain competitive. The market potential for solar water heaters in Maryland is $2 billion for retrofit applications alone. Solar PV is a $12 billion global industry. The PV equipment market is projected to be $30.8 billion by 2013. Renewable-energy project finance is up from $10.8 billion in 2004 to $18.2 billion last year. The preponderance of financing is in wind (72%), with the U.S. leading the world with $3.9 billion invested in 2005.

10. **Maryland is well-positioned to take advantage of the growth in the energy efficiency and renewable energy market.** Maryland has a rich landscape of services and capabilities to support new business growth. Maryland has real strength in the biotechnology sector, which positions the State well to be a leader in the biofuels sector.
11. **While Maryland has some pro clean-energy policies, it lags behind the States that have been reaping the benefits of the rapidly growing clean energy market. T**he solar industry has shown explosive growth in California and New Jersey, where they have aggressive tax incentives, buy down programs, good interconnection policy and aggressive Renewable Portfolio Standards (RPS). New Jersey's solar industry has experienced a 500 percent growth rate in the past three years as a result of its aggressive policies.
12. **Maryland's Renewable Portfolio Standard (RPS) will do little to grow the clean energy industry in Maryland.** According to the Maryland Power Plant Research Program, barring unforeseen levels of renewable energy generation retirements, increases in demand in the state, or widespread difficulties certifying resources in states adjacent to PJM, it is likely that new renewable energy projects will not have to be developed to meet Maryland's RPS requirement. The Maryland RPS legislation, therefore, may fall short of its expectations.
13. **A reduction is needed in the environmental impacts from fossil fuel-based energy production in Maryland.** Maryland struggles to maintain good air quality and protect the Bay. Because of our heavy coal use, power plants in Maryland contribute significantly to health threatening air pollution. These plants currently contribute nearly 80 percent of the total sulfur dioxide (SO2) emissions and 30 percent of the total nitrogen oxides (NOx) emissions. Currently, coal-fired plants are also significant sources of mercury, a neurological toxicant that contaminates the fish in our rivers, lakes and oceans. Energy efficiency and renewable energy can significantly mitigate the environmental impact of electricity generation in Maryland. The Maryland Healthy Air Act of 2006, with some of the toughest restrictions in the country for emissions of NOx, SO2 and mercury, is a good start, but doesn't take effect till 2009/2010, and much more remains to be done.
14. **Clean energy development in Maryland will allow the State to reduce greenhouse gas emissions that contribute to global climate change.** The Maryland Healthy Air Act also requires that, in 2007, Maryland will join the Regional Greenhouse Gas Initiative, which is a regional consortium of Northeast states committed to reducing greenhouse gas emissions. The Initiative establishes a cap-and-trade mechanism for reducing emissions of greenhouse gases. Maryland will thus join seven other states in the Northeast - Connecticut, Delaware, Maine, New Jersey, New York, New Hampshire, and Vermont - that have agreed to reduce carbon dioxide emissions by10% in 2019. During negotiations about the bill in the Maryland Legislature, the Maryland Governor and Maryland utility companies expressed concerns about the effects of this legislation on electricity prices. As a result, it was amended to require a comprehensive study of reliability and cost issues in 2008. Depending

on the outcome of this study, the State can withdraw from the Regional Greenhouse Gas Initiative in 2009.

15. **Performance based incentive programs could be used to encourage local growth of renewable manufacturing.** The best example of this is Washington State, who rejected the RPS mechanism in favor of a feed-in tariff program, similar to the one implemented in Germany. Washington State's program pays producers of renewable electricity a feed-in tariff of up $0.15 kWh or up to $2000 per year for nine years. Larger tariffs are paid, if products are produced in-state. If, for example, the inverter was made locally, the rate jumps to 18 cents. If the system uses a locally-made inverter and modules, the rate jumps to 54 cents. The customer also receives the net metered value of the power and the renewable energy credits. This is the first state end-user incentive program to encourage local growth of renewable manufacturing.
16. **Energy efficiency is the most cost effective energy saving investment.** The potential to reduce energy consumption and cost through energy efficiency is significant. Through a modest set of programs, Maryland can reduce anticipated total electricity demand by 6 percent by 2010. Studies have shown that a broader set of measures could yield cost-effective savings of five times this amount in a similar time frame. In addition, energy efficiency is 60-70 percent cheaper than new generating capacity.
17. **One of the best opportunities for clean energy economic development in Maryland is in the biofuels sector**. Ethanol is one of the fastest growing and hottest investment opportunities today with returns on investment of 27-34 percent on an average investment of over $100 million.
18. **Maryland has excellent technical resources particularly in biotechnology and therefore is well positioned to be a leader in the biofuels market.** MCEC intends to catalyze the application of biotechnology in the biofuels field.
19. **Stable and progressive energy policy is needed to stimulate the clean energy market.** The most effective policies have been performance based incentives, such as the feed-in tariff adopted in Washington State. California and New Jersey have seen explosive growth in the clean energy sector due to their stable and progressive policies.
20. **Maryland needs a focal point to realize the potential of clean energy in Maryland.** Currently the clean energy industry has no identity or voice in Maryland. MCEC proposes to be the champion of the clean energy industry.
21. **Policy makers need accurate data in order to make sound, informed policy that maximizes the potential of clean energy in Maryland.** In addition, they need timely feedback on policy decisions and how well their programs and policies are working.
22. **The public and businesses need to be informed of the potential and benefits of energy efficiency and renewable energy.** The benefits are great but generally unknown to the average consumer. In order to create the market demand for clean energy products and services and grow the clean energy industry in Maryland, the message needs to be broadcast loud and clear across the whole State.
23. **Doing everything we can to promote clean energy in Maryland is good for the economy, good for the people, good for the environment, and is good policy.** This has been clearly demonstrated in many States.
24. **Effective policy and programs can only be developed and managed through a collaborative process.** The MCEC will build public/ private partnerships and facilitate

communication and collaboration between all stake holders, including citizens, government, industry, researchers and academia.

25. **Long-term stable funding for the MCEC should be secured through a small public benefit charge on the utility bills.** Fourteen States currently fund their clean energy investment programs through some sort of public benefit charge on the utility bills. The average funding level is $25 million per year. Every State has found a significantly-positive return on their investment in clean energy for their State.
26. **For the MCEC to be effective, it needs to do the following:**
    a. Identify and organize the clean energy industry in Maryland;
    b. Coordinate the industry's interests and provide a forum for collaboration;
    c. Be a technology resource to the State, institutions, businesses and citizens;
    d. Be a resource for the State legislature and local governments;
    e. Help coordinate all the State's resources to support the clean energy industry;
    f. Categorize and coordinate the work of the university, federal and private-sector research community;
    g. Expand the linkages between the Maryland clean energy sector and the federal agencies;
    h. Catalyze the application of biotechnology to the emerging clean energy field in Maryland;
    i. Promote linkages between existing incubators and research parks and clean energy companies;
    j. Conduct an assessment of the extent to which promoting the development of renewable energy in Maryland, especially wind and solar power, could facilitate the development of an industry involved in the production of renewable-energy power components and balance-of-systems products, and the extent to which this could assist the State in stabilizing or growing employment in its manufacturing sector;
    k. Broadly promote the benefits of clean energy throughout the State;
    l. Coordinate the development of a Maryland "Real-Time Regional Energy Monitoring and Alerting System (RREMAS)."

1. Scope of the Study

Introduction

U.S. energy costs and our dependence on energy imports are at record levels and continue to rise. The environmental, social and economic impacts of our consumption of fossil fuels have become well-documented problems. What has also been well-documented is that these problems can be effectively remedied through the deployment and application of energy efficiency, renewable energy, and alternative fuels technologies, commonly referred to as clean energy technologies. The clean energy industry, which markets, deploys, applies, and services these technologies, has become one of the fastest growing industries in the U.S. and the world. Many states have recognized the economic development potential of this multi-billion dollar industry and the associated social and environmental benefits that come with building a strong local clean energy industry. It is this realization that led Maryland to investigate the potential for developing a vigorous clean energy industry in the State. Building on its success in growing the biotechnology sector, Maryland is now looking to the growth of the clean energy sector as an engine for economic development in the State.

In view of the economic benefits associated with developing a clean energy industry, the International Center for Sustainable Development (ICSD) was commissioned by the Baltimore Development Corporation, with funding from the Maryland Department of Business and Economic Development (DBED), the Maryland Energy Administration (MEA), and the Abell Foundation to analyze the economic development potential of growing the clean energy sector in Maryland, and explore the role that a Maryland Clean Energy Center can play in being a focal point to facilitate this growth.

Scope and Objective

The primary objective of this study is to determine the feasibility of creating a Maryland Clean Energy Center designed to stimulate economic development and create jobs in the clean energy sector in Maryland. The Center will support the existing clean energy businesses, facilitate the growth of new businesses, and attract companies to move to Maryland. As a result of having better access to clean energy from a vigorous clean energy business sector, people and businesses will save energy and money, resulting in a reduction in Maryland's dependence on energy imports, a reduction in pollution and environmental impacts, and a general improvement in the quality of life in Maryland.

The study analyzes the market opportunity for clean-energy business development in Maryland and projects the potential economic impact on the economy and the job creation potential that will result from the creation of the Center. The study also looks at policy options and what other states are doing to promote clean energy development. Finally, the study outlines a vision and a business plan for a Maryland Clean Energy Center.

To address these issues, the study is divided into 6 sections.

1. **Scope of the Study**
2. **Energy Use in Maryland**

   This section discusses the past and projected energy use in Maryland by fuel and end-use sector. This creates a baseline from which to project the economic impacts of the Center

3. Clean Energy Technologies
This section discusses the primary clean energy technologies that are of interest to Maryland and their potential in terms of addressing Maryland's energy demand. The technologies considered include energy efficiency and green buildings, solar thermal, solar electric PV, wind power, hydrogen, ethanol and biodiesel. The section includes a brief introduction to the technology, a discussion of the market and market trends, and the economics of these systems compared to conventional sources.

4. Clean Energy Policy
This section discusses public policies that could assist in the growth of the clean energy sector in Maryland and Baltimore. It reviews policy options in general and for the various technologies.

5. Economic Development Potential of a Maryland Clean Energy Center
This section discusses the jobs and the economic development potential for developing the clean energy sector in Maryland and Baltimore. This section also discusses Maryland's competitive position both now and in the future and the role of the Center in developing this potential.

6. Maryland Clean Energy Center- Business Plan
This section is the business plan for the proposed Center. It discusses similar centers in other states and proposes a model for the Maryland Center. In addition, this section discusses the proposed Center's mission, vision, objectives, key players, potential activities, activities time line, management and staffing plan, operating budget, potential funding methods, and the role of the Center in relation to the Maryland Energy Administration (MEA).

7. Conclusions
This section provides the conclusions from the study.

2. Energy Use in Maryland

Background

In order to perform the economic impact analysis of establishing a Clean Energy Center in Maryland, which was needed to develop section 5 – Economic Development Potential of a Maryland Clean Energy Center, an up-to-date scenario of current and future energy consumption in Maryland was needed, by end-use sector and energy source. The Energy Information Administration (EIA) of the U.S. Department of Energy publishes historical State Energy Consumption Data by end-use sector and source, but the information often consists of data for a period that is 3-4 years in the past. Also, EIA does not publish energy consumption forecasts on a state-basis. In the case of electricity, the Public Service Commission (PSC) of Maryland does publish current and future electricity-sales data. This data, which is provided by Maryland's electric companies, was of limited use for us, because the electricity sales forecasts are not broken out by end-use sector and energy source, and the current electricity data, which is broken out by end-use sector, is based on sector definitions/characterization of the commercial and industrial sectors that are different from EIA commercial and industrial sector definitions/characterization. Therefore, a Maryland-specific energy-consumption scenario was developed, which consists of an energy consumption estimate by end-use sector and energy source for 2004, and an energy consumption forecast, also by end-use sector and energy source, for 2005 through 2030.

The point of departure for the Maryland 2004 energy consumption estimates was the EIA Maryland State Energy Data 2002: Consumption, Tables 7-12. Parts of the 2002 data in these Tables were updated for 2003 and 2004, using information from other EIA publications, such as the EIA Natural Gas Navigator, State Electricity Profiles, Electric Power Industry Generation, Petroleum Navigator, Annual Coal Report, and the Electric Power Annual. Based on discussions with EIA analysts, [1]other 2003/2004 consumption estimates were derived by ratio-ing down from EIA national 2003/2004 consumption estimates in a manner similar to how some actual EIA state consumption estimates are derived from national estimates. Having developed the 2004 Maryland energy consumption estimates by sector and energy source, the 2005-2030 forecast of Maryland energy consumption, also by sector and energy source, was developed using regional growth rates from the EIA Energy Outlook 2006 [2]

The EIA Energy Outlook 2006 presents regional energy consumption growth rates by sector and energy source, for 2004-2030, for the South Atlantic Region, which includes Maryland and the States of Delaware, Florida, Georgia, North Carolina, South Carolina, Virginia and West-Virginia, and for the Mid-Atlantic Region, which includes New Jersey, New York and Pennsylvania. In

[1] Among others, discussions were held with Paul Holtberg, Director, EIA Demand and Integration Division, Julia Hutchins, EIA petroleum analyst, and Louise Guei'lee, renewable energy analyst.

[2] Regional growth rates for the South Atlantic region can be found in the EIA Annual Energy Outlook 2006, Supplemental Table 5, Energy Consumption by Sector and Source, South Atlantic. Regional growth rates for the Mid-Atlantic Region can be found in Supplemental Table 2.

order to decide which region's growth rates to use for Maryland, the average growth rates in energy consumption by sector and by energy source for the two regions for the years 1992-2002 were analyzed and compared to Maryland's average energy consumption growth rates, also by sector and energy source, for the same time period. The analysis of these regional growth rates showed no clear favorite for us to select, so we decided to use the growth rates for the region that Maryland belonged to; the South Atlantic region. The results of our forecast of Maryland energy consumption, by sector and energy source, for the time period 2005-2030, can be found in Appendix 1. The discussion, below, is based on the data in these tables.

Maryland Energy Consumption

It is estimated that, in 2005, Maryland consumed the equivalent of around 1.55 quadrillion Btu of energy, including over 100 million barrels of petroleum, over 13 million tons of coal, over 197 billion cubic feet of natural gas, over 13 billion kWh of nuclear electric power, and over 2,640 million kWh of hydroelectric power. Almost all of the coal is used to generate electricity. In 2005, Maryland consumed over 69 billion kWh of electricity. In 2003, Maryland was ranked the 24th highest among the States in terms of total energy use. With regard to coal, natural gas, petroleum, and electricity consumption in the same year, Maryland was ranked 27th, 33rd, 23rd, and 21st respectively. And with regard to energy prices, total energy expenditures, and energy expenditures per person, Maryland ranked 13th, 22nd, and 42nd. In 2003, Marylanders spent about $12.6 billion for the energy they consumed.

Energy Consumption by Source

At the national level, energy consumption in 2005 was 99.9 quadrillion Btu, including 20.66 million barrels of petroleum per day, 21.98 trillion cubic feet of natural gas, and 1,128 million tons of coal. National electricity consumption in 2005 was estimated by EIA to be 3.8 trillion kWh. The percentage breakout of national energy consumption in Btu by source for 2005 is given in Figure 1 below. As indicated, petroleum (40.4 Quads) is the largest national energy source, followed by coal (22.8 Quads) and natural gas (22.6 Quads). Nuclear provided 8.1 Quads, and renewables 6.8 Quads.

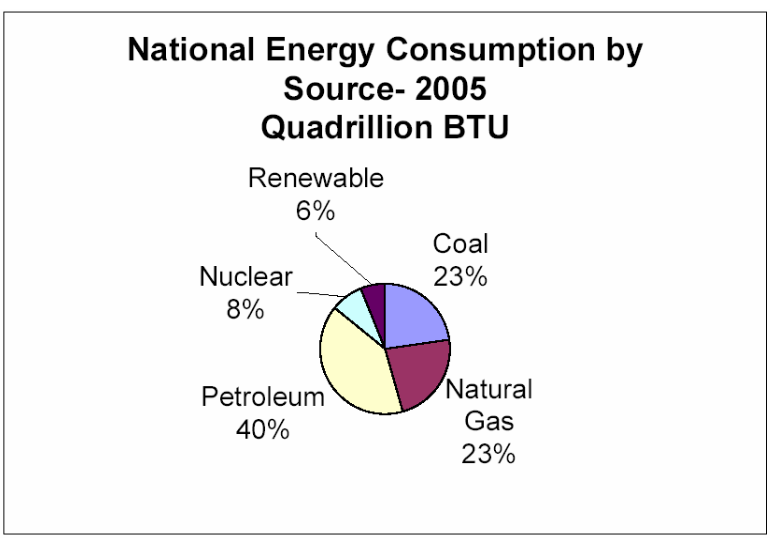

Figure 1

In Maryland, the percentage breakout of energy consumption in Btu by source is slightly different from the national level energy use. In 2004, Maryland consumed about 1.54 quadrillion Btu in primary energy. The percentage breakout of Maryland energy consumption by source for 2004 is given in Figure 2 below. As is the case at the national level, on a Btu-basis, petroleum is the largest energy source consumed in Maryland, at a level of 588.7 trillion Btu. Coal is the second largest energy source, providing 326.7 trillion Btu, and natural gas is third at 198.7

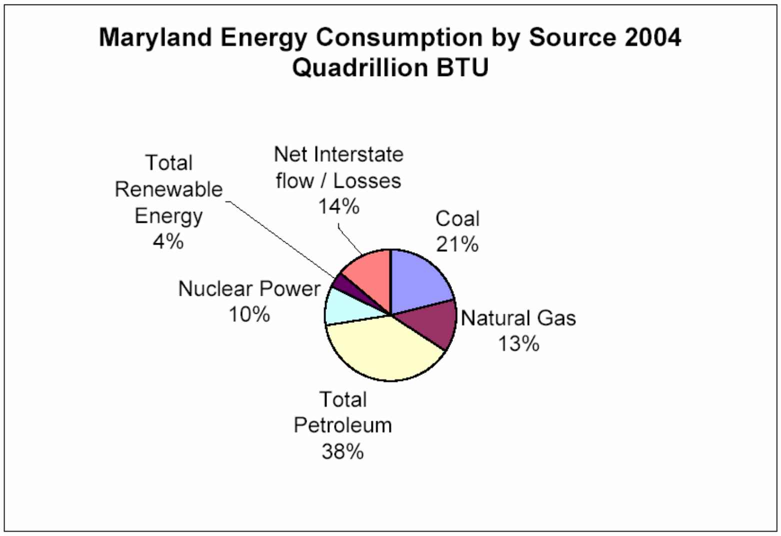

Figure 2

trillion Btu. In 2004, Maryland also consumed 151.9 trillion Btu in nuclear power and 59.3 trillion Btu in renewable energy.

The growth in Maryland's actual energy consumption by source from 1960-2004 and the forecasted growth for 2005-2030 is given in Figure 3 below. The forecast shows all energy sources continuing to grow between 2005 and 2030.

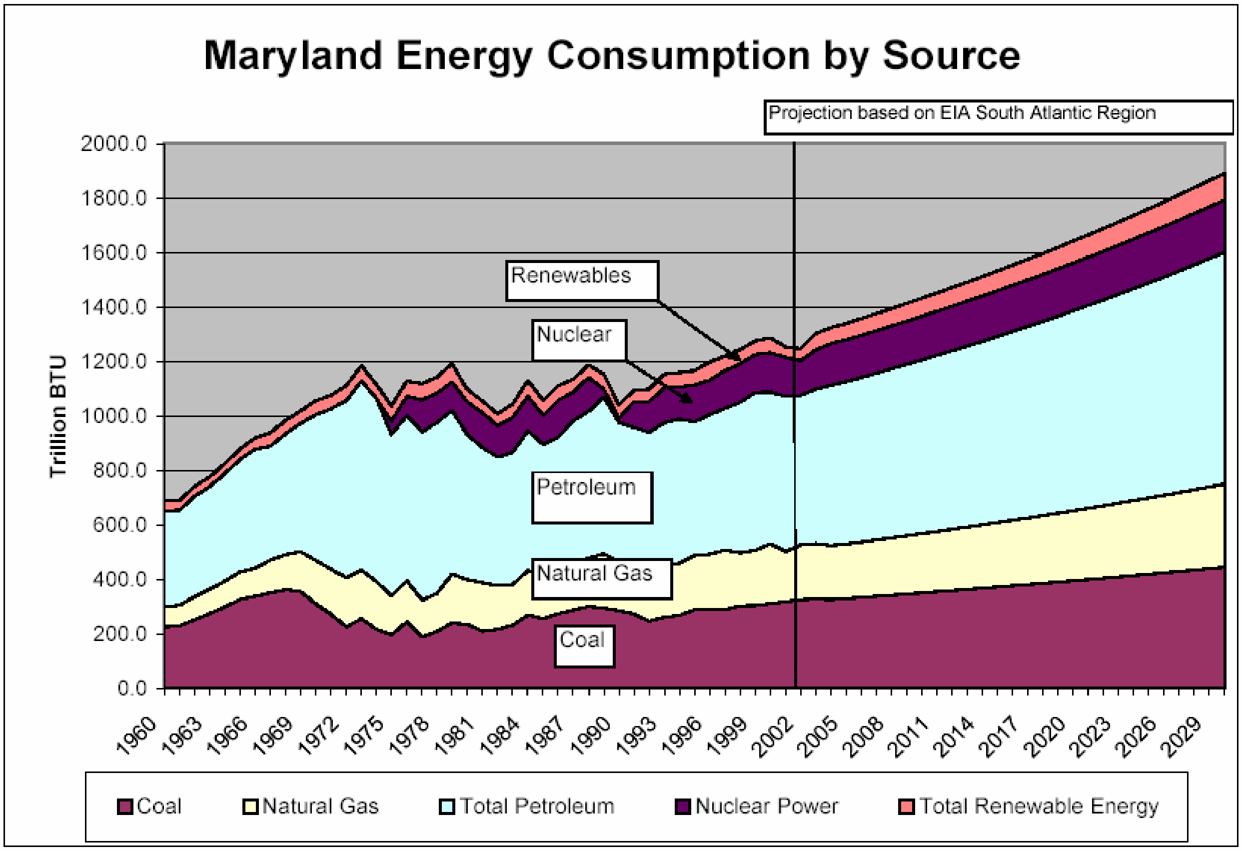

Figure 3

By 2030, the forecasted level of energy consumption for Maryland is 2.092 Quads in primary energy. As shown in the Figure 4 below, the percentage breakout of this level of energy consumption by source for 2030 is not drastically different than the breakout in 2004. The largest energy source in 2030 is still petroleum, with coal in second place and natural gas in third. The EIA regional forecast upon which our Maryland energy forecast is based did not consider a Maryland RPS requirement of 7.5% in 2019 and thereafter. The RPS focuses on renewables-based electricity generation. It is expected that the RPS will be mainly satisfied through the use of renewable energy trading certificates (RECs) obtained from resources outside of Maryland [3] The actual impact of the Maryland RPS legislation will not be fully understood for several years. We do expect, however, that the percentage of renewables in Maryland's energy consumption will be somewhat higher than in our current forecast.

[3] "Inventory of Renewable Energy Resources Eligible for the Maryland Renewable Energy Portfolio Standard," June 2006. Publication by the Maryland Power Plant Research Program

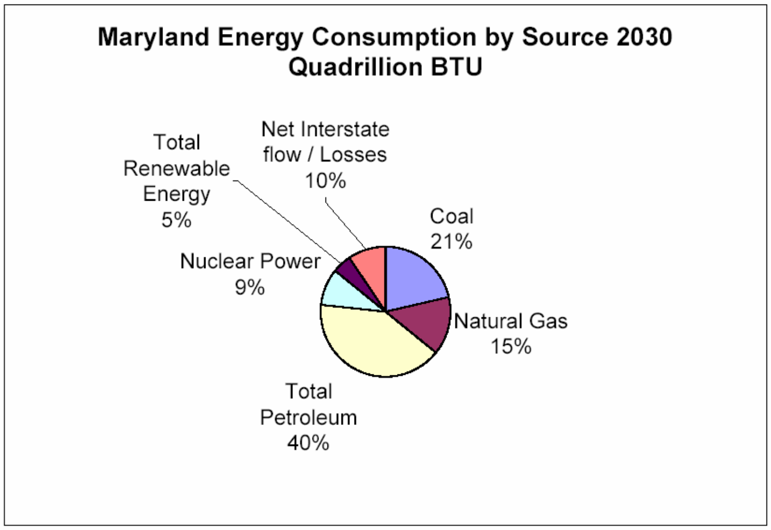

Figure 4

Maryland consumes over 100 million barrels of petroleum each year. Because there are no refineries or crude oil reserves in Maryland, all petroleum supplies are imported. In 2003, Maryland's petroleum expenditures were over $6.3 billion. Petroleum supplies come to Maryland by barge to the Port of Baltimore or through the Colonial pipeline, which runs from New Orleans all the way to New York. Besides Maryland, several other mid-Atlantic states are supplied with petroleum products via this pipeline. Figure 5, below, shows that in Maryland, the largest portion of petroleum is consumed in the transportation sector. In 2004, on a Btu basis, seventy-two percent of all petroleum was consumed in the transportation sector. Fourteen percent of petroleum was consumed in the industrial sector, 6 percent in the residential sector, 5 percent in the electric power sector, and 3 percent in the commercial sector. In 2003, sixty percent of all petroleum was consumed in the form of motor gasoline and 21 percent as distillate fuel. The remainder was consumed as residual fuels (6.1%), LPG (3.4%), asphalt & road oil (3.3%), industrial products (2.6%), jet fuel (2.3%), and kerosene, lubricants and aviation gasoline (combined for 1.3%). Distillate fuel includes about 55% "on-highway" diesel, about 5% "off-highway" diesel, and about 40% fuel oil and various industrial uses. So, in 2003, roughly 72% of all petroleum was used for transportation fuels (gasoline and diesel), which corresponds to the percentage of 2004 petroleum consumption that took place in the transportation sector on a Btu basis (as mentioned above, also 72%).

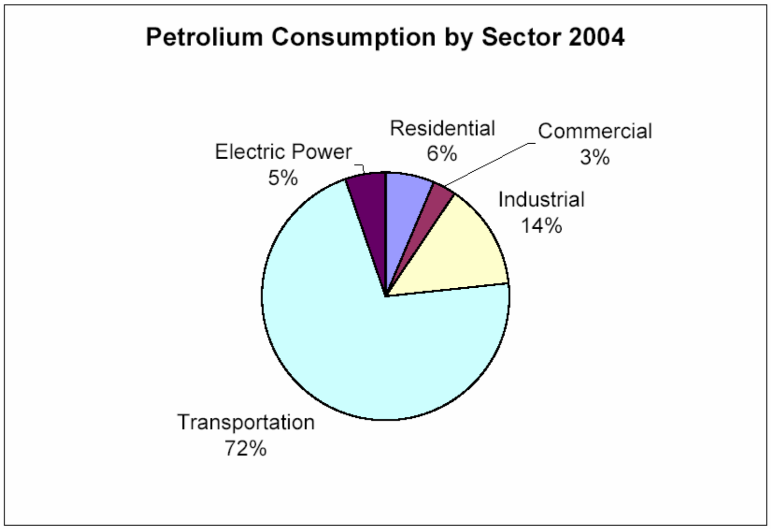

Figure 5

As shown in Figure 6 below, the forecast shows that the percentage of petroleum consumption that is accounted for by the transportation sector on a Btu-basis will increase to 80% by 2030, with the industrial sector consuming the next largest amount of 10%. Again, very little is expected to be consumed in the residential, commercial and power sectors.

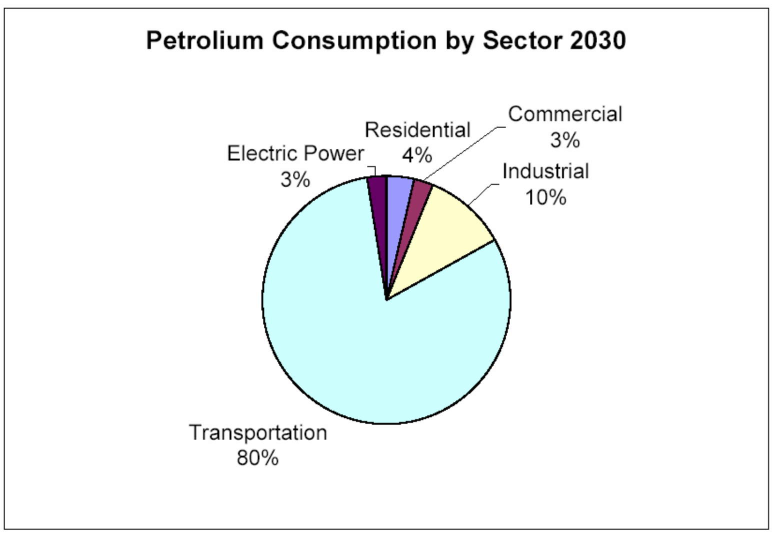

Figure 6

Natural gas reserves in Maryland are very small and not economical to develop. So, like petroleum, natural gas is imported into Maryland via interstate pipeline. Maryland natural gas expenditures in 2003 were almost $2 billion. Four pipelines provide bulk natural gas to the state; the Columbia Gas Transmission Corporation, Transco, Consolidated Natural Gas Corporation, and Eastern Shore Natural Gas interstate pipelines. In 2004, as shown in Figure 7, below, most of the natural gas in Maryland was consumed in the residential (45%) and commercial (36%) sectors. Twelve percent was consumed in the industrial sector, six percent in the electric power sector and one percent in the transportation sector.

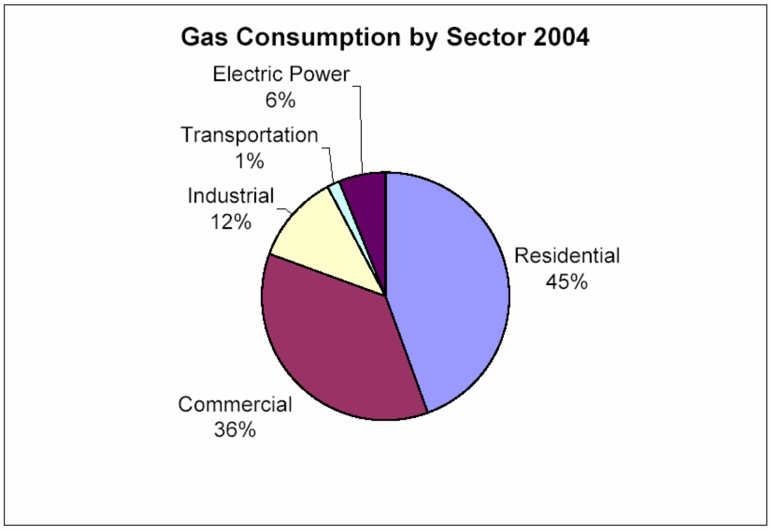

Figure 7

By 2030, the sectoral make-up of natural gas use is not expected to change much. Most natural gas is forecasted to be consumed in the residential (46%) and commercial (38%)

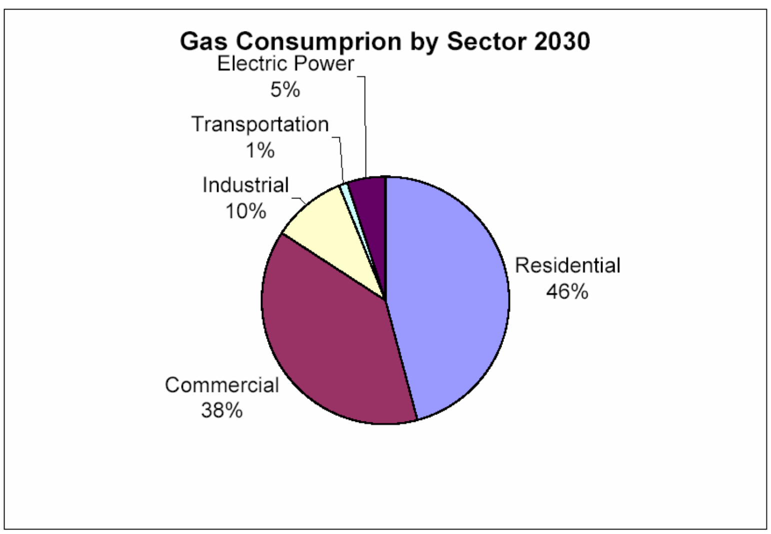

Figure 8

sectors. Ten percent is expected to be consumed in the industrial sector, five percent in the electric power sector, and the remaining one percent in the transportation sector.

The second largest energy source utilized in Maryland is coal. The state consumes about 13 million tons of coal each year, and, in 2003, this cost Marylanders about $534 million. Some of this coal is mined in Maryland. The State's coal reserves can be found in five fields in western Allegheny county and in Garrett county. These are the Georges Creek, Upper Potomac, Casselman Lower Allegheny, and Upper Allegheny basins. Respectively, these fields contain 41%, 26%, 13.6%, 12.4%, and 7% respectively of the State's 678 million tons of recoverable coal reserves. Approximately 65 million tons of coal are believed to be available if only conventional mining methods are used. Coal production in Maryland in recent years has been in the range of 4.6-5.1 million tons per year[4]. As shown in Figure 9, below, ninety percent of all coal consumed in Maryland, in 2004, was used in the electric power sector, with the other 10 percent consumed in the industrial sector. The majority of this coal burned at Maryland power plants, however, was mined in other states in the Appalachian Basin. In 2004, about 11.6 million tons of coal was burned in Maryland power plants. Of this amount, only 6.4% was mined in Maryland. Most of the coal came from West Virginia (almost 60%) and Pennsylvania (over 26%). Smaller amounts came from Kentucky (almost 4%), Virginia (1%), Illinois (0.2%), and various international sources, i.e., Venezuela, Poland, Columbia, and Russia (2.8% combined)[5].

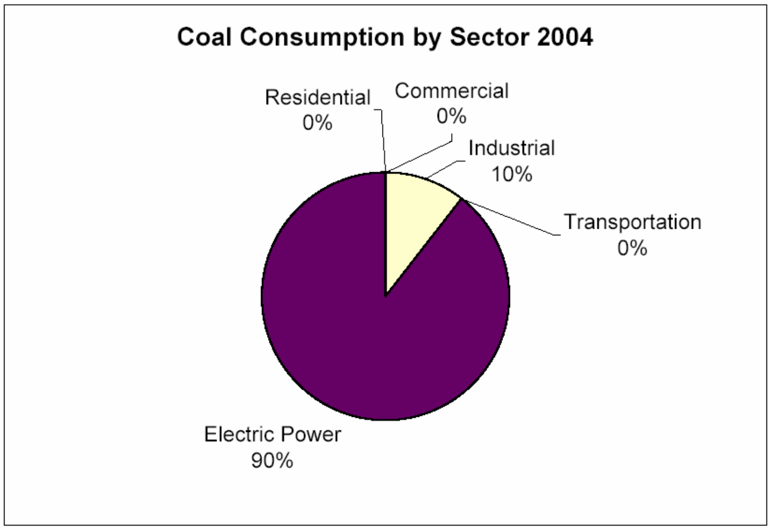

Figure 9

As shown below, in Figure 10, there is also no change in the sectoral outlook of coal consumption in 2030. The electric power and industrial sectors continue to account for 90% and 10%, respectively, of total coal consumption in Maryland.

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[4] "Maryland Power Plants and the Environment," January 2006. Publication by the Maryland Power Plant Research Program.

[5] Ibid

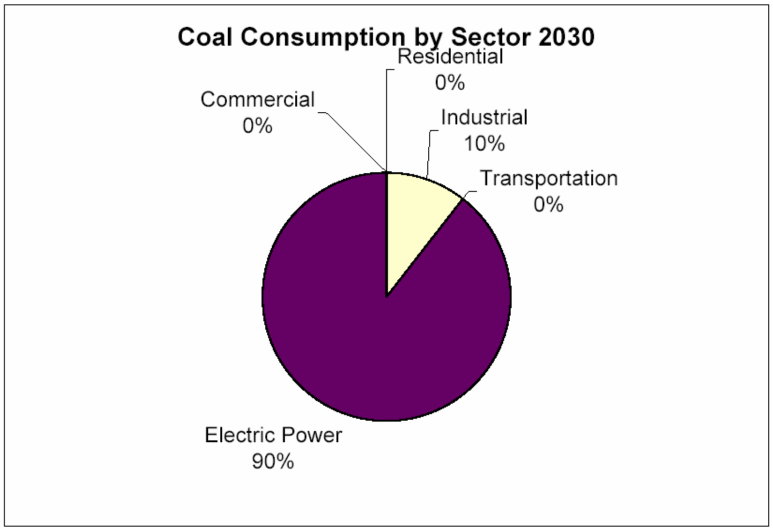


Figure 10

Maryland's electric industry currently consists of 33 power plants (2 MW or greater), 13 distribution utilities, and more than 2000 miles of transmission lines operating at voltages between 115 kV and 500 kV. The power plants have a combined capacity of over 13,000 MW and consist of independent power producers (IPPs), publicly owned electric companies, and self-generators. There were also over 110 distributed generation projects approved by the Maryland PSC that totaled 140 MW of capacity. The IPPs are either affiliates of Maryland distribution companies, affiliates of distribution companies in other states, or independent companies. The publicly owned companies include municipal power companies, electric power cooperatives, and two county-owned and operated generation facilities. Of the 13 distribution companies, four are investor-owned [Allegheny Power (AP), Baltimore Gas and Electric (BGE), Potomac Electric Power Company (PEPCO), and Delmarva Power] , five are municipally-owned (Hagerstown, Berlin, Easton, Thurmont, and Willimasport), and four are cooperatives (Southern Maryland, A&N, Choptank, and Somerset). The investor-owned companies serve about 90 percent of the customers in the State. Retail electricity expenditures in Maryland in 2003 were over $4.5 billion.

In 2003, the total expenditures for retail electricity in Maryland were over $4.5 billion. As shown in Figure 11, below, electric losses incurred in the generation, transmission and distribution of electricity made up the largest amount (69%) of electric energy consumed by the end-use sectors in 2004. End-use electricity consumed in the residential sector represented 13% of overall electric energy consumption. For the industrial and commercial sectors, end-use electricity consumed represented 10% and 8% of overall electric energy consumption.

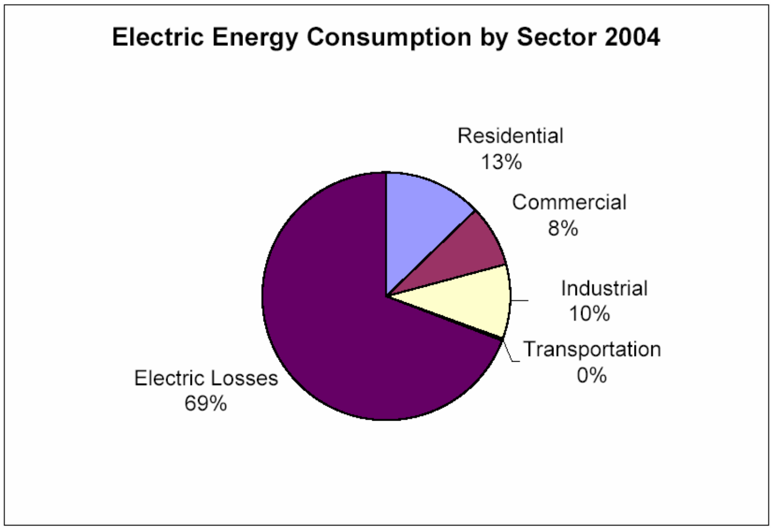


Figure 11

The growth in Maryland's electricity consumption by end-use sector from 1960-2004 and the forecasted growth for 2005-2030 is given in Figure 9, below. The forecast shows a steady growth in electricity consumption in all end-use sectors through 2030.

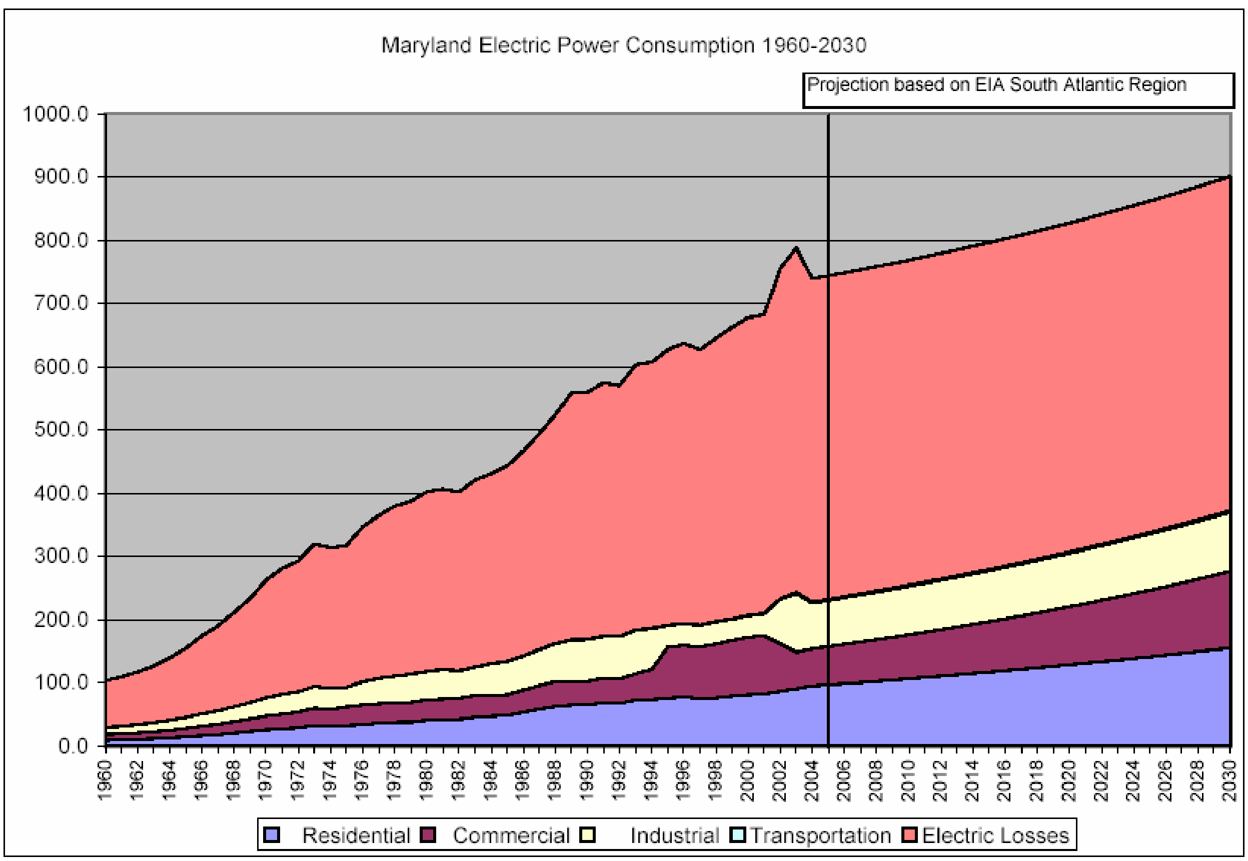


Figure 12

By 2030, the forecasted level of electric energy consumption in Maryland is about 900 trillion Btu. As shown in the Figure 13, below, the percentage of electricity consumption attributed to electric losses in 2030 will decrease somewhat to 60%. Both residential and commercial electricity energy use will increase to 17% and 13% respectively. Industrial electricity energy use will remain constant at 10%.

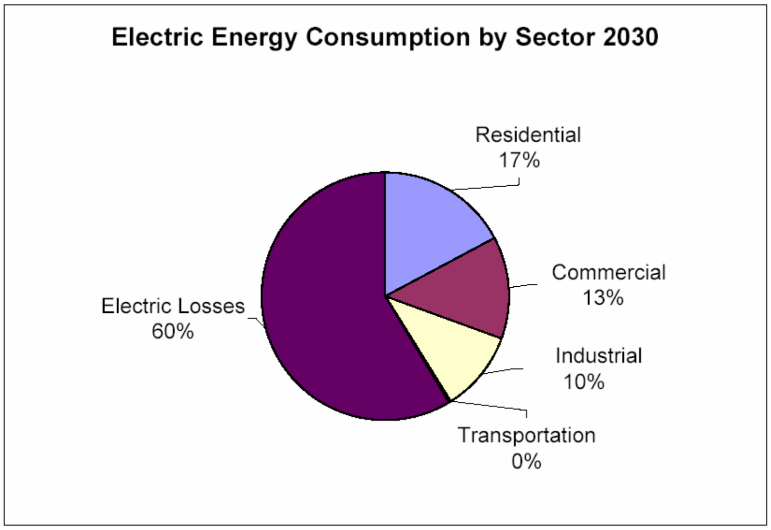


Figure 13

As mentioned above, in 2004, renewable energy provided 4% of total energy consumption in Maryland. In the same year, 7% of Maryland electricity was generated using renewables. As shown in Figure 14, below, in 2004, the largest percentage (55%) of renewables, mostly in the form of hydro and biomass, was utilized in the electric power sector. Twenty-five percent of all renewables was consumed in the industrial sector (mostly in the form of wood and waste), fourteen percent in the residential sector (mostly in the form of wood and geothermal), and six percent in commercial sector (mostly in the form of wood and waste also). There was some consumption of ethanol in the transportation sector, but the amount was very small.

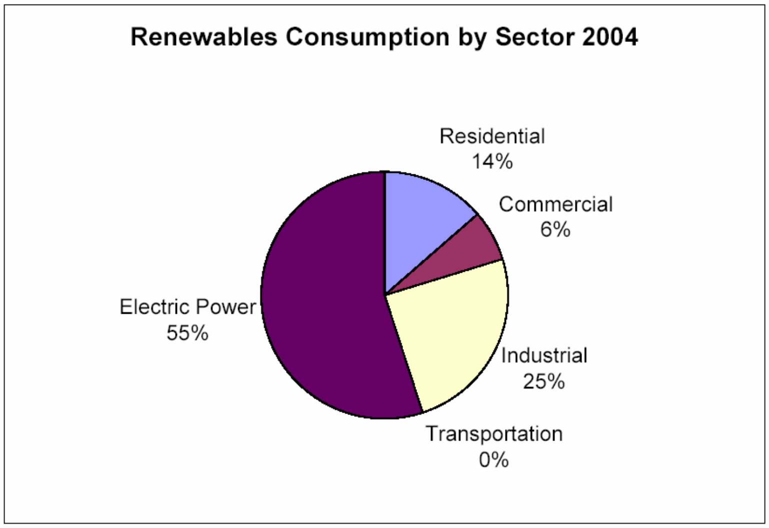


Figure 14

As shown in Figure 15 below, the forecasted percentage make-up of renewable-energy use by sector in 2030 is somewhat different than in 2004. The electric power sector is expected to utilize 74% of the renewable resources consumed in Maryland in 2030. The industrial and residential sectors will consume 16% and 7% respectively, and the commercial sector will consume 3%.

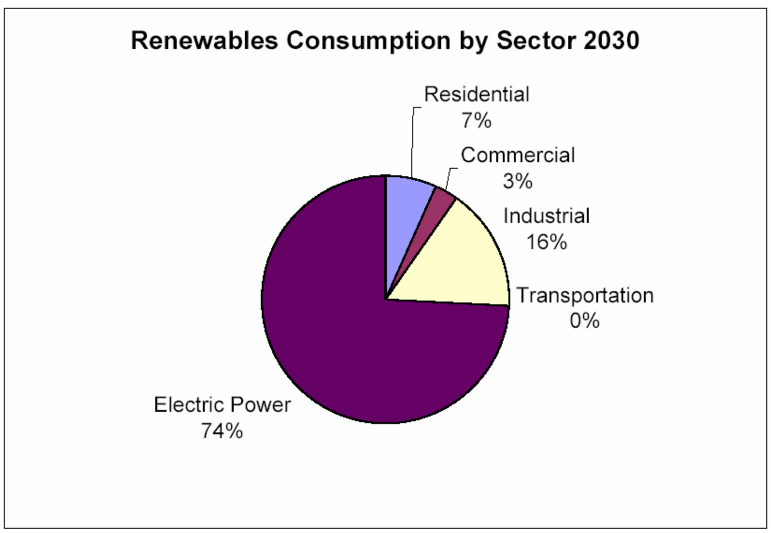


Figure 15

Energy Consumption by Sector

In 2005, the 99.9 Quads of national energy consumption consisted of 21.9 Quads of residential energy consumption, 18 Quads of commercial energy consumption, 32 Quads of industrial energy consumption, and 28 Quads of transportation energy consumption. The equivalent of these numbers in percentages is given in Figure 16, below.

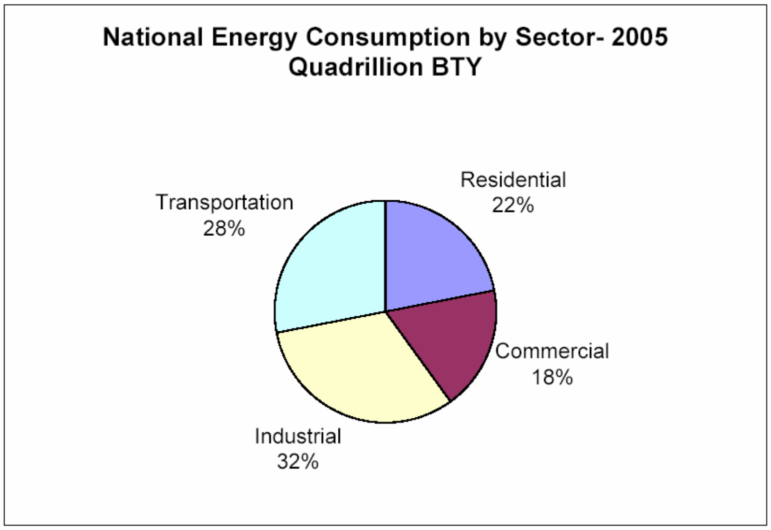


Figure 16

According to the latest estimates, Maryland consumed 1.54 Quads in 2004. This consisted of 0.44 Quads of residential energy consumption, 0.285 Quads of commercial energy consumption, 0.385 Quads of industrial energy consumption, and 0.428 Quads of transportation energy consumption. The percentage breakout of Maryland energy consumption by sector is given in Figure 17, below. The Maryland percentages for the transportation and commercial sectors are the same as the national percentages. Percentage-wise, Maryland consumes more energy in the residential sector and less in the industrial sector than the nation as a whole.

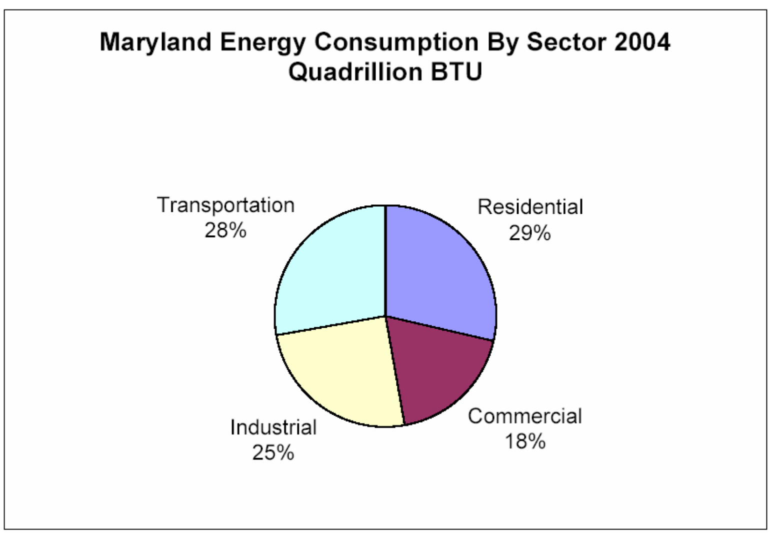


Figure 17

As is shown in Figure 18, below, in 2030, Maryland is expected to consume more energy in the transportation (33%) and commercial (21%) sectors, and less in the residential (26%) and transportation (20%) sectors, than in 2004.

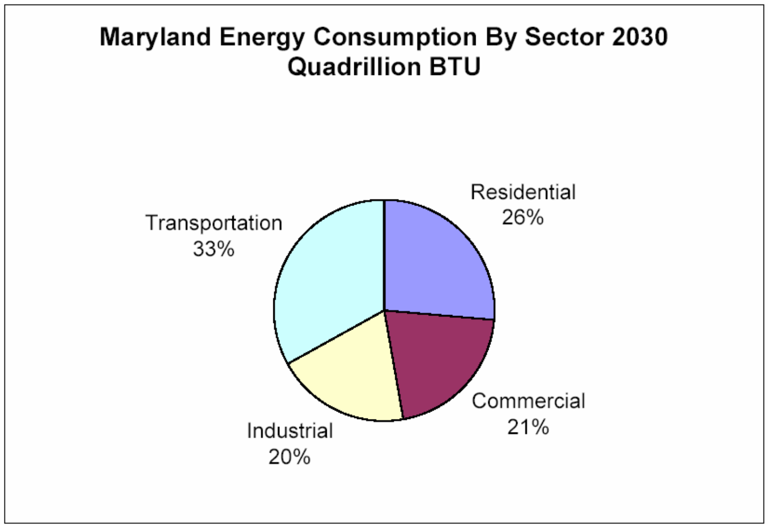


Figure 18

In 2003, Marylanders spent over $3.5 billion for energy use in the residential sector. Figure 19, below, shows that, in 2004, the largest source of residential energy consumption were the energy losses incurred in the generation, transmission, and distribution of the electricity consumed by residential customers. These electricity losses made up 49% of total residential energy consumption. Electricity, itself, represented 22% of residential energy consumption, natural gas 20%, petroleum 8% and renewables 1%. Almost no coal was consumed in the residential sector.

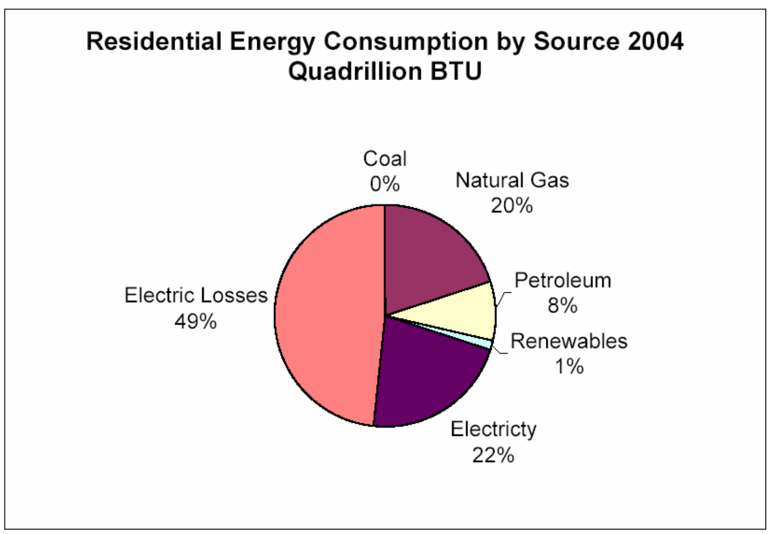


Figure 19

As shown in Figure 20, residential electricity losses are forecasted to remain rather stable through 2030, while electricity and gas use will increase steadily. The use of petroleum products, including distillate fuel, kerosene, and LPG, will decrease slightly, while coal consumption will remain virtually zero.

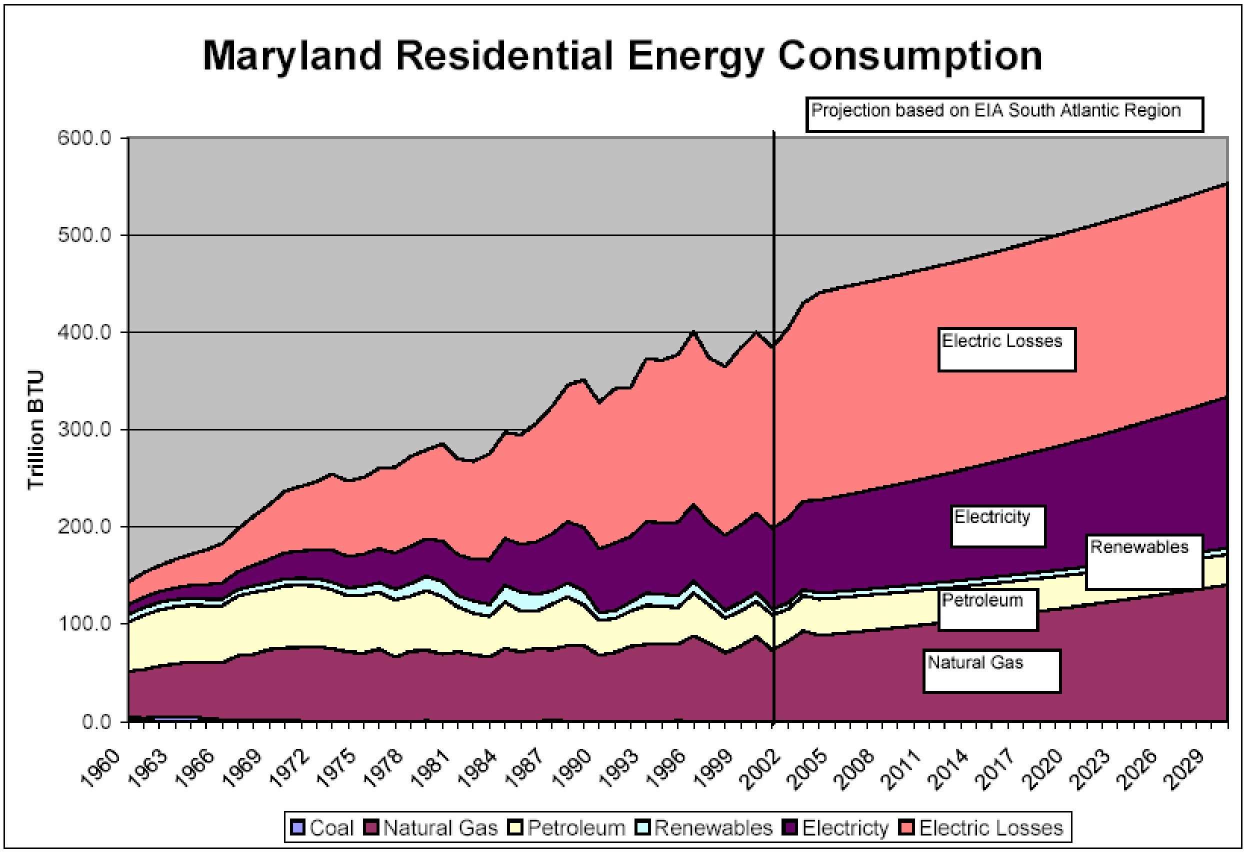


Figure 20

By 2030, as shown in Figure 21, below, electrical losses will still make up a significant percentage (40%) of residential energy consumption. Electricity and natural gas use will increase to 28% and 25% respectively, petroleum will decrease to 6%, and renewables use will remain unchanged at 1%.

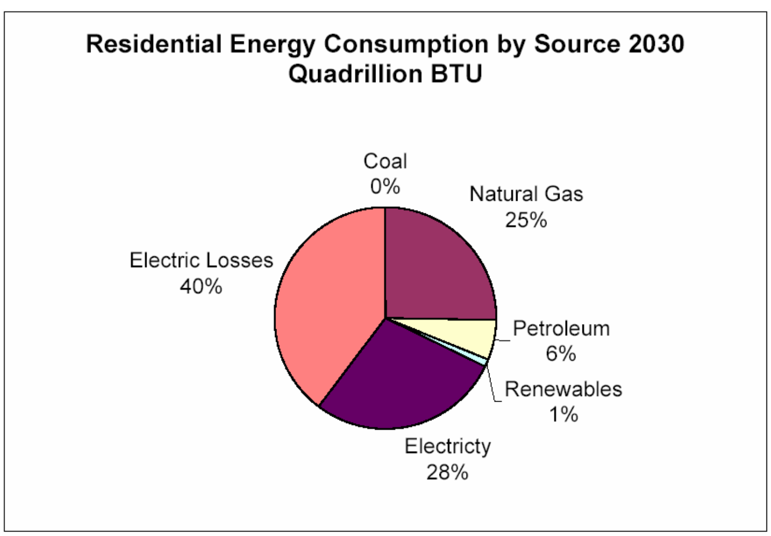


Figure 21

As was the case in the residential sector, commercial-sector electricity losses, in 2004, were more than twice as large as commercial electricity consumption. As shown in Figure 22, below, electricity losses made up 46% of total commercial energy consumption. Natural gas and electricity made up 25% and 21% respectively, and petroleum and renewables, 7% and 1% respectively. Coal consumption was almost non-existent. In 2003, the commercial sector spent almost $2 billion on energy.

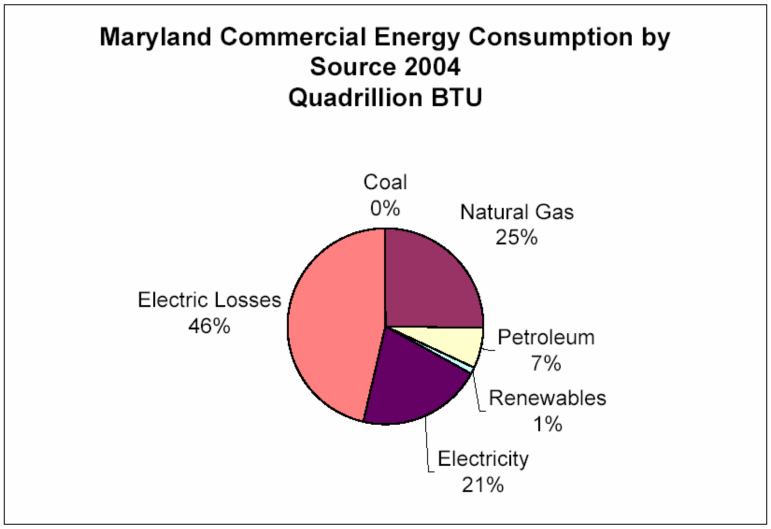


Figure 22

As shown in Figure 23, commercial electricity losses are forecasted to remain rather stable through 2030, while, as in the residential sector, electricity and gas use increase steadily. The use of petroleum products will also remain almost stable.

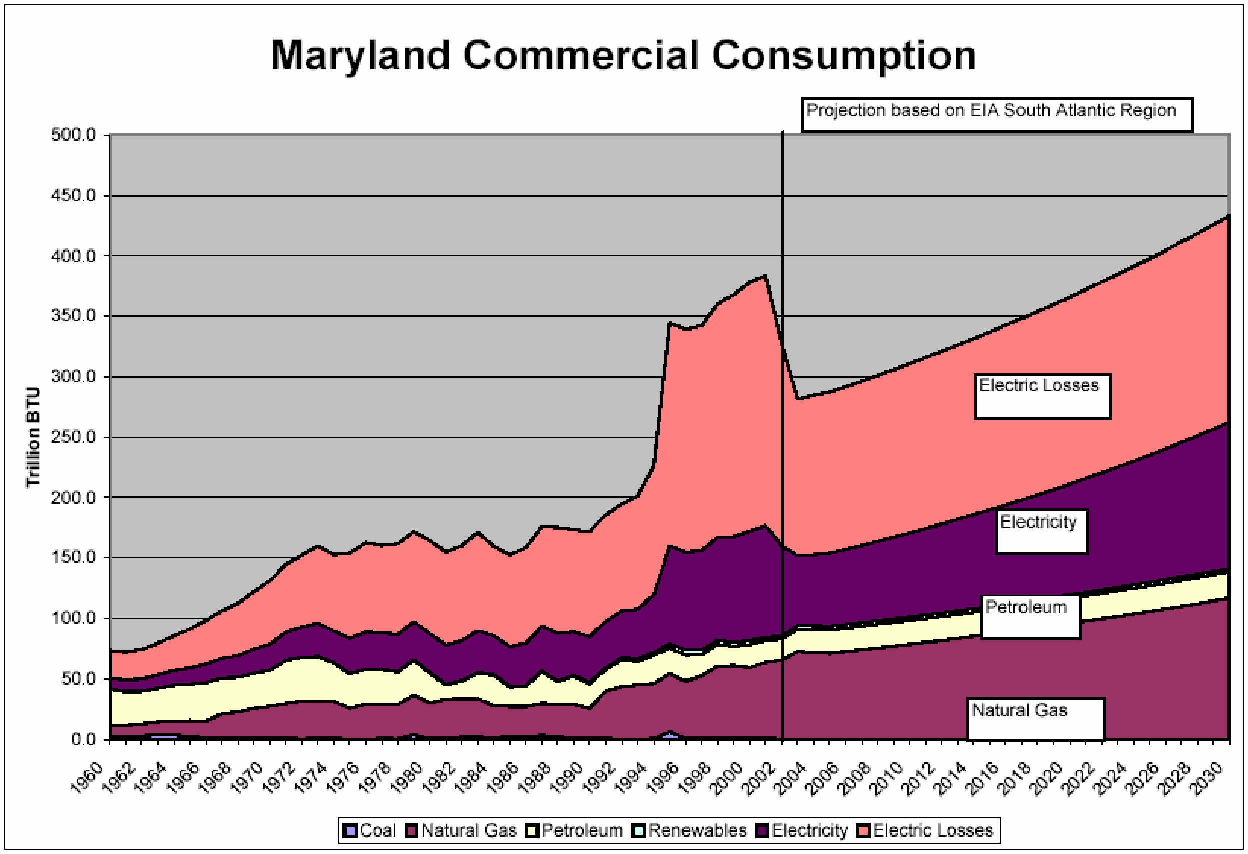


Figure 23

By 2030, as shown in Figure 24, below, electrical losses will still make up a significant percentage (39%) of commercial energy consumption. Electricity and natural gas use will have increased to 28% and 27% respectively, while petroleum will have decreased to 5%, and renewables will remain stable at 1%.

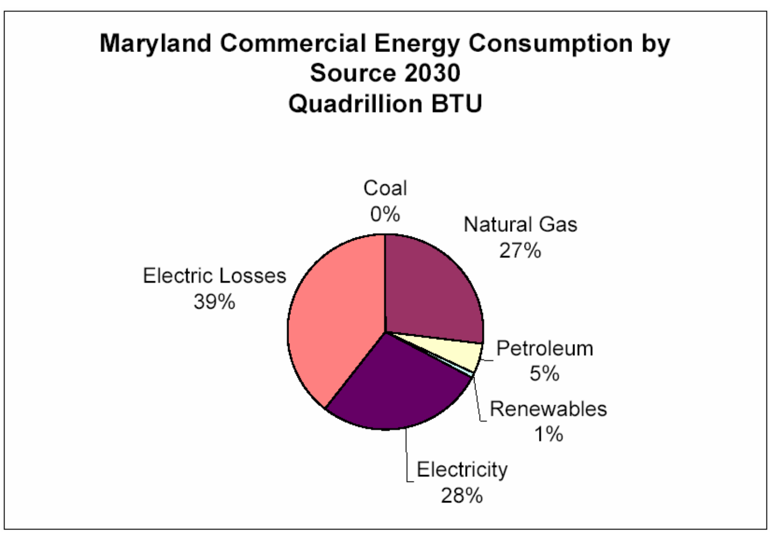


Figure 24

In the industrial sector, energy expenditures in 2003 were over $2 billion. In 2004, this sector was a bigger user of petroleum and coal than the residential and commercial sectors. As shown in Figure 25, below, electricity losses also made up the largest portion of industrial energy consumption.

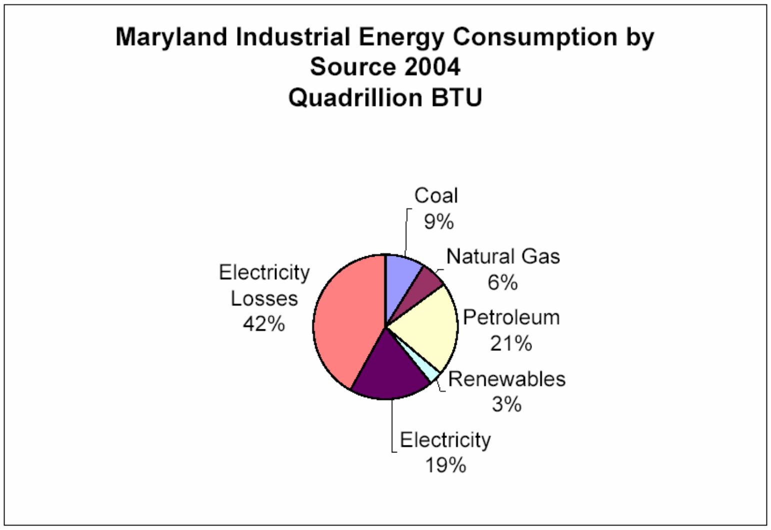


Figure 25

Figure 26, below, shows that coal use in the industrial sector has decreased sharply since the early 1970s. Over the last ten years, there has also been a sizable decrease in natural gas use. Electricity use started to decrease in the 1990s, but started to rise again in 2002. From 2005 through 2030, all energy sources are forecasted to moderately increase, except for electricity losses, which are expected to slightly decrease.

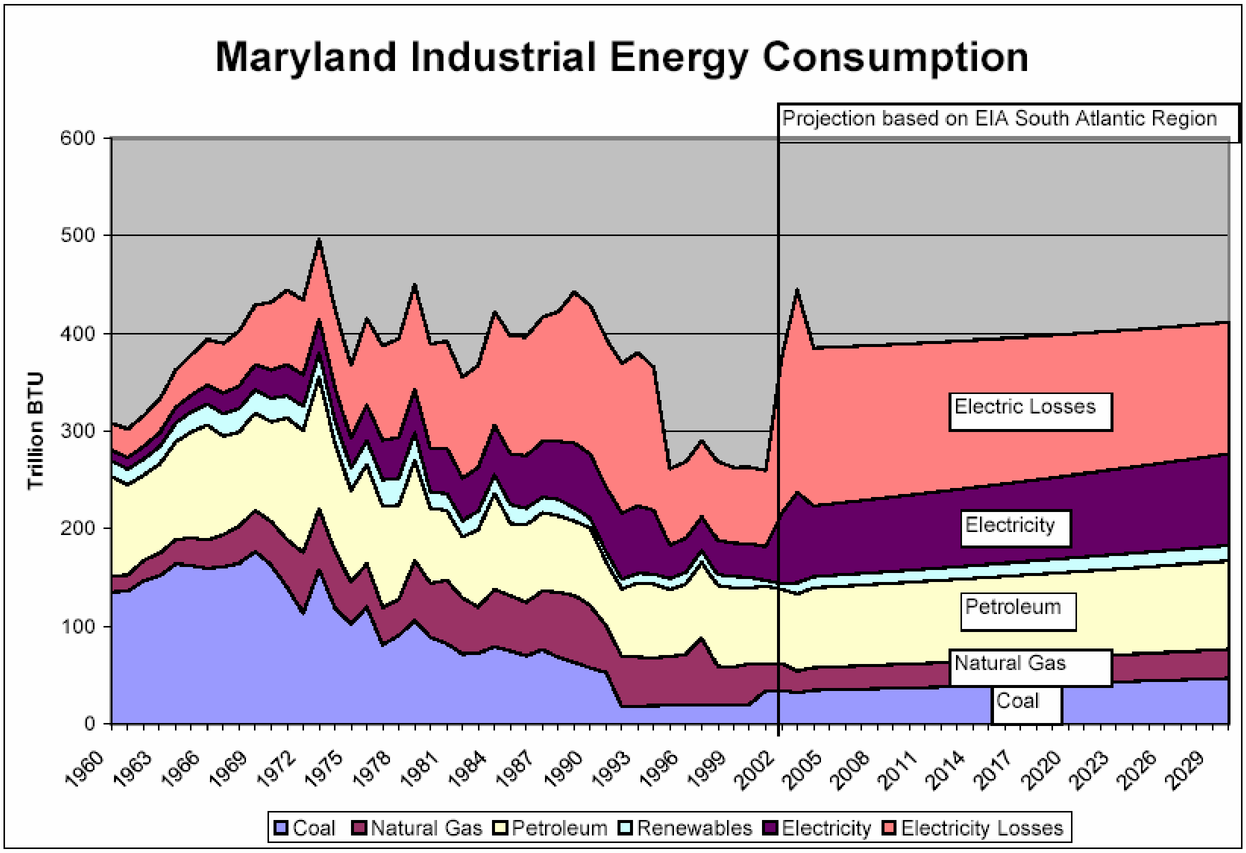


Figure 26

In 2030, as shown in Figure 27, below, electricity losses will still make up the largest component (33%) of industrial energy consumption. Electricity and petroleum consumption will increase their relative shares to 23% and 22% respectively. Coal, natural gas, and renewables will also increase; to 11%, 7% and 4% respectively.

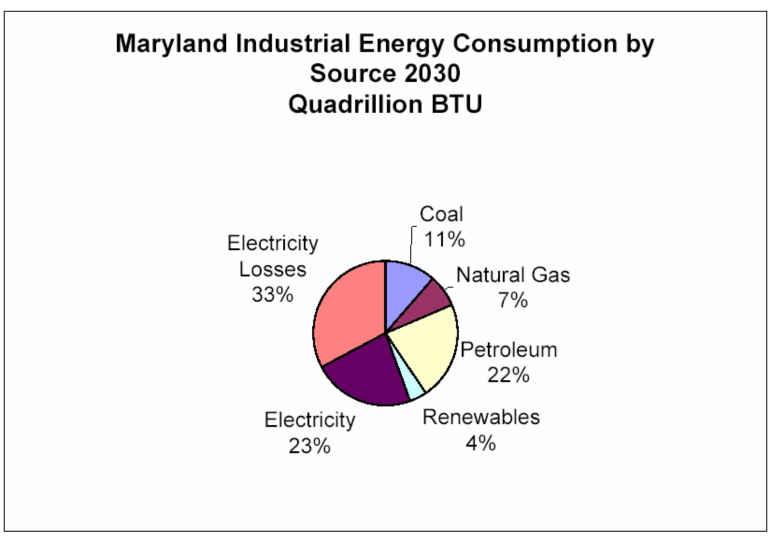


Figure 27

In 2003, the transportation sector had the largest energy expenditures of all the end-use sectors in Maryland; over $5.1 billion. Most transportation-sector expenditures are expenditures for petroleum. Figure 28, below, shows that, in 2004, petroleum consumption made up 98% of energy consumption in the Maryland transportation sector. The next figure, Figure 29, shows that this sector's consumption has steadily increased each year since 1960, and that it is expected to continue to increase at roughly the same pace through 2030. Figure 30 shows that in 2030, transportation energy consumption will still mostly consist of petroleum (99%).

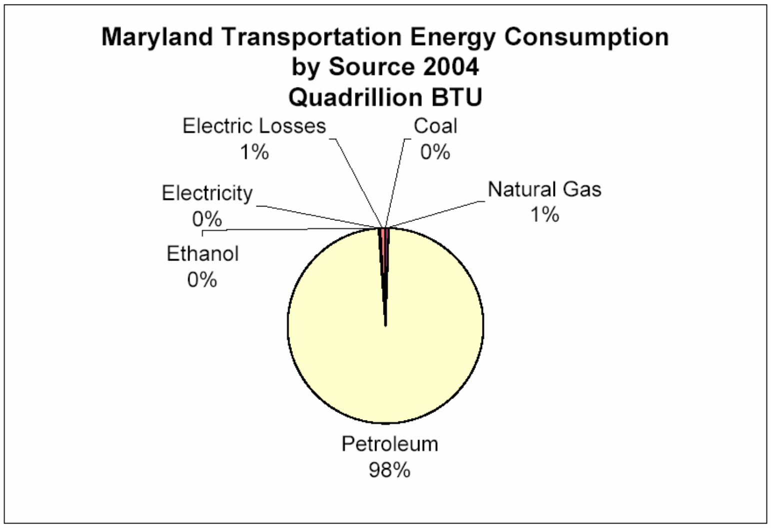


Figure 28

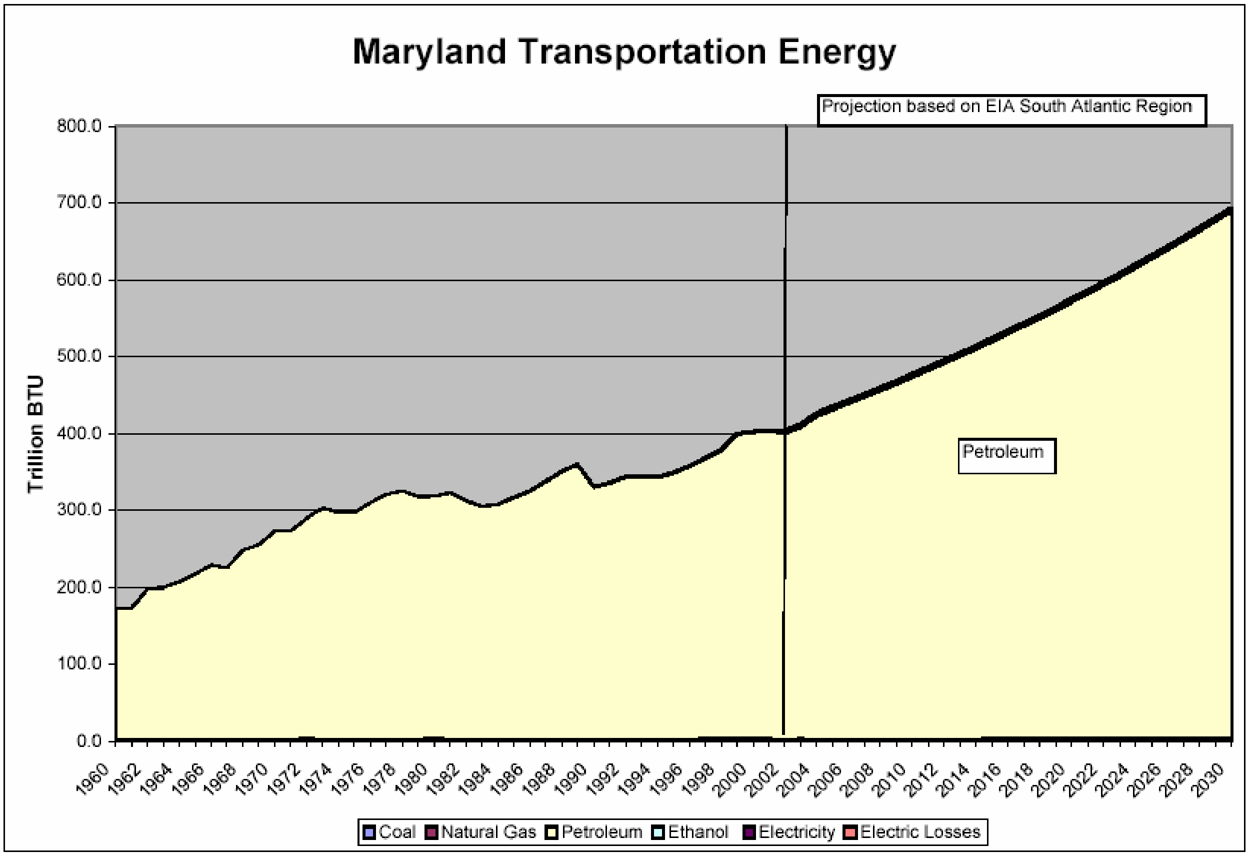


Figure 29

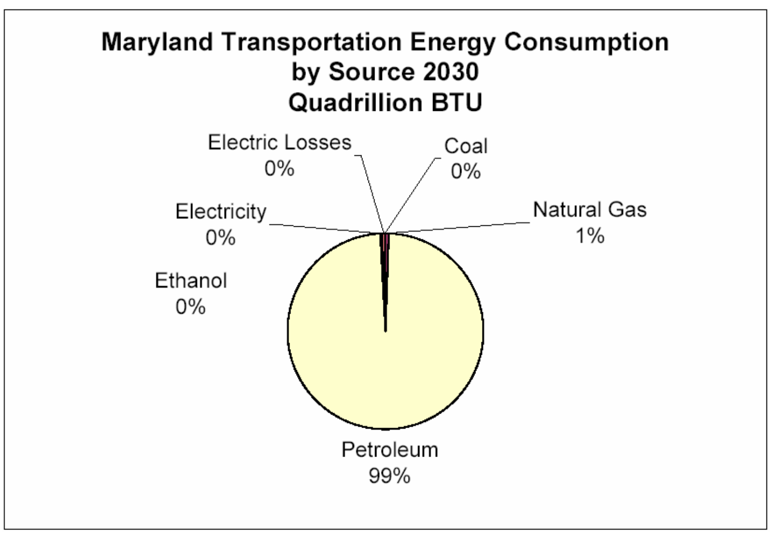


Figure 30

In 2004, the electric power sector in Maryland consumed about 525 trillion Btu to produce electricity at a cost of $823 million. This consumption included electrical system losses incurred in the generation, transmission and distribution of electricity. Figure 31 below shows that 56% of this amount was accounted for by the use of coal in electricity generation. The next biggest energy source was nuclear (29%), followed by renewables (7%), petroleum (6%), and natural gas (2%).

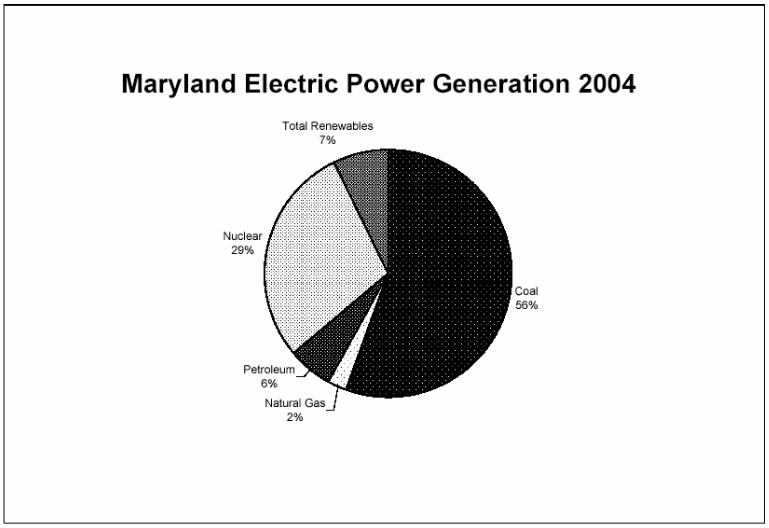


Figure 31

The actual growth in Maryland's electric-power sector's consumption, by source, from 1960-2004, and the forecasted growth for 2005-2030 is given in Figure 32 below. The forecast shows all electricity sources continuing to grow between 2005 and 2030.

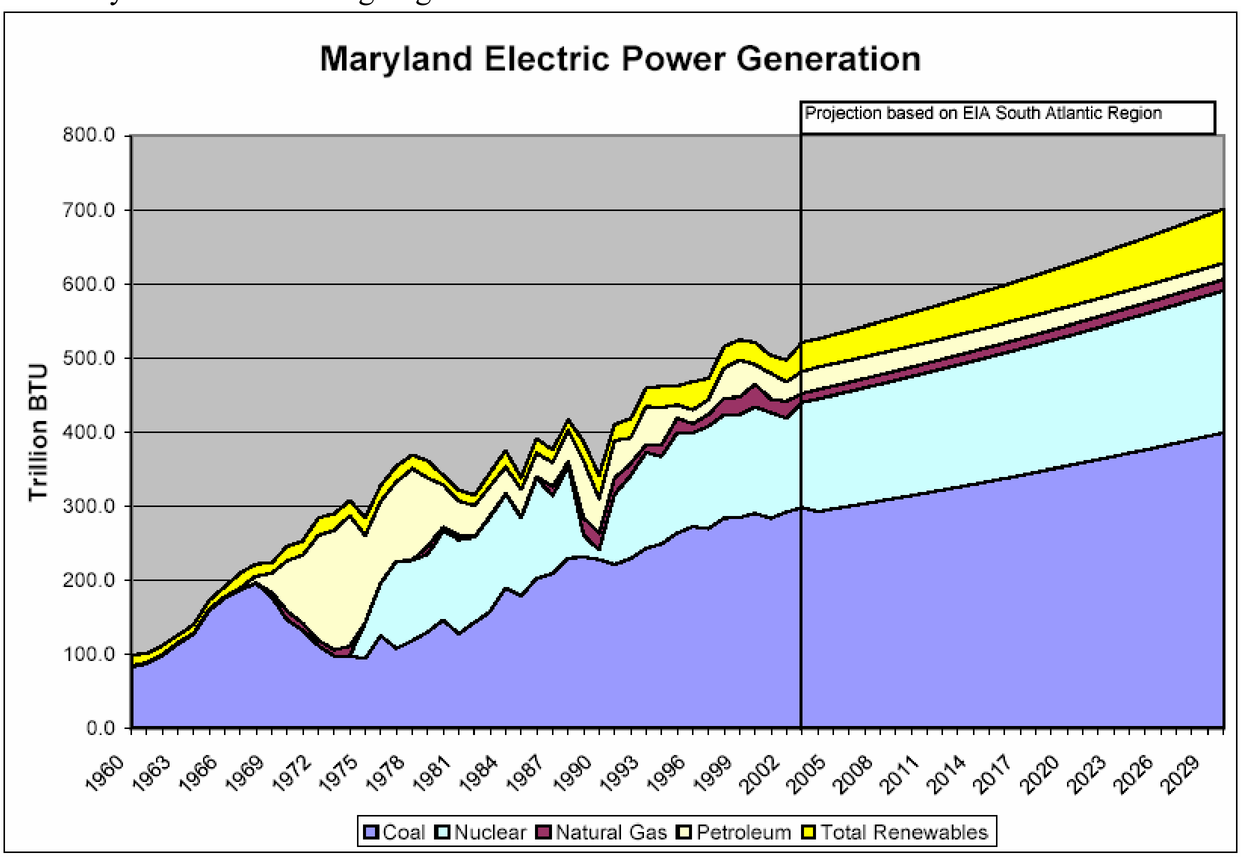


Figure 32

By 2030, the forecasted level of consumption of the electric power sector in Maryland is about 700 trillion Btu. As shown in the Figure 33, below, the percentage breakout of electricity generation by source for 2030 is not drastically different from the breakout in 2004.The largest energy source in 2030 is still coal (58%), with nuclear (27%) in second place, and renewables (10%) in third.

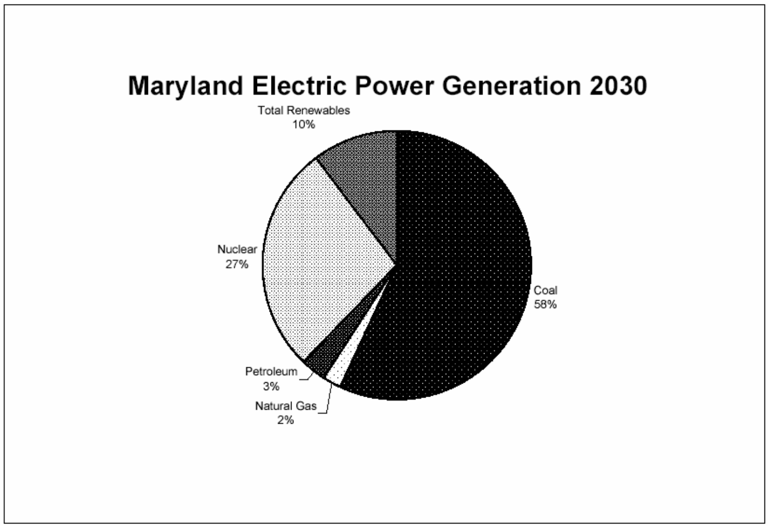


Figure 33

Because of their heavy coal use, power plants in Maryland contribute significantly to health threatening air pollution. These plants currently contribute nearly 80% of the total sulfur dioxide (SO2) emissions and 30% of the total nitrogen oxides (NOx) emissions. Coal-fired plants are also currently significant sources of mercury, a neurological toxicant that contaminates the fish in our rivers, lakes and oceans.

3. Clean Energy Technologies

CLEAN ENERGY MARKET OUTLOOK

Energy efficiency and renewable energy are the fastest growing technology sectors in the world today. The industry is literally taking off with major investments being made world wide in wind power, ethanol plants and solar energy just to name a few. At the latest meeting of the American Council for Renewable Energy (ACORE), ACORE's president said that the renewable energy sector is about to turn a corner. Commercially available and economically competitive in many locations, renewables will further U.S. national interests by helping end our addiction to oil and begin to address the issue of global warming. The industry is ready to put America's 30-year, $15 billion investment in research, development, and demonstration of renewable energy technologies to use in the marketplace.

ACORE identified three key drivers pulling markets toward renewables. The first is national energy security. Current projections show U.S. oil consumption increasing and outpacing flat domestic production curves, leaving the United States increasingly dependent on foreign oil markets. This makes the U.S. economy vulnerable to disruption in oil imports. Additionally, the rapid growth of developing countries such as China and India places an increasing strain on world oil markets, a problem that is likely to get worse over time. The effects of this can already be seen. The price of oil surpassed $70 per barrel in mid-June 2006, up from $30 only a few years ago. Renewable energy can help the United States rely on domestic sources of energy, which will reduce our need for oil and lessen the growth of our oil consumption.

A second driver toward renewable energy is concern about climate change. Renewable energy can help satisfy our energy requirements, while decreasing our greenhouse gas emissions. According to several news sources, more than 2,000 scientists have concurred that greenhouse gases, such as carbon dioxide and methane, are building up in the Earth's thin atmosphere and that this buildup of gases is increasing global temperatures. Many of these scientists believe that this increase of temperatures portends negative and potentially catastrophic consequences, that the time frame for addressing the issue is now, and that there are actions that can be taken. Use of carbon-free renewable energy is one of them.

A third market driver is the cost of renewable energy, which has been decreasing for decades. The decreasing costs of renewables can be attributed to manufacturing improvements in the basic technologies and balance of systems components. As the industry matures, costs will continue to decrease.

Large investments are being made in renewable energy companies and projects. According to Price Waterhouse Coopers, Thomson Venture Economics, and the National Venture Capital Association, venture capitalists invested close to $181 million in alternative energy companies in 2005; an increase of $78 million from the previous year. Major industry leaders have begun to take notice of this growing market opportunity and are showing their support. For example, General Electric recently invested $51 million in a 50-megawatt wind project in California, and Cascade Investment LLC placed $84 million into Pacific Ethanol, which produces and markets renewable fuels. The accelerated market growth has created a favorable environment for investors, with opportunities for substantial profits in this now $50-billion-a-year industry.

Navigant Consulting recently surveyed 60 executives from energy firms representing a mix of utility companies, renewable energy companies, and oil companies to obtain their perspectives on the outlook for renewable energy. The survey concluded that the market for renewable energy technologies will grow steadily in next 10-15 years. Almost 7 out of 10 (67 percent) of the executives surveyed agreed that renewable energy will "emerge" over the next 10-15 years, as some technologies will quickly become mainstream, while others will evolve more slowly. Two out of 10 (24 percent) believed renewable energy technologies will see only "slow market growth" in the coming decade. The survey also identified wind, biomass, and photovoltaics (PV) as the most promising technologies, with a few executives pointing to concentrating solar power, geothermal power, small hydroelectric, and wave/tidal technologies as holding the greatest promise.

Wind

Almost 9 out of 10 (88 percent) of the executives surveyed believed that wind has high promise for progress in the next 10 years. This is not surprising, since offshore and onshore wind power are increasingly competitive with conventional energy options and accessible to a growing number of users. Onshore wind power can produce power at good wind sites for 3¢ /kWh today, without incentives and exposure to traditional fuel price volatility. This cost compares favorably to the all-in cost of electricity from a new gas-fired combined cycle gas turbine of about 3-4¢/kWh (depending on the cost fuel), or from a new coal plant of about 4¢/kWh. In the United States, the Long Island Power Authority is pursuing a 100-MW offshore wind power initiative, and Cape Wind has proposed a 400+MW offshore wind project for Nantucket Sound. Several offshore wind projects are in operation globally, and 4800 MW of additional offshore wind is planned for Europe over the next five years. In a "business as usual" technology-development scenario, wind energy systems will be broadly cost competitive with grid power and installed throughout the world by 2015.

Photovoltaics (PV)

Almost half of the executives surveyed (47 percent) believe that PV has high promise to gain significant ground in providing electricity in the next 10 years. Today, PV is competitive in many niche off-grid applications, such as communications and water pumping. Some major corporations such as Johnson & Johnson and Volkswagen have installed PV on the rooftops of their buildings. Such rooftop applications in homes and commercial buildings could become commonplace in developed countries by 2015 through aggressive PV technology development in the next few years. Moreover, with concerted technology-development efforts, PV could also become the standard approach to generating power in rural areas of the developing world in the same time frame. Manufacturing improvements, advanced materials, and economies of scale could reduce the levelized cost of electricity from PV, in 2015, to less than 10¢/kWh; down from about 35¢/kWh in 2003, without incentives.

Biomass

More than half of the executives (57 percent) identified biomass as a high-promise technology to emerge rapidly over the next 10 years. Many biomass technologies already offer attractive economic and environmental benefits, including biogas (methane) from landfill gas and anaerobic digestion of animal wastes, and co-firing of biomass at existing coal plants. With aggressive development, other biomass technologies could unlock very large markets for biomass power in the near-medium term, such as biomass integrated gasification combined cycle (BIGCC) technology deployed as combined heat and power in bio-based industries like pulp and paper or sugar mills. As the biomass industry grows and matures, bio-refineries could begin to emerge in the 2015 timeframe as the most cost- and resource-efficient way to utilize biomass, converting it into a slate of fuels, chemicals, power, and other value-added products.

The executives identified several potential impediments to progress in the renewable energy area over the next 10 years. Potentially, the biggest impediments to renewable energy technology growth over the next 10 years are the lack of consistent government support and political and lobbying issues. Poor technology economics and technology problems are also potential impediments for some technologies. However, no major roadblocks were identified. The majority of those surveyed indicated that technology progress will not be halted because of a lack of funding or a lack of business interest. The least likely potential impediment identified by these executives was lack of public interest. Tied to this, the executives indicated that the majority of North Americans today are only vaguely aware of one or two renewable energy technologies, such as solar and wind energy, but generally not aware of other technologies.

The outlook for renewable energy in the United States and around the world is positive and constantly improving. This is a challenge for government policy planners who have to rely on computer modeling projections that can become quickly out of date, because oil prices often increase rapidly and the demand for renewable energy is constantly growing. For example, while the official U.S. forecast from the Energy Information Agency shows renewable energy contributing only about 10 percent of U.S. energy supply in 2030, various industry groups are more optimistic. The Energy Future Coalition believes that 25 percent of our energy supplies should be renewables-based by 2025, and ACORE sees the renewables potential as 20 percent, 30 percent, and 40 percent of total energy supplies by 2020, 2030, and 2040, respectively.

CLEAN ENERGY TECHNOLOGIES

Energy Efficiency and Green Buildings

Increasing energy end-use efficiency, or technologically providing more desired service per unit of delivered energy consumed, is generally the largest, least expensive, most benign, most quickly deployable, least visible, least understood, and most neglected way to provide energy services. Energy efficiency is not a single technology, but a process of improving the efficiency of any energy consuming system. Simply put, energy efficiency is doing more with less energy input. Productive applications exist in industrial processes, electric generation and distribution, buildings, lighting, heating and cooling, motors, etc. Energy efficiency can also include better energy management, like turning off lights and equipment when not in use or automatic controls that optimize the performance cycle. Major energy-efficiency opportunities exist in improving the performance of building envelopes and HVAC systems, high efficiency lighting, high efficiency motors, particularly in large pumping systems, variable speed control on fans and pumps and building energy management systems. At the utility scale, major improvements can be made by decentralizing the power production to reduce transmission losses and capturing the waste heat in cogeneration systems. Cogeneration systems make power, and the waste heat from the system is used for heating and/or air conditioning. Distributed cogeneration systems have multiple benefits. First, they are significantly more efficient than large central systems that have large transmission losses and waste the heat. This results in lower costs and lower emissions. Second, because the power generation is distributed among many small generators, the system is more resilient to potential failure of one large power plant. This leads to a more reliable electricity infrastructure, less vulnerable to disruption by natural or man made disasters. Finally, the development of an efficient distributed generation infrastructure can help meet the utilities growing peak demands and offset the need to build new base line generation.

Residential
Most homes in Maryland can reduce energy cost by 30%, and savings of 60% or greater are possible through measures such as:

- Air tightening the building envelope and ducts
- Better insulation
- Better windows
- Energy efficient appliances and lighting
- Passive solar heating and solar control strategies for summer
- Solar water heating
- High efficiency heat pumps

Commercial/Industrial Energy Efficiency
In most commercial, industrial, and institutional facilities, there are abundant opportunities to save including:

- 70%–90% of the energy and cost for lighting, fan, and pump systems
- 50% for electric motors
- 60% in areas such as heating, cooling, office equipment, and appliances

Improved energy efficiency delivers better services. Efficient lighting systems can look better and help you see better. Efficient motors run quieter, and are more reliable and controllable. Efficient refrigerators can keep food fresher for longer time periods. Efficient "clean-rooms" can improve the yield, flexibility, throughput, and setup time of microchip fabrication plants. Aerodynamically efficient chemical fume hoods can improve safety. Airtight houses with constantly-controlled ventilation have more healthful air than leaky houses. Efficient supermarkets can improve food safety and merchandising. Retail sales can rise 40% in well-daylit stores. Students' test scores show 20–26% faster learning in well-daylit schools.

Green Buildings
Green buildings incorporate and address renewable energy, energy efficiency, indoor air quality, water consumption, waste and landscape and site issues. Green buildings popularity is due, in large part, to the US Green Building Council's (USGBC) LEED green building rating system for commercial buildings. USGBC includes 6,300 member companies and organizations.

Cost competitiveness
Energy efficiency is the least cost strategy for reducing energy cost and the use of fossil fuels. A recent study by the North East Energy Efficiency Partnership showed that energy efficiency is 60-70% cheaper than new generating capacity. Many energy efficiency opportunities have very low

or no implementation costs.. Economical energy efficiency opportunities are available to all customers, sectors, end uses and markets. The potential return of energy efficiency technologies is a function of engineering and design. For example, a home can be designed to be 10% to 100% more energy efficient by adding insulation, better windows, air tightening and high efficiency HVAC and appliances. The designer can pick an acceptable return on investment (ROI) and design the home to meet that target. If the ROI is very short, significant savings opportunities are limited. However, the longer the ROI, the greater the energy savings potential.

Energy efficiency also applies to transportation planning, Smart Growth, and Sustainable Community Planning

Current Size of the market and Market Projections
There is very little market research in the energy-efficiency market sector, because it is so diverse. Trends however are clear from the Green building sector. In the past four years alone, USGBC's membership has tripled, and over half a billion square feet of building space is participating in the LEED Rating System, and the annual U.S. market in green building products and services has grown to $7 billion. The exploding market for sustainable, environment- friendly and recycled building products, along with the greater availability of educational opportunities for builders, has accelerated green buildings' acceptance rate by home builders. By the end of 2007, more than half of NAHB's members, who build more than 80 percent of the homes in this country, will be incorporating green practices into the development, design and construction of new homes.

A newly released report on residential green building published by McGraw-Hill provides a positive outlook for the residential green building marketplace. The study, which analyzed a representative sample of more than 75,000 builders, indicates that green building will reach its "tipping point" in late 2006 / early 2007. In 2006, the growth in the number of green home buildings is expected to rise by 20% over 2005, and in 2007, there is a projected growth of 30% over 2006 numbers. As a result, more than two-thirds of builders will be building green homes (more than 15% of their projects), with only one-third not yet engaged in this marketplace. Beyond 2007, the sheer number of participants in the green home building market will pull the rest of the market up to green standards in order to remain competitive.

The energy efficiency market is also helped by federal tax credits. Homeowners can claim up to $500 in tax credits for purchasing highly energy efficient equipment that qualifies under the law. Examples include boilers with an AFUE of at least 95%, water heaters with an energy factor of at least 0.80, and electric heat pumps with an EER of at least 13. Further, homeowners can receive an incentive of up to $2,000, or 30% of a qualifying expenditure, when they install alternative energy equipment, such as solar panels and fuels cells, in their homes. Commercial customers can claim up to $1.80 per sq. ft. for energy-efficient improvements such as water heating and HVAC equipment for their buildings.

Another driving force in the energy efficiency market is the EPA Energy Star program. Energy Star is a labeling program for energy efficient appliances and buildings. For manufacturers and retailers, ENERGY STAR is a valuable market, with its own loyal consumers, products, manufacturers, retailers, and (in many states) utility incentive programs. In fact, since the program's inception in 1992, more than 1 billion ENERGY STAR qualified products have been sold in the United States alone. EPA market research on ENERGY STAR shows that consumers of energy efficient products are a large and growing segment of the population. ENERGY STAR is recognized by 56% of consumers nationwide and by 67% in many major markets, including New York, Boston, Seattle and San Francisco. Ninety-five percent of recent purchasers of an ENERGY STAR qualified product say they are likely to purchase an item with the ENERGY STAR mark in the future. Ninety-five percent of consumers believe we must be responsible for energy use and that they can make a difference. Seventy-two percent of adults "… make a special effort to look for products that are energy efficient". Seventy-eight percent of consumers rate energy efficiency as important to their purchase decision. Seventy-one percent and sixty-seven percent of people, respectively, indicated that energy efficiency and electric bill reductions were very important in the purchase of appliances.

According to EPA, ENERGY STAR products enjoy increasing market share and sales, and high public visibility. Sylvania, a leading lighting manufacturer, increased yearly sales of ENERGY STAR- qualified compact fluorescents by more than 85%. Participation in the "ENERGY STAR Change a Light" campaign increased sales by 120%. In 2002, Lowe's ENERGY STAR products inventory rose 30% over the prior year, and sales of ENERGY STAR qualified products rose 39%. Over 28% of Maytag's residential appliance sales in 2002 were ENERGY STAR qualified, a 33% rise over 2001. Maytag's qualified dishwasher sales rose 63% and qualified refrigerator sales rose 53%.

Maryland Resource Potential

The potential of increasing the efficiency of energy use with currently available technology is vast. Two-thirds of U.S. energy use per unit of economic output can be eliminated using available technology, while still maintaining all the functions that present-day fuel use brings with it. With a sensible program of energy research and public policy, it is quite possible to reduce energy use per unit of economic output to one-tenth of the present levels within a few decades. With some care in energy use and very high efficiency, economic output can be tripled over the next fifty years, while reducing energy use overall by more than three times. Through a modest set of programs to help Marylanders improve their energy efficiency, Maryland can reduce anticipated total electricity demand by 6% by 2010. As shown in Table 1, below, studies have shown that a broader set of measures could yield cost-effective savings of up to five times this amount in a similar timeframe.

Energy efficiency policies save money. For example, energy efficiency standards to keep the highly energy-inefficient models of six electricity-using products out of the Maryland market would provide Marylanders with net savings of $234 million over the first 17 years.

Table 1: Potential Energy Efficiency Savings

Study	Range of Potential Savings per year
ACEEE Report 2004 (Review of 11 studies)	0.50% - 3.10%
Synapse Report 2004 (Review of 8 studies)	1.40% - 1.60%
NEEP Report 2005 (Review of 7 studies)	0.70% - 2.99% NE Region forecast 2.58%
WGA Report 2006 (Review of 7 studies)	0.50% - 1.80%
SWEEP Gas DSM 2006 (Survey of 10 utilities)	0.10% - 1.00% (gas only)

In 2004, the American Council for an Energy Efficient Economy (ACEEE) conducted a review of published literature assessing the potential for energy efficiency in the United States.[6] ACEEE looked at eleven studies focusing on various geographies (California, New York, Massachusetts, the entire U.S., etc.). The results of ACEEE's review determined that the median achievable[7] savings potential for electricity is 24 percent over a 20 year horizon or 1.2 percent per year. For natural gas, the median achievable savings potential is 9 percent over a 20 year horizon or 0.5 percent per year. Also, in 2004, Synapse Energy Economics, Inc. conducted a review of four nation-wide studies and four regional studies on energy efficiency and determined the following: "These studies include forecasts of the amount and cost of energy efficiency available through 2010 and, in most cases, 2020. They find that there is enough cost-effective efficiency available to reduce electric demand in 2010 by as much as 11%-23% and in 2020 by as much as 21-35 percent."[8]

According to 2003 estimates produced by ACEEE[9], Maryland could realistically reduce its electricity consumption (through energy efficiency and conservation efforts) by 5.5 percent over a five year horizon. The 5.5 percent applied to the 20 year horizon considered in this analysis would yield electricity savings of 22 percent, which is greater than the baseline savings scenario

[6] The Technical, Economic and Achievable Potential for Energy-Efficiency in the U.S. – A Meta-Analysis of Recent Studies. Steven Nadel, Anna Shipley and R. Neal Elliott, 2004.
[7] The study defines achievable potential as the potential that is "contained by the rate at which homes and businesses will actually adopt energy saving technologies and practices" and further notes that the achievable potential figures are always less than the economic and technical potentials determined in such studies.
[8] Synapse Energy Economics Inc. A Responsible Electricity Future: An Efficient, Cleaner and Balanced Scenario for the US Electricity System, June 11, 2004. Page 13.
[9] ACEEE Estimates of Near-Term Electricity and Gas Savings, R. Neal Elliott, Anna Monis Shipley, Steven Nadel and Elizabeth Brown, August 15, 2003.

considered in this analysis. With regard to natural gas, the same study concluded that Maryland could realistically reduce its natural gas consumption (through energy efficiency and conservation efforts) by 4.2 percent over a five year horizon. The 4.2 percent applied to the 20 year horizon considered in this analysis would yield electricity savings of 16.8 percent, which is greater than the mid-range savings scenario considered in this analysis.

Maryland Competitiveness and Companies

Energy efficiency is not a discrete industry like solar or wind. Energy efficiency cuts across almost all sectors and is therefore hard to define. Companies engaged solely in energy efficiency are typically energy service companies (ESCOs). The National Association of Energy Service Companies only lists one ESCO in the region; PEPCO Energy Services in Arlington, VA. There are only two companies in Maryland certified by the Residential Energy Services Network to rate homes for energy efficiency. The US Green Building Council (USGBC) lists 10 LEED Certified Green buildings in Maryland and 58 projects registered and pending certifications. Architects, engineers and green building consultants are accredited also by USGBC. There are over 700 LEED accredited professionals in Maryland. The Association of Energy Engineers (AEE) has Chapters in Baltimore and the National Capitol Chapter. AEE also certifies energy professionals.

Maryland's existing capacity to capture energy efficiency savings suffers from a lack of businesses that can deliver energy efficiency services, such as Energy Service Companies (as mentioned above, only one is listed in our region) or home weatherization contractors that serve the general public. All the existing weatherization contractors serve only the small subsidized low income market. There is, however, a potential to capture efficiency improvements in new construction given the surge in architects and engineers being accredited by the US Green Building Council's LEED program. There are over 700 LEED Accredited Professionals in Maryland who are qualified to design energy efficient Green buildings.

The potential for developing energy efficiency companies in Maryland is good and will depend largely on government policy and support. Maryland has a rich landscape of support services organizations for new companies, such as TEDCO and the network of business incubators.

Solar Energy

Solar energy can be used for both thermal applications and to generate electricity. The most common solar thermal applications include pool heating, water heating in domestic, commercial and industrial applications, and space heating. These are low temperature applications generally requiring temperatures below 150 degrees F. High temperature applications generate steam that can be used in industrial applications and to generate electricity. High temperature applications work best in climates with high solar radiation like the South West. Maryland is best suited for low temperature applications, such as water heating and space heating.

Solar water heating and space heating systems consist of a solar collector, thermal storage, pumps or fans, and controls. The collectors are called flat plate collectors. A flat plate of steel or copper, coated with a heat absorbing surface, is located inside an insulated box and covered with glass. The sun passes through the glass and heats the flat plate. The glass and the insulated box, trap the heat. Solar water heaters have water pipes attached to the flat plate to transfer the heat from the plate to the water. In some space heating applications, air is blown across the flat plate to heat the air. Some systems replace the flat plate collector with evacuated tubes. These solar water heaters have a small flat plate inside an evacuated tube about 4" in diameter and 6' long. The vacuum creates a very good insulator to keep the heat in and improve the efficiency of the collector. Multiple tubes are connected to a manifold to achieve the area required for the application. The hot water generated in the solar collector is circulated to an insulated storage tank. In most cases, the collectors are on the roof and the storage tank in the basement. In this case, a pump circulates the hot water from the collector to the tank. The pump is typically controlled by a differential controller that senses the temperature in the collector and in the tank. When the collector is hotter than the tank, the controller turns on the pump. When the tank is hotter than the collector, the controller turns off the pump. Some applications use a solar powered pump. The pump is wired directly to a small solar electric PV panel. When the sun comes out, the PV panel powers the pump. This eliminates the controller. Passive solar water heaters eliminate the pump altogether by locating the tank above the collector. As the collector gets hot, the hot water naturally rises into the cooler tank.

In Maryland, solar water heaters need to be protected from freezing. Therefore a mixture of water and antifreeze is typically used in the collector water loop and a heat exchanger is used to transfer the heat to the potable water.

Another excellent application of solar energy in Maryland is passive solar heating of buildings. Passive solar heating is not a devise like a solar water heater that you buy and put on your home. Passive solar is designing the building as a solar collector to provide heat in the winter and to shade the building in summer. Sun coming through the windows, like the glass on the flat plate collector, heats the floor and objects in the building. A well designed passive solar home can get as much as 50-60% of its heating from the passive solar design. Passive solar can be integrated into any architectural style. In fact, many early colonial homes exhibit an understanding of passive solar design with large south facing windows and smaller windows to the north.

Solar PV

Solar energy can also be converted to electricity with photovoltaic (PV) panels. PV systems can be as small as those that power your calculator or as large as a utility scale mega Watt system. The basic solar cells are combined to form panels and panels are arranged to form arrays to meet the power needs of the application. A typical panel used on buildings is 100-200 watts. A typical residential system is 1-3 kW.

Photovoltaic devices can be made from various types of semiconductor materials, deposited or arranged in various structures, to produce solar cells. There are three main types of materials used for solar cells. The most common type is silicon, which can be used in various forms, including single-crystalline, multicrystalline, and amorphous. The second type is polycrystalline thin films, with can be of copper indium diselenide (CIS), cadmium telluride (CdTe), and thin-film silicon. The third type of material is single-crystalline thin film made with gallium arsenide.

A PV system consists of the PV panels or array, an inverter to convert the DC electricity to AC power used in the home, and in some cases batteries and a battery charge regulator. The simplest application of PV is to connect the panel directly to a load like water pumping. The PV panel runs the pump when the sun shines. In homes and commercial installations, the most popular application is tied directly to the electric grid (grid tied). In this application, the PV panels are connected to a grid-tied inverter that converts the DC current from the PV to AC current for the home (or manufacturing facility). The power is used directly in the home to offset the power from the grid. If the home can't use all the power from the PV, the excess goes into the grid. As the power goes into the grid, the meter slows down and can even run backwards, giving the customer a credit. States like Maryland allow a one-for-one credit for solar generated power. In other words, the utility company gives the customer a one-for-one credit for each kWh he or she generates. These net metering laws are a great incentive and help improve the economics of PV power.

The draw back to the grid-tied application is that it does not provide back up power. If the grid goes down, the PV power system shuts down to prevent power being sent back to the grid and injuring someone working on the line. PV back up power applications include a battery system to provide power when the grid goes down or in remote power applications where there is no central power grid. Back up power applications can also be tied to the grid and sell power back. Some smaller stand-alone applications include solar yard lights and solar street lights. Also, many portable road signs are now using PV power systems, as do remote communications stations.

Economics

Solar thermal
Domestic solar hot water (SHW) and solar pool heaters are cost effective today in Maryland and the economics will continue to improve as the price of gas, oil and electricity increases. A typical home solar water heating system cost approximately $4,000-$5,000, produces up to 80% of your hot water and pays back in 4-5 years at today's rates. Payback is faster as rates increase. With 4 to 5 times the energy density of solar photovoltaic (PV), solar water heating produces the most solar power for the least cost. For every $20 to $30 spent on a PV system, you can save the same amount for $1 spent on a solar hot water system. The Los Angeles Air Quality Control Management Board has stated, "next to car pooling, solar water heating is the most cost-effective way to reduce air pollution." Each solar water heater installed saves about as much energy as an economy car uses in a year.

Solar PV
The economics of PV are driven by several factors; the cost of the power it replaces, the cost of the system, financing cost, and the life of the system. Solar PV offsets electric power and, therefore, its cost effectiveness is a function of the cost of the power it is replacing. In parts of the world were power is generated by diesel generators and is not highly subsidized, the cost of power is very high. For example, in the Caribbean, electricity costs are $0.25- $0.30 per kWh. In Maryland, the cost of electricity is about $0.11 per kWh. Current cost of PV is high. Capital cost is $6,000-$8,200 per installed KW or about 25¢ per kWh, assuming no tax incentives or buy downs. In States like California, combined State and Federal buy downs and tax incentives reduce the cost by about 50%, making PV very competitive with utility power. As a result, California is one of the largest markets in the world for PV.

Maryland residents can apply for grants of up to $3,000 toward the cost of a photovoltaic system of solar panels --- which can cost at least $20,000 for a single-family home, and $2,000 for a solar water heating system. Homeowners can also apply for a federal income tax credit of 30 percent of the cost of the system, up to $2,000.

Financing is also a factor in the cost of PV. Lower interest rates and longer financing terms will lower the annual cost of PV power. For new homes, combining the cost of PV into the mortgage cost reduces the annual cost of PV power. In the Caribbean, new homes with PV financed with the mortgage have less overall costs per month (monthly mortgage plus utility cost) than homes without PV. Subsidized low interest loans can also improve the system economics.

Today, PV is competitive in many niche off-grid applications, such as communications and water pumping. According to US DOE, manufacturing improvements, advanced materials, and economies of scale could reduce the levelized cost of electricity from PV, in 2015, to less than 10¢/kWh - down from about 35¢/kWh in 2003, without incentives. In 2005, the U.S. Energy Policy Act established a 30-percent federal tax credit for solar systems purchased for both residential and business applications in the United States, on top of substantial subsidy programs in states such as California and New Jersey.

Energy Payback Time

Energy payback time (EPBT) is the length of deployment required for a photovoltaic system to generate an amount of energy equal to the total energy that went into its production. As shown in Table 2, below, roof-mounted photovoltaic systems have impressively-low energy payback times of 1-2.7 years as documented by recent (2004) engineering studies. The value of EPBT is dependent on three factors: (i) the conversion efficiency of the photovoltaic system; (ii) the amount of illumination (insolation) that the system receives (about 1700 kWh/m^2/yr average for southern Europe and about 1800 kWh/m^2/yr average for the United States); and (iii) the manufacturing technology that was used to make the photovoltaic (solar) cells.

Table 2. System Energy Payback Times for Several Different Photovoltaic Module Technologies.
(1700 kWh/m^2/yr insolation and 75% performance ratio for the system compared to the module.)

Cell Technology	**Energy Payback Time**
Single-crystal silicon	2.7
Non-ribbon multicrystalline silicon	2.2
Ribbon multicrystalline silicon	1.7
Cadmium telluride	1.0

V. Fthenakis and E. Alsema, "Photovoltaics energy payback times, greenhouse gas emissions and external costs: 2004-early 2005 status," *Progress in Photovoltaics*, vol. 14, no. 3, pp. 275-280, 2006.
Assumes 30-year period of performance and 80% maximum rated power at end of lifetime.

Market for Solar

Solar Water Heating (SWH)

The potential market for SWHs is huge. According to the International Energy Agency, "the general opinion is that there will be strong growth in coming years." Europe, where annual growth has been 18 percent in the last ten years, provides a healthy example. Annual growth for the next 10 years has been estimated to be 23 percent. A study by Hoffman, Wells and Guiney estimates that the replacement market for existing gas and electric water heaters is 6 to 9 million units per year. The total installed base of SWHs in both the residential and commercial sectors is above 1.5 million, or between one fifth and one quarter of annual turnover of existing water heaters (Hoffman et al., 1998). Clearly, the potential market for SWHs is huge, especially in regions with favorable natural and economic conditions.

Twenty-five percent of all single-family homes have suitable roof availability. According to Census estimates, there were about 1.6 million single-family homes in the State of Maryland in 2005, which makes about 400,000 homes suitable for solar hot water or PV. At an average cost of $5,000 for a solar hot water system, that is a market potential of $2 billion in potential retrofit applications alone. Solar currently represents only 1% of the water heating market. More than 1 million U.S. homes and 23 million houses in the world use solar water heating systems. The world's largest market for solar hot water collectors is China, with 80% of global additions in 2004. China now accounts for 60% of total installed capacity worldwide and employs some 250,000 people in this industry. The Los Angeles Air Quality Control Management Board has stated, "next to car pooling, solar water heating is the most cost-effective way to reduce air pollution." Each solar water heater installed saves about as much energy as an economy car uses in a year.

Worldwide solar thermal capacity was 70,000 MWth (megawatts thermal energy) in 2001 – more than wind and PV combined. China has over 32 million m2 of solar thermal collector area installed. Europe had 14 million m2 by the end of 2004, with an ambitious target of 100 million m2 by 2010. Spain announced in November 2004, that all new homes must have solar water heating collectors. The technology is mature. Manufacturers around the world are producing high quality solar heating collectors that convert over 80% of the sunlight that hits them into useable heat. With the recent increase in gas and oil cost, SHW is more cost effective than ever. The technology has improved and the industry is poised for resurgence.

Solar PV

PV is one of the fastest growing sectors in the clean energy market. Global sales for the photovoltaic industry are rising about 30% per year. Solar PV is a $12 billion global industry and the leading renewable power source for distributed power generation (consumers who generate heat or electricity for their own needs and send surplus electrical power back to utilities), with recent growth in Japan, Germany, and Spain. The PV equipment market is projected to be $30.8 billion by 2013. California is currently the third largest market for PV in the world and will drive the market for years to come. One hundred and ten MW of PV were installed in the U.S. last year, enough to power 100,000 homes. California's current plan will produce 300 MW annually for the next 10 years. Renewable energy policy at the state and federal level is a significant driver of the industry's growth. The PV industry has shown explosive growth in California and New Jersey, where they have aggressive tax incentives, buy down programs, good interconnection policy, and aggressive Renewable Portfolio Standards (RPS). A RPS requires utilities to generate a minimum amount of their electricity from renewable sources. California's RPS is 20% by 2017, New York's is 24% by 2013, New Jersey's is 6.5% (90MW) by 2008 and the State is considering increasing it to 20% by 2020, and Maryland's is 7.5% by 2019. New Jersey's solar industry has experienced a 500% growth rate in the past 3 years as a result of its aggressive policies.

A study by Rutgers University of the economic impact of New Jersey's proposed 20% RPS, over its current RPS requirement, showed:

- Negligible impact on the cost of electricity to consumers
- Reduction in natural gas prices, as a result of decreasing gas demand
- 11,700 new jobs by 2020
- increased energy reliability

Maryland Solar Resource Potential

On a sunny summer day Maryland receives about 196,000 Gigawatt hours of solar energy. This is more than all the power plants in the state would produce in one year. Solar energy can be used for a variety of end uses, including hot water, space heating, daylighting, and production of electricity via solar photovoltaics (PV) and solar thermal generators. Of these five technologies, thermal concentrating solar is not considered viable in Maryland. While space heating and daylighting are considered viable, and may be quite practical, this assessment is limited to electricity generation via distributed PV and residential solar hot water heating.

Maryland's solar resource potential is described as "good" with the majority of the state receiving about 4.5 kWh/sq meter of solar insolation per day.[10] This can be compared to the "best" locations in the U.S. at 7-7.5 kWh/sq meter in the southwest, and 3-3.5 kWh/sq meter in the "worst" locations in the northwest.

Photovoltaics

Solar photovoltaics can be used to produce electricity on buildings and offset centralized generation. Expected solar PV output can be quantified using previously recorded ground station data. Ground station hourly weather data collected from 1961 through 1990 were compiled and used to generate a "typical meteorological year" (TMY) for each of 216 sites in the lower 48 U.S. states.[11] This TMY data includes solar insolation, which can be placed into a solar PV simulation tool to generate an expected hourly output for a typical year.

There are 5 TMY sites (1 each in MD, DE, NJ, VA and WV) representative of weather conditions in Maryland. Solar resources in Maryland are presented in Figure 34, below. The 5 TMY sites are shown in Figure 35. For each of these sites, we ran a PV simulation tool to derive the expected hourly output for a rooftop mounted PV system.[12] We simulated the output of two system types: a flat roof system and a pitched, south facing roof system.

[10] Solar Radiation Data Manual for Flat-Plate and Concentration Collectors NREL/TP-463-5607 1994.
[11] http://rredc.nrel.gov/solar/old_data/nsrdb/tmy2/
[12] http://rredc.nrel.gov/solar/codes_algs/PVWATTS/version1/

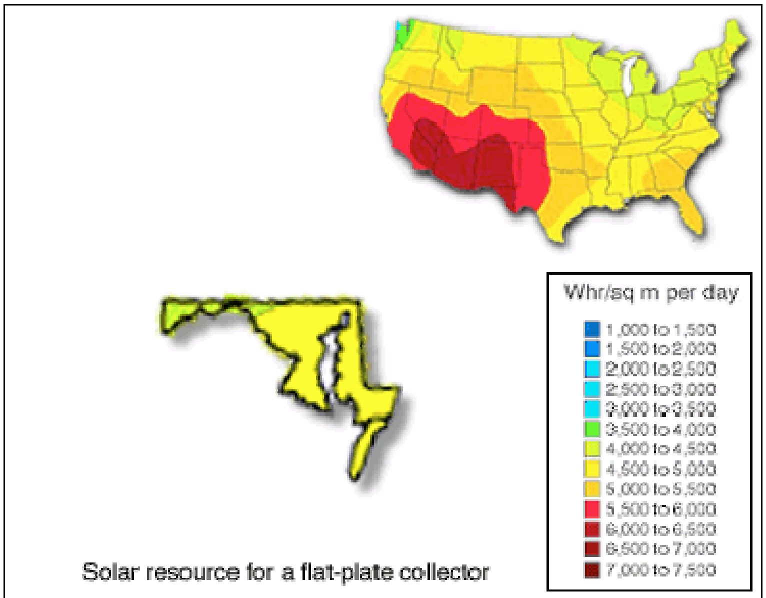


Figure 34: Solar Resources in Maryland.[13]

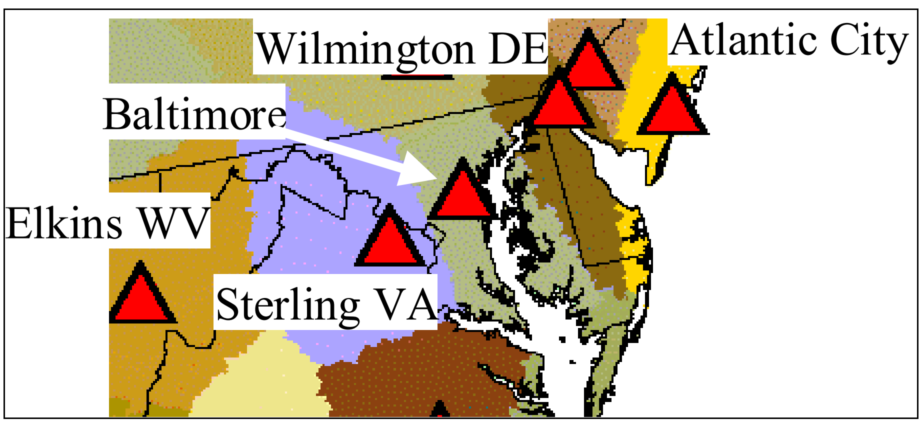


Figure 35: TMY Sites Used for PV evaluation

Table 3, below, provides the estimated capacity factor for each of the five sites. Also provided is a population allocation, indicating the fraction of the state's population that could be assigned to that particular site, based on the states 2000 census.

[13] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy "Alternative Energy Resources by State" http://www.eere.energy.gov/states/alternatives/resources_md.cfm

Table 3: Relevant Maryland TMY Ground Stations, Population Allocation and PV System Capacity Factors[14]

TMY Site	% Population Allocated to Site	System Capacity Factor	
		South Facing, Latitude Tilt	Flat
Baltimore	72.7%	17.7	15.0
Sterling (VA)	20.5%	17.8	15.2
Wilmington (DE)	4.3%	17.7	15.0
Elkins (WV)	1.9%	15.7	14.0
Atlantic City (NJ)	0.6%	18.0	15.2
Population Weighted Average		17.7	15.0

Solar Hot Water

Solar hot water (SHW) heat is an alternative use for solar energy, and currently more cost competitive, particularly with current high natural gas prices.

This analysis used a previous study of domestic solar hot water heating to derive the potential performance in Maryland.[15] This previous study analyzed system performance in the same sites used in the PV analysis, and found that a normally sized solar hot water heater in most sites in Maryland can reduce total water heating energy demand by about 40-70% for a 60-80 gallon/day demand. The roof space required for this level of performance is around 40-64 square feet of collector area.

Solar hot water systems are considerably more efficient that PV systems, with roughly 40% of the incident solar energy being converted into useful energy. However, there is a limit to the usefulness of solar hot water, since excess solar energy cannot be used for other uses, or shipped to a neighbor like PV generated electricity. Table 4, below, illustrates the simulated performance for a solar hot water heating system in three Maryland cities.

Table 4: Solar Hot Water System Performance in Maryland

System Size (gallons/day)	Approximate Solar Fraction*	Efficiency
40	60-70%	34%
60	50-60%	40%
80	40-50%	43%

*Solar fraction is the fraction of hot water heating energy derived from solar energy. The remainder is derived from traditional heating sources.

Commercial buildings are also suitable for solar hot water heaters, with overall performance at least comparable to residential systems in their ability to reduce water heating demand by 50% or more.

[14] Capacity Factor is defined as expected annual energy from a 1 kW **AC** rated PV system / 8760.
[15] Christensen, C.; Barker, G. (1998). Annual System Efficiencies for Solar Water Heating. Campbell-Howe, R.; Cortez, T.; Wilkins-Crowder, B., eds. Proceedings of the 1998 American Solar Energy Society Annual Conference, 14-17 June 1998, Albuquerque, New Mexico. Boulder, CO: American Solar Energy Society pp. 291-296; NREL Report No. 25569

Total State Rooftop Solar Resource

Solar PV or hot water systems may be deployed on existing rooftops, having minimal impact on land use. Both solar technologies requires rooftops that are unshaded, able to bear the additional load of the PV or SHW system, and if pitched, the pitch of the roof cannot be too great (perhaps less than 45%). Total roof area in the State of Maryland can be estimated using a variety of sources, including census data and the EIA's building surveys.[16] However, these sources provide no information on orientation, pitch, or shading. Two prior studies do provide some estimates of rooftop availability on a national basis.[17,18]

Table 5, below, provides an estimate for roof availability in the state of Maryland for solar energy utilization. The values in the table are base on the following assumptions:

1) Of all residential building types, including attached homes, and apartment buildings 22% of the total roof area is suitable for solar PV.
2) Of commercial buildings 50% of the roof area is suitable for solar PV.

Table 5: Estimated Rooftop Area Available for Solar Energy Systems in 2005 (Million square feet)

Building Class	Roof space
Residential	640
Commercial (Small/Medium)	396
Commercial (Large)	49
Total	**1086**

For SHW, we assumed that 25% of all single-family homes have suitable roof availability. According to Census estimates, there were about 1.6 million single-family homes in the state of Maryland in 2005, resulting in 400,000 homes suitable for SHW using the 25% estimate.[19]

These available roofspace estimates can be used to estimate the total potential contribution of Solar PV and solar hot water systems (SHW) on rooftops in the State of Maryland. Rooftop area may be converted to PV peak capacity by applying the typical peak efficiency (AC Watts per square foot.) This assessment uses a system efficiency of 8.7 peak W_{AC}/ sq. foot, which is equivalent to a 10.8 W_{DC}/sq. foot and a derate factor of 0.81. A state-average 15.5% capacity factor was assumed,

[16] http://www.eia.doe.gov/emeu/consumption/index.html

[17] PV Grid Connected Market Potential in 2010 under a Cost Breakthrough Scenario Prepared by Navigant Consulting for The Energy Foundation, March 2005.

[18] Building-Integrated Photovoltaics (BI-PV)—Analysis and US Market Potential, Prepared by Arthur D. Little, Inc. for the US Department of Energy Office of Building Technologies, NREL/TP-472-7850, DE95004055, February 1995.

[19] U.S.Census Bureau, Population Division, Interim State Population Projections, 2005.

based on an equal distribution of flat and tilted orientation, with an additional 0.9 derate factor applied for non-optimum orientation of tilted systems.

SHW systems were assumed to be used only on single family homes. This conservative assumption eliminates the use of SHW on apartment buildings and commercial buildings. We assumed that SHW systems have a 40% efficiency, a 60% solar fraction, and occupy 50 square feet of roof area. (The roof area used for SHW was subtracted from the roof availability for solar PV to avoid double counting.)

Table 6, below**,** illustrates the rooftop solar energy potential in Maryland using the above assumptions. As indicated by Table 6, the assumptions used in this analysis produce a potential electricity reduction in the State of Maryland from rooftop solar systems of around 19%. Assuming building stock grows at the same rate as electricity demand, this fraction could be expected to remain nearly constant. However, if PV efficiency increases at a rate faster than building energy intensity as expected, this fraction could significantly increase.

Table 6: Estimated Potential for Solar Energy on Rooftop Deployed PV and SHW in Maryland

Building Class	**Residential Buildings**	**Commercial Buildings**	**State Total**
Potential PV Capacity (Peak MW_{AC})	5600	3900	9500
Annual Potential from PV on Rooftops (GWh)	7580	5290	12,860
Estimated Total State Electricity Demand in 2005 (GWh)	28,550	17,830	68.430
Potential Fraction of Total Electricity from PV in 2005 (%)	**25.7**	**29.7**	**18.8**
Annual Potential from SHW (billion BTU)	**4456**	Not Evaluated	Not Evaluated

The use of SHW would reduce both electricity use and natural gas use. A large fraction of energy for domestic water heating is derived from electricity, which itself is derived from a mix of coal, natural gas, and nuclear energy. In 2004, Maryland consumed about 190 BCF (billion cubic feet) of natural gas.[20] Of this about 86 BCF was delivered to residential customers, with about 30% of residential natural gas consumption used for water heating.[21]

This analysis excludes the use of SHW on non-residential buildings, and also the significant rooftop potential of industrial buildings, parking lot awnings, or other non-occupied structures. Solar PV systems may also be deployed on ground-based systems, including PV tracking arrays, which feature increased technical performance.

[20] http://tonto.eia.doe.gov/dnav/ng/ng_cons_sum_a_EPG0_veu_mmcf_a.htm
[21] 2001 Residential Energy Consumption Survey

Maryland' Current Solar Industry and Competitiveness

Solar Thermal- hot water and pool heating
The solar water heater industry in Maryland consists of a hand full 3-5 small solar contractors and no solar water heater manufacturers. The SWH industry was devastated by the boom and bust federal tax policies in the 80's. In 1984, there were 225 SHW manufacturers in the US. Today there are fewer than 50. In 2003, 11.4 million sq. ft. of collector area were delivered by 27 manufacturers. Most of these were unglazed collectors for swimming pools, a very cost-effective application. Maryland has the potential to grow a very strong SHW industry. Solar thermal collector manufacturing is a fairly low-tech industry and could take advantage of much of the unused light industrial space available in Baltimore.

Solar PV
Maryland is also home to BP Solar, one of the largest solar cell producers in the world. This company alone accounts for 8% of alternative and clean energy sector employment in Maryland. The presence of one of the leading solar companies in the world in the state presents an opportunity to develop an industry cluster around this new and growing technology. The Renewable Energy Policy Project list Maryland as having 105 businesses with 5,120 employees that could potentially benefit from expanded manufacturing of solar cells. As a result of California's policies, it is home to 15 manufacturers of solar PV technology and more than 62 companies doing retail solar sales. Maryland currently has one large solar manufacturer, BP Solar located in Frederick, and two smaller manufacturers of solar components. Maryland has less than a hand full (3-5) solar installers in the state.

BP Solar plans a $70 million expansion of its manufacturing plant in Frederick, which will give it twice the capacity to produce solar panels and create 70 new jobs. When completed, it will be the largest integrated solar manufacturing plant in North America. Construction at the facility, which serves as BP Solar International's North American headquarters, will begin next year and is expected to be completed in 2008. The plant in Frederick is one of the few that make the panels from start to finish. It takes crude silicon and casts, and sizes the silicon into square silicon wafers - just 200 microns to 300 microns thick - and assembles them as solar panels. The expansion is the second significant one BP Solar has announced at the plant in the past two years. Last year, the company wrapped up a $25 million expansion that doubled the plant's capacity and introduced faster, more efficient manufacturing equipment. The jobs being added over the next couple of years will be both technical and in manufacturing, and many won't require a high school diploma. The 140,000-square-foot expansion includes manufacturing, warehouse and meeting space. It also will have environmentally-friendly features, such as water recycling and energy-efficient lighting, heating and cooling.

Wind Power
Wind has been used for hundreds of years to grind grain and pump water. Modern wind machines turn a generator or alternator to generate electricity. The output of a wind generator or wind turbine, is a function of the wind speed and the size of the wind turbines rotor blades that catch the wind and turn the generator. A wind turbine generally needs a minimum of about 7-10 mph wind to start up and usually reaches maximum capacity about 25 mph. Wind turbines range from small four hundred watt generators for residential use to several megawatt machines for wind farms

offshore. The small ones have direct drive generators, direct current output, aeroelastic blades, lifetime bearings, and use a vane to point into the wind. The larger ones generally have geared power trains, alternating current output, flaps and are actively pointed into the wind. Direct drive generators and aeroelastic blades for large wind turbines are being researched and direct current generators are also sometimes used. The three most important factors for a successful wind project is location, location, location. If you don't have good steady reliable wind, the wind turbines can't produce adequate power. The best locations for wind power typically are mountain ridges and offshore locations.

Wind Economics

The cost of generating electricity from wind has fallen dramatically. In the 1980s, wind power generation cost as much as 30 cents per kilowatt hour. Today, that cost has dropped 80%, to as little as four cents per kWh, after factoring in tax credits and government incentives. The system installation costs are $2-$4 per Watt installed. Recent breakthroughs in technology mean that state of-the-art windmills of suitable scale for use by electric utilities can generate electricity at less than one-half the cost of gas-fired power. There is an accelerated tax depreciation schedule for wind turbines, in addition to a 1.8 cent-per-kilowatt production tax credit for wind power equipment. Consequently, several major utility firms and energy companies have been investing significant amounts of money in new windmill farms.

Wind Market

Wind power is the leader in wholesale renewable electricity production in the United States. Total installed U.S. wind power capacity was 9,149 megawatts at the beginning of 2006, according to the American Wind Energy Association. A large part of this — 2,420 megawatts — was installed in 2005, and an estimated 3,000 megawatts was planned for installation in 2006. With recent technological advances, the price competitiveness of wind generation versus natural gas has improved, supporting continued growth. In addition, the U.S. federal government offers companies a production tax credit for wind power equal to about 1.9 cents per watt-hour. This has been a powerful incentive to attract tax-oriented investors, such as utility companies, into wind farm ownership.

The original markets for wind power were in Denmark in the late 1990s, followed by Germany. Today, the hot markets are Spain, Italy, France, the United Kingdom, and India. But wind power is available almost everywhere. Wind provides about 0.4% of energy consumed in the U.S. and is growing rapidly thanks to the continual construction of new wind farms. Installed U.S. wind power plants already serve more than 1.6 million average households with 4.3 million people in 2004. In 2005, that number jumped to over 2.3 million households with 6 million people. The wind industry will be capable of supplying about 6% of our nation's electricity (as much as hydropower generates today) by 2020. Global wind generation capacity topped 50 gigawatts in 2005, according to the Global Wind Energy Council. This represents an increase of 20% over the previous year, making wind the fastest growing energy source on a percentage basis.

Marylanders can purchase electricity generated by wind power through Green Power marketers, including PEPCO and Washington Gas Energy Services (WGES). An aggregation of Maryland city and county agencies led by Montgomery County signed a contract with Washington Gas Energy Services and Community Energy, Inc., to purchase 38 million kWh of wind energy annually, sourced from the 66-MW Mountaineer Wind Energy Center in West Virginia. Montgomery County is one of the top 25 purchasers of Green Power in the country. Montgomery County has included wind energy purchases as a control measure for ozone pollution in a "State Implementation Plan" (SIP) for air quality improvement, which was recently submitted for approval to the U.S. Environmental Protection Agency. Ecoprint, a printing and mail services company in Silver Spring, Maryland, has committed the company to purchasing wind power for 100% of the its electricity needs.

Wind energy is growing so quickly in Europe, that by 2020, it will generate about 12% of all of Europe’s electricity needs. Noteworthy new projects include the proposed 130-turbine wind farm in Nantucket Sound offshore of Cape Cod, Massachusetts. It is expected to include as much as 420 megawatts. An Irish wind power company, Airtricity, in partnership with GE Energy, has completed the Arklow Bank Wind Park in the Irish Sea. The park has seven GE 3.6-megawatt turbines and can power approximately 16,000 homes per year. General Electric, a top Fortune 500 company and one of the largest technology manufacturing firms in the world, has been investing in both wind and solar energy. Wind Energy is one of the fastest-growing divisions at GE, which expected to generate about $2 billion in revenues in 2005 from its wind operations alone

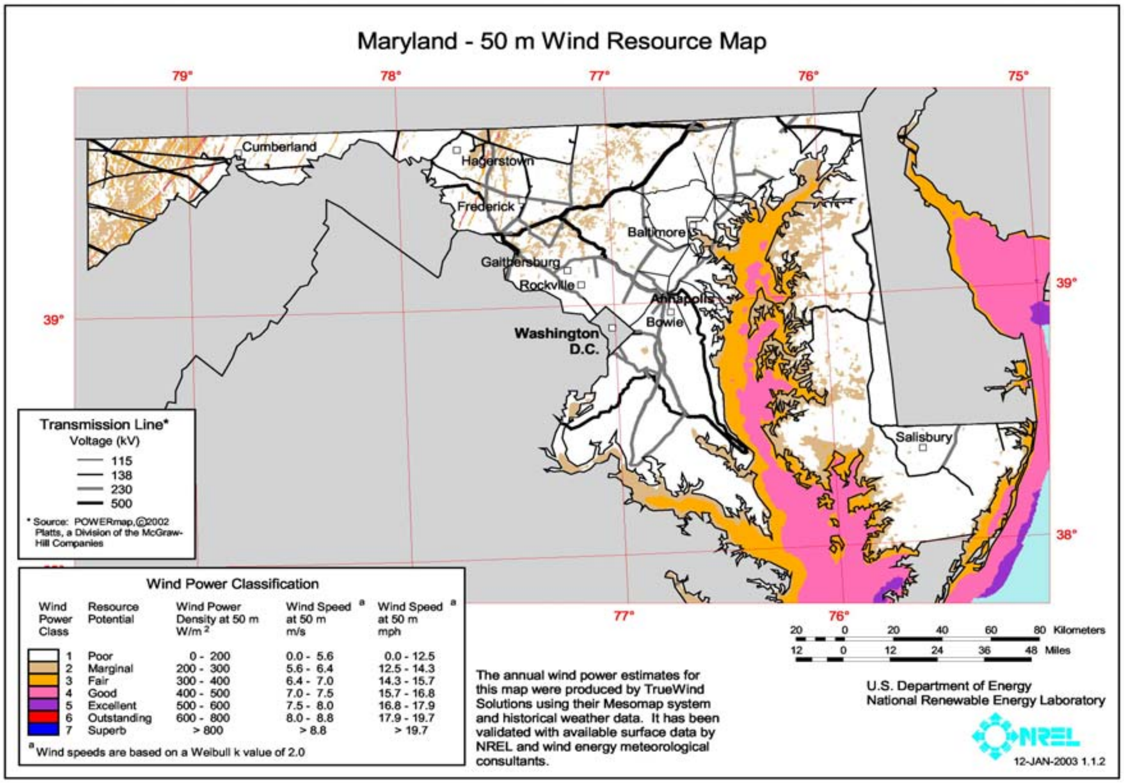
The wind industry has been growing at 28% a year for the past five years, and if growth trends continue at this pace as is expected, wind capacity will double about every three or four years. This statement can be found in "Investing in Wind Energy," a report just released by the Progressive Investor. Renewable energy project finance was up from US$10.8 billion in 2004 to $18.2 billion in 2005. The preponderance of this investment was in wind (72%), with the U.S. leading the world with $3.9 billion invested in 2005.The wind industry used to be centered in Europe, mostly Germany. Now 50 countries are actively installing turbines, employing at least 100,000 people. Manufacturers of wind turbines have become global companies, thanks to government support, renewable energy certificates (RECs), investors and wind park developers.

Wind park ownership is consolidating, and one-third of the world's wind capacity belongs to the top 20 wind farm owners. The Spanish utility Iberdrola and U.S.-based FPL Energy ended 2005 tied as the world leaders in wind farm ownership with 3400 MW in service, followed by Spanish Acciona Energia. The world wind turbine market is dominated by 10 major companies that control almost 100% of the market: Vestas (34%), Gamesa (18%), Enercon (15%), GE Wind (11%), Siemens (6%), Suzlon (4%), REpower (3%), Mitsubishi (2%), Ecotecnia (2%) and Nordex (2%).

According to Mark Cox, Managing Director, New Energy Fund, "Wind has accelerated faster than the wildest dreams of the turbine makers. Because it requires such a huge capital investment, management hasn't added enough capacity in advance and now has to catch up."

Wind Resource Potential

For our analysis of wind resource potential, we use annual wind power data that were produced by TrueWind Solutions, using their Mesomap system and historical weather data. It was validated with available surface data by NREL and wind meteorological consultants. The resource is represented as annual average wind power class at 50 meters above ground. The wind resource data have been screened to eliminate areas that may not be compatible with wind development, such as urban areas, airfields, steep slopes, parks, wetlands, and wildlife refuges. These exclusions are detailed in Table 7, below.[22] The Maryland wind resource map developed by NREL, with transmission lines overlaid is presented below.



Two methodologies were used to determine available wind resources with access to transmission. First, because transmission costs generally increase with distance to transmission, they calculated wind resources within 5, 10, 15, and 20 miles of transmission. Second, because existing transmission lines may not be fully available to carry wind generation, the analysis restricted the wind resources to that which can be supported by 20% of the capacity of existing transmission lines. This algorithm, which has been used in other NREL analyses, competes the best wind resources against each other to a total that is equivalent to 20% of the capacity of the available transmission lines. Because of the potential for double counting of transmission lines, particularly when large transmission lines split into smaller lines, the available transmission lines were further restricted to include only the lines that supply in-state load areas or cross power control areas (and therefore could export power to other regions). For both of the methodologies, the analysis considered only wind resources and transmission lines in Maryland.

Table 8, below, summarizes the results of the assessment of the technical potential for onshore wind energy generating capacity with consideration of distance to transmission. It assumes 5 MW of wind capacity per square kilometer. Typically, utility scale wind projects require wind resources of Class 4 or higher. The analysis shows that onshore Class 4 through Class 6 wind resources in

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[22] Note that some of these restrictions, such as excluding 50% of all USDA lands and 50% of all non-ridge crest forestlands, may be conservative and limit resource estimates.

Maryland located within 20 miles of transmission could support about 185 MW of wind energy capacity. If Class 3 resources are included, nearly 1,570 MW of wind capacity could be supported within 20 miles of transmission.

Table 7: Criteria for Defining Available Windy Land

Environmental Criteria	*Data/Comments:*
100% exclusion of National Park Service and Fish and Wildlife Service managed lands	USGS Federal and Indian Lands shape file, Feb 2003
100% exclusion of federal lands designated as park, wilderness, wilderness study area, national monument, national battlefield, recreation area, national conservation area, wildlife refuge, wildlife area or wild and scenic river.	USGS Federal and Indian Lands shape file, Feb 2003
100% exclusion of state and private lands equivalent to criteria 2 and 3, where GIS data is available.	State/GAP land stewardship data management status 1, available for the 48 conterminous states from the Conservation Biology Institute Protected Areas Database, Version 2 (2003). Status 1 lands have the greatest protection from disturbance or conversion.
50% exclusion of remaining USDA Forest Service (FS) lands (incl. National Grasslands)	USGS Federal and Indian Lands shape file, Feb 2003
50% exclusion of remaining Dept. of Defense lands	USGS Federal and Indian Lands shape file, Feb 2003
50% exclusion of state forest land, where GIS data is available	State/GAP land stewardship data management status 2, available for the 48 conterminous states from the Conservation Biology Institute Protected Areas Database, Version 2 (2003). Status 2 lands are protection from disturbance or conversion, but allow some extractive uses.
Land Use Criteria	
100% exclusion of airfields, urban, wetland and water areas.	USGS North America Land Use Land Cover (LULC), version 2.0, 1993; ESRI airports and airfields (2003)
50% exclusion of non-ridge crest forest	Ridge-crest areas defined using a terrain definition script, overlaid with USGS LULC data screened for the forest categories.
Other Criteria	
Exclude areas of slope > 20%	Derived from elevation data used in the wind resource model.
100% exclude 3 km surrounding criteria 2-5 (except water)	Merged datasets and buffer 3 km
Exclude resource areas that do not meet a density of 5 km^2 of class 3 or better resource within the surrounding 100 km^2 area.	Focal sum function of class 3+ areas (not applied to 1987 PNL resource data)
Note – Criteria are numbered in the order they are applied. 50% exclusions are not cumulative. If an area is non-ridgecrest forest on FS land, it is just excluded at the 50% level one time.	

Table 8: Potential Wind Generating Capacity by Distance to Transmission (Onshore only)

Distance to Transmission	Class 3 Area (MW)	Class 4 Area (MW)	Class 5 Area (MW)	Class 6 Area (MW)	Total
0 - 5 miles	534.1	117.1	37.4	8.7	697.3
5 - 10 miles	170.4	11.4	1.9	0.0	183.7
10 - 20 miles	678.3	8.9	0.0	0.0	687.2
> 20 miles	44.1	0.0	0.0	0.0	44.1
Total	*1,426.9*	*137.4*	*39.3*	*8.7*	1,612.3

Maryland has considerable potential offshore wind resources, using the same methodologies described above. Table 9 presents the potential for wind energy generating capacity for offshore resources within 5, 10 and 20 miles of transmission. Maryland's Class 5 and Class 6 offshore wind resources have the technical potential to collectively support a total of about 19,400 MW of wind energy generating capacity and, of this, about 2,100 MW is within 20 miles of transmission. Note that costs are higher for the development of offshore wind resources than onshore resources.

Table 9: Wind Energy Resource and Generation Potential by Distance to Transmission for Offshore Resources

Distance to Transmission	Class 4 Area (MW)	Class 5 Area (MW)	Class 6 Area (MW)	Total
0 - 5 miles	0.0	0.0	0.0	0.0
5 - 10 miles	9.9	371.4	0.0	381.3
10 - 20 miles	1.1	1,755.1	0.0	1,756.3
> 20 miles	276.4	2,006.9	15,300.7	17,584.0
Total	*287.4*	*4,133.5*	*15,300.7*	19,721.6

In the analysis that assumes that only 20% of the capacity of existing transmission lines would be available for wind, the estimated capacity that could technically be supported by onshore resources of class 4 and higher is still 185 MW. If class 3 resources are included, the total is about 1420 MW, which is a little lower than the 1,570 MW potential within 20 miles of transmission lines. The potential offshore wind capacity drops further. The analysis shows that there are adequate Class 5 and Class 6 offshore resources to support about 1670 MW of capacity, with about 750 MW of potential in Class 6 resource area (Table 10).

Table 10: Potential Wind Energy Capacity Assuming 20% Availability of Existing Transmission Lines (MW)

	Class 3	*Class 4*	*Class 5*	*Class 6*	*Total*
On-shore	1235.9	137.4	39.3	8.7	1421.3
Off-shore	N/a	2.2	926.0	746.0	1674.2
Total	1235.9	139.6	965.3	754.7	3095.5

The estimates of technical potential presented above do not attempt to evaluate the operating costs of grid generators due to wind variability or to evaluate reliability implications of high levels of penetration of wind generation. The integration of about 1,400 MW of onshore wind generation in an approximately 13,000 MW system should be manageable and result in ancillary costs similar to those experienced in other regions. Offshore resources have been developed in Europe, but have yet to be developed in the U.S.; therefore, there is less experience with actual operating costs.

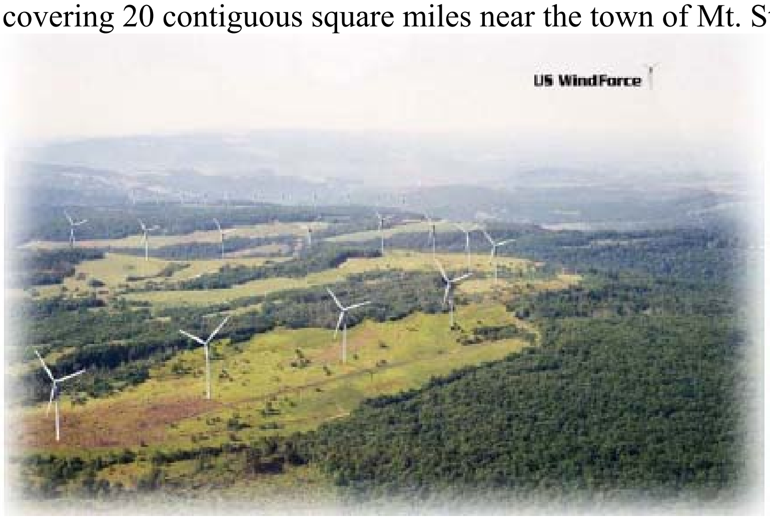
Wind Companies in Maryland and Competitiveness

Maryland has several areas with good to excellent wind resource.

- The barrier islands along the Atlantic coast,
- The southeastern shore of Chesapeake Bay,
- Ridge crests in the western part of the state, including nearly all of Garrett and Allegany Counties.

In addition, small wind turbines may have good applications in many areas. The 66-MW Mountaineer Wind Energy Center located in West Virginia, which began operating in December 2002, is now the largest wind generating facility in the eastern United States. WGES now has nearly 5,000 residential and small commercial customers in the Washington, DC-area supporting a total of 3.3 MW of wind energy generation. In Maryland, applications have been approved to build two dozen turbines atop Big Savage Mountain and 67 turbines along 10 miles of Backbone Mountain, the state's tallest peak. Located in western Maryland, US Wind Force's Savage Mountain project is expected be the first utility scale wind project in the state. This is a 40 MW project scheduled for completion in 2008. Clipper Windpower's Criterion project for up to 67 turbines on Blackbone Mountain was approved by the Maryland Public Service commission in 2003, but is still seeking contractual agreements with power buyers and investors that will allow the project to proceed. The newest project is being planned by Synergics Wind Energy LLC, a private firm based in Annapolis and affiliated with conventional power plant operator Synergics Inc. Synergics filed an application with the PSC for permission to place 24 windmills atop Backbone Mountain, south of U.S. 50 near Table Rock in Garrett County. The 262-foot turbines would collectively generate about 40 megawatts of electricity for sale to a power supplier. Another Maryland wind project is being planned for placement on almost four contiguous miles of ridgeline in Western Maryland's Allegany County, atop Dan's Mountain. This 60 MW project by US Windforce was scheduled for completion in 2008, but its status is currently uncertain.

US Wind Force is also developing a 150 MW project in Grant County, West Virginia, near the Maryland border. The site is located on ridgelines, varying in altitude from 3,000 to 3,400 feet and spread over an area covering 20 contiguous square miles near the town of Mt. Storm.



Another US Wind Force/ Liberty Gap, LLC project is located in the southern portion of Pendleton County, West Virginia, atop Jack Mountain at elevations ranging between 3,600 and 4,000 feet above sea level. It will have a generating capacity of up to 100 megawatts. The project is currently being contested by a local citizen's group. A hearing is scheduled for April 2007.

Thousands of wind turbines are currently being proposed for all along the Eastern Seaboard -- 858 off Maryland, 221 off Virginia, and 130 off Cape Cod.

Bio Fuels
Biofuels, principally corn-based ethanol, present the biggest investment opportunity in renewable energy in the United States for the next several years. Recent evidence assembled by Lawrence Berkeley Laboratory rebuts outdated beliefs from the 1970s that, because of the energy-intensive production, environmental benefits from corn-based ethanol are non-existent. It now appears that producing corn-based ethanol requires much less petroleum than producing gasoline and that greenhouse gas emissions from such an ethanol are about 15 percent to 20 percent lower than from gasoline. New cellulosic ethanol technology reduces both greenhouse gas emissions and petroleum inputs even more substantially. With ethanol replacing methyl tertiary-butyl ether (a chemical compound used as a fuel component in gasoline that has been banned in 22 states), demand has grown rapidly. In 2006, more than 4.7 billion gallons (17.9 billion liters) of ethanol will be produced, and there are 2 billion gallons (7.6 billion liters) per year of new processing capacity under construction in the United States. The U.S. auto manufacturers have taken notice of the recent interest in biofuels. General Motors, for example, currently produces nine models that can run on E85, a mixture of 85 percent ethanol and 15 percent gasoline.

Ethanol
Ethanol, or ethyl alcohol, is an alcohol-based alternative fuel produced by fermenting and distilling starch crops that have been converted into simple sugars. Feedstocks for this fuel include corn, barley, and wheat. Ethanol can also be produced from "cellulosic biomass," such as trees and grasses, and is called bioethanol. Ethanol is most commonly used to increase octane and improve the emissions quality of gasoline. Ethanol can be blended with gasoline to create E10, a blend of 10% ethanol and 90% gasoline. Ethanol can also be blended to create E85, which is 85% ethanol.

Ethanol has been around since the beginning of recorded history. In ancient times, the Egyptians produced alcohol by naturally fermenting vegetative materials. The ancient Chinese also discovered the art of distillation, which is used to increase the concentration of alcohol in fermented solutions. In 1907, Henry Ford caused quite an uproar, when he brought ethanol to the attention of the American motoring public by introducing his first automobile which ran on ethanol. Due to the discovery of crude oil, however, and the fact that our oil companies could easily and efficiently refine it into gasoline, ethanol started to fade into the background as a motor fuel in the early 1900s. But in the 1970s, ethanol began to reemerge again, when it was used as a fuel extender during the gasoline crises invoked by the OPEC oil embargoes. Later, when gasoline was more plentiful, ethanol began to see widespread use as a cleaner burning octane enhancer, perfect for replacing other, less desirable, gasoline components, such as lead. As a result of clean air regulations, agricultural interests, and energy security needs, U.S. ethanol demand has grown from less than 200 million gallons annually in the early 1980s to nearly 4 billion gallons in the year 2005.

In the United States, ethanol is produced in corn wet or dry mills. Corn *wet* mills fractionate the corn grain for products like germ and oil before converting the clean starch to sugars for fermentation or for such valuable food products as high-fructose corn syrup and maltodextrins. The corn fiber by-product usually is sold as animal feed. In corn *dry* mills, the grain is ground, broken into sugar monomers (saccharified), and fermented. Since the grain is not fractionated, the only by-product is the remaining solids, called distillers' dried grains with solubles, a highly nutritious protein source used in livestock feed. A bushel of corn yields about 2.5 gal ethanol from wet-mill processing and about 2.8 gal from dry grind (Bothast and Schlicher 2005). Some 75% of corn ethanol production is from dry-mill facilities and 25% from wet mills.

In the last twenty-five years, the cost of building a dry-mill ethanol plant has been reduced by around 30 percent, while the cost of ethanol production has fallen by around 50 percent. This is primarily due to the adoption of "fuel-grade" process technologies that streamlined the production process, as opposed to the utilization of industrial/beverage grade production processes. In 2003, the U.S. Department of Agriculture surveyed 21 dry-mill ethanol plants to estimate their 2002 production costs, including both variable (feedstock and plant operation) and capital expenses. [23]These plants produced about 550 million gallons of ethanol in 2003. Net feedstock costs for the surveyed plants ranged from 39 to 68 cents per gallon in 2002. For cash operating expenses, the average energy expenditure was 17.29 cents per gallon. Labor costs ranged from 3 to 11 cents per gallon, maintenance costs from 1 to 7 cents, and administrative costs from 1 to 18 cents. For capital expenditures, new plant construction costs from $1.05 to $3.00 per gallon of ethanol. Average investment to expand existing ethanol production capacity was 50 cents per gallon; hence, expansion tends to cost less than new capacity.

Modern ethanol plants are more efficient, because they utilize the following important innovations:

- Molecular sieves: If there is one predominant advance in the ethanol industry, it is the introduction of the molecular sieve, or molsieve. The molsieve is basically compared to a bed of ceramic-like beads that absorb the water molecules as vaporized ethanol passes through the bed. Molsieves replaced azeotropic distillation systems using cyclohexane or benzene, which were expensive, costly to operate, energy intensive and potentially hazardous.

- Thermal integration: Engineering companies are providing turnkey services enabling a more streamlined production process and integrated energy saving technologies. Heating and cooling liquids is part of the ethanol production process; capturing the process heat and re-using or redirecting it to other areas of the plant can significantly reduce energy requirements and costs.

- Enzymes: Improvements in enzyme technology and reductions in the cost of producing enzymes have lowered the price of ethanol by more than 6 cents per gallon. Enzyme manufacturers have increased enzyme production yield fivefold in the last 15 years. Furthermore, the new enzymes are more productive in hydrolyzing the starches to fermentable sugars and they no longer require the addition of lime for pH balance. Ammonia is now used, providing nutrients (nitrogen) to the yeast, making it more effective during fermentation.

- Yeasts: Most ethanol plants today propagate their own yeast. The practice of "pitching," which was the discarding of spent yeast and replacing it with a batch of new yeast, is no longer used.

[23] USDA. 2002 Ethanol Cost-of-Production Survey. Shapouri, H; Gallagher, P. July 1, 2005.

- High-gravity fermentation: This evolving technology will provide the opportunity to ferment “beer” mash containing considerably higher levels of solids. In doing so, it will reduce the amount of water required, which will then reduce the cost of handling and treating the water later in the process. In addition, higher solids result in higher “beer” yields in the same or less time.

- High-temperature yeast: The development of yeast strains that withstand higher temperatures will not only increase the alcohol content of the beer but also reduce energy costs.

- Quick steeping: The quick-steep process may evolve to be a major change for the dry-mill ethanol

The record 3.904 billion gallons of ethanol delivered in 2005, which meant an increase of more than 139 percent from 2000, was produced by 95 ethanol plants in 19 states[24]. In 2006, the U.S. has more than 4.3 billion gallons of ethanol production capacity (equal to about 3% of our 140 billion gallons per year gasoline consumption) and nearly 2 billion additional gallons under construction. From 2000 to 2005, the estimated annually compounded growth rate of ethanol production and usage in the US was approximately 19% per year. Driven by the stable policy environment provided by the Energy Policy Act of 2005 (EPACT) and passage of the Volumetric Ethanol Excise Tax Credit (VEETC), as well as high margins for producers, ethanol production and usage are expected to grow rapidly through 2008 at approximately 27% per year. In 2008, ethanol production is forecast to be 7.9 billion gallons, which exceeds the 7.5-billion-gallon level of the RFS (see below) in 2012.[25]

VEETC was implemented in 2004 and provides an alcohol-fuel mixture excise credit of $0.51/gallon of ethanol for the blender. EPACT(2005) created a national Renewable Fuels Standard (RFS). It establishes a baseline for renewable fuel use, beginning with 4 billion gallons per year in 2006 and expanding to 7.5 billion gallons by 2012.The vast majority of the renewable fuel used will be ethanol. Under the RFS program, each gallon of cellulosic ethanol or waste-derived ethanol counts as 2.5 gallons. While the 2.5-to-one ratio ends in 2012, after that time, the RFS will require a minimum of 250 million gallons of cellulosic biomass fuels be produced annually. EPACT(2005) also expanded coverage of the “small producer tax credit” to producers of up to 60 million gallons per year, an increase of 30 million gallons. It also created a similar tax credit for agri-biodiesel producers. Small ethanol producers receive a 10-cent/gallon production income tax credit on up to 15 million gallons of production annually. The credit is capped at $1.5 million/year/producer.

Cellulose, from which cellulosic ethanol is made, is the main component of plant cell walls and is the most common organic compound on earth. It is more difficult to break down cellulose to convert it into usable sugars for ethanol production than it is to pretreat corn for ethanol

[24] RFA. From Niche to Nation: Ethanol Industry Outlook 2006.

[25] Private discussions with USDOE.

production. Yet, making ethanol from cellulose dramatically expands the types and amount of available material for ethanol production. This includes many materials now regarded as wastes requiring disposal, as well as corn stalks, rice straw and wood chips or "energy crops" of fast-growing trees and grasses. Producing ethanol from cellulose promises to greatly increase the volume of fuel ethanol that can be produced in the U.S. and abroad. A recent report found the land resources in the U.S. are capable of producing a sustainable supply of 1.3 billion tons per year of biomass, and that 1 billion tons of biomass would be sufficient to displace 30 percent or more of the country's present petroleum consumption. Importantly, it offers tremendous opportunities for new jobs and economic growth outside the traditional "grain belt," with production across the country from locally available resources. Cellulose ethanol production will also provide additional greenhouse gas emissions reductions.

Currently, Iogen Corporation in Ottawa, Canada produces just over a million gallons annually of cellulose ethanol from wheat, oat and barley straw in their demonstration facility. Several existing ethanol plants in the U.S. are engaged in research and demonstration projects with the U.S. Department of Energy (USDOE) utilizing the existing fiber in their facility that typically goes into the livestock feed coproduct. Enzyme companies including Genencor International and Novozymes have led successful research projects with the Department to significantly reduce enzyme cost and increase enzyme life and durability. Other research has led to improved fermentation strains that enable simultaneous saccharification and fermentation (SSF), in which hydrolysis of cellulose and fermentation of glucose e combined in one step.

Currently it costs about two to three times as much to produce cellulosic ethanol as compared to ethanol made from corn. Despite years of public and private research, the Department of Energy estimates that it still costs $2.20 a gallon to produce cellulosic ethanol. Companies have told the Energy Department privately that they have cut the cost of making cellulosic ethanol to $1.50 a gallon. Such claims are difficult to evaluate, because companies keep their data confidential. USDOE has set a goal of replacing 30 percent of the nation's current motor fuel usage with ethanol by 2030. That would require 60 billion gallons of ethanol, which is four times the estimated 15 billion gallons that can be economically distilled from corn. With continued advancements in pretreatment technology, fermentation, and collection and storage logistics, the commercial production of cellulose ethanol becomes more economically feasible. Much research is being undertaken by USDOE to drive the production cost of cellulosic ethanol down to $1.07/gallon by 2012.

Five states, California, Ohio, Hawaii, Minnesota and Montana, have either a RFS or have passed legislation to promote the use of biofuels. In addition, a number of states are currently considering state-level ethanol mandates, including Iowa, Illinois, Missouri, Nebraska, Washington, and Oregon.

In Maryland, ethanol can be produced from corn for less than $1.30 per gallon and for less in the Corn Belt. A recent feasibility study done for ethanol production in Maryland shows an equity internal rate of return of 27-34%. [26] As a result of its Renewable Fuels Promotion Act of 2005,

[26] NREL. Technical Analysis Support for Identifying Risks and Deployment Barriers for the Biomass Program. May 23, 2006

Maryland has a $0.20 per gallon producer credit for ethanol produced from small grains (winter grain) and a $0.05 per gallon producer credit for ethanol from other agricultural products. Maryland's maximum total payment is $3 million/year for all ethanol produced. To reach this maximum would require at least 15mgy of ethanol from small grains in a facility that began operating or expanded after 12/31/04. Maryland's program Sunsets on 12/31/2017.

There are currently no ethanol plants in operation on the East-coast of the U.S. Maryland currently uses about 2.5 billion gallons of gasoline per year. At E-10 levels, the State could use about 250 million gallons of ethanol per year. At E-85 levels, the utilization will be over 2 billion gallons of ethanol. Similarly, the State of Virginia uses about 4 billion gallons of gasoline per year. Virginia's E-10 requirement would be 400 million gallons of ethanol, and its E-85 requirement would be almost 3.5 billion gallons of ethanol. In Maryland, there are currently at least five organizations that are in either the planning or permitting stage for building an ethanol plant:

- Atlantic Ethanol, $100 million, 54-100 mgpy plant in Baltimore City;
- Chesapeake Renewable Energy, LLC, $120 million, 50 mgpy facility in Somerset County;
- Ecron, $150 million, 100 mgpy facility in Baltimore City;
- Greenstock , 30 mgpy facility in Dorchester County; and
- Maryland Grain Producers Board, 50 mgpy facility

According to the USDOE, the economics of cellulosic ethanol production can be enhanced by producing ethanol in a biorefinery in combination with electric power and bio-chemicals. By integrating the production of higher value bioproducts into the biorefinery's fuel and power output, the overall profitability and productivity of all energy related products will be improved. Increased profitability makes it more attractive for new biobased companies to contribute to our domestic fuel and power supply by reinvesting in new biorefineries. Increased productivity and efficiency can also be achieved through operations that lower the overall energy intensity of the biorefinery's unit operations, maximize the use of all feedstock components, byproducts and waste streams, and use economies of scale, common processing operations, materials, and equipment to drive down all production costs, including the cost of ethanol.

In 2004, USDOE published a report that identified what some of these biorefinery high value by-products might be [27]. The report identified twelve building block chemicals that can be produced from sugars via biological or chemical conversions of cellulosic biomass. These twelve building blocks can be subsequently converted to a number of high-value bio-based chemicals or materials. Building block chemicals, as considered in this analysis, are molecules with multiple functional groups that possess the potential to be transformed into new families of useful molecules. The twelve sugar-based building blocks are 1,4-diacids (succinic, fumaric and malic), 2,5-furan dicarboxylic acid, 3-hydroxy propionic acid, aspartic acid, glucaric acid, glutamic acid, itaconic acid, levulinic acid, 3-hydroxybutyrolactone, glycerol, sorbitol, and xylitol/arabinitol. As stated in the report, the selection of 12 building blocks began with a list of more than 300 candidates. A shorter list of 30 potential candidates was selected using an iterative review process based on the petrochemical model of building blocks, chemical data, known market data, properties, performance of the potential candidates and the prior industry experience of the team at the two USDOE Laboratories that produced the report; Pacific Northwest National Laboratory

[27] USDOE. Top Value Added Chemicals from Biomass, Volume 1. NREL/PNNL 2004.

(PNNL) and the National Renewable Energy Laboratory (NREL). This list of 30 was ultimately reduced to 12 by examining the potential markets for the building blocks and their derivatives and the technical complexity of the synthesis pathways. A second-tier group of building blocks was also identified as viable candidates. These include gluconic acid, lactic acid, malonic acid, propionic acid, the triacids, citric and aconitic; xylonic acid, acetoin, furfural, levoglucosan, lysine, serine and threonine.

In a paper presented at the Twenty-Fifth Symposium for Biotechnology for Fuels and Chemicals in 2004, it is pointed out that by using biotechnology and novel chemistries, biomass carbon can be rearranged to yield products that are equivalent or superior to the fossil-based products used today.[28] They also state that new genetic mapping techniques allow researchers to sequence genes more quickly and to determine the relationship between structure and function. These genetic tools are being used to create new and improved microorganisms to convert biomass components into end products or intermediaries that can then be thermochemically upgraded. These tools are also being used to improve biomass feedstocks by increasing the content of desired components, decreasing the content of components such as lignin, and/or adding the capability to produce a new component such as a new fatty acid in oilseeds. This same article summarizes some of the research done by USDOE and other experts in industry regarding potential markets for bio-based products that relate to biofuels production. These markets include the polymer, lubricant, solvent, adhesive, herbicide, and pharmaceutical markets. Organic chemicals, with an annual production of eighty million metric tons, and lubricants, with an annual production of nine million metric tons, are the largest and most accessible markets. Within the organic chemicals market, the market for polymers, with an annual production of 46 million metric tons, represents a large opportunity. The polymers market includes, among others, polyolefins (22.4 million metric tons), polyvinyl chlorides (6.5 million metric tons), styrenics (4.1 million metric tons), and thermosets (3.6 million metric tons). The market for solvents is also large, with an annual production of 4.8 million metric tons.

Building on the above-mentioned and other related reports, the Maryland Energy Administration (MEA) and the Maryland Department of Business and Economic Development (DBED) are funding a study to identify potential regional markets for high value by-products derived from cellulosic ethanol production in Maryland. This study will also focus on identification of potential biomass feedstocks available in Maryland for cellulosic ethanol production.

With regard to being able to produce cellulosic ethanol on a large scale, USDOE also believes this will require transformational breakthroughs in science and technology and that incremental improvements in current bioenergy-production methods will not suffice. [29] Several developments have converged in recent years to suggest that systems biology research into microbes and plants promises solutions that will overcome critical roadblocks on the path to cost-effective, large-scale production of cellulosic ethanol and other renewable energy from biomass. The ability to rapidly sequence the DNA of any organism is a critical part of these new capabilities, but it is only a first step. Other advances include the growing number of high-throughput techniques for protein

[28] Applied Biochemistry and Biotechnology: Opportunities in the Industrial Biobased Products Industry. Tracy M. Caroll, Joan Pellegrino, and Mark D. Paster. Spring 2004

[29] USDOE Genomics: GTL – Bioenergy Research Centers White Paper. August 2006.

production and characterization; a range of new instrumentation for observing proteins and other cell constituents; the rapid growth of commercially available reagents for protein production; a new generation of high-intensity light sources that provide precision imaging on the nanoscale and allow observation of molecular interactions in ultrafast time intervals; major advances in computational capability; and the continually increasing numbers of these instruments and technologies within the national laboratory infrastructure, at universities, and in private industry. All these developments expand our ability to elucidate mechanisms present in living cells, but much more remains to be done.

According to USDOE, microbes can provide the basis for a biotechnology revolution in energy and environmental applications. In a White Paper on the need for Genomics-based Bioenergy Research Centers, they point out that these untapped natural organisms are the foundation of the biosphere and sustain all life on earth and that extreme genetic diversity and the ability to function in complex communities give microbes extraordinary biochemical capabilities and adaptability. The single-celled organisms are masters at living in almost every environment and harvesting energy in almost any form, from solar radiation to mineral chemistry, and transforming it into chemical compounds that power life. Furthermore, the overwhelming majority of microbes do not cause disease; rather, they enable life to exist. By understanding how microbes function in their many environments and by continuing to explore their diversity, we can reveal their contributions to earth ecosystems and gain access to an extraordinarily vast living library of genetic potential. We also can understand how microbes can provide the basis for environmental remediation and for creating new sources of renewable, less-polluting energy sources and new generations of processes for industrial application.

USDOE researchers also believe that optimizing plant biomass for more efficient processing to biofuels requires a better understanding of plant cell-wall structure and function. In the same White Paper they note that plant cell walls contain molecules (cellulose, lignin, and hemicellulose) composed of long chains of sugars (polysaccharides) that can be converted to transportation fuels such as ethanol. This process involves using enzymes to break down (hydrolyze) the polysaccharides into their component sugars for fermentation by microbes to ethanol. Significant challenges for efficient conversion are both the large number of enzymes required to hydrolyze diverse sugar linkages and the physical inaccessibility of these compounds due to the presence of other cell-wall components. Several thousand genes are estimated to participate in the synthesis, deposition, and function of cell walls, but very few have been identified, and little is known about their corresponding enzymes. Many questions remain, for example: how polymers such as cellulose and lignin are synthesized, how cell-wall composition is regulated, and how composition relates to the biological functions of cell walls. To answer these questions, researchers say that we need to discover the functions of many hundreds of enzymes, where proteins are located within cells, whether or not they are in complexes, where and when the corresponding genes are expressed, and what genes control the expression and activities of the proteins involved. Application of new or improved biological, physical, analytical, and mathematical tools will facilitate a detailed mechanistic understanding of cell walls. That knowledge will permit optimization of various processes involved in growing and producing biomass, and converting it to biofuels.

Currently, DBED is facilitating the formation of a mid-Atlantic Consortium to respond to an USDOE Solicitation for establishing two Bioenergy Research Centers to undertake systems biology research on plants and microbes necessary for the cost-effective, large-scale production of cellulosic ethanol and other renewable energy from biomass. DBED intends to have such a Center be established in Maryland in cooperation with several Maryland-based organizations (University of Maryland College Park, University of Maryland Biotech Institute, Johns Hopkins Applied Physics Laboratory, the Institute for Genomics Research, the International Center for Sustainable Development, BCS Inc, and several private-sector bioenergy companies) and several partners from other States in the mid-Atlantic region (Brook Haven National Laboratory, North Carolina State University, Rutgers University, and several other research centers).

Biodiesel

Biodiesel is a domestically produced, renewable fuel that can be manufactured from vegetable oils, animal fats, or recycled restaurant greases. Biodiesel is safe and biodegradable. Blends of 20% biodiesel with 80% petroleum diesel (B20) can generally be used in unmodified diesel engines. Biodiesel can also be used in its pure form (B100), but it may require certain engine modifications to avoid maintenance and performance problems and may not be suitable for wintertime use. Almost all biodiesel is produced using a process called catalyzed transesterification, as it is the most economical process, requiring only low temperatures and pressures, and producing a 98% conversion yield. The transesterification process is the reaction of a triglyseride (fat/oil) with an alcohol to form biodiesel and glycerol. Methanol or ethanol is the alcohol most often used. Glycerol is a by-product commonly used in soap and other cosmetic applications.

Because it is oxygenated, biodiesel dramatically reduces air toxins, carbon monoxide, soot, small particles, and hydrocarbon emissions by 50% or more, reducing the cancer-risk contribution of diesel up to 90% with pure biodiesel. Air quality benefits are roughly proportional for diesel/biodiesel mixtures. Biodiesel's superior lubricity also helps reduce engine wear, even as a small percentage additive. Lubricity is the characteristic in diesel fuel necessary to keep diesel fuel systems properly lubricated. Fuel that lacks lubricity can cause premature wear or malfunction. In January of 2001, the EPA finalized a rule that required that sulfur levels in diesel fuel be reduced from 500 ppm to 15 ppm, a 97% reduction, by 2006. On October 15th, 2006, these new rules went into effect. The EPA, the petroleum industry, and equipment manufacturers all recognized during the rulemaking process that the refinery changes necessary to meet this requirement will also dramatically reduce lubricity of the fuel. Biodiesel is uniquely positioned to address ultra low-sulfur diesel fuel because it has no sulfur and currently meets the 2006 standard. As mentioned above, biodiesel offers superior lubricity even in very low blends. A 1% blend of biodiesel can improve lubricity by as much as 65% according to tests done by Stanadyne Automotive Corp.

In 2005, the estimated U.S. biodiesel production was 75 million gallons, triple the production of 2003. There are presently 86 companies producing biodiesel with a total capacity of 581 million gallons per year. Sixty-five companies are building biodiesel plants that will be completed in the next 14 months and 13 plants are expanding their existing operations. Their combined capacity, if realized, would result in another 1.4 billion gallons per year of biodiesel production capacity.[30] The use of biodiesel has grown dramatically during the last few years. The Energy Policy Act was amended by the Energy Conservation Reauthorization Act of 1998 to include biodiesel fuel use as a way for federal, state, and public utility fleets to meet requirements for using alternative fuels. Pure biodiesel (B100) is considered an alternative fuel under EPAct. Lower-level biodiesel blends

[30] National Biodiesel Board Fact Sheets

are not considered alternative fuels, but covered fleets can earn one EPACT credit for every 450 gallons of B100 purchased for use in blends of 20% or higher. This amendment started the sharp increase in the number of biodiesel users, which now include the U.S. Postal Service and the U.S. Departments of Defense, Energy, and Agriculture. Countless cities, counties, school districts, transit authorities, national parks, public utility companies, and garbage and recycling companies also use the fuel. In Maryland, the Beltsville Agricultural Research Center uses soy-based B20 in all its 150 vehicles and equipment. This includes trucks, tractors, farm equipment, mowers, and a bus. Mechanics at the Center report good performance from the B20-fueled vehicles.

The American Jobs Creation Act that created the VEETC also includes a tax credit for biodiesel of $1.00/gallon for agri-biodiesel (from virgin oils) and renewable diesel (from biomass), and 50 cents/gallon for biodiesel made from recycled oil and grease. EPACT 2005 extended the tax credit through 2008 and created a new credit for small agri-biodiesel producers equal to 10 cents/gallon of agri-biodiesel produced at facilities with annual capacity not exceeding 60 million gallons. The tax credit is capped at $1.5 million/year per producer. The USDA conducted a study that estimated this tax incentive will increase the demand for biodiesel to at least 124 million gallons per year. Depending on other factors, including crude oil prices, the industry projects that demand could be much higher. Missouri has a biodiesel incentive of 30 cents/gallon for up to 15 million gallons of production by companies that are at least 51% owned by agricultural producers. Missouri also has an incentive that reimburses the school district so that their net price of biodiesel will not exceed the rack price of regular diesel.

Without the tax incentives, biodiesel is expensive to produce because it requires a high-value feedstock – vegetable oil or animal fats. It takes about 7.43 pounds of refined soybean oil to make one gallon of biodiesel (or 1.5 gallons of soydiesel per bushel of beans). With soybean oil at 22 cents/lb, each gallon of biodiesel feedstock would cost $1.63 plus additional cost of refining, transportation, storage.[31] This is considerably more than ethanol with feedstock costs of perhaps $0.81/gallon at corn prices of $2.20/bushel. In the unlikely event that the current tax incentive is not extended beyond 2008 (unlikely because the program has broad and bipartisan legislative support), capacity expansion will be limited. Without the $1/gallon tax incentive, biodiesel production will not be profitable, unless crude oil prices are in excess of $70-75/barrel, assuming average crude soybean oil prices are in the 22-24 cents/gallon range. Only yellow grease-based biodiesel shows a positive margin of 6 cents/gallon before the tax incentive is included. Fats and greases cost less and produce less expensive biodiesel, sometimes as low as $1.00 per gallon. The quality of the fuel is equivalent to soy biodiesel fuel.[32] In 2004, with the tax incentive and soybean oil prices of 19 cents/lb and diesel prices of $1.75/gallon, the gross margin per gallon was about $0.77/gallon. This implied that a 30 mgpy facility could have a gross profit of $23.1 million; that is equivalent to 75-80% of the capital equipment costs required to build a new biodiesel plant. Today, with diesel prices in the $2.50+ range, the current environment offers significant economic incentives to expand biodiesel production.

In Maryland, under the Renewable Fuels Promotion Act of 2005, ethanol and biodiesel producers may apply to the Renewable Fuels Incentive Board for biodiesel and ethanol production credits. To

[31] Personal communication with USDOE
[32] Alternative Fuels Data Center, Biodiesel Fuel Markets

be eligible for the credits, the producer must first apply to the Board in order to receive certification as a producer. The biodiesel production credits are as follows: (a) $0.20 per gallon of biodiesel produced from soybean oil (the soybean oil must be produced in a facility or through expanded capacity of a facility that began operating after December 31, 2004), and (b) $0.05 per gallon for biodiesel produced from other feedstocks (including soybean oil produced in a facility that began operating on or before December 31, 2004. The Board may not certify biodiesel production credits for more than a total of five million gallons per calendar year, of which at least two million gallons must be from soybean oil produced in a facility as described under (a) above. At least 50 percent of Maryland state vehicles must use a minimum biodiesel blend of B5 beginning in fiscal year 2008. This requirement does not apply to any state vehicles for which mechanical failure due to the use of biodiesel will void the manufacturer's warranty for that vehicle. The Maryland Soybean Board offers a rebate to consumers for half the cost of biodiesel purchased by the consumer. The rebate also applies to the incremental cost of biodiesel blends and is issued for a minimum of $100 per rebate request. Consumers may apply for rebates for one fiscal year only (October 1 through September 30), up to a maximum rebate per consumer of $500, and are required to complete the Maryland Soybean form.

Maryland's first biodiesel plant opened in Berlin on June 19, 2006. It planned to produce 1.5 million gallons per year by September 2006. There are also at least four other organizations that are in either the planning or permitting stage for building a biodiesel plant in Maryland:

- Cropper/Maryland Biodiesel, $1.2 million 5 mgpy facility in Worcester County;
- Windridge Farms/Chesapeake Green Fuels $4 million, 30 mgpy facility;
- Valley Proteins project under consideration in Curtis Bay; and
- Perdue, $15-18 million, 15 mgpy facility

Most current plants in the U.S. are in the 60 thousand gpy to 30 mgpy. Currently, the largest plant produces about 38 mgpy. Approximately 83% of the biodiesel produced today is made from uses soybean. Yellow grease accounts for about 9%, animal fats (tallow, lard, byproducts from the production of Omega-3 fatty acids from fish oil) for 6% and other vegetable oils for 2%. These other crops show promise, because their oil yield per acre are much larger than that of soybeans, which yields 46 gallons of oil per acre. Safflower, for example, yields 80, rapeseed 122, Jatropha 194, and oil palm 610 gallons per acre.[33] There is no doubt that biodiesel has the potential to be a very large agriculturally produced commodity. However, biodiesel produced from vegetable oils can never displace a significant portion of our petroleum diesel because of the limited capacity we have to produce vegetable oil and because there are other important food uses for the major portion of our edible fats and oils. The U.S. currently consumes roughly 60 billion gallons of petroleum diesel and 120 billion gallons of gasoline. According to a study by the University of Idaho[34], it would be very ambitious to produce the amount of diesel used on the farm – 3.1 billion gallons. This would require all of the vegetable oil produced in the U.S. and would require about 15% of our total production land area. According to the same study, it would in fact be very ambitious to have a 0.5 billion gallons per year biodiesel industry. This would require all of the surplus

[33] Tickell, Joshua. From the Fryar to the Fuel Tank, 3rd Edition, 2000

[34] Peterson, Charles L., "Potential Production of Biodiesel." No date. Downloaded from www.uidaho.edu/bioenergy/Publications.htm.

vegetable oil (0.13 billion gallons), half of the used oil (0.17 billion gallons), and all of the oil which would be produced on the 37 million acres of idle crop land (about 0.3 billion gallons) or the equivalent by displacing current crops.

Making biodiesel from algae appears to be a different story. Algae has been estimated to theoretically yield 15, 000 gallons of oil per acre.[35] Based on adequate research and proof of concept, biodiesel produced from algae may, in the not to distant future, become a feasible solution for replacing petro-diesel ***completely***. As of today, no other feedstock has the oil yield high enough for it to be in a position to produce such large volumes of oil. As mentioned above, in order for a crop such as soybean or palm to yield enough oil capable of replacing petro-diesel completely, a very large percentage of the current land available needs to be utilized only for biodiesel crop production, which is quite infeasible. If the feedstock were to be algae, owing to its very high yield of oil per acre of cultivation, it has been found that about 10 million acres of land would need to be used for biodiesel cultivation in order to produce enough biodiesel to replace not only all the petrodiesel used currently in the U.S., but also all petroleum transport fuels, if all gasoline vehicles were replaced with diesels This is just 1% of the total land used today for farming and grazing together (about 1 billion acres).

In practice, biodiesel has not yet been produced on a wide scale from algae, though large scale algae cultivation and biodiesel production appear feasible in the near future. Finding algae strains to grow is not too difficult. Cultivating specific strains of algae for biodiesel is more difficult, as they require high maintenance and could get easily contaminated by undesirable species. Species of algae that have the highest oil content are not necessarily the quickest to reproduce, thereby allowing other species to take over the growing process. For several years, scientists at the University of Maryland Biotechnology Institute (UMBI) and the University of Maryland in College Park (UMCP) have been looking at these issues and working on the use of algae as a feedstock in biodiesel and biofuels production. To date, the results of their research are very promising. As mentioned earlier, both organizations are also involved in the efforts of the Maryland Department of Business and Economic Development (DBED) to establish a USDOE-funded genomics-based Bioenergy Research Center in Maryland. Among the activities being proposed for such a Center are algae-based biofuels projects. Genetics-based improvements in biodiesel plant and algae feedstock can substantially increase the potential biodiesel supplies. There is also renewed interest at the U.S. Department of Energy in algae-based biodiesel. The Department’s Sandia National Laboratory recently announced that they are teaming up with a California company, LiveFuels Inc, with the intent of producing algal oil on marginal lands, unsuitable for foods crops. The company estimates that, by using algal-based oil production, all U.S. oil imports could be replaced by biocrude grown on 20 to 40 million acres of marginal lands that exist across the country.[36]

According to the U.S. Department of Energy’s Energy Information Agency (EIA), in 2004, Maryland consumed approximately 535 million gallons of No 2 On-Highway diesel and 2.5 billion

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[35] Briggs, Michael. “Widescale Biodiesel Production from Algae,” University of New Hampshire, Physics Department, August 2004

[36] MSNBC article dated October 27, 2006. Downloaded from www.msnbc.msn.com/id/15250836/from/ET/

gallons of gasoline in the transportation sector. At B-20 levels, Maryland can currently utilize 100+ million gallons of biodiesel without engine modifications. In the same year, Maryland also consumed about 450 million gallons of Off-Highway diesel (55 million gallons for machinery in such areas as railroads, agriculture, and vessels/boats) and distillate used for fuel oil in the residential (172 million gallons), commercial (89 million gallons), industrial (86 million gallons), and electric power (48 million gallons) sectors. These uses represent substantial opportunities for biodiesel additives, but more in-depth analysis is needed to more clearly define what the actual potential is for these biodiesel applications in Maryland. In the longer term, high-efficiency diesels will most likely start to replace some low-efficiency gasoline engines. It is not clear at this stage how large this replacement is going to be. It is clear, however, that for biodiesel to have a real impact on this country's energy future, a massive conversion from gasoline-powered autos and light trucks to cleaner-burning diesel autos will need to take place. This sort of change is not without precedent. U.S. farmers switched from gasoline to diesel powered farm equipment in the late 1970s and '80s—an important factor in agriculture's big energy use reduction since the 1970s. Also, major automakers (General Motors, Toyota, Ford, and Daimler-Chrysler) plan to produce more diesel-powered cars for the U.S. market in the years ahead.

Various studies have been conducted on the potential macroeconomic benefits of large scale biodiesel production in several locations around the country. These studies also give some indication of the potential economic impacts across the nation. According to the Hampel Oil Distributors' Biodiesel Fact Sheet[37], three major economic benefits would accrue to a state (in this case, Iowa) from the increased use of biodiesel:

1. Biodiesel expands demand for soybean oil, which raises the price processors pay for soybeans.
2. Soybean farmers near the biodiesel plant receive slightly higher prices for soybeans.
3. The presence of a facility that creates energy from soybeans adds value to the state's industrial and income base.

The University of Missouri estimates that 100 million gallons of biodiesel production could generate an approximate $8.34 million increase in personal income and more than 6,000 temporary or permanent jobs in a metropolitan region. Another study predicts a 100 million-gallon biofuels plant could generate a one-time economic boost of $250 to $359 million during the construction phase. Additionally, the local economic base is projected to expand by $250 million through annual direct spending of $140 million. More than 100 new full-time jobs would be created at the plant and more than 1,500 indirect jobs in the state, and annual community household income in the area would increase by $50 million.[38]

Another dimension to job creation from biodiesel production is the additional income and employment that can be created by producing biodiesel as part of a biorefinery, along the same lines as ethanol biorefinery production. This could be the most economically sustainable means of

[37] Hampel Oil Distributors Fact Sheet. No date. Downloaded from www. Hampeloil.com

[38] Kansas City Transportation Authority Tallow Based Biodiesel Test. No date. Prpared by MarcIV Consulting , Inc., and Kansas State University

larger-scale biodiesel production. Within this production design, the crude vegetable oil pressed from bioenergy crops, potentially including algae, is the base for all sorts of products, ranging from relatively lower-value biodiesel to higher-value biolubricants for motors. Other potential high-value byproducts include nutritional supplements, biopesticides/bioherbicides, glycerin-derived alcohols and specialty chemicals, and animal feed.[39]

Hydrogen;
The best way to reduce our Nation's dependence on imported oil in the short-term—over the next 5 to 10 years — is through the increased use of gasoline hybrid-electric vehicles, which are available to consumers today, and through the increased use of alternative fuels, like ethanol and biodiesel. In the longer-term, however, 15 to 20 years from now, increases in fuel efficiency and the use of biofuels can begin to be significantly supplemented by the use of hydrogen and fuel cell technologies. According to the U.S. Department of Energy, hydrogen fuel cell vehicles will begin to reach the mass consumer market in 2020.

The most common element in the universe, hydrogen has the highest energy content per unit weight of any known fuel. Yet it never occurs by itself in nature - it always combines with other elements such as oxygen (for water) and carbon (for fossil fuels). Once separated, hydrogen is the ultimate clean energy carrier. It is non-polluting, as safe as gasoline, and can be produced anywhere. NASA's space shuttles use hydrogen-powered fuel cells to operate electrical systems and the key emission, water, is consumed by the crew. Hydrogen can be produced using diverse, domestic resources, including biomass and other renewable energy technologies, such as wind, solar, geothermal, and hydro-electric power; fossil fuels, such as natural gas and coal (with carbon sequestration); and nuclear. It can be produced in a distributed manner at or near the point of use, such as at refueling stations or stationary power sites; or at large plants many miles away from the point of end-use. A fuel cell is an electrochemical device that combines hydrogen and oxygen to produce electricity, with water and heat as its by-product. As long as fuel is supplied, the fuel cell will continue to generate power. Since the conversion of the fuel to energy takes place via an electrochemical process, not combustion, the process is clean, quiet and highly efficient – two to three times more efficient than fuel combustion.

At the present time, the cost of producing, delivering and storing hydrogen is too high for hydrogen to be competitive with gasoline and other fossil fuels. Also, the cost of fuel cells in stationary and transportation applications are too high compared to traditional electricity-generation technologies and internal combustion engines. Improving fuel cell durability is also a major challenge to fuel cell commercialization. Researchers and engineers are hard at work to resolve these performance issues and, in the meantime, it is becoming more and more apparent, that in the long run no other energy generation technology offers the combination of benefits that hydrogen and fuel cells do.

The case in favor of hydrogen and fuel cells can be made from several broad perspectives. First, hydrogen fuel cell vehicles appear to be a superior consumer product desired by the automotive

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[39] Miller, Paul. Value-Added Tree in a Biodiesel Vision for Montana and the Pacific Northwest. Presentation at the Greening under the Big Sky Conference. Big Sky, MT. June 2003

industry and fuel cells have many other extremely-useful applications. All the major automotive manufacturers have a fuel cell vehicle either in development or in testing right now, and Honda and Toyota have already begun leasing vehicles in California and Japan. Automakers and experts speculate that fuel cell vehicles will be fully commercialized by 2020. Fuel cells are also being incorporated into buses, boats, locomotives, airplanes, scooters, golf carts and even bicycles. There are fuel cell-powered vending machines, vacuum cleaners, and highway road signs. Miniature fuel cells, once available in commercial markets, will allow consumers talk for up to a month on a cellular phone without recharging. Fuel cells will change the telecommuting world, powering laptops and palm pilots hours longer than batteries. Other applications for micro fuel cells include pagers, video recorders, portable power tools, and low power remote devices such as hearing aids, smoke detectors, burglar alarms, hotel locks and meter readers. These miniature fuel cells will generally run on methanol, an inexpensive wood alcohol also used in windshield wiper fluid. Fuel cells currently operate at landfills and wastewater treatment plants across the country, proving themselves as a valid technology for reducing emissions and generating power from the methane gas these plants produce. Hospitals, credit card centers, police stations, and banks are all using fuel cells to provide power to their facilities. The possibilities are endless. More than 2500 stationary fuel cell systems have been installed all over the world — in hospitals, nursing homes, hotels, office buildings, schools, utility power plants, and airport terminals, providing primary power or backup capacity.

Fuel cells also have several military applications. They can help the military reduce the cost of battlefield logistics, provide a source of energy for the modern soldier, save money and reduce pollution at military installations and on board ships and terrestrial vehicles, and most importantly, save lives and materiel by reducing telltale heat and noise. A recent Defense Science Board report entitled "More Capable Warfighting Through Reduced Fuel Burden" concluded, that "over 70 percent of the tonnage required to position today's U.S. Army into battle is fuel."[40] The report also found that significant war-fighting, logistics and cost benefits occur when weapons systems are made more fuel-efficient. Many organizations are working on miniature fuel cells for portable military applications, since soldiers are starting to carry a range of enabling electronic technologies, computers, personal radios, displays and thermal imaging, all intended to increase his/her effectiveness, lethality and survivability. Right now, these devices are limited by their power source. Miniature fuel cells can operate 10 times longer than conventional batteries used to power hand-held battlefield computers, and are much more cost-effective. Stationary fuel cells are also helping the military to address their peak electric power needs, while complying with the presidential directive to reduce energy use at Federal facilities by 20%. Stationary fuel cells for military applications can also provide back up or standby power for special operations and activities, and can provide power in remote areas.

From a second broad perspective, the potential exists for dramatic reductions in the cost of hydrogen production, distribution and storage. Currently, the majority of the 40 million tons of hydrogen used worldwide comes from natural gas through a process called reforming. Natural gas is made to react with steam, producing hydrogen and carbon dioxide. The hydrogen is then used to make such products as ammonia for fertilizer or, as in the case of refineries, to make reformulated gasoline. It is also used to make chemical, food and metal products. This is the cheapest way to make hydrogen today and is likely the way we will make hydrogen for fuel cell vehicles in the

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[40] Report and findings quoted on the website of Fuel Cells 2000, www.fuelcells.org

near future. Currently, in the U.S., 48 percent of hydrogen is produced from natural gas, 30 percent from oil, and 18 percent from coal.[41] Another method, called partial oxidation, produces hydrogen by burning methane in air. Both steam reforming and partial oxidation produce a "synthesis gas," which is then reacted with water to produce hydrogen. Hydrogen can also be made from biomass or coal in a similar process, where, by applying heat under pressure, these feedstocks are reacted with steam. A subsequent series of chemical reactions produces a synthesis gas, which is reacted with steam to produce hydrogen that can then be separated and purified. Producing hydrogen directly from coal by gasification and reforming processes is much more efficient than burning coal to make electricity that is then used to make hydrogen. Either way, though, both processes release carbon dioxide, a gas tied to global warming. Since biomass resources consume CO2 from the atmosphere as part of their natural growth process, producing hydrogen from biomass gasification and steam reforming releases near-zero net greenhouse gases.

Carbon-free hydrogen production methods involve splitting water into its component parts of hydrogen and oxygen through electrolysis. The electric current driving the electrolysis process can be produced using fossil fuels. The holy grail of hydrogen, however, is to use a renewable source like solar, wind, hydro, geothermal or biomass power to create the current, making the overall hydrogen-production process pollution free and sustainable. Heat or electricity from a nuclear power plant can also be used to split water, but that path still faces nuclear waste and security issues. Using heat from a nuclear reactor will improve the efficiency of water electrolysis to produce hydrogen. By increasing the temperature of the water, less electricity is required to split the water into hydrogen and oxygen, which reduces the total energy required. Alternatively, this heat can also be used to drive a series of chemical reactions to split the water. In this case, all of the chemicals used are recycled within the hydrogen-production process. This process, high-temperature thermo-chemical water splitting, can also be driven by solar concentrators that focus and intensify sunlight. Future hydrogen-production possibilities also include using the power of ocean waves to generate electricity for electrolysis, and utilizing microorganisms that can be adapted to produce hydrogen. When certain microbes, such as green algae and cyanobacteria, consume water in the presence of sunlight, they produce hydrogen as a byproduct of their natural metabolic processes. Similarly, photoelectrochemical systems produce hydrogen from water using special semiconductors and energy from sunlight.
The overall challenge to hydrogen production is cost reduction. For hydrogen to have a real impact on this country's energy future and succeed in the commercial marketplace, it must become cost-competitive with conventional fuels and technologies on a per-mile basis. According to the U.S. Department of Energy (USDOE), this means that the cost of hydrogen, regardless of the production technology utilized, and including the cost of delivery, must be in the range of $2.00 to $3.00 per gallon gasoline equivalent (gge) untaxed. USDOE is currently funding research to achieve this cost range by 2015.[42]

A hydrogen economy also requires a cost-effective and energy-efficient infrastructure to deliver hydrogen from where it's produced to the point of end-use, such as a dispenser at a refueling station or stationary power site. Infrastructure includes the pipelines, trucks, storage facilities,

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[41] Quote from "Future fuel? On the road to a hydrogen economy. A conversation with Bruce Logan." Available on the web at http://www.rps.psu.edu/unplugged/spring06/logan.html

[42] From USDOE Hydrogen, Fuel Cell & Infrastructure Technologies Program

compressors, and dispensers involved in the process of delivering fuel. Most of the hydrogen used in the U.S. is produced via steam reforming at or very near its point of use – typically at large industrial sites. A cost-effective and energy-efficient infrastructure for delivering large quantities of hydrogen fuel over long distances is, therefore, not yet available. There are currently only about 700 miles of pipelines for transporting hydrogen in the U.S., as compared to more than one million miles of natural gas pipelines. These hydrogen pipelines are mostly located near large petroleum refineries and chemical plants in Illinois, California, and the Gulf Coast. Because of the limited availability of current pipeline transport, hydrogen is often transported over long distances as a liquid in super-insulated cryogenic, over-the-road tankers, and then vaporized for use at the customer site. Liquefaction is costly and takes a great deal of energy. But the alternative, transporting compressed hydrogen gas over the road in high-pressure tube trailers is cost-prohibitive when transporting farther than about 200 miles from the point of production. USDOE is currently undertaking research to lower the cost of reliable hydrogen compression and bulk hydrogen storage technologies. They are also looking at developing new materials for lower-cost hydrogen pipelines, more energy-efficient and lower-cost hydrogen liquefaction processes, and integrated production, delivery, and end-use technologies. By 2010, USDOE aims to reduce the cost of compression, storage and dispensing at refueling stations and stationary power facilities to <$0.80/gge of hydrogen (independent of transport). By 2015, they aim to reduce the cost of hydrogen delivery from the point of production to the point of use in vehicles or stationary power units to <$1.00/gge of hydrogen in total.[43]

Developing safe and reliable hydrogen storage technologies that meet performance and cost requirements is also critical to achieving a future hydrogen economy. Hydrogen storage will be needed for both vehicular applications and off-board uses such as for stationary power generation and for hydrogen delivery and refueling infrastructure. The ability to carry enough hydrogen on-board a vehicle to enable a driving range of greater than 300 miles, within packaging and cost constraints, is the focus of the USDOE's Hydrogen Storage activities. In order to meet these critical needs, USDOE has established a "National Hydrogen Storage Project" that is funding research and development on various technologies such as advanced high-capacity metal hydrides, carbon-based and high surface area sorbents, as well as chemical hydrogen storage and new materials and concepts.

From a third broad perspective, hydrogen provides the potential for zero tailpipe pollution, near-zero emission of greenhouse gases, and the elimination of oil imports, simultaneously addressing the most vexing challenges facing the fuels sector, well beyond what can be achieved with hybrid vehicles and energy efficiency. Air pollution continues to be a primary health concern in America. Exposure to ozone, particulate, or airborne toxic chemicals has substantial health consequences. Scientists are now directly linking air pollution to heart disease, asthma and cancer. Recent health studies suggest polluted urban air is a comparable health threat to passive smoking. Fuel cells can reduce pollution today and offer the promise of eliminating pollution tomorrow. Fuel cell vehicles are the least polluting of all vehicles that consume fuel directly. Fuel cell vehicles, operating on hydrogen stored on-board the vehicles, produce zero pollution once the hydrogen has been produced. Neither conventional pollutants nor green house gases are emitted. The only byproducts

[43] Ibid

are water and heat. Systems that rely on a reformer on board to convert a liquid fuel to hydrogen produce small amounts of emissions, but still reduce smog-forming pollution by up to 90 percent compared to traditional combustion engines.

The simple reaction that takes place inside the fuel cell is highly efficient. Even if the hydrogen is produced from fossil fuels, fuel-cell vehicles can reduce emissions of carbon dioxide, a global warming concern, by more than half. Tests performed on a fuel cell bus, fueled by methanol, showed zero emissions of particulate matter and hydrocarbons, and near-zero emissions of carbon monoxide and nitrous oxides - levels far below the 1998 emission standard for buses. Fuel cells used as auxiliary power units (APUs) to power air conditioners and accessories in over-the-road trucks can reduce emissions by up to 45% from long haul vehicles, and deliver economic benefits to the truck owner in lower fuel use and less wear and tear. According to USDOE, fuel cell APUs in Class 8 trucks can save 670 million gallons of diesel fuel per year and 4.64 million tons of CO_2 per year. Fuel cells also offer excellent environmental performance compared to power generation technologies that rely on combustion. Based on measured data, a fuel cell power plant may create less than one ounce of pollution per 1,000 kilowatt-hours of electricity produced - compared to the 25 pounds of pollutants for conventional combustion generating systems. Fuel cell power plants are so low in emissions that some areas of the United States have exempted them from air permit requirements. As we move towards the use of renewable fuels in fuel cells, producing electricity will become a zero emission process. Furthermore, U.S. energy dependence is higher today than it was during the "oil shock" of the 1970s, and oil imports are projected to increase. Passenger vehicles alone consume 6 million barrels of oil every single day, equivalent to 85 percent of oil imports. If just 20 percent of cars used fuel cells, we could cut oil imports by 1.5 million barrels every day.

From a fourth broad perspective, hydrogen stores energy more effectively than current batteries, burns twice as efficiently in a fuel cell as gasoline does in an internal combustion engine (more than making up for the energy required to produce it), and can be efficiently used for power generation. Hydrogen is plentiful, clean, and critically- capable of powering cars. As mentioned above, miniature fuel cell power sources have been developed for portable electronic devices. In these applications, the fuel cell can provide a much longer operating life than a battery would, in a package of lighter or equal weight per unit of power output. The fuel cell would not require "recharging," and a liquid, solid, or gaseous fuel canister could be replaced in a moment. Fuel cells also have an environmental advantage over batteries, since certain kinds of batteries require special disposal treatment. Fuel cells provide a much higher power density, packing more power in a smaller space. Because they make energy electrochemically, and do not burn fuel, fuel cells are also fundamentally more efficient than combustion systems. When the fuel cell is sited near the point of use, its waste heat can be captured for beneficial purposes (cogeneration). In large-scale building systems, these fuel cell cogeneration systems can reduce facility energy service costs by 20% to 40% compared to conventional energy service. Fuel cells are ideal for power generation, either connected to the electric grid to provide supplemental power and backup assurance for critical areas, or installed as a grid-independent generator for on-site service in areas that are inaccessible by power lines. Since fuel cells operate silently, they reduce noise pollution as well as air pollution and the waste heat from a fuel cell can be used to provide hot water or space heating for a home. Many of the prototypes being tested and demonstrated for residential use extract hydrogen from propane or natural gas. Fuel cell power generation systems in operation today achieve 40% to 50% fuel-to-electricity efficiency utilizing hydrocarbon fuels. Systems fueled by hydrogen can consistently provide more than 50 percent efficiency. Even more efficient systems are under development. In combination with a turbine, electrical efficiencies can exceed 60 percent. When waste heat is put to use for heating and cooling, fuel utilization can exceed 85 percent. Fuel cell passenger vehicles are up to three times more efficient than internal combustion engines, which now operate at 10 to 16 percent efficiency.

From a fifth broad perspective, hydrogen and fuel cell uses are extremely versatile and practical. One beauty of fuel cells is their versatility - since they are scalable, fuel cells can be stacked anywhere, until the desired power output is reached. The voltage from a single cell is about 0.7 volts, just about enough for a light bulb. When the cells are stacked in a series, the operating voltage increases to 0.7 volts multiplied by the number of cells stacked. Fuel cell versatility also allows for distributed power generation. This, in turn, allows the country to move away from reliance on central station power generation, and long-distance, high voltage power grids, which are the most likely terrorist targets in any attempt to cripple our energy infrastructure. Fuel cells also enable us to think about power generation in innovative ways. A fuel cell car, for example, is also a clean, efficient electrical power-generating unit on wheels. Another beauty of fuel cells is that they offer clean, high quality power, crucial to an economy that depends on increasingly sensitive computers, medical equipment and machines. The National Power Laboratory estimates that the typical computer location experiences 289 power disturbances a year that are outside the voltage limits of the computer equipment. U.S. businesses lose $29 billion annually from computer failures due to power outages and are quickly realizing that fuel cells may help prevent not only loss of power, but also loss of dollars. Fuel cells can be configured to provide backup power to a grid-connected customer, should the grid fail. They can also be configured to provide completely grid-independent power or can use the grid as the backup system. Modular installation provides extremely high reliability in specialized applications. Properly configured fuel cells can achieve up to 99.9999% reliability, less than one minute of down-time in a six year period. Fuel flexibility also adds to the practicality of fuel cells. As mentioned above, a fuel cell system that includes a "fuel reformer" can utilize the hydrogen from a hydrocarbon or alcohol fuel. Hydrogen can be extracted from novel feed stocks such as landfill gas or anaerobic digester gas from wastewater treatment plants, from biomass technologies, or from hydrogen compounds containing no carbon, such as ammonia or borohydride. Fuel cells, in combination with solar or wind power, or any renewable source of electricity, offer the promise of a totally zero-emission energy system that requires no fossil fuel and is not limited by variations in sunlight or wind speed.

From a sixth broad perspective, there is a large potential for dramatic reductions in the cost of fuel cells and hydrogen can also be used in internal combustion engines. Currently, many different types of fuel cells are being produced. [44] Phosphoric acid fuel cells (PAFC) are commercially available today. Hundreds of these fuel cell systems have been installed in 19 nations - in hospitals, nursing homes, hotels, office buildings, schools, utility power plants, landfills and waste water treatment plants. PAFCs generate electricity at more than 40% efficiency - and nearly 85% of the steam this fuel cell produces is used for cogeneration - this compares to about 35% for the utility power grid in the United States. PAFCs use liquid phosphoric acid as the electrolyte and operate at about 450°F. One of the main advantages to this type of fuel cell, besides the nearly

[44] Information on fuel cell types was taken from the website of Fuel Cell 2000

85% cogeneration efficiency, is that it can use impure hydrogen as fuel. PAFCs can tolerate a CO concentration of about 1.5 percent, which broadens the choice of fuels they can use. If gasoline is used, the sulfur must be removed.

Alkaline fuel cells have long been used by NASA on space missions. These cells can achieve power generating efficiencies of up to 70 percent. They were used on the Apollo spacecraft to provide both electricity and drinking water. Alkaline fuel cells use potassium hydroxide as the electrolyte and operate at 160°F. However, they are very susceptible to carbon contamination, so require pure hydrogen and oxygen.

Proton Exchange Membrane (PEM) fuel cells operate at relatively low temperatures (about 175°F), have high power density, can vary their output quickly to meet shifts in power demand, and are suited for applications, such as in automobiles, where quick startup is required. According to the U.S. Department of Energy (DOE), "they are the primary candidates for light-duty vehicles, for buildings, and potentially for much smaller applications such as replacements for rechargeable batteries." This type of fuel cell is sensitive to fuel impurities. Cell outputs generally range from 50 watts to 75 kW.

Direct Methanol Fuel Cells (DMFC) are similar to the PEM cells in that they both use a polymer membrane as the electrolyte. However, in the DMFC, the anode catalyst itself draws the hydrogen from the liquid methanol, eliminating the need for a fuel reformer. Efficiencies of about 40% are expected with this type of fuel cell, which would typically operate at a temperature between 120-190°F. This is a relatively low range, making this fuel cell attractive for tiny to mid-sized applications, to power cellular phones and laptops. Higher efficiencies are achieved at higher temperatures. Companies are also working on DMFC prototypes to be used by the military for powering electronic equipment in the field.

Molten Carbonate fuel cells (MCFC) use an electrolyte composed of a molten carbonate salt mixture suspended in a porous, chemically inert matrix, and operate at high temperatures - approximately 1,200ºF. They require carbon dioxide and oxygen to be delivered to the cathode. To date, MCFCs have been operated on hydrogen, carbon monoxide, natural gas, propane, landfill gas, marine diesel, and simulated coal gasification products. 10 kW to 2 MW MCFCs have been tested on a variety of fuels and are primarily targeted to electric utility applications.

Solid Oxide fuel cells (SOFC) use a hard, non-porous ceramic compound as the electrolyte, and operate at very high temperatures - around 1800°F. One type of SOFC uses an array of meter-long tubes, and other variations include a compressed disc that resembles the top of a soup can. Tubular SOFC designs are closer to commercialization and are being produced by several companies around the world. SOFCs are suitable for stationary applications as well as for auxiliary power units (APUs) used in vehicles to power electronics.

Regenerative fuel cells could be attractive as a closed-loop form of power generation. Water is separated into hydrogen and oxygen by a solar-powered electrolyser. The hydrogen and oxygen are fed into the fuel cell which generates electricity, heat and water. The water is then recirculated back to the solar-powered electrolyser and the process begins again. These types of fuel cells are currently being researched by NASA and others worldwide.

In a typical zinc-air fuel cell (ZAFC), there is a gas diffusion electrode (GDE), a zinc anode separated by electrolyte, and some form of mechanical separators. The GDE is a permeable membrane that allows atmospheric oxygen to pass through. After the oxygen has converted into hydroxyl ions and water, the hydroxyl ions will travel through an electrolyte, and reach the zinc anode. Here, it reacts with the zinc, and forms zinc oxide. This process creates an electrical potential. When a set of ZAFC cells are connected, the combined electrical potential of these cells can be used as a source of electric power. This electrochemical process is very similar to that of a PEM fuel cell, but the refueling is very different and shares characteristics with batteries. ZAFCs contain a zinc "fuel tank" and a zinc regenerator that automatically and silently regenerates the fuel. In this closed-loop system, electricity is created when zinc and oxygen are mixed in the presence of an electrolyte (like a PEMFC), creating zinc oxide. Once fuel is used up, the system is connected to the grid and the process is reversed, leaving once again pure zinc fuel pellets. The key is that this reversing process takes only about 5 minutes to complete, so the battery recharging time is not an issue. The chief advantage zinc-air technology has over other battery technologies is its high specific energy, which is a key factor that determines the running duration of a battery relative to its weight. When ZAFCs are used to power EVs, they have proven to deliver longer driving distances between refuels than any other EV batteries of similar weight. Moreover, due to the abundance of zinc on earth, the material costs for ZAFCs and zinc-air batteries are low. Hence, zinc-air technology has a potential wide range of applications, ranging from EVs, consumer electronics to the military.

A protonic ceramic fuel cell (PCFC) is a new type of fuel cell that is based on a ceramic electrolyte material that exhibits high protonic conductivity at elevated temperatures. PCFCs share the thermal and kinetic advantages of high temperature operation at 700 degrees Celsius with molten carbonate and solid oxide fuel cells, while exhibiting all of the intrinsic benefits of proton conduction in polymer electrolyte and phosphoric acid fuel cells (PAFCs). The high operating temperature is necessary to achieve very high electrical fuel efficiency with hydrocarbon fuels. PCFCs can operate at high temperatures and electrochemically oxidize fossil fuels directly to the anode. This eliminates the intermediate step of producing hydrogen through the costly reforming process. Gaseous molecules of the hydrocarbon fuel are absorbed on the surface of the anode in the presence of water vapor, and hydrogen atoms are efficiently stripped off to be absorbed into the electrolyte, with carbon dioxide as the primary reaction product. Additionally, PCFCs have a solid electrolyte, so the membrane cannot dry out as with PEM fuel cells, or liquid can't leak out as with PAFCs.

Reducing costs and improving durability are the two most significant challenges to fuel cell commercialization. Fuel cell systems must be cost-competitive with, and perform as well or better than, traditional power technologies over the life of the system. Ongoing research at the USDOE is focused on identifying and developing new materials that will reduce the cost and extend the life of fuel cell stack components , including membranes, catalysts, bipolar plates, and membrane-electrode assemblies. Low cost, high volume manufacturing processes will also help to make fuel cell systems cost competitive with traditional technologies. By 2010, USDOE aims to develop a distributed generation PEM fuel cell system operating on natural gas or LPG that achieves 40% electrical efficiency and 40,000 hours durability at $400-$750/kW. They also aim to develop a durable, 60% peak efficient, direct hydrogen fuel cell power system for transportation at a cost of \$30/kW by 2015. [45]

Currently, most of the fuel cell-related research and demonstration activities are taking place in California. California is developing a Hydrogen Highway Network with the intent of building 150-200 hydrogen fueling stations throughout the State by 2010. According to the Network's website, as of 2005, there were 23 stations in operation to refuel 158 fuel cell vehicles. Another 14 stations were in the planning stage. Also, according to the Fuel Cell 2000 fuel-cell installation database, at least 60 fuel cells have been installed in California in the last decade or so. The same database lists 8 locations in Maryland where fuel cells have been installed; four at the Patuxent River Naval Air Station (two in 2002, and two in 2004), and one each at Fort Meade (2005), at the U.S. Naval Academy (1990s), at a fiber optic repeater station in Hancock (2003), and at an Emergency 911 (MIEMSS) System remote telecommunications site in Elk Neck State Park (2003). It also lists a planned site at the Aberdeen Proving Grounds.

In 2005, the Maryland Energy Administration (MEA) received a hydrogen-powered fuel cell vehicle from General Motors to utilize on a fixed route in Prince George's County. MEA also received a complimentary one-MW electrolyzer from Teledyne Energy Systems with the understanding that a suitable use and proper home would be found for this equipment within an allotted period of time. Johns Hopkins University (JHU) and the University of Maryland (UMD) are both actively involved in hydrogen and fuel cell research and development. UMD, along with Virginia Polytechnic Institute, recently received a grant from USDOE to develop the Virginia-Maryland Hydrogen Technology Education Center. The Center will offer learning opportunities in the area of hydrogen technologies by offering courses at the graduate and undergraduate levels. UMD has also received funds from the U.S. Department of Transportation (USDOT) to operate a fuel cell bus on its campus. As was pointed out in previous discussions of ethanol and biodiesel, the Maryland Department of Business and Economic development (DBED) is currently facilitating the formation of a mid-Atlantic Consortium to respond to an USDOE Solicitation for establishing two Bioenergy Research Centers to undertake systems biology research on plants and microbes necessary for the cost-effective, large-scale production of cellulosic ethanol and other renewable energy from biomass. DBED intends to have such a Center be established in Maryland in cooperation with several Maryland-based organizations and several partners from other States in the mid-Atlantic region. Among the activities being proposed for such a Center are research activities that look into how some microorganisms produce hydrogen naturally (biophotolysis) and how biotechnologies based on these microbial systems could lead to clean, renewable sources of hydrogen. Biophotolysis holds huge potential for the scale of hydrogen production necessary to meet future energy demand.

Currently, there are 11 companies operating in Maryland in the hydrogen and fuel cell field. These companies are listed below by category:

Fuel Cells (materials, components and systems):

- GORE Fuel Cell Technologies
- Clear ENERGY, Inc

[45] From USDOE Hydrogen, Fuel Cell & Infrastructure Technologies Program

- Trans-Tech, Inc
- Teledyne Energy Systems, Inc

Support Services and Systems Integration:

- Energetics, Inc
- Engineering Software
- General Physics Corporation
- Hyenergy Consulting, LLC
- New West Technologies, LLC
- Prescient Marketing, Inc
- Sentech, Inc

Maryland is also home to the Mid-Atlantic Hydrogen Coalition (MAHC). MAHC is an initiative under Baltimore's International Center for Sustainable Development to promote the deployment of hydrogen energy and fuel cell technologies in the mid-Atlantic region. This region includes the States of Delaware, Maryland, New Jersey, Pennsylvania, Virginia, and West-Virginia, and the District of Columbia. To achieve its mission, MAHC adopted the following objectives:

- Advocate and publicize the strengths and experiences of the mid-Atlantic region in the hydrogen energy and fuel cell areas;
- Promote and coordinate hydrogen energy and fuel cell activities, codes and standards development, and information sharing in the region;
- Facilitate the development of a Mid-Atlantic Hydrogen Energy and Fuel Cell Corridor/Highway;
- Assist State Energy Offices and other organizations in the region in obtaining Federal, foundation, private-sector and other funding for hydrogen energy and fuel cell research, demonstration, development and commercialization projects.

As MAHC points out on its website, the mid-Atlantic region represents the premier opportunity and best geographic area for the first full-scale commercialization of hydrogen-energy, fuel cell vehicles, and stationary fuel-cell applications in the country. First of all, a large number of people, constituting a very large continuous market, live in a rather densely-populated corridor that runs throughout the region; the I-95 mid-Atlantic corridor. This corridor contains some of the most important cities in the country. It stretches from New York City, through Trenton, Philadelphia, Wilmington, Baltimore and Washington, D.C., to Richmond, Virginia, and has the potential to become the busiest and largest hydrogen highway in the country. Secondly, the region has many universities and technical centers that are actively involved in hydrogen-energy and fuel cell research and demonstration. Thirdly, the region is home to some of the most important hydrogen-energy and fuel-cell companies in the world. Fourthly, the region is home to the Federal Government. Finally, a number of State Energy Offices in the region have agreed to work together to jointly develop an initial hydrogen-energy and fuel-cell infrastructure as part of their cooperation under the MAHC. MAHC further believes that, if the States in the region are successful in this cooperative infrastructure-development effort, the region can favorably compete with California in attracting the demonstration fuel-cell vehicles of the large automobile companies to the region. Similarly, the region will also be in a good position to attract refueling-infrastructure development by the large oil companies.

The states that surround Maryland in the mid-Atlantic region are all heavily involved in the hydrogen and fuel cell area and all have various programs in place to promote hydrogen and fuel cell technology development within their own borders. In Delaware, fuel cells qualify for research and development grants of 35% of the project cost, up to $250,000. They also qualify for rebates of 50% of installation costs, up to $22,500 for residential fuel cells and $250,000 for non-residential. The University of Delaware received a total of $6,083,000 in the form of a Federal grant through the Highway and Mass Transit bill that passed Congress late last year. Of this amount, $4.98 million was allocated to their automotive-based fuel cell hybrid program, $685,000 went to the university's fuel cell bus program, and $418,000 went towards the purchase of the fuel cell bus. Delaware State University also received $2 million through the same bill for the university's hydrogen storage research program. DuPont is also heavily involved in improving the durability of fuel cell membranes and various other fuel-cell-related projects.

In New Jersey, there are several programs that support the commercialization of hydrogen and fuel cell technologies as part of their support for renewable energy. The Renewable Energy Business Venture Assistance Program (REBVAP) provides grants for the development of renewable energy businesses, technologies, services and market infrastructure. The program's budget is approximately $5 million and individual awards range from $50,000 to $500,000. Half of the program's funding promotes the development, deployment and demonstration of renewable-energy projects. The remainder supports commercialization projects for renewable-energy products, services or systems. Eligibility is limited to renewable-energy companies primarily located in New Jersey that are independently operated and employ no more than 500 employees. The Clean Energy Financing for Local Schools and Governments Program offers local governments and schools low-interest, long-term financing for energy efficiency and renewable energy projects. The loan may cover the entire cost of the project, and the interest rates are between three to five percent for varying loan terms. A third program, the New Jersey Clean Energy Rebate Program, rebates $0.15 - $5.40/W dc depending on technology, capacity and application type. Maximum incentives also vary according to the technology employed. The Local Government Alternative Fuel Infrastructure Program reimburses eligible local governments, State colleges and universities, school districts, and governmental authorities for 50% of the cost of purchasing and installing refueling infrastructure for alternative fuels. Up to $50,000 is available per applicant. Hydrogen is among the fuels listed as eligible for funding. Finally, Rutgers University runs the Hydrogen Learning Center for the State of New Jersey. The Center's mission is to enhance public knowledge about hydrogen and fuel cell technologies by providing opportunities for policymakers, educators, students, and other stakeholders to experience hands-on demonstrations, tours of facilities and other activities related to hydrogen and fuel cell technologies. The Center, which conducts statewide hydrogen and fuel cell workshops and seminars, is a partnership between Rutgers and four colleges that house fuel cells on their campuses, allowing people from all over the State to obtain hands-on experience with fuel cells.

Pennsylvania has seven sustainable energy development funds that are financed from a combination of surcharges on electric bills, investments, and foundation and donor support. The resources offered by these funds range in size from $25,000 to $1 million per project. Funding is usually dispersed in the form of venture capital, loans or grants. Fuel cells are among the list of technologies that qualify for these resources. Examples of these funds include the West Penn Power Sustainable Energy Fund and the Sustainable Development Fund. At the State level, two

grant programs and one loan program, offer resources to projects that incorporate fuel cells. The Pennsylvania Energy Development Authority (PEDA) offers Alternative Energy Deployment Grants and Applied Research Grants. The former mainly supports demonstration and commercialization projects and the latter supports research and demonstration projects. PEDA also runs a loan and loan guarantee program under the same guidelines as its grant program. Both programs share the same pool of resources ($10 million). The maximum limit for loans was set at $1 million dollars in 2005. The maximum limit for loan guarantees was set at $500,000.
The other grant program offered at the State-level is the Pennsylvania Energy Harvest Program. It finances the implementation of clean and renewable-energy technologies that have measurable benefits in terms of pollution reduction, environmental quality and reduced energy use. Approximately $5 million a year is allocated for the program. Penn State University has several fuel cell vehicles and a hydrogen refueling station, and more than a hundred of its researchers are fully involved in developing new hydrogen energy and fuel cell technologies. Penn State and its collaborations are involved in research in hydrogen storage, production, utilization, education, inventing new hydrogen technologies, and enhancing the growth of a hydrogen infrastructure in Pennsylvania and the United States. Five other universities are also involved in hydrogen and fuel cell research, development and demonstration.

Virginia stands out in the mid-Atlantic region for its official political commitment to hydrogen energy. In 2005, both houses of the Virginia General Assembly announced their support for the State's hydrogen energy plan. The Virginia Department of Mines, Minerals and Energy (DMME), in collaboration with Clean Cities Virginia, has created the Hydrogen Economy Roundtable, which develops recommendations for DMME on developing the Virginia hydrogen economy. The Roundtable recently published its hydrogen strategy document (i.e., hydrogen roadmap), which was a follow-on to the hydrogen-vision document that was published last year. Several of Virginia's universities are also involved in hydrogen and fuel cell research, development and demonstrations, and General Motors maintains and services a fleet of six fuel cell cars at Fort Belvoir.

West Virginia has also recently developed a Hydrogen Roadmap which details plans to capitalize on the estimated 35-50 billion tons of recoverable coal in West Virginia, as well as on the Department of Energy's $1 billion FutureGen Initiative. FutureGen aims to create the first coal sequestration and hydrogen production plant by extensively funding coal-to-hydrogen research and implementation projects. West Virginia feels that it is well positioned to secure much of this funding, because of the State's coal resources and its research institutions, including West Virginia University, Marshall University, and the National Energy Technology Lab, all of which are involved in coal-based hydrogen research and fuel cell development. The Hydrogen Roadmap also details plans to educate the public on the benefits of hydrogen and on the existing obstacles to the development of hydrogen and fuel cell technologies. Finally, Washington, D.C., is also home to several private-sector and non-profit organizations that strive to promote hydrogen-energy and fuel-cell technologies world-wide. Georgetown University operates a fleet of hydrogen-powered fuel-cell shuttle buses, and, in 2004, Shell Hydrogen installed a hydrogen refueling station in northeast Washington, D.C. This station also refuels the six GM fuel cell cars stationed at Fort Belvoir, Virginia.

The mid-Atlantic region is also home to many companies involved in the hydrogen-energy and fuel-cell field. Below is a listing of these companies by state and category:

Delaware

Fuel Cells (materials, components and systems):

- Compact Membrane Systems
- Ion Power, Inc.
- Power Avenue
- DuPont Fuel Cells

Hydrogen Production:

- Apex Piping Systems

New Jersey

Fuel Cell components:

- Applied Sensor, Inc.
- ASCO Valve, Inc.
- Bio-Chem Valve
- Bios International Corporation
- Cluster Alteration Technology
- Domel,Inc.
- Engelhard
- E-TEK, Division De Nora, Inc.
- GFI Advanced Technologies, Inc.
- Millennium Cell
- Perma Pure, Inc.
- PowerZyme
- Sensor Products, Inc.
- Telcordia Technologies
- Transistor Devices

Fuel Cell materials:

- Asbury Carbons
- Element 1 Energy Corp
- Rhodia Rare Earths and Silica Systems
- SiGNa Chemistry
- Ticona Engineering Polymers

Hydrogen Production:

- Ergenics Hydride Solutions

Support Services and Systems Integration:

- J.J. Kelley Associates
- Mellenium Cell, Inc.
- Keyspan Business Solutions
- Metallix, Inc.

Pennsylvania

Fuel Cells (materials, components and systems):

- Abacus Controls
- Air Products & Chemicals, Inc
- Allegheny Ludlum Corp
- Atrofina Chemicals
- Carpinter Technology Corp
- ESL Electro-Science
- Foamex
- Franklin Fuel Cells, Inc
- Gamry Instruments
- HydroGen, LLC
- Kronosport, Inc
- Nanologix, Inc
- Nuvera Fuel Cells
- Primax, Inc
- PPL Corp
- Seimens Westinghouse

Hydrogen Production:

- Airgas, Inc
- Air Products & Chemicals
- H2OPower
- Media Process and Technology, Inc
- Nanologix, Inc
- Power + Energy, Inc
- Pdc Machines, Inc

Support Services and Systems Integration:

- Blue Hill Partners
- Global Marketingpros
- Protium energy Technologies
- PWI Energy
- Overseas Consultants
- Technical Staffing Professionals
- TRF's Sustainable Development Fund

Virginia

Fuel Cells (materials, components and systems):

- Luna Innovations
- BWX Technologies
- US General Fuel Cell Corp
- Ashlawn Group

Hydrogen Production:
- H2Gen, Inc.
- HCE, LLC

Support Services and Systems Integration:
- Directed Technologies, Inc.
- ICF Consulting

Washington, D.C.
Fuel Cells (materials, components and systems):
- Ecological Balances, Ltd.
- Teledyne Energy Systems, Inc

Support Services:
- Capital Technology Group
- England & Company
- Global Policy Group
- National Hydrogen Association
- Impala Co

As discussed above, the economic and environmental benefits from developing and deploying hydrogen and fuel cell technologies are rather significant. Maryland will have to make a decision as to whether or not it wants to play a leadership role in the commercial development and application of these technologies in the State, and the corresponding infrastructure build-out that will be required, in order to capture the economic and environmental benefits from their utilization. In order for Maryland policymakers and other stakeholders to be able to make an informed decision, several issues are worth noting:

In Maryland, the use of hydrogen as a fuel and the application of fuel cell technologies are still on the periphery of public understanding. The development of an informed public policy addressing these two energy issues will require a detailed education and outreach effort targeted on policymakers, business leaders, consumers, public-interests groups, and foundations and other donor organizations.

If Maryland is to be a leader in establishing a fully functioning commercial market for hydrogen and fuel cell technologies in Maryland by 2020, it must start laying the groundwork for such a market today.

Cost-effective stationary fuel cell applications will most likely come to fruition before passenger vehicle applications. Developing the infrastructure needed to implement these applications will also lay the groundwork for developing the infrastructure needed for vehicle applications. Other early-adoption or early-production opportunities for hydrogen include the use of hydrogen in internal combustion engines (ICE) and hythane systems (natural gas mixed with hydrogen).

In order for the State of Maryland to be able to seriously consider a leadership role in the commercialization of hydrogen and fuel cell technologies, a framework for public-private cooperation is needed and further analysis is required of a number of issues, including the prospects for economic development and likely environmental impacts of such commercialization in Maryland. These issues can be addressed as part of a Maryland Hydrogen Vision and Roadmap process, whereby coordination, and the potential impacts of this coordination, between government, the private sector, and academic interests, with regard to hydrogen-energy and fuel-cell use, can be formulated and identified.

Like gasoline and natural gas, hydrogen is a fuel that must be handled appropriately. The characteristics of hydrogen are different and a number of its properties are advantageous with regard to safety. Hydrogen can be used as safely as other common fuels we use today, when guidelines are observed and users understand its behavior. USDOE is working to develop and implement these guidelines, practices and procedures that will ensure safety in operating, handling, and using hydrogen and hydrogen systems. The Department is also facilitating the creation and adoption of model building codes and equipment standards for hydrogen systems in commercial, residential and transportation applications. To promote hydrogen safety, Maryland can facilitate the timely adoption of codes and standards and could take the initiative in educating and training code enforcement officials on proper implementation of the codes. Also, education of consumers and retailers could promote a better understanding of specific safety practices and guidelines required by the use of hydrogen fuel.

The National Academy of Sciences [46]has pointed out that dependence on natural gas as a source of hydrogen would likely lead to an increase in imports, replacing our nation's dependence on imported oil with a dependence on imported natural gas (LNG).

Several studies have pointed out that, in the near term, the cost of generating hydrogen from renewables is much larger than the cost of generating it by alternative means. They further point out that using renewables to generate hydrogen for powering vehicles is not their optimum use from the perspective of CO2 mitigation, since, in the near term, better results can be achieved by using the renewable sources directly to replace the dirtiest forms of electricity generation. By supporting renewables, however, states can bring down the cost of renewables in the future and, thereby, facilitate the transition to a truly renewable hydrogen future. [47]

Because Maryland is surrounded by States that actively support hydrogen and fuel cell development, Maryland can more easily learn from these states' experiences. Also, the fact that the mid-Atlantic region is home to some of the most important hydrogen-energy and fuel-cell companies in the world represents an opportunity for the State of Maryland to attract some of these companies or their subsidiaries to Maryland, in case the State becomes more active in supporting hydrogen and fuel cell development in Maryland.

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[46] National Research Council and National Academy of Engineering of the National Academies, The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs, 2004

[47] Tony Dutzik, "Making Sense of Hydrogen," National Association of State PIRGs, August 2004

Because Maryland has several military facilities within its borders, with more personnel to come into the State because of the 2005 Base Realignment and Closure (BRAC) process (some 16,000 new jobs and 40,000-60,000 secondary economic-impact jobs), and since fuel cells have several useful military applications, and since there are currently six fuel cell installed at Maryland military installations, the State will be in a good position to further demonstrate the uses, application and benefits of deploying hydrogen and fuel cell technologies in stationary and transportation applications at military facilities. Maryland could also look into using military applications for hydrogen and fuel cell education, training, and outreach initiatives. There also may be some economies of scale opportunities for hydrogen and fuel cell infrastructure development supporting both military and non-military applications.

If Maryland decides to undertake new hydrogen and fuel cell research programs in basic and applied research, these programs could benefit from the experiences of researchers in the hydrogen and fuel cell fields at the University of Maryland College Park, the University of Maryland Biotech Institute, the John Hopkins University, the Johns Hopkins Applied Physics Laboratory, and the various Federal Government Laboratories and Technical Centers located in Maryland.

Electricity generated by fuel cells can be used to satisfy the Maryland Renewable Energy Portfolio Standard (RPS), if the fuel cells use hydrogen supplied from biomass, landfill gas, or wastewater treatment. A study done for the Maryland Power Plant Research Program [48] concludes, however, that renewable energy requirements under the Maryland RPS will be mostly satisfied by renewable energy certificates (RECs) obtained from eligible facilities located outside of Maryland.

Finally, Maryland has one nuclear-powered facility, the Calvert Cliffs Nuclear Power Plant, with a capacity of 1,829 MW that generates more than one-fourth of the state's electricity. With permission of the Plant's owners, the State could study the pros and cons of utilizing this facility to generate hydrogen during off-peak hours from the Plant's heat or electricity. Among several options, the hydrogen might then be used to demonstrate running a fuel cell for peak electricity production at the plant.

Summary of the Clean Energy Potential in Maryland

The Table below, from the study done by the National Renewable Energy Laboratory (NREL) for this report, summarizes the renewable energy potential in Maryland. The full NREL report is in Appendix 2. The Table shows the electric sales in Maryland for 2004 and the renewable energy potential with a low and high estimate. As we can see, renewable energy technology can provide 30% to over 136% of the States electric energy needs with off shore wind and solar PV having the greatest potential. PV could provide 17%-25% and off shore wind could provide 8% to almost 100% of the power needs of the State.

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[48] Maryland Power Plant Research Program, "Inventory of Renewable Energy Resources Eligible for the Maryland Renewable Energy Portfolio Standard," June 2006

Technology	MD Electric Sales 2004 MWh	RE Potential Low MWh	RE Potential High MWh
Wind on Shore		560,640	5,606,400
Wind off shore		5,212,200	66,576,000
Solar PV		11,650,800	16,644,000
Biomass direct		2,472,072	2,472,072
MSW landfill gas		275,940	275,940
Total	**66,892,000**	**20,171,652**	**91,574,412**
% of 2004 Electric Sales		30.16%	136.90%

Solar thermal and new hydro not included

4. Clean Energy policy

Introduction
This section is a general introduction to the policy issues for clean energy with some examples of model policies in other states and countries. The clean energy sector is very diverse, creating policy issues that are very complex and often unique to each industry, such as solar, wind, and biofuels. Some policy issues cut across industries, as in the case of electric generation technologies and grid interconnection issues. While we have cited examples of policy and policy concepts that have worked in other places and may be good models for Maryland, we have not made specific policy recommendations for Maryland in this feasibility study. States that have developed the most successful policies have done so through a collaborative effort with the clean energy industry and all the stake holders in the clean energy sector. As can be seen in the business plan for the Center in Chapter 6, we are proposing a process of industry collaboration in setting industry specific policy.

Energy Efficiency Policy Options
Energy efficiency policy options can be categorized as prescriptive or financial incentives. Both mandatory and voluntary prescriptive incentives exist at the national, state and local levels, as do financial incentives. Financial incentives can be further distinguished in two primary ways; performance-based incentives versus cost-based incentives, and managed incentives versus long-term incentives.

Prescriptive Incentives
Prescriptive measures include incentives that require particular efficiency levels for new construction or establish minimum efficiency standards for home appliances. Incentive programs can vary in focus; some address commercial building issues, others address residential property issues, or both. Prescriptive standards must be in compliance with local building codes, which often include efficiency standards. There are also new voluntary standards that architects, developers and home builders seek to fulfill, so their homes and buildings may be recognized as being above the minimum standards. Such standards have been established by the Home Energy Rating System (HERS), and by the US Green Building Council, known for their Leadership in Energy and Environmental Design (LEED) rating system.

The LEED rating system encourages building designers to earn points within the rating system, in order to achieve the silver, gold, or platinum rating for their project's holistic approach to the environmental design and use of the building. Energy efficiency is not the only objective of this rating system, so in spite of a building being energy self-sufficient, it may not reach the highest rating level. Nevertheless, the establishment of a hierarchy and a system by which to compare building design and performance has moved the architectural community to look more closely at these issues and develop training programs for the architectural community, and also to offer the consumer an option in design criteria that features energy usage and environmental impact.

Prescriptive policies can have far reaching consequences and be very effective. Many Federal, State and local government agencies are now requiring that their new buildings meet some of these ratings. The government of Barcelona, Spain, passed an ordinance, in 2005, that all new buildings must pre-heat their hot water with solar energy. Two years later, the success of this requirement was recognized and now the entire country passed such an ordinance, giving new life to Spain's solar heating industry.

Prescriptive requirements, while effective, typically meet with opposition from the design and construction industries, because they require expenditures that the consumer may not consider a priority. For example, an energy efficiency upgrade package which incorporates some renewable energy may cost the same as a Jacuzzi or high-end granite countertops for the kitchen. The consumer, not understanding the energy impact of their choices, will likely choose less energy savings and features that entail more energy consumption. Prescriptive incentives requiring higher efficiency appliances will help guide consumers toward greater energy savings and help create a more energy efficient environment.

One problem with prescriptive incentives is that they offer few incentives to existing buildings that were constructed prior to current standards. Also, when local building standards are modified or efficiency standards increased, code enforcement officials cannot expect older buildings to readily comply. Often energy improvements are required when a larger renovation is under way. Furthermore, appliance efficiency standards do impact all buildings and codes by obligating owners to upgrade to greater efficiency. For this reason, they are generally universally-opposed by the building community.

Financial Incentives

Cost-based incentives provide a fixed fraction of the expenditures on efficiency, or in some cases the incremental expenditures on efficiency, as the incentive.
Performance-based incentives pay a fixed amount of money for meeting a specified performance level or perhaps pay a fixed amount per unit of energy savings for products that meet or exceed a certain efficiency threshold level. These amounts are usually the same, irrespective of the incremental cost of achieving the efficiency, and are available even if the incremental cost turns out to be zero.

Managed incentives are programs in which an administrator actively manages the program to maximize its savings within a given cost budget. A managed incentive program may be marketed more heavily if it is below forecast and marketing support may be withdrawn if it is too far ahead of forecast (that is, threatening to bust the budget). In extreme cases, managed incentives can be changed in terms of the dollar amount or the qualifying level in response to market conditions. Long-term incentives are fixed for a multi-year period. They are intended to give designers and manufacturers, as well as other elements of the supply chain, some assurances that the incentives will continue to be available, in order to plan for investments that would not otherwise be justified in a business plan. There has been very little direct use of long-term incentives to date, but a number of market transformation programs have functioned, in a crude way, like long-term incentives, because the qualifying levels were held constant for several years. Current tax incentives enacted in the U.S. Energy Policy Act of 2005 were designed as long-term (4-5 year) incentives, but due to perceived budget constraints were cut back to 2-year programs.

Managed incentives and long-term incentives are generally complementary. Used together, they can provide a cost minimizing approach to promoting continuously-improving levels of energy efficiency, including some very advanced levels. Cost-based incentives, however, have proven to be ineffectual or even counter-productive in the limited number of cases where they have been evaluated. Performance-based incentives, in contrast, have been effective in the overwhelming majority of cases where they have been evaluated.

Most policies offer the consumer financial incentive options to purchasing the highest efficiency products versus lower efficient products. These incentives apply to appliances that are purchased when the house is under construction or renovation, or due to an appliance replacement. Incentives typically designate ENERGY STAR rated appliances for state rebates or property tax exemptions at specific times of the year for selected appliances[49]. Maryland had such a law, which expired in 2004 and was not renewed due to fiscal restraints on the state budget.

The federal government's passage of the Energy Policy Act of 2005 established tax credits for energy efficiency improvements in the building envelope of existing homes and for the purchase of high-efficiency heating, cooling, and water-heating equipment. The improvements or equipment must be placed in service from January 1, 2006 through December 31, 2007, and must serve a dwelling in the United States owned by the tax payer and used as a primary residence. The maximum amount of homeowner credit for all improvements combined is $500 during the two-year period of the tax credit.

Prior to the passing in 1999 of the Electric Customer Choice and Competition Act, utility companies were able to add the expenses of the energy conservation program to their compensation rate adjustments. PEPCO was quite successful in launching the use of demand-limiting devices and establishing the "Kilowatchers Club," a group effort to reduce demand by switching off electric water heaters and cycling air conditioning compressors for 8 minutes per hour. Energy audits were also provided and some even included blower-door testing for infiltration analysis. These services were provided to homeowners, and the expense was included in the rate base and not charged to individual rate payers. However, after restructuring, these programs were deemed to be not cost-effective, and the utilities cancelled them. The demand-limiting switches, which were paid for by the rate payers, were thus abandoned when PEPCO eliminated the Kilowatcher incentives program.

Currently, there is less of an "electric-rate incentive" for consumers to limit their demand. This is so, because the demand tariff is very flat and peak rates are not as expensive, which reduces the motivation to shut down and decrease peak energy consumption. The difference in the "true cost" of energy per hour versus the average cost is due, in part, to the length of the electricity contracts that utilities are purchasing. If they purchase power with less dependency on time-of- day or demand, then they are less likely to charge more for the peak energy consumption. Longer-term power purchase contracts, therefore, tend to discourage conservation at the critical peak energy consumption times.

Federal Incentives: Building Envelope Improvements

Owners of existing homes can receive tax credits of up to 10% of the cost of upgrading the building envelope's efficiency. Components eligible for the credit include:

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[49] Legislation proposed in 2006 session to create two moratoriums on sales tax exemption for major appliances, heating systems in the fall and cooling systems in the spring died in Senate Finance committee.

- Insulation materials and systems designed to reduce a home's heat transfer;
- exterior doors and windows (including skylights); and
- Pigmented metal roofs designed to reduce heat gain.

Credits for windows may not exceed $200. The total amount of credits for building envelope measures and other qualified energy property outlined in the section below, including heating, cooling and water heating equipment, must not exceed $500. Improvements should be expected to remain in use for at least 5 years. Roofs with pigmented coatings must meet Energy Star requirements, and all other improvements must meet 2000 International Energy Conservation Code criteria, including code supplements. Manufactured homes conforming to Federal Manufactured Home Construction and Safety Standards also qualify.

Federal Incentives: Heating, Cooling, and Water Heating Equipment
Purchasers of qualified energy efficient property are eligible for tax credits up to the total expenditures on such property. The credit can also be applied to labor costs for assembly and original installation of this property. Eligible property and maximum credit amounts are as follows:

- electric heat pump water heaters [$300];
- electric heat pumps [$300];
- geothermal heat pumps [$300];
- central air conditioners [$300];
- natural gas, propane, or oil water heaters [$300];
- natural gas, propane, or oil furnace or hot water boilers [$150]; and
- advanced main air circulating fans [$50].

Performance and quality standards for tax credit eligibility vary by technology and are detailed in 26 USC § 25C. In addition, the Internal Revenue Service (IRS) has provided interim guidance, pending the issuance of regulations relating to the credit, in IRS Notice 2006-26.

Department of Defense Facilities: Energy Saving Performance Contracting
There is language in the Operations and Maintenance Section of the Defense Appropriations Report (109-292) that reads as follows: "*Energy Savings Performance Contracting* -- the Committee urges the Department of Defense to utilize Energy Savings Performance Contracting whenever possible to upgrade facilities and retain base operating funding. The Committee further urges the Department to incorporate the highest energy efficiency standards possible into the renovation and construction of DOD Facilities."

State Efficiency Programs:
State energy efficiency programs vary widely around the country depending on the energy requirements for the residential, commercial and industrial sectors. The population densities also impact the way energy is distributed through major distribution utilities or smaller municipal and cooperative distribution companies. As discussed below, several states in the mid-Atlantc region have implemented State Energy Efficiency Programs to reduce demand and improve efficiency.

Delaware:
Delaware has established a public benefits fund of $1.5 million annually for renewable energy & energy efficiency, and $0.8 million annually for low-income assistance. The Green Energy Fund is the only financial incentive approved primarily for renewable energy applications. Solar water heating (SWH) is included among those incentives. Homeowners who undertake residential renewable-energy installations can receive either 50% of the installed cost or $3000, whichever is less, and those who undertake non-residential applications can receive up to $250,000. Delaware also offers cost shared grants for research and development projects, and technology and demonstration proposals. Proposals can ask for up to 25% of proposed project costs, but are limited to $200,000 per proposal.

New Jersey
New Jersey's Clean Energy Program was initiated by the passing of N.J. Stat. § 48:3-60, which created a Public Benefit Fund in February of 1999. A Societal Benefits Charge on rate payers' bills funds the New Jersey Clean Energy Program, which was established in March 2001 by the New Jersey Board of Public Utilities (BPU). The BPU administered total program funding of $358 million for the years 2001-2003, including $115 million in 2001, $119 million in 2002, and $124 million in 2003. Of this original funding, 75% supported energy-efficiency programs. The remaining 25% supported Class I renewables, which include solar, wind, fuel cells using renewable fuels, geothermal, wave and tidal action, landfill gas, and sustainable biomass facilities. New Jersey's energy efficiency programs contain $71 million in financial rebates; $27.3 million for residential consumers and $43.7 million for the Commercial and Industrial sectors. Besides the rebates programs, as mentioned in the previous section, New Jersey also has a Renewable Energy Business Venture Assistance Program (REBVAP) that provides grants for the development of renewable energy businesses, technologies, services and market infrastructure, The State also supports a clean energy financing program for schools and local governments, and a local government alternative fuels infrastructure development program. New Jersey has also received the ENERGY STAR award from the US Environmental Protection Agency and US Department of Energy for the most effective and proactive programs.

Pennsylvania
As also discussed in the previous section, Pennsylvania has seven sustainable energy development funds that are financed from a combination of surcharges on electric bills, investments, and foundation and donor support. The resources offered by these funds range in size from $25,000 to $1 million per project. Funding is usually dispersed in the form of venture capital, loans or grants. Additionally, the State also supports two clean energy grant programs and one clean energy loan program. The Pennsylvania Energy Development Authority (PEDA) offers Alternative Energy Deployment Grants and Applied Research Grants. The former mainly supports clean energy demonstration and commercialization projects and the latter supports clean energy research and demonstration projects. PEDA also runs a loan and loan guarantee program under the same guidelines as its grant program. Both programs share the same pool of resources ($10 million). The maximum limit for loans was set at $1 million dollars in 2005. The maximum limit for loan guarantees was set at $500,000. The other grant program offered at the State-level is the Pennsylvania Energy Harvest Program. It finances the implementation of clean and renewable-energy technologies that have measurable benefits in terms of pollution reduction, environmental quality and reduced energy use. Approximately $5 million a year is allocated for the program.

Pennsylvania's Alternative Energy Portfolio Standard (AEPS) is a statewide program that includes Demand Side Management (DSM) and energy efficiency measures in its Tier II technologies. Implementing the AEPS is a challenging opportunity to include energy saving technologies in the creation and trading of energy credits. It is developing slowly and will be based on the regulations still being designed by the Board of Public Utilities (BPU). Determining which energy efficiency measures should qualify for inclusion in the regulations and how they should be valued have been issues that appear to be near resolution. More information on the Pennsylvania AEPS is presented below.

Virginia

The Virginia General Assembly passed an energy policy act in the last legislative session of 2006. Drafted by and named the after Sen. Wagner, the bill offers several steps toward creating a more comprehensive energy plan for Virginia. This bill was being revised this past summer so that funds can be appropriated towards its objectives. These objectives include issuing grants for energy efficiency and renewable energy projects, and paying production incentives for renewable energy produced from wind, sun, biomass, and waste coal. The provisions for energy efficiency are as yet undefined.

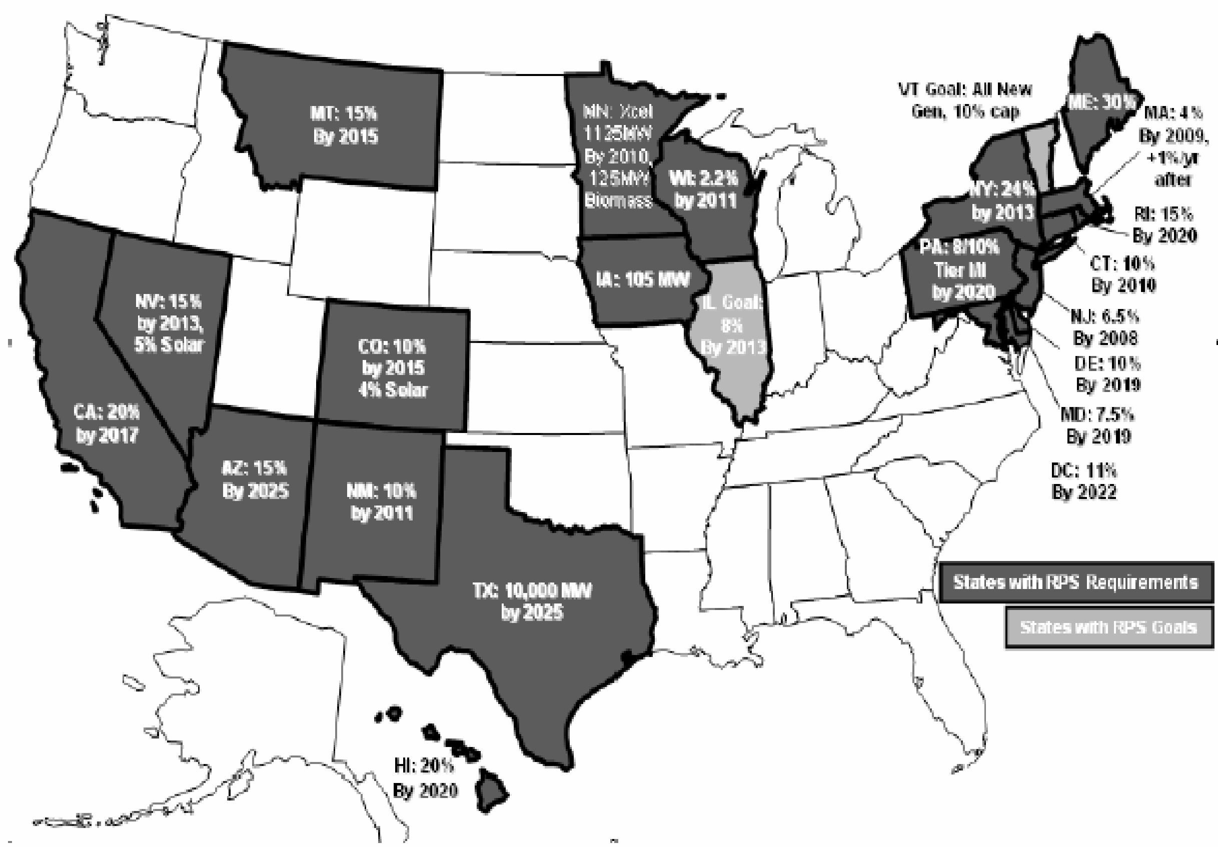
Other Financial Incentives for Energy Efficiency

States and local communities have offered a myriad of incentives to attract industry to expand in their locations and install their products on local buildings. These incentives include sales tax exemptions, property tax exemptions or property tax credits, installation permit assistance, permit priority assistance, low interest financing, bond issues for local public buildings, and energy tax credits.

The Renewables Portfolio Standard

The Renewables Portfolio Standard (RPS) is a mandate that requires a portion of the electricity used within a state come from renewable energy resources. The implementation of an RPS requires the production of Renewable Energy Credits (RECs) that utilities can use as tradable certificates that indicate that electricity has been generated by a renewable resource. RECs are typically denominated in megawatt hours (MWh) and are treated as a separate commodity from the electricity itself. The REC value is the quantification and valuation of the environmental attributes that clean energy can provide. By disaggregating the attributes from the actual flow of electrons, clean energy can be purchased anywhere by purchasing REC's. The value of the REC is often determined by the type of renewable energy included in the tiers specified in a state's RPS, Should utilities not wish to present renewable energy credits, they can pay the alternative or non-compliance payment rather than turning in the REC's for retirement to the BPU as the statute requires. The alternative compliance payments can also vary by tier. Solar-generated REC (Solar REC's) can be worth 10 times the Tier II REC's. With 23 states currently implementing an RPS, there are a variety of programs and they can differ greatly. Pennsylvania's law, for example, is called an Alternative Energy Portfolio Standard, since not all energy sources allowed are renewable. They include, under Tier 2 eligible resources, Demand Side Management (DSM) or peak energy reduction programs, as well as waste coal and other non-renewable fossil fuels technologies for electrical generation. The states that have an RPS and their RPS requirements are summarized in the map and tables below. Also included is a comparison table for states in our region.

United States Renewable Energy Portfolio Standards



RPS Requirements Have Been Adopted in 20 States & the District of Columbia

(Vermont & Illinois Have Enacted RPS Goals)

STATE	RENEWABLES REQUIREMENT	NOTES
Arizona	15% by 2025	30% of the requirement must be met by local onsite renewables installed by homes and businesses.
California	20% by 2017 (must increase use of renewables by 1% each year)	Currently, 12% of electricity in state from renewables.
Connecticut	0.5% takes effect in July 2000, increasing to 1% by July 2002, 3% by 2006, and 6% by July 2009	Eligible technologies: wind, solar, sustainable biomass, landfill gas, or fuel cells.
Delaware	10% by 2019	Solar Thermal Electric, Photovoltaics, Landfill Gas, Wind, Biomass.
Colorado	10% by 2015	Photovoltaics, Landfill Gas, Wind, Biomass, Geothermal Electric,
District of Columbia	11% by 2022. Tier system. 1.5% from Tier 1 by 2007 increasing gradually to 11% by 2022. 2.5% from Tier 2 by 2007 decreasing gradually to 0% by 2020.	Tier 1: wind, solar, biomass, geothermal, methane, tidal, fuel cells. Tier 2: hydro, waste energy. Includes a solar set-aside.
Hawaii	7% by end of 2003; 8% by end of 2005, 10% by end of 2010, 15% by end of 2015, 20% by end of 2020 (including existing renewables)	Wind, Photovoltaics, Landfill Gas, Biomass, Hydroelectric, Renewable Transportation Fuels, Geothermal Electric, Geothermal Heat Pumps, Municipal Solid Waste, Cogeneration, etc.
Iowa	Requires investor-owned utilities to contract a combined total of 105 megawatts (MW) of their generation from renewable resources, including small hydropower facilities.	Wind, Photovoltaics, Biomass, Hydroelectric, Municipal Solid Waste.
Illinois (Goal)	8% by 2013 (approved by Illinois Commerce Commission in July 2005 but pending implementation). State has goal of 8% by 2013 in place.	Under the ICC approved RPS, 75% of the renewable energy generated to meet the state's goal should come from wind.
Maine	30% of retail sales in 2000 and thereafter as a condition of licensing.	Wind, solar, geothermal, tidal, hydro, biomass, municipal solid waste under 100MW, and qualified small power generation facilities. [Note that renewables, mainly hydro, currently account for approximately 50% of Maine's electricity mix].
Maryland	7.5% by 2019 under a tiered system.	Two-tiered system: Tier 1: Wind, biomass, geothermal, solar, landfill gas, wave. Tier 2: Hydroelectric, poultry litter, waste energy.
Massachusetts	1% of sales in new renewables in 2003 or 1 year after any renewable is within 10% of average spot market price, and increasing by 0.5% per year to 4% by 2009 and 1% per year thereafter.	Wind, advanced biomass, landfill gas, solar, geothermal or wave/tidal technologies.
Minnesota	For Xcel Energy: 1,125 MW of wind by 2011 For other electricity providers: goal of 10% by 2015	Xcel requirement must allow for 100 MW of wind from small producers (2 MW or less).
Montana	15% by 2015.	Solar Thermal Electric, Photovoltaics, Landfill Gas, Wind, Biomass.
Nevada	5% by 2003 rising by 2% every two years until reaching 15% by 2013 and thereafter.	A minimum of 5% must be from solar.
New Jersey	0.5% takes effect in 2001, increasing to 1% by 2006, then increases by .5% per year to 4% by 2012.	Two-tiered system: Class 1: wind, solar, fuel cells, geothermal, wave/tidal, landfill/ methane gas, and sustainably harvested biomass. Class 2: hydro or resource recovery facilities.
New Mexico	5% by 2006 increasing to 10% by 2011.	Wind, solar, geothermal, biomass, hydro, and fuel cells.
New York	25% by 2013	Wind, photovoltaics, landfill gas, biomass, hydroelectric, fuel cells, cogeneration, biogas, liquid biofuel, anaerobic digestion, tidal energy, wave energy, ocean thermal, ethanol, methanol, biodiesel.
Pennsylvania	18% by 2020 (8% from Tier 1, 10% from Tier 2). For Tier 1, 1.5% by 2007 increasing 0.5/yr.	Tier 1 includes: wind, solar, geothermal, biomass, coal bed methane and fuel cells. Tier 2 includes: waste coal, municipal solid waste, large hydro, coal gasification. Includes a solar set-aside of 0.5% by 2020.
Rhode Island	16% by end of 2019	Photovoltaics, Wind, Biomass, Geothermal Electric, Small Hydroelectric, Tidal Energy, Wave Energy, Ocean Thermal, Fuel Cells (Renewable Fuels).
Texas	EXPANSION OF EXISTING RPS: In 2005, RPS requirement of 2,000 MW by 2009 expanded to 5,580 MW by 2015.	Wind, solar, geothermal, hydroelectric, wave or tidal energy, and biomass or biomass-based waste products including landfill gas. Establishes a credit trading program administered by ERCOT.
Vermont (Goal)	10% by 2012 *(not a requirement but an established goal)*	If the goal is not met by 2012, the percentage of new load growth will become a mandatory standard.
Wisconsin	EXPANSION OF EXISTING RPS: In 2006, state requirement of 2.2% by 2010 raised to 10% by 2015.	Wind, solar, biomass, geothermal, tidal, fuel cells and small hydro.

Local Renewable Portfolio Standards Comparison Table

RPS	# of Tiers	% Solar Goal	Goals % Renewable	Goal by Year	Alternative Compliance fee	Special Features:
DC	2	0.386 % solar	11%	2022	$25/MWh Tier1 $10/MWh Tier 2 $300/MWh Solar	120% solar, wind produced before Jan 2007; 110% solar, wind before 2010; 110% for landfill gas and waste water treatment; ACP Payments deposited to a REDF Fund
DE	2	300% extra REC's	10%	2019	Year one $25/ MWh, Year 2 $ 50/MWh, $150/MWh Solar (300%)	Minimum % TBD each year after 2020; 300% for solar and Fuel cells using renewable fuels 150% RECS for wind sited in DE, final rules due July 2006
MD	2	200% solar REC's, 120% wind REC's	7.5 % Tier 1 increase 1% ea 2 years, Tier 2 =2.5% then in 2019 drops to 0	2019	$20/MWh Tier 1 $15/MWh Tier 2 $40/MWh Solar (200%)	2006 – 2008 110% wind REC credit PJM GATS No solar support other than 200% value for REC lowest of all states in chart
NJ	3	2.12% solar	22.5% 2.12 Solar 17.8 Tier 1 2.5 Tier 2	2020/ 2021	ACP or SACP determined by BPU annually greater than installed cost	Solar REC can meet any Tier 1,500 MW Solar REC worth $250-$300, aggregation of solar by contractor PJM GATS
PA APS	3	0.5%	18%	2020/ 2021	$45 per MWh /ACP Solar = 200% the average ACP ($80-$90) MWh	DSM measures, coal bed methane, waste coal included; Distributors can get reasonable cost recovery, but not generators.
VA	3	1.0%	15%	2015		To include Energy Eff. Solar resources

The Virginia RPS is in proposal stages, having been carried forward from last year's legislative session to next year's session. All information taken from the Database of State Incentives for Renewable Energy, www.dsireusa.org

Colorado
In 2004, Colorado became the first state to have its renewable energy standard mandated directly by voters. In November 2005, Colorado customers buying a percentage of wind energy paid $10 less/month for their electricity than those relying on traditional sources.

California
California accelerated its 2002 goal of 20% renewables by 2017 to a goal of 20% by 2010; the state's 2020 goal is now at 33%. California continues to review and improve its renewable energy mandates

Performance and Capacity Based Incentives
Today, discussions regarding incentives for renewable energy programs center around whether incentives should be based on the actual energy delivered from the generation equipment or the capacity of the installed hardware to deliver the energy as designed. This issue has received significant debate in California where governor Schwarzenegger recently signed into law the California Solar Initiative, where $3.2 billion dollars are to be spent over 15 years to support a solar tariff to pay producers for the solar energy they produce per kWh. Some incentives for smaller systems will have an up front incentive, but larger systems will be based purely on energy production and electric meter readings. This mechanism offers the State greater assurance that the energy is in fact delivered and produced. Germany has been the stellar example of such a program offering payments annually for the energy produced from the systems installed. Reports and presentations on this topic can be found at the Interstate Renewable Energy Council (IREC) website [50] Performance based programs, like the feed in tariff, have proven to be most effective in creating a market transformation.

Feed in Tariff and Renewable Portfolio Standards
Germany is a world leader in developing the solar energy industry using financial incentives that stimulate market development. They have utilized a feed-in tariff, where owners are paid for their annual production of kWh from solar, wind, and other renewables. The value of the renewable electricity is set at a level, where those who can afford the up front capital cost will be willing to invest in producing their own energy. Building a renewable energy industry in Germany has not occurred overnight. It has taken more than five years to develop the products and establish a real consumer market. These incentives are a direct payment to the customer and add great value to the lifecycle costs of the product for the owner. This program has been so successful, that it has been duplicated in Spain, Washington State, and now Ontario, Canada. In Washington State, additional incentives are offered, if the components are manufactured within the state. Inverters, controllers and solar cells, but not complete modules, are currently being built in Washington. The state is hoping that this incentive will prompt the manufacture of complete modules.

Washington State
The State rejected the RPS mechanism in favor of a feed-in tariff program, similar to the one implemented in Germany. Washington's State's program pays producers of renewable electricity a feed-in tariff of up $0.15 kWh or up to $2000 for nine years. Larger tariffs are paid if products

[50] PV Incentives Design handbook: http://www.clean-power.com/research/customerPV/PVIncentiveDesignHandbook.pdf and Incentive Level Analysis: http://www.clean-power.com/research/customerPV/2006-06-12_CLEAN_POWER_INCENTIVE.pdf

are produced in-state. If, for example, the inverter was made locally, the rate jumps to 18 cents. If the system uses a locally-made inverter and modules, the rate jumps to 54 cents. The customer also receives the net metered value of the power and the renewable energy credits. This is the first state end-user incentive program to encourage local growth of renewable manufacturing.

Local promotion and development of the renewable energy industry is a feature that Washington considered when it developed its feed-in tariff. This is also expected from the implementation of the Maryland RPS. **Maryland's Renewable Portfolio Standard (RPS), however, will do little to grow the clean energy industry in Maryland.** According to the Maryland Power Plant Research Program, barring unforeseen levels of renewable energy generation retirements, increases in demand in the state, or widespread difficulties certifying resources in states adjacent to PJM, it is likely that new renewable energy projects will not have to be developed to meet Maryland's RPS requirement. The Maryland RPS legislation, therefore, may fall short of its expectations.

Ontario, Canada
The predominance of hydro-electric generation within Ontario stabilizes electricity prices around $0.06. As a result of this low cost energy, the tariffs for solar and wind generated electricity were set at $0.42 and $0.11, respectively. This is a significant opportunity for generating revenue and selling REC's.

Solar Electric Incentives and Programs
Solar electric systems face several hurdles which prevent them from gaining wide acceptance in the traditional energy market place: (1) They are higher in initial cost than other energy options; (2) Due to the intermittent nature of sunlight, they require a backup source of energy, (3) They require a delivery mechanism for they are individually purchased and owned by end user; and, (4) they require good access to sunlight.

Costs of solar energy equipment have steadily dropped and will continue to follow this trend as manufacturing volume grows. As a result of assembly automation, the capacity to produce solar cells has exceeded the available supply of solar grade silicon, the primary ingredient in mono-crystal and poly-crystal silicon. Once production of solar grade silicon catches up to demand, further cost decreases will occur.

The long life of solar cells creates a difficult comparison, when comparing solar energy to electricity generated with fossil fuels. The costs per kWh of solar electricity over solar modules lifetime have been calculated to range from $0.15- $0.22 per kWh. Conventional electric power depends largely on fuel costs in the future, and that is a very difficult to predict. If electricity generation costs were to reach $0.10 a kWh and delivery cost another $0.05, then solar energy will become financially competitive. In fact, while solar energy might appear to be less competitive now, in ten years, it may well be less expensive than conventional energy sources. Solar energy systems are well-suited to decentralized energy needs, which is the opposite of the current energy delivery mechanisms that provide our energy today. The large central generation stations and distribution grids, that merge on the fringes of cities or back each other up, are well-suited for commercial and industrial energy delivery, since large quantities of energy are present to support large swings in energy usage. The residential customer presents a rather steady cyclical daily load that peaks reliably with the summer and winter according to weather patterns. Summer peak demand usage is very important when evaluating solar energy, because peak energy is the most valuable and typically coincides with solar energy availability and the need for air conditioning. Solar energy is produced at peak, has no pollution effects, has zero emissions, is mostly available anywhere, can be installed and capitalized by the end user rather than the generation or distribution utilities, and employs more people per kWh than other energy sources. Since it is initially more expensive, solar electricity faces a severe disadvantage in entering the marketplace when it is also presumed to be more expensive in the long run and therefore less competitive. This in part is due to its higher initial capital cost per unit of energy. Solar electricity must, therefore, be viewed differently and the incentives for this energy must be established to help overcome these barriers.

Solar Prescriptive Incentives
Unlike energy efficiency, there are no prescriptive incentives in the United States obligating the use of solar energy. Such incentives do exist in other countries, including Israel, Spain, and most recently some small percentage of new homes in Northern Ireland, which are required to use solar water heating. There are some prescriptive incentives for new home builders to get preferential treatment at the local planning and permitting departments, if they use solar energy in their standard homes designs. This mechanism has been very effective in the overheated California real estate market and has been successful in stimulating the new home construction industry to look at solar options. This scenario would only be possible, however, so long as the state is able to offer grants, discounts, or buy downs to new home buyers from their State Clean Energy Funds.

Solar Financial Incentives
The principal financial incentives for solar energy are grants, buy downs or financial incentives that come from electrical system benefit charges, Renewable Portfolio Standards that create valuable Solar Renewable Energy Credits (SRECS's), Federal, State and local tax credits, and feed-in tariffs payments. The debate has grown significantly in recent years as to whether financial incentives should be based on the potential capacity of the solar array or on the actual kWh generated and supplied to an electric load. The debate has expanded to include the California solar program, which is the third largest solar program in the world. Several states, including Virginia and North Carolina, offer manufacturing incentives to companies in other states to locate factories to their states, thereby creating jobs and tax revenue.

Grants, rebates, and buy downs are generally supported by funds levied across all energy consumers. These funds are collected from commercial and residential customers and generally exempt industrial customers, so as not to impact the competitiveness of their products. California is an excellent example of a well-structured buy down program, where the incentives decrease over time, as the marketplace becomes more active. While the current incentives are lower than they once were, they have remained at a level where consumers and industry can both benefit. Commercial projects have also been successful in California and they have built some of the larger commercial systems in the country due these incentives. Had the incentives been sourced from the state income or property taxes, the program would have been cut off during the California economic crisis. Since funding was independently sourced from electric rates, the program continued over the years to build industry infrastructure. New Jersey also has a similar incentive, based on the system benefit charge that all customers pay. This charge was created at the time when energy was deregulated, so funds were stored to create the Clean Energy Fund.

The RPS policies work well in conjunction with a System Benefits Fund, due to the need for some upfront cost assistance to keep systems affordable. By themselves, RPS programs are like un-funded mandates that have little power to make real change. Without Funds, the only financial incentives are the ability to sell or trade REC's, which can be a very insignificant incentive to solar energy systems. In the case of large wind systems and biomass systems in the 5 – 100 MW range, while the incentives are small in size, the sheer quantity of energy produced makes make the incentives attractive. In Maryland, even a $0.005 incentive per kWh is significant for wind and landfill gas, but not for a solar. So the RPS has to be adapted to make allowances for those technologies that cannot adequately cover the upfront costs. The Federal government has added some support for new technologies entering the marketplace and is providing incentives for solar, wind, and biomass technologies through the Energy Policy Act of 2005.

Though the mechanisms of evaluating the value of renewable energy have been inadequate in the past, they are showing signs of changing. This is in part due to the RPS and RECs, which create a way of attributing value to clean energy. This value is quite arbitrarily-determined by legislation or by an estimated value that is higher than the cost of installing the renewable resource in order to create favorable market opportunity. The true value of a diversified energy mix is that there is less dependency on one energy resource. This is important because as our dependence on fossil fuels increases, so does our vulnerability to interruptions of supply and escalating fuel prices. Recently, in the Virginia-RPS debate, an RPS coalition presented a paper that indicated that an RPS can be helpful in keeping electrical prices lower.[51] In fact, we have seen this happen in Texas, where customers buying wind power were paying less than the other customers. Under certain conditions, renewable energy will be less expensive than conventional power, and using renewable technologies will always be less harmful to our environment than burning fossil fuels.

When utilities were regulated by public service commissions, any major investment or services provided to customers could be negotiated in the rate settlements and a reasonable rate of return was allowed to the company. An owner generator would also seek a reasonable rate of return on his investment in producing his own energy. If having a diversified energy supply will benefit all the consumers in some way, then they should cover the expenses for the incentives for those who create this diversity and are willing and able to invest in producing their own energy. This has been the case in most active markets around the world and in several states here in the US. When California, for instance, was in the midst of a fiscal crisis, it could never have supported their clean energy policies using only State tax revenues. Only with the electrical consumers having the responsibility for these expenses, and the California Public Service Commission enforcing the public benefits funds collection, were such incentives possible. This enabled California to develop the third largest world market for photovoltaic modules, following Japan and Germany. However, by themselves, financial incentives are not sufficient to motivate the consumer. The State should also create programs to educate the consumer, enforce codes and quality control, and promote the growth of a new clean industry. This industry can then be seen as a current economic benefit that will continue to flourish, providing the state jobs and exports. It is this economic development argument that is really catching on as the financial community begins to embrace these new emerging industries. Wall Street is enjoying the re-emergence of the solar

[51] Paper presented by Aden Hathaway, Dr. Pat Delaquil.

and wind industries. These are new challenges and opportunities for states and American business to capture and develop.

Renewable Energy Credits (REC)

The REC (also the Alternative Energy Credit or Solar Energy Credit) are certified certificates of energy generation at specific meters and sites that generate renewable energy. The REC is usually issued for the verified production of 1 MWh of electricity generated by a renewable-fueled resource. There are meter readings that can be traced back to each REC. However, in the case of smaller systems, solar systems in particular, often 10 kW or less, engineering estimates can also serve to validate generation performance.

The REC can also be awarded to generation that displaces the use of fossil fuels. Solar heating, for example, is a qualifying technology, because it produces heat from a renewable resource and while it does not generate electricity directly, it indirectly assists our energy mix by permitting more resources to be allocated to generation. At 2.5 MWh per year, a solar water heater can produce that energy for less than half the cost of a photovoltaic system. To not permit this technology to participate in RPS is misguided for it forces the consumer to make an unwise economic choice due to the incentives offered to one technology and not the other.

Currently, solar water heating and other energy efficiency programs are producing Alternative Energy Credits and benefiting from RPS mechanism. Clearly, if producing clean energy deserves support, so does consuming energy more efficiently, since all energy users' benefit from the reduced use.

Biomass

Conversion of solar energy by means of photosynthesis to vegetable matter provides a concentrated form of energy for gasification or fermentation to yield more-useful forms of energy. These fuels can be used for generating electricity or for transportation needs by blending ethanol with gasoline. Incentives vary widely depending on agricultural production in states and opportunities for processing and refining. The following table gives a summary of the biomass policies in the region.

State Actions to Support Biofuels in the Northeast

State	*Def. of Alt. Fuel*	*Tax Incentives*	*Research*	*Other*
CT	[ref.4a-67d and Senate Bill 218 (Public Act 04-231), 2004. "clean alternative fuel" shall mean natural gas, hydrogen or electricity when used as a motor vehicle fuel or propane when used as a motor vehicle fuel or shall mean compressed natural gas, liquefied petroleum gas, liquefied natural gas or electricity when used as a motor vehicle fuel and "incremental cost" shall mean the difference between the purchase price of a vehicle which is exclusively powered by a clean alternative fuel and the manufacturer's suggested retail price of a comparably equipped vehicle which is not so powered]	1-cent-per-gallon gas tax exemption for E10 SB 193 An Act Concerning The Sulfur Content Of Home Heating Oil And Off-Road Diesel Fuel grants an exemption to the petroleum GRT (effective 7/1/06 for tax years beginning 2006) for commercial heating oil blends that contain at least 10% alternative fuel (agricultural produce, food waste, waste vegetable oil, municipal solid waste, biodiesel).	Eastern CT State University Biodiesel Project: CT DEP has allocated $45,200 to conduct a pilot project to use biodiesel fuel (a blend of 20% biodiesel and 80% ultra low sulfur #2 fuel oil) for space heating at ECSU for one year. The project will provide an opportunity to collect needed data and provide education and outreach to others about the fuel and its benefits in heating applications. It will identify all regulatory steps needed for a facility to use biodiesel (i.e., permit modifications), gather data on fuel efficiency and emissions factors and monitor air emissions associated with using a B20 blend, test fuel quality, impacts on equipment (maintenance and performance satisfaction), and costs. Project began in Fall 2005; 16,000 gals B20 delivered to date. Emissions testing performed; boiler modified as needed; Final report 8/06.	Will implement light-duty motor vehicle emission standards of the state of CA standards for model year 2008. The following workshops have been held: *Biodiesel for Heating Workshop* - 9/26/05 - A workshop for fuel oil distributors and users on "bioheat", including its availability in Connecticut. *Biodiesel for New England, Can we make it in New England?* held March 2003 at the Institute for Sustainable Energy at Eastern CT State University. *2006 UConn Biodiesel Consortium Spring Workshop: Production & Use of the Fuel of the Future* – 5/10/2006, with tours of labs – continuous microwave reactor and small batch demo. DEP has a biodiesel webpage - http://www.dep.state.ct.us/wst/p2/energy/biodiesel.htm CT Dept of Transportation uses B20 blend in its heavy equipment. CT Dept of Transportation has an E-85 in Newington, CT and will be fueling about 475 flexible-fuel vehicles there. CT Clean Diesel Plan submitted in January as per 2005 Legislation. Little action taken on recommendations in 2006 session. Recommendations include: to require a low sulfur bioheat fuel for heating oil. (500 ppm sulfur up to 5% biodiesel blend); encourage the purchase of Alternatively Fueled Vehicles (AFVs) and the development of related refueling infrastructure. Specific changes would include: extending eligibility rules to private companies to apply for funds, allowing costs of related refueling infrastructure, and allowing eligible entities to apply for costs of certified AFV conversions and alternative fuel engine. CT DPUC biomass rulings: A ruling was made in June 2005 that biodiesel will be considered a class 1 renewable.

State	*Definition of Alternative Fuel*	*Executive Orders*	*Tax Incentives*	*Other*
DE	"Special fuel" means and includes all combustible gasses and liquids suitable for the generation of power for propulsion of motor vehicles, except that it does not include gasoline as defined in § 5101 of this title and except that it does not include combustible gases and liquids used prior to January 1, 1996, in a program to determine commercial feasibility of alternatively fueled vehicles.	Energy Task Force, developing an energy plan to recommend to the governor; it includes representation from agriculture for biofuels. Example Potential Actions (a starting point of things to consider): Establish and/or promote establishment of biodiesel, ethanol and natural gas fueling stations, Establish a biodiesel production facility on the Delmarva Peninsula, Use biodiesel in place of diesel for school buses, Support establishment of an ethanol production plant in the region.	Taxes on AFs used in official vehicles are waived	The Delaware Soybean Board offers rebates and marketing, promotion and education assistance for biodiesel use on a case-by-case basis.

State	*Definition of Alternative Fuel*	*Executive Orders*	*Tax Incentives*
NY	To qualify, a vehicle must draw propulsion energy from both an internal combustion engine (or heat engine that uses combustible fuel) and an energy storage device; and must employ a regenerative braking system that recovers waste energy to charge that device, and, for model year 2004 and later, vehicles must meet or exceed the California LEV II emission standard. Def.: new light-duty natural gas vehicles (NGVs) or EVs, and medium and heavy-duty CNG, electric, or hybrid electric vehicles.	The city's fleet is to be 80% AFVs, and 20% of bus fleet. Auto makers must sell at least 10% ZEVs, starting in 2005. The State is to phase in AFVs to 100% by 2010.	There is a partial sale and use tax exemption for buying and converting AFVs; and for alternative fueling stations.

State	*Executive Orders*	*Other*
MA	Beginning in 2001, an Executive Order mandated that at least 75% of new nonexcluded vehicles shall be the cleanest AFVs available, at least 10% will be ZEV's.	The contract award for a statewide RFR should be issued soon – cities, towns and state agencies will be able to purchase fuel from the contract. Held a workshop on bioheat for the MA oilheat industry. Working on an SEP with the RI energy office to lower market barriers for bioheat distribution. Trying to get a bioheat emissions test performed at a MA state facility.

State	Definition of Alternative Fuel	Executive Orders	Tax Credits	Grant and Loan Programs	Research	Other
ME	"Biofuel"- any product or energy source used to propel motor vehicles or otherwise substitute for liquid fuels that is derived from agricultural crops or residues or from forest products or byproducts, as distinct from petroleum or other fossil carbon sources. ethanol, methanol derived from wood, levulinic acid, biodiesel, pyrolysis oils from wood or combinations of any of the above that may be used to propel motor vehicles either alone or in blends with conventional gasoline or diesel fuels or may be used in place of petroleum products in whole or in part to fire heating devices or any stationary power device	The Energy Resources Council, in coordination with the Department of Environmental Protection, shall study the costs and benefits of state government actions to stimulate an increase in use of alternative fuels and AFVs as well as stimulate the use and production of biofuels in the State.	A tax credit is available for up to 25% of costs incurred between 2002-2005 for building or improving clean fuel stations. Income tax credit of $0.05 per gallon of biofuel to the producer. Partial tax exemption for AFVs (including AFV's powered by alcohol fuels containing at least E85) up to 2006. Ethanol (E85) is taxed at a rate of $0.156 per gallon (i.e., a 6.4 cent-per-gallon gas tax exemption for E85), propane (LPG) at $0.16 per gallon, and compressed natural gas (CNG) at $0.191 per 100 standard cubic feet. Gasoline is taxed at a rate of $0.22 per gallon. A new energy bill cuts the excise tax on biodiesel by 8 cents per gallon.	The Sustainable Energy Trust Fund will provide loans for sustainable energy projects. Clean Fuel Vehicle fund may provide loans for a clean-fuel vehicle project. Agriculturally Derived Fuel Fund provides loans and subsidies for a facility to produce agriculturally derived fuel. The Maine Technical Institute provides seed grants to establish businesses to increase biodiesel production and distribution in the State.	The University of Maine was awarded $6.9 million in federal grants to build its bioproducts research and create a forest biorefinery.	Has adopted California's vehicle exhaust emissions requirements; **The "Biodiesel for Maine Project"** is expanding its biodiesel outreach to the marine sector through a grant from the **Gulf of Maine Council on the Marine Environment** for design, exploration, and the first steps of an outreach campaign to educate fishing fleet, ferries, schooners and marinas on the benefits of biodiesel.

State	Executive Orders	Tax Credits	Other
MD	75 percent of new state vehicles purchased must be AFVs, 50 percent of fuel used must be alternative.	The Maryland Renewable Fuels Promotion Act of 2005 includes an ethanol production incentive that establishes a 20-cpg credit when small grain crops are used as the feedstock source, and a 5-cpg credit when other feedstocks are used. There is a 15-mmgy total cap, and funding is set to run from 2008 to 2017.	Baltimore Clean Cities- encourages wider adoption of alternative fuel blends (diesel/biodiesel, ethanol/gasoline, and compressed natural gas (CNG)/hydrogen)- though with limited funding. will pay up to $10,000 of the incremental cost. The Agriculture Stewardship Act expands the cover crop program by $3 million and allows harvesting of cover crops for energy. The State Fleet Biodiesel Fuel Usage Act requres that by 2008 the state uses a B5 blend in 50% of diesel vehicles.

State	Executive Orders	Other
NH	Governor issued executive order to use clean fuels in state fleet.	Granite State Clean Cities Coalition (GSCCC) has offered funds to offset the incremental cost of biodiesel (and storage tanks for one project) over the past 5 years. Funds will be available again through FY07. GSCCC is working with fuel distributors statewide helping advertise availability of the fuel and participating in workshops for potential customers to help educate them about the benefits of biodiesel. Worked with the State legislature to develop definitions of biodiesel in state statute and will continue to work to develop legislation that promotes the use of biofuels for both transportation and heating. Legislature directed DOT to undertake a pilot project. DES Air Resources Division worked with all divisions within DES to clarify permitting requirements associated with biodiesel production operations and developed a fact sheet for potential producers. DES and OEP helped plan full day conferences held in June (just biodiesel) and October (all alt fuels) 2005 DES worked with DOT to establish fuel specifications to go out to bid for a B20 blend at a state refueling site. OEP worked with Congressional delegation to try to secure funding for paper sludge to ethanol project.

State	Def. of Alt. Fuel	Executive Orders	Tax Incentives	Grant Programs
NJ	Eligible fuels include natural gas, propane, electricity, ethanol (E85) and hydrogen	After 2009, will implement California Low Emission Vehicle (CLEV) program. Beginning July 1, 2007, all buses purchased by the New Jersey Transit Corporation shall be buses with improved pollution controls and that reduce particulate emissions or buses powered by fuel other than conventional diesel fuel. Qualifying vehicles include compressed natural gas (CNG) vehicles, HEVs, fuel cell vehicles, vehicles operating on ultra low sulfur fuel or biodiesel, or vehicles operating on any other bus fuel approved by the U.S. Environmental Protection Agency.	Rebates for buying or converting AFVs are available to local government and educational institutions under New Jersey's Alternative Fuel Vehicle (AFV) Rebate Program, the Local Government Biodiesel Fuel Rebate Program, and the Local Government Alternative Fuel Infrastructure Program. Rebates are available the help cover the cost of: converting a vehicle to operate on an alternative fuel; purchasing an AFV; the use of biodiesel; and refueling infrastructure purchase and installation. For 50% of the cost of purchasing and installing refueling infrastructure for alternative fuels, up to $50,000 per applicant.	Up to 50% of the cost for infrastructure of AFS, up to $50,000 per applicant.

State	Definition of Alternative Fuel	Tax Incentives	Grant Programs	Other
PA	Eligible alternative motor fuels and fuel systems are compressed natural gas (CNG), liquefied natural gas (LNG), liquid propane gas (LPG), ethanol (E85), methanol (M85), hydrogen, hythane, electricity, coal-derived liquid fuels, fuels derived from biological materials, and fuels determined by the Secretary of the U.S. Department of Energy as meeting the requirements of Section 301 of the Energy Policy Act of 1992	For ethanol and biodiesel there is a 5-cent-per-gallon producer payment up to 12.5 mmgy. There is an AF tax determined on gasoline gallon equivalent	Alternative Fuels Incentive Grant (AFIG) Program: 1. Incremental Buydown Program: for tax-exempt, non-profit entities(schools, transits, local governments), AFIG will offset the added cost to use B20 or E85 2. PA Producer Reimbursement program: 5 cents for each gallon produced in one calendar year by PA qualified producers not to exceed 12,500,000 gallons a year per producer 3. Pay a percentage of the cost to tax-exempt, non-profit entities who install storage and dispensing equipment on their property for B20 or E85. 4. Pay a percentage of the cost to install storage and dispensing equipment for E85 at pubic gasoline retail stations. 5. Pay a percentage for biofuel production projects that involves a new application or next phase technology. Offered a grant for two projects - one will use waste oils and the other will use oil from algae for biodiesel production. The AFIG program receives dedicated funding of about $3.5 million a year from the state's general fund, any unspent money will rollover for use in future years. The Energy Harvest Grant Program funds a wide variety of stationary renewable and alternative energy projects but does not have a dedicated funding source. It has funded biodiesel blending equipment and a new application biodiesel production project using trap grease as the feedstock. Clean Cities program will also provide rebate for installing and buying AF facilities.	PA Energy Development Authority (PEDA) funded one soybean oil to biodiesel production plant and has a dedicated funding source of up to $10 million annually for a wide variety of stationary source alternative and renewable energy projects.

Wind Energy Policies and Incentives

Wind energy systems offer a low cost reliable energy source that can provide electricity to existing grids quickly and efficiently. They are also available as smaller-scale technologies to provide electric power to consumers for net metering applications or for electric self sufficiency. Both large systems, greater than 100 kW, and smaller systems are still more expensive than conventional energy and deserve incentives to produce clean energy credits that are emission free. While each size needs different support systems, they are the fastest growing renewable energy technology in the world.

Large Wind

Large wind machines today have grown significantly in the last 5 years. Wind turbines capacity has grown from the .250 - .750 MW to 1 - 5 MW range. Wind developers have perfected placement techniques and wind site analysis to better locate wind resources and improve yield. Further technological improvements and continued support from the Production Tax Credit[52] have been key drivers in maintaining a growing industry. These projects are very large and a small incentive if established over a long term makes projects happen. In fact, some wind farms are actually producing electricity cheaper than fossil fuel plants. Market expansion has been astonishing in Texas, California and the Midwest.[53] These leaders have had strong state incentives and encouraged the diversification of generation resources through strong Renewable Portfolio Standards (RPS).

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[52] Wind Energy Basics, American Wind Energy Association: http://www.awea.org/newsroom/pdf/Wind_Energy_Basics.pdf, Appendix

[53] Growth curve of US Installed capacity in MW 1981-2005 http://www.awea.org/faq/instcap.html, States where development has occurred http://www.awea.org/projects/index.html

Small Wind

Smaller capacity wind turbines have great potential to deliver energy to individuals who seek to displace their fossil energy consumption on an annual basis. Net metering programs have been designed to include wind power generators who choose to displace a portion or all their power consumption by producing their own electricity. Maryland modified its net metering laws during the 2005/2006 legislative session to permit surplus electricity production by a net metered customer to carry forward for one year from when it was incurred. This provision allowed for real net metering in Maryland and will encourage the placement of larger systems on farms and ranches and home sites, where wind energy is available. Small wind systems are more expensive than the larger wind farms and are generally classified as a Tier 1 renewable resource, thereby receiving a higher value for the REC than Tier 2 large-scale wind farms. Incentives for small wind utilization and production should be established as a means of economic development for this local industry. However, some controls on siting systems in areas of low wind resources are needed. Examples of these issues are available in more detail at the American Wind Energy Association's website.[54]

Land Based

Wind farms are typically located where developer's site analysis indicates that prevailing winds exceed average wind speeds of 16-18 miles per hour. Farms in the Midwest and Texas are ideal sites where flat lands provide good uninterrupted wind access. Wind farms have been developed and installed recently in Texas, producing up to 210 MW at the Horse Hollow Wind Energy Center with 140 kW - 1.5 MW turbines. Siting issues have been a concern for developers and residents. Discussions in Virginia considered locating turbines in wind energy parks to isolate and concentrate them in wind rich areas. Conflicts over siting are particularly acute when ridge top siting is considered. Ridge tops are ideal sites for wind farms due to the exposure to- and concentration of- high wind speeds at these summits. They are also the habitat for numerous birds and bats, that live and travel along in the Appalachian Mountains. Environmentalists and anti-wind energy groups have become increasingly vocal and opposed to any ridge top development. They have been able to stop development in Maryland and Virginia. Only West Virginia has one wind farm in operation at this time. More research is being devoted to studying bird population and migration issues to better understand their behavior and adapt wind farms to the needs of wild life.

Off-shore Development

In order to avoid siting conflicts and to insure good wind resources, more consideration for off shore wind farms is starting to occur. In many cases, however, siting is just as big an issue in the ocean as it is on land, due to shipping channel requirements and high underwater transmission line costs. But there is new interest in the Atlantic Ocean coast line as a potential site and major projects are being planned all along the East coast. The Chesapeake Bay coastal areas have seasonal wind resources and could also become very useful if new technologies are perfected that allow turbines to capture the wind resources at lower wind speeds. Off shore wind energy collaborative groups have been established by the Massachusetts Technology Collaborative[55]

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[54] American Wind Energy Association: http://www.awea.org

[55] Off shore Wind Energy Collaborative: http://www.masstech.org/RenewableEnergy/owec.htm Framework for US Offshore Wind Development: http://www.masstech.org/renewableenergy/press/pr_9_30_05_wind.htm

Siting Commissions
Siting issues have continued to delay construction of wind farms in the mid-Atlantic states. Maryland and Virginia have no operating wind energy generation at this time. While two wind projects are approved for installation in Maryland, there have been delays, at least one of which was related to one of the project's location, that have prevented their construction. Siting issues must be addressed in an open and transparent process, which should provide equal opportunity for participation for all parties involved. The need for wind power sites will not diminish with time and the methods of installation can be controlled so as to be less harmful to the environment and even allow wind sites to become local attractions for tourists. The American Wind Energy Association has guidelines and a toolbox for the proper way to go about siting large and small wind systems.[56]

Maryland's Power Grid Policy
Because of their heavy coal use, power plants in Maryland contribute significantly to health threatening air pollution. These plants currently contribute nearly 80% of the total sulfur dioxide (SO2) emissions and 30% of the total nitrogen oxides (NOx) emissions. Coal-fired plants are also currently significant sources of mercury, a neurological toxicant that contaminates the fish in our rivers, lakes and oceans. In April 2006, Maryland passed the Healthy Air Act, with some of the toughest restrictions in the country for emissions of NOx, SO2 and mercury. As required by the new law, power plants and industrial facilities can either reduce emissions or buy credits to meet the following caps:

- NOx limited to 20,216 tons a year in 2009
- SO2 limited to 48,618 tons a year in 2010
- Mercury emissions reduced by 80% in 2010

In addition, the law requires that in 2007, Maryland will join the Regional Greenhouse Gas Initiative, which is a regional consortium of Northeast states committed to reducing greenhouse gas emissions that contribute to global climate change. The initiative establishes a cap-and-trade mechanism for reducing emissions of greenhouse gases that is very similar to the one established for the regulated pollutants listed above. Maryland will thus join seven other states in the Northeast - Connecticut, Delaware, Maine, New Jersey, New York, New Hampshire, and Vermont - that agree to reduce carbon dioxide emissions by10% in 2019. During negotiations about the bill in the Maryland Legislature, the Maryland Governor and Maryland utility companies expressed concerns about the effects of this legislation on prices. As a result, it was amended to require a comprehensive study of reliability and cost issues in 2008. Depending on the outcome of this study, the state can withdraw from Regional Greenhouse Gas Initiative in 2009.

A recent study done for the Abel Foundation finds Maryland's electrical system outdated and inefficient.[57] The study makes several recommendations for making the state's current mostly-centralized electric power industry more innovative, efficient and competitive. It also contends that, if Maryland policy makers and regulators implement these recommendations, they can

[56] http://www.awea.org/smallwind/toolbox/default.asp

[57] Richard Munson, "Maryland's Electricity Opportunity: How to Fix the Power Breakdown and Pave the Way to Innovation, Efficiency, and Competitive Rates," June 2006.

stimulate immense environmental and economic benefits for the state and provide Maryland with the opportunity to become known for its electricity innovation, rather than for its barriers to innovation. The study touches on a number of issues, including the following:

- Today's centralized coal plants, which account for approximately 60 percent of Maryland's power, have not improved their delivered efficiency in almost five decades;
- Most of today's technological innovations suggest a shift toward dispersed generation, with a more efficient grid linking turbines, cogenerators, energy recyclers, fuel cells, or renewable technologies;.
- Localized power can avoid or reduce distribution bottlenecks and curtail the need for massive investments in high-voltage transmission lines;
- While today's centralized power system offers numerous backup redundancies, harsh weather, terrorist attacks, and simple accidents have highlighted the vulnerability of large power plants and far-flung transmission wires;
- Several of decentralization's key benefits are financial, since smaller modules are less risky economically, take less time to devise and construct, obtain greater efficiencies, are portable, and are less vulnerable to fuel shortages and price volatility;
- Potential innovation goes well beyond increased efficiency and improved generators and might involve issues such as utilities taking better advantage of computing and telecommunications advances, including the use of electric wires for telecommunications, downloading movies, or integrating home management and security systems;
- Since entrepreneurs can be blocked from connecting to the distribution grid, we need clear and fair interconnection standards;
- Although Maryland's interconnection-approval process has improved slightly in recent years, it still takes nine months to two years, a delay that few small projects can afford;
- The fact that today's utilities enjoy the sole right to string wires could block entrepreneurs from generating their own electricity;
- The possibility of exorbitant rates for backup power could also keep electricity entrepreneurs from entering the electricity market.

Some of the study's key recommendations are as follows:

- The mayor of Baltimore should organize an Energy Policy Task Force to create a five-year plan that would have the city lead by example. Within six months of its forming, the task force should issue a document that outlines what the city will do through building codes, bulk purchases, land-use plans, and other tactics to enhance electricity reliability and efficiency. The governor of Maryland should organize a similar taskforce for the state;
- Regulators should allow the stringing of independent wires across any public street, enabling independent generators to send power to their customers;
- Regulators must establish clear and fair interconnection rules, enabling independent generators to connect with the distribution system;
- Regulators must set reasonable backup rates for entrepreneurs who occasionally need to purchase power from the grid;
- Maryland's net-metering provisions should be strengthened to provide more opportunity for independent generators to sell their excess power to the grid. Maryland's effort is limited to generators up to only 0.8 megawatts. The state should increase its level to 10 megawatts;

- Maryland should spur the adoption of advanced meters that would enable consumers to obtain real-time prices for their power and use electricity more efficiently, and when it is less costly;
- Legislators should adopt output-based environmental regulations that calculate emissions on the amount of electricity generated, thereby rewarding generators that supply more electricity and less pollutants;
- The State should provide a repository of independent analysis and calculations for judging energy alternatives and offer unbiased information on how homeowners can weatherize and insulate their homes. Also useful would be consumer-protection monitoring, as well as a clearinghouse of objective information on contractors able to provide energy services to Maryland consumers;
- To become a leader in energy innovation, Maryland must go out of its way to attract entrepreneurs. Although states typically use subsidies to lure businesses, Maryland could achieve substantial gains with simple outreach and the public declaration that the state wants to break down market barriers and attract electricity entrepreneurs. Such efforts would be enhanced if Maryland also expanded its university research efforts on innovative energy technologies;
- Communities should encourage or participate in power-buying cooperatives. Aggregation is particularly important for residential customers. At present, Maryland forbids city and county governments from creating buying coops on behalf of their residents;
- Promote initiatives, such as Weatherization, that help low-income residents make their homes more energy efficient, thus cutting their power demand and costs. Maryland should also provide aggregation services and reach out to low-income residents with energy efficiency information and resources.

Best Practices

At least 28 countries and regions offer government-sponsored incentives for clean energy, as well as most of U.S. states and Canadian provinces. But, there has been little cross-fertilization of ideas and even less scientific evaluation of the results of these programs. This lack of dialogue and evaluation has led to disproportionate reliance on the simplest solutions, which generally base incentives on costs. (Sometimes, other performance parameters are also used in addition to costs.) A recent study [58] examines economic incentives for clean energy programs around the world. It shows that purely cost-based incentives, whenever they have been evaluated, have shown excessive levels of free ridership and failed to transform markets. It finds anecdotal evidence for mixed performance and cost-based incentives working in some cases, but a scarcity of evidence to corroborate these anecdotes. These results are contrasted to the experience with performance based programs, which have proven to be effective both at acquiring efficiency resources and transforming markets. This finding is consistent with analysis of the market barriers and market failures that clean energy faces.

Based on the above sited study, one of the best programs for market transformation has been the Washington State feed-in tariff program, similar to the one implemented in Germany, whereby

[58] Fairey, P. and D. Goldstein, "Getting It Right Matters: Why Efficiency Incentives Should Be Based on Performance and Not Cost." Proceedings of 2006 ACEEE Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Washington DC, August 2006.

producers of renewable electricity are paid a feed-in tariff of up $0.15 kWh or up to $2000 for nine years. Additional funding is paid if products are produced in-state. For example, if the inverter was made locally, the rate jumps to 18 cents. If the system uses a locally-made inverter and modules the rate jumps to 54 cents. The customer also receives the net metered value of the power and the renewable energy credits. This is the first state end-user incentive program to encourage local growth of renewable manufacturing.

Other examples of good programs can be seen in California. Although it has yet to be implemented, the new California Solar Initiative has features that are commendable and they have published a "Handbook" on developing incentives for photovoltaic's[59]. California's Center for Resource Solutions has also issued "Regulator's Handbook on Renewable Energy Programs & Tariffs." This handbook is for regulators involved in the design of renewable energy programs, with a focus on tariffs. It suggests best practices for renewable energy program design and tariff setting, and highlights successful renewable energy programs in a series of case studies.

New Jersey has an excellent incentive program coupled with a system benefits fund that can provide meaningful incentives. The program has been very successful for both residential and commercial customers. They have expanded the caps on the number of net metering systems permitted and will likely exceed those expectations also. System cost incentives in New Jersey are only for solar electrical systems and unfortunately no incentives are currently available for solar water heating.

In addition, New Mexico has approved an excellent incentive program with the cooperation of the local utility company. Pennsylvania's RPS has a Tier that includes energy efficiency improvements and, in that tier, solar water heating can qualify as a means for creating alternative energy credits. So, while Pennsylvania's goal may be electrical diversification, there are many ways to achieve that, including rewarding conservation and efficiency improvements, as they are often the lowest hanging fruit.

Boiler plate language for clean energy-related laws and regulations has been developed by the Interstate Renewable Energy Council, IREC, and is available at their website: http://www.irecusa.org. Laws currently passed can be found in the Database of State Renewable Energy Incentives or http://dsireusa.org. This site is continually updated and contains current renewable energy information.

[59] Clean Power Research web site : http://www.clean-power.com/research/customerPV/PVIncentiveDesignHandbook.pdf

5. Economic Development Potential of a Maryland Clean Energy Center

Overall Methodology
In order to perform the analysis to identify the economic development potential of establishing a Clean Energy Center in Maryland, ICSD undertook several tasks:

(1) Conducted a review of the literature on clean energy related economic development;
(2) Developed estimates of current and future energy use in Maryland;
(3) Initiated a study on Maryland Renewable Energy Resources and Costs at the National Renewable Energy Laboratory (NREL) in Golden, Colorado;
(4) Commissioned an Economic Impact Analysis of Energy Efficiency and Renewable Energy in Maryland with RESI Research and Consulting of Towson University, Maryland;
(5) Commissioned a study on the Economic Development Potential of the Proposed Maryland Clean Energy Center with the Jacob France Institute (JFI) of the Merrick School of Business at the University of Baltimore, including the development of a Database of Maryland Companies in the Clean Energy Field.

The review of the literature on clean energy related economic development was undertaken to determine what type of economic impact analysis to undertake and to develop the energy-efficiency and renewable-energy parameters, and other pertinent information, upon which to base the analysis. A listing of some of the articles and studies reviewed by subject area are given in Appendix 6. A summary table of the most recent reports on potential technical, economic, and achievable electricity and gas savings of state and utility programs is given in Appendix 7. After the review of the literature, it was decided to (1) undertake an input/output-based economic impact analysis using the IMPLAN model, (2) develop estimates of current and future energy use in Maryland, which were needed to run the IMPLAN model, (3) obtain Maryland-specific renewable resource potential and costs estimates, also needed to run the IMPLAN model, and (4) conduct an assessment of economic development potential of the proposed Maryland Clean Energy Center.

Input/output models are the primary tools used by economists to measure the total economic impact of a policy, business or event. IMPLAN is a standard input/output software package. A significant feature of the IMPLAN model is that it is customizable to better reflect specific economic aspects of regions or localities. In the case of this study, the model was calibrated to reflect the economies of Maryland and the Baltimore Metropolitan Area. This study defines the Baltimore metropolitan area as consisting of the following Maryland jurisdictions: Anne Arundel County, Baltimore County, Baltimore City, Carroll County, Harford County and Howard County. This definition corresponds to the Maryland Office of Planning's definition of the Baltimore metropolitan region. IMPLAN is not very expensive to obtain or run, and has been extensively used at the national, state and local levels. It has been used by both the U.S. Department of Energy and the State of Maryland for their program/project impact analyses. The work ICSD undertook to develop estimates of current and future energy use in Maryland has been discussed in the previous chapter. In order to obtain Maryland-specific renewable resource potential and cost estimates, NREL agreed to initiate the study on Maryland Renewable Energy Resources and Costs. The results of this study can be found in Appendix C. The study by JFI that looks at the economic development potential of the proposed center will be further discussed below and can be found in Appendix 3.

The theory behind economic impact analysis is that the total economic impact of a new firm entering a region is not merely limited to the number of employees the firm hires or to the payroll associated with these employees. Rather, the total economic impact includes these impacts as well as additional, multiplicative impacts. Multiplicative impacts occur as the new firm spends money in the region on goods and services and as the wages of employees trickle through the local economy.

Specifically, there are three types of impacts captured by input/output models:

- ***Direct impacts:*** these impacts are generated when the new business creates new jobs and hires workers to fill those jobs.
- ***Indirect impacts:*** these impacts accrue as the new firm purchases goods and services from other locally situated businesses.
- ***Induced impacts:*** both the direct and indirect impacts result in an increase in area household income. This increase allows local households to ramp up their spending at local area businesses. The increase in local spending is referred to as the induced impacts.

Our analysis quantified the total economic impacts for the following:

1. Energy Efficiency – Electricity
2. Energy Efficiency – Natural Gas
3. Renewable Energy – Wind Power, Solar Photovoltaic and Biomass
4. Alternative Energy – Ethanol
5. Firm Attraction, Expansion & Start Up Activity
6. Business Incubation.

The direct, indirect and induced impacts were defined as follows for each of these areas:

- ***Energy Efficiency - Electricity***

For the purpose of this analysis, the direct impacts are considered to be equal to the value of electricity savings as they accrue to existing businesses (as savings are recycled through the economy). The indirect impacts accrue to additional supporting businesses (through purchases of goods and services by businesses that receive the direct impacts). The induced impacts result from increased household income and related spending which is driven by the direct and indirect impacts.

- ***Energy Efficiency – Natural Gas***

The direct impacts are considered to be equal to the value of natural gas savings as they accrue to existing businesses (as savings are recycled through the economy). The indirect impacts accrue to additional supporting businesses (through purchases of goods and services by businesses that receive the direct impacts). The induced impacts result from increased household income and related spending which is driven by the direct and indirect impacts.

- ***Renewable Energy – Wind Power, Solar Photovoltaic and Biomass***

In the case of this analysis, the direct impacts result from employees working in the wind power, solar photovoltaic and biomass facilities, the indirect impacts are driven by the facilities themselves as they purchase local goods and services and the induced impacts are derived from increases in area household spending due to both the direct and indirect impacts. Total economic impacts referenced in this study refer to the sum of all three of these impacts.

- ***Alternative Energy - Ethanol***

Direct impacts result from employees working in the ethanol facilities, the indirect impacts are driven by the facilities themselves as they purchase local goods and services and the induced impacts are derived from increases in area household income and spending due to both the direct and indirect impacts. Total economic impacts referenced in this study refer to the sum of all three of these impacts.

- ***Firm Attraction, Expansion & Start Up Activity***

In the case of this analysis, the direct impacts result from employees working at estimated Maryland renewable energy firms, the indirect impacts are driven by the firms themselves as they purchase local goods and services and the induced impacts are derived from increases in area household income and spending due to both the direct and indirect impacts. Total economic impacts referenced in this study refer to the sum of all three of these impacts.

- ***Business Incubation***

Direct impacts are equal to the incubator investment, the indirect impacts are driven by the incubated firms as they purchase local goods and services from local support firms and the induced impacts are derived from increases in area household income and spending due to both the direct and indirect impacts. Total economic impacts referenced in this study refer to the sum of all three of these impacts.

Job Creation and Economic Benefits:

Energy Efficiency - Electricity

The analysis of electricity savings due to improved energy efficiency measured the total economic impacts associated with cost savings of reduced electricity consumption (current and projected) in Maryland and the Baltimore metropolitan area. The idea is that as the State and region achieve increased energy efficiency, electricity consumption will decline. Dollar savings associated with three scenarios of reduced electricity consumption between 2006 and 2025 were estimated:

(1) 20% reduction in electricity consumption (baseline scenario);
(2) 30% reduction (mid-range scenario); and
(3) 40% reduction (high scenario).

Using our economic input/output model, the analysis calculated the economic benefits experienced by the State and region, if these savings were cycled back through local economies. The impacts considered in this analysis did not include jobs and related economic impacts associated with implementing energy efficiency. The economic benefits are therefore understated because of this.

The choice of scenarios was based on the following research findings:

- In 2004, the American Council for an Energy Efficient Economy (ACEEE) conducted a review of published literature assessing the potential for energy efficiency in the United

States. [60]ACEEE looked at eleven studies focusing on various geographies (California, New York, Massachusetts, the entire U.S., etc.). The results of ACEEE's review determined that the median achievable savings potential for electricity is 24 percent over a 20 year horizon or 1.2 percent per year. A summary of the results of this review can be found in Appendix 7.

- A 2004 report produced by Synapse Energy Economics, Inc., conducted a review of four nation-wide studies and four regional studies on energy efficiency and determined the following: "These studies include forecasts of the amount and cost of energy efficiency available through 2010 and, in most cases, 2020. They find that there is enough cost-effective efficiency available to reduce electric demand in 2010 by as much as 11%-23% and in 2020 by as much as 21-35 percent." [61]A summary of the results of this review can also be found in Appendix 7.
- According to 2003 estimates produced by ACEEE [62], Maryland could realistically reduce its electricity consumption (through energy efficiency and conservation efforts) by 5.5 percent over a five year horizon. The 5.5 percent applied to the 20 year horizon considered in this analysis would yield electricity savings of 22 percent, which is greater than the baseline savings scenario considered in this analysis.
- In 2005, a review of seven studies focusing on New England states prepared for the Northeast Energy Efficiency Partnership (NEEP) found that annual achievable electricity savings from energy efficiency programs ranged from 0.7 – 3.15% per year [63]. This equates to 14-63 percent over 20 years. The forecast for the Northeastern U.S. estimated that electricity savings per year from 2004-2013 would be 2.58% per year or over 51 percent over 20 years. A summary of the results of this review can also be found in Appendix 7.
- In 2006, a review of seven studies focusing on Western states prepared for the Western Governors' Association (WGA) found that annual achievable electricity savings from energy efficiency programs ranged from 0.5 – 1.8% per year [64]. This equates to 10-36 percent over 20 years. A summary of the results of this review can also be found in Appendix 7.

The estimates presented in this analysis were calculated using the following steps:

(1) The analysis utilized current and projected electricity consumption data for both Maryland and the Baltimore metro area. Two sets of electricity consumption forecasts (broken out by residential, commercial, industrial and transportation sectors) were considered. The first was produced by the International Center for Sustainable Development (ICSD) and the second by EIA for the Electricity region for the Mid-Atlantic Area Council. To adjust for the difference in electricity growth rates projected

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60 The Technical, Economic and Achievable Potential for Energy-Efficiency in the U.S. – A Meta-Analysis of Recent Studies. Steven Nadel, Anna Shipley and R. Neal Elliott, 2004.

61 Synapse Energy Economics Inc. A Responsible Electricity Future: An Efficient, Cleaner and Balanced Scenario for the US Electricity System, June 11, 2004.

62 ACEEE Estimates of Near-Term Electricity and Gas Savings, R. Neal Elliott, Anna Monis Shipley, Steven Nadel and Elizabeth Brown, August 15, 2003.

63 Optimal Energy, Inc. Economically Achievable Energy Efficiency Potential in New England, May 2005.

64 Western Governors' Association, Clean and Diversified Energy Initiative, January 2006.

by these two sources, the analysis discounted the electricity rates to reflect this difference.

(2) To determine the value of reduced electricity consumption, the analysis used electricity rates produced by the Energy Information Administration.
(3) The analysis disaggregated savings to households using household income distribution data produced by the U.S. Census Bureau (2005 American Community Survey estimates).
(4) The analysis disaggregated savings to industry using industrial distribution data produced by the U.S. Census Bureau (2003 American Community Survey estimates).
(5) Direct savings were entered into the IMPLAN model to derive the total economic impacts including employment, wage, tax revenue and GSP/GMP estimates.

The following assumptions were made:

- Energy prices will keep pace with inflation (in other words, prices are assumed to remain constant over the time horizon considered in this analysis). This assumption errs on the conservative side.
- There is a cost associated with implementing energy efficiency. The analysis assumed a 30% implementation cost evenly spread across the 20 year time horizon. The 30% implementation cost estimate is taken from a 2005 study produced by the Ernest Orlando Lawrence Berkeley National Laboratory[65].
- The estimates of dollar savings due to decreased electricity consumption are discounted by the estimated implementation costs of increased energy efficiency.

Summary of Results:
As detailed in the following figure, reduction in electricity consumption over the 20 year horizon considered in this analysis (2006-2025) is estimated to yield significant economic benefits including an increase in Maryland job creation ranging between 93,400 and 194,562 jobs. Associated wages and salaries for these jobs range from $3.7 billion to nearly $7.7 billion, while expected state and local tax revenues exceed $650 million in the low reduction scenario (20%) and surpass $1.3 billion in the high reduction scenario (40%). The impact on Maryland's GSP is estimated to be quite substantial and ranges from $10.3 to $21.6 billion.

65 Ernest Orlando Lawrence Berkeley National Laboratory. Easing the Natural Gas Crisis: Reducing Natural Gas Prices through Increased Deployment of Renewable Energy and Energy Efficiency.

Figure A: Total Economic Impacts of Reduced Electricity Consumption in Maryland
(Due to Increased Energy Efficiency)

2006-2025	20% Reduction	30% Reduction	40% Reduction
Employment	93,400	142,815	194,562
Wages & Salaries*	$ 3,681.33	$ 5,629.13	$ 7,669.00
State & Local Tax Revenues*	$ 650.06	$ 994.04	$ 1,354.28
Gross State Product(GSP)*	$ 10,368.51	$ 15,855.63	$ 21,603.05
2006-2015			
Employment	21,053	32,922	45,985
Wages & Salaries*	$ 831.92	$ 1,300.93	$ 1,817.14
State & Local Tax Revenues*	$ 147.17	$ 230.14	$ 321.46
Gross State Product(GSP)*	$ 2,359.42	$ 3,689.68	$ 5,153.82
2016-2025			
Employment	72,347	109,893	148,577
Wages & Salaries*	$ 2,849.42	$ 4,328.20	$ 5,851.86
State & Local Tax Revenues*	$ 502.90	$ 763.90	$ 1,032.82
Gross State Product(GSP)*	$ 8,009.09	$ 12,165.95	$ 16,449.22

*millions of dollars

Baltimore impacts are also quite significant and are detailed in Figure B. Job creation ranges between roughly 46,000 and 97,000 jobs. Associated wages and salaries for these jobs range from $1.6 billion to $3.4 billion, while expected state and local tax revenues exceed $289 million in the low reduction scenario (20%) and surpass $603 million in the high reduction scenario (40%). The impact on the Baltimore Metropolitan region's GSP is estimated to be quite substantial and ranges from $4.8 to $9.9 billion.

Figure B: Total Economic Impacts of Reduced Electricity Consumption in the Baltimore Metropolitan Area (Due to Increased Energy Efficiency)

2006-2025	20% Reduction	30% Reduction	40% Reduction
Employment	46,391	70,935	96,637
Wages & Salaries*	$ 1,641.31	$ 2,509.73	$ 3,419.20
State & Local Tax Revenues*	$ 289.83	$ 443.19	$ 603.80
Gross State Product(GSP)*	$ 4,768.67	$ 7,292.30	$ 9,935.65
2006-2015			
Employment	10,457	16,352	22,840
Wages & Salaries*	$ 370.91	$ 580.02	$ 810.17
State & Local Tax Revenues*	$ 65.61	$ 102.61	$ 143.32
Gross State Product(GSP)*	$ 1,085.14	$ 1,696.95	$ 2,370.34
2016-2025			
Employment	35,934	54,583	73,797
Wages & Salaries*	$ 1,270.40	$ 1,929.71	$ 2,609.03
State & Local Tax Revenues*	$ 224.21	$ 340.58	$ 460.48
Gross State Product(GSP)*	$ 3,683.53	$ 5,595.35	$ 7,565.31

*millions of dollars

Energy Efficiency – Natural Gas

The analysis of natural gas savings due to improved energy efficiency measured the total economic impacts associated with cost savings of reduced natural gas consumption (current and projected) in Maryland and the Baltimore metropolitan area. The idea is that as the State and region achieve increased energy efficiency, natural gas consumption will decline. Dollar savings associated with three scenarios of reduced natural gas consumption are estimated:

(1) 10% reduction in natural gas consumption (baseline scenario);
(2) 15% reduction (mid-range scenario); and
(3) 20% reduction (high scenario).

Using the economic input/output model, the analysis calculated the total economic benefits the State and region if these savings were to be cycled back through local economies. The impacts considered in this analysis do not include potential cost savings to Maryland and Baltimore metro consumers due to lower natural gas prices (reduced natural gas demand has been found to lower prices). The analysis also did not consider jobs and related economic impacts associated with implementing energy efficiency.

The choice of scenarios was based on the following research findings:

- In their above mentioned 2004 review that assessed the potential for energy efficiency in the United States, ACEEE determined that the median ***achievable*** savings potential for natural gas is ***9 percent*** over a 20 year horizon or 0.5 percent per year. A summary of the results of this review can be found in Appendix 7.
- According to the above mentioned 2003 estimates produced by ACEEE, Maryland could realistically reduce its natural gas consumption (through energy efficiency and conservation efforts) by 4.2 percent over a five year horizon. The 4.2 percent applied to the 20 year horizon considered in this analysis would yield electricity savings of ***16.8 percent,*** which is greater than the mid-range savings scenario considered in this analysis.
- In a 2006 survey of ten major gas utilities in different regions of the country, done for the Southwest Energy Efficiency Project (SWEEP), average gas savings from the utilities' gas demand-side management (DSM) programs was 0.5% in one year [66]. This equates to 10% over 20 years. Two utilities reported 0.9% and 1.0% annual gas savings, respectively. This equates to 18% and 20%, respectively, over 20 years. The survey also found that the more is spent on gas DSM programs, the more that is saved, in percentage terms. A summary of the results of this review can also be found in Appendix 7.

The estimates presented in this analysis were calculated using the following steps:

1. The analysis utilized current and projected natural gas consumption data for both Maryland and the Baltimore metro area (broken out by residential, commercial, industrial and transportation sectors) from the Maryland energy analysis produced by the International Center for Sustainable Development (ICSD);
2. To determine the value of reduced natural gas consumption, the analysis used natural gas rates produced by the Energy Information Administration;

66 Suzanne Tegen, Howard Geller, Natural Gas Demand-Side Management Programs: A national Survey, SWEEP, January 2006.

3. The analysis disaggregated savings to households using household income distribution data produced by the U.S. Census Bureau (2005 American Community Survey estimates);
4. The analysis disaggregated savings to industry using industrial distribution data produced by the U.S. Census Bureau (2003 American Community Survey estimates);
5. Direct savings were entered into the IMPLAN model to derive the total economic impacts including employment, wage, tax revenue and GSP/GMP estimates.

The following assumptions were made:

- Energy prices will keep pace with inflation. This assumption errs on the conservative side.
- There is a cost associated with implementing energy efficiency. The analysis assumed a 30% implementation cost evenly spread across the 20 year time horizon. The 30% implementation cost estimate is taken from the above-mentioned 2005 study produced by the Ernest Orlando Lawrence Berkeley National Laboratory. The estimate of dollar savings due to decreased natural gas consumption are discounted by the estimated implementation costs of increased energy efficiency.

Summary of Results:
As detailed in the following figure, reduction in natural gas consumption over the 20 year horizon considered in this analysis (2006-2025) is estimated to yield significant economic benefits including an increase in Maryland job creation ranging between approximately 11,500 and 28,300 jobs. Associated wages and salaries for these jobs range from $430 to nearly $879 million, while expected state and local tax revenues exceed $75 million in the low reduction scenario (10%) and approach $155 million in the high reduction scenario (20%). The impact on Maryland's GSP is estimated to be quite substantial and ranges from $1.2 to $2.4 billion.

Figure C: Total Economic Impacts of Reduced Natural Gas Consumption in Maryland
(Due to Increased Energy Efficiency)

2006-2025		**10% Reduction**		**15% Reduction**		**20% Reduction**
Employment		11,551		17,496		28,319
Wages & Salaries*	$	430.29	$	651.66	$	878.97
State & Local Tax Revenues*	$	75.79	$	114.76	$	154.72
Gross State Product(GSP)*	$	1,173.05	$	1,776.45	$	2,395.64
2006-2015						
Employment		3,574		5,461		12,149
Wages & Salaries*	$	133.06	$	203.34	$	276.47
State & Local Tax Revenues*	$	23.41	$	35.77	$	48.63
Gross State Product(GSP)*	$	363.40	$	555.36	$	755.09
2016-2025						
Employment		7,978		12,034		16,170
Wages & Salaries*	$	297.23	$	448.32	$	602.50
State & Local Tax Revenues*	$	52.39	$	78.99	$	106.09
Gross State Product(GSP)*	$	809.65	$	1,221.09	$	1,640.55

*millions of dollars

Baltimore impacts are also quite significant and are detailed in Figure D. Job creation ranges between roughly 6,000 and 14,000 jobs. Associated wages and salaries for these jobs range from $191 million to $391 million, while expected state and local tax revenues exceed $33 million in the low reduction scenario (10%) and amount to $69.0 million in the high reduction scenario (20%). The impact on the Baltimore Metropolitan region's Gross Metro Product (GMP) is estimated to be quite substantial and ranges from nearly $540 million to $1.1 billion.

Figure D: Total Economic Impacts of Reduced Natural Gas Consumption in the Baltimore Metropolitan Area (Due to Increased Energy Efficiency)

2006-2025	**10% Reduction**	**15% Reduction**	**20% Reduction**
Employment	5,737	8,690	14,066
Wages & Salaries*	$ 191.84	$ 290.54	$ 391.89
State & Local Tax Revenues*	$ 33.79	$ 51.16	$ 68.98
Gross State Product(GSP)*	$ 539.51	$ 817.02	$ 1,101.80
2006-2015			
Employment	1,775	2,713	6,034
Wages & Salaries*	$ 59.32	$ 90.66	$ 123.26
State & Local Tax Revenues*	$ 10.44	$ 15.95	$ 21.68
Gross State Product(GSP)*	$ 167.13	$ 255.42	$ 347.28
2016-2025			
Employment	3,962	5,977	8,031
Wages & Salaries*	$ 132.52	$ 199.88	$ 268.62
State & Local Tax Revenues*	$ 23.36	$ 35.22	$ 47.30
Gross State Product(GSP)*	$ 372.37	$ 561.60	$ 754.52

*millions of dollars

Renewable Energy

The analysis estimated the total economic impacts attributable to the operations of onshore wind facilities, solar photovoltaics and biomass facilities with the capacity to power enough renewable energy to replace select proportions of current and projected electricity consumption in Maryland and the Baltimore metropolitan area. Specifically, this analysis considers the following scenarios of renewable power generation over 20 year horizon:

(1) 10% of current and projected electricity consumption;
(2) 20% of current and projected electricity consumption; and
(3) 30% of current and projected electricity consumption.

In addition, the analysis considers the following scenarios of renewable power generation over a 10 year horizon:

(1) 5% of current and projected electricity consumption;
(2) 10% of current and projected electricity consumption; and
(3) 15% of current and projected electricity consumption.

The analysis did not consider the potential cost savings to consumers due to the introduction of a competitive energy source (wind power, solar power or biomass). The economic benefits are therefore understated because of this. The choice of scenarios was based on the following research findings obtained from the above mentioned study by NREL on Maryland Renewable Energy Resources and Costs. These findings are reflected in the Table below. As shown in the Table, in 2004, renewable energy could have provided over 30% of total Maryland electricity sales using low capacity factor assumptions and over 136% if higher capacity factors.

Technology	**MD Electric Sales 2004 MWh**	**RE Potential Low MWh**	**RE Potential High MWh**
Wind on Shore		560,640	5,606,400
Wind off shore		5,212,200	66,576,000
Solar PV		11,650,800	16,644,000
Biomass direct		2,472,072	2,472,072
MSW landfill gas		275,940	275,940
Total	**66,892,000**	**20,171,652**	**91,574,412**
% of 2004 Electric Sales		30.16%	136.90%
Solar thermal and new hydro not included			

The estimates presented in this analysis were calculated using the following steps:

(1) The analysis utilized current and projected electricity consumption data for both Maryland and the Baltimore metro area. Two sets of electricity consumption forecasts (broken out by residential, commercial, industrial and transportation sectors) were considered. The first was produced by the International Center for Sustainable Development (ICSD) and the second by EIA for the Electricity region for the Mid-Atlantic Area Council. To adjust for the difference in electricity growth rates projected by these two sources, the analysis discounted the electricity rates to reflect this difference.
(2) For each of the six scenarios, the analysis converted the appropriate proportion of electricity consumption from trillions of British thermal units (BTUs) to megawatt hours (MW).
(3) Once the annual MW generating capacity was established for each scenario (previous step), the analysis estimated the number of operational jobs necessary to staff renewable

power facilities by applying an operational jobs per MW ratio of 0.79 to each scenario's generating capacity [67].

(4) The number of jobs per scenario was then run through the IMPLAN model to derive the total economic impacts including employment, wage, tax revenue and GSP/GMP estimates.

The following assumptions were made:

- The impacts for each region (the State and Baltimore metro area) assume that all necessary renewable facilities will be located within each region.
- According to published research, the renewable sector creates a larger jobs impact than other fossil fuel sectors. This factor is partially attributed to the fact that wind and solar are free resources while biomass is renewable. The relative youth of the sector is a contributing factor as well. As industry investments rise and economies of scale are increasingly realized, it can be expected that the jobs impact for renewable facilities will decline beyond a 5 to 10 year period. According to a 2002 CALPIRG Charitable Trust study, conservative jobs per MW estimates would register a decline of roughly 5 percent per year (beyond a 10 year horizon)[68]. The analysis discounted the total economic impacts in each scenario by 5 percent per year beyond the first 10 years of the time horizon considered in this analysis (i.e., for years 2016-2025).

Summary of Results:

The operational impacts of annual MW renewable capacity generation considered in this analysis are substantial and include an increase in Maryland job creation ranging between nearly 15,000 and more than 46,000 jobs over the 20 year horizon. Associated wages and salaries for these jobs range from $700 million to more than $2.24 billion, while expected state and local tax revenues exceed $72 million in the low proportion scenario (10%) and are $224 million in the high proportion scenario (30%). The impact on Maryland's GSP is estimated to be quite substantial and ranges from $1.8 billion to $5.6 billion.

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[67] The jobs per MW ratio was obtained from a 2004 NJPIRG study entitled "Renewables Work, Job Growth from Renewable Energy Development in the Mid-Atlantic

68 Renewables Work, Job Growth from Renewable Energy Development in California. CALPIRG Charitable Trust, June 2002.

Figure E: Total Economic Impacts of Renewable Facilities with the Collective Capacity to Generate Select Proportions of Maryland Electricity Consumption

2006-2025	**10% Proportion**	**20% Proportion**	**30% Proportion**
Employment	15,030	30,552	46,723
Wind	11,569	23,516	35,963
Solar PV	189	383	586
Biomass	3,273	6,652	10,173
Wages & Salaries*	$ 707.11	$1,439.86	$ 2,203.28
Wind	$544.27	$1,108.27	$1,695.88
Solar PV	$ 8.87	$ 18.07	$ 27.65
Biomass	$ 153.97	$ 313.51	$ 479.74
State & Local Tax Revenues*	$ 72.11	$ 146.84	$ 224.70
Wind	$55.51	$113.03	$172.95
Solar PV	$ 0.91	$ 1.84	$ 2.82
Biomass	$ 15.70	$ 31.97	$ 48.93
Gross State Product(GSP)*	$1,818.81	$3,703.58	$ 5,667.25
Wind	$1,399.96	$2,850.68	$4,362.14
Solar PV	$ 22.83	$ 46.48	$ 71.13
Biomass	$ 396.03	$ 806.42	$ 1,233.98

*millions of dollars

Ten Year Impacts

The operational impacts of annual MW renewable capacity generation considered in this analysis are substantial and include an increase in Maryland job creation ranging between nearly 4,000 and more than 11,000 jobs over the 10 year horizon. Associated wages and salaries for these jobs range from $182 million to more than $550 million, while expected state and local tax revenues exceed $18 million in the low proportion scenario (5%) and are $56 million in the high proportion scenario (15%). The impact on Maryland's GSP is estimated to be quite substantial and ranges from $460 billion to $1.4 billion.

Figure F: Total Economic Impacts of Renewable Facilities with the Collective Capacity to Generate Select Proportions of Maryland Electricity Consumption over ten year horizon

2006-2015	**5% Proportion**	**10% Proportion**	**15% Proportion**
Employment	3,869	7,797	11,790
Wind	2,978	6,001	9,075
Solar PV	49	98	148
Biomass	842	1,698	2,567
Wages & Salaries*	$ 182.64	$ 368.08	$ 556.56
Wind	$140.58	$283.31	$428.39
Solar PV	$ 2.29	$ 4.62	$ 6.99
Biomass	$ 39.77	$ 80.15	$ 121.19
State & Local Tax Revenues*	$ 18.63	$ 37.54	$ 56.76
Wind	$14.34	$28.89	$43.69
Solar PV	$ 0.23	$ 0.47	$ 0.71
Biomass	$ 4.06	$ 8.17	$ 12.36
Gross State Product(GSP)*	$ 469.78	$ 946.77	$ 1,431.58
Wind	$361.59	$728.74	$1,101.90
Solar PV	$ 5.90	$ 11.88	$ 17.97
Biomass	$ 102.29	$ 206.15	$ 311.71

*millions of dollars

Baltimore impacts are also quite significant and are detailed in Figure F. Job creation approaches 7,500 in the low scenario to more than 23,000 jobs in the high scenario. Associated wages and salaries for these jobs range from $315 million to more than $1.3 billion, while expected state and local tax revenues exceed $32 million in the low proportion scenario (10%) and surpass $100 million in the high proportion scenario (30%). The impact on the Baltimore Metropolitan region's GMP is estimated to be quite substantial and ranges from nearly $840 million to nearly $1.9 billion.

Figure G: Total Economic Impacts of Renewable Facilities with the Collective Capacity to Generate Select Proportions of Baltimore Metropolitan Area Electricity Consumption

2006-2025	**10% Proportion**	**20% Proportion**	**30% Proportion**
Employment	7,491	15,201	23,233
Solar PV	5,766	11,700	17,883
Wind	94	191	292
Biomass	1,631	3,310	5,059
Wages & Salaries*	$ 315.26	$ 846.56	$ 1,302.24
Solar PV	$242.66	$651.61	$1,002.35
Wind	$ 3.96	$ 10.63	$ 16.34
Biomass	$ 68.64	$ 184.33	$ 283.55
State & Local Tax Revenues*	$ 32.15	$ 65.47	$ 100.18
Solar PV	$24.75	$50.39	$77.11
Wind	$ 0.40	$ 0.82	$ 1.26
Biomass	$ 7.00	$ 14.26	$ 21.81
Gross State Product(GSP)*	$ 836.51	$ 1,703.35	$ 1,949.78
Solar PV	$643.87	$1,311.08	$1,500.76
Wind	$ 10.50	$ 21.38	$ 24.47
Biomass	$ 182.14	$ 370.89	$ 424.54

*millions of dollars

Ten Year Impact

Baltimore impacts are also quite significant and are detailed in Figure F. Job creation approaches 2,000 in the low scenario to more than 5,800 jobs in the high scenario over the ten year horizon. Associated wages and salaries for these jobs range from $81 million to more than $248 million, while expected state and local tax revenues exceed $8.3 million in the low proportion scenario (5%) and surpass $25 million in the high proportion scenario (30%). The impact on the Baltimore Metropolitan region's GMP is estimated to be quite substantial and ranges from nearly $216 million to $500 million.

Figure H: Total Economic Impacts of Renewable Facilities with the Collective Capacity to Generate Select Proportions of Baltimore Metropolitan Area Electricity Consumption over a ten year horizon

2006-2015	**5% Proportion**	**10% Proportion**	**15% Proportion**
Employment	1,922	3,873	5,856
Solar PV	1,479	2,981	4,507
Wind	24	49	73
Biomass	418	843	1,275
Wages & Salaries*	$ 81.43	$ 164.11	$ 248.14
Solar PV	$62.68	$126.31	$191.00
Wind	$ 1.02	$ 2.06	$ 3.11
Biomass	$ 17.73	$ 35.73	$ 54.03
State & Local Tax Revenues*	$ 8.30	$ 16.74	$ 25.31
Solar PV	$6.39	$12.88	$194.79
Wind	$ 0.10	$ 0.21	$ 3.18
Biomass	$ 1.81	$ 3.64	$ 55.10
Gross State Product(GSP)*	$ 216.06	$ 435.44	$ 658.41
Solar PV	$166.30	$335.16	$506.79
Wind	$ 2.71	$ 5.47	$ 8.26
Biomass	$ 47.04	$ 94.81	$ 143.36

*millions of dollars

Construction Impacts of a Hypothetical Maryland Wind Farm

To further illustrate the impacts that investment in the renewable industry could have on Maryland's economy, the analysis estimated the construction impacts associated with a hypothetical 50 MW wind facility in Maryland. It should be noted that construction impacts are temporary in nature and span the build-out period of the construction project.

The estimates were calculated using the following steps:

1. According to a 2006 study published by the Jacob France Center, 21 construction jobs are created for every 10MW of wind power generating capacity. The analysis applied this number to the 180MW of wind facilities currently being planned or proposed in Maryland.
2. The resulting number of direct construction employees (378) was then inputted into our IMPLAN model to generate total economic impacts.
3. Results were then scaled down to a 50MW basis.

Summary of Results:
Annual construction jobs total 181 and associated wages exceed $8 million. Tax revenues approach $1 million, while the impact on GSP surpasses $19 million.

Figure I: Annual Economic Impacts of a Hypothetical, 50MW Maryland Wind Facility

Annual	Direct	Indirect	Induced	Total
Employment	105	24	51	181
Wages & Salaries*	$5.3	$1.2	$1.8	$8.3
State & Local Tax Revenues*	$0.4	$0.1	$0.2	$0.8
Gross State Product(GSP)*	$11.3	$2.8	$5.1	$19.3

*millions of dollars

Alternative Fuels
For the purpose of the analysis, the term alternative fuel refers to biofuels such as ethanol (grain based fuel) and biodiesel. The focus of this portion of the analysis, however, was limited to one type of alternative fuel in particular: ethanol. The analysis estimated the total economic impacts attributable to the operations of ethanol facilities with the capacity to generate enough alternative fuel to replace select proportions of current and projected gasoline consumption in Maryland and the Baltimore metropolitan area. Specifically, this analysis considers the following ethanol utilization scenarios:

(1) 10% of gasoline consumption;
(2) 20% of gasoline consumption; and
(3) 30% of gasoline consumption.

The impacts considered in this analysis do not include potential cost savings to consumers due to the introduction of a competitive energy source (ethanol). The economic benefits are therefore understated because of this. The impacts for the State and the Baltimore metro area also assume that all necessary ethanol facilities will be located within each region.

The estimates presented in this analysis were calculated using the following steps:

1. The analysis utilized current and projected petroleum consumption data for both Maryland and the Baltimore metro area broken out by residential, commercial, industrial and transportation sectors and produced by the International Center for Sustainable Development (ICSD);
2. For each of the three scenarios, the analysis converted the appropriate proportion of petroleum consumption from trillions of British thermal units (BTUs) to gallons of ethanol;
3. Once the annual amount of ethanol (in gallons) was established for each scenario (previous step), the analysis estimated the number of operational jobs necessary to staff ethanol facilities by applying an operational jobs per million of gallons ratio (18:1) to each scenario's utilization level;
4. The number of jobs per scenario was then run through the IMPLAN model to derive the total economic impacts including employment, wage, tax revenue and GSP/GMP estimates.

Summary of Results:
As detailed in the following figure, the impacts of ethanol facilities necessary to generate sufficient fuel for the scenarios considered in this analysis are substantial and include an increase in Maryland job creation ranging between 56,867 and more than 182,000 jobs. Associated wages and salaries for these jobs range from $1.9 to nearly $6.0 billion, while expected state and local tax revenues exceed $28 million in the low proportion scenario (10%) and approach $90.6 million in the high proportion scenario (30%). The estimated impact on Maryland's GSP ranges from nearly $8 to more than $25 billion.

Figure J: Total Operating Impacts of Ethanol Facilities Necessary to Generate Select Proportions of Maryland Energy Consumption

2006-2025	**10% Proportion**	**20% Proportion**	**30% Proportion**
Employment	56,867	118,356	182,311
Wages & Salaries*	$1,886.6	$3,926.5	$6,048.2
State & Local Tax Revenues*	$28.3	$58.8	$90.6
Gross State Product(GSP)*	$7,970.3	$16,588.5	$25,552.3

*millions of dollars

Baltimore impacts are also quite significant and are detailed in Figure K. Job creation ranges between roughly 28,000 to more than 90,000 jobs. Associated wages and salaries for these jobs range from $841 million to nearly $2.7 billion, while expected state and local tax revenues exceed $12.6 million in the low proportion scenario (10%) and surpass $40 million in the high proportion scenario (30%). The estimated impact on the Baltimore Metropolitan region's GMP ranges from nearly $3.6 to $11.7 billion.

Figure K: Total Operating Impacts of Ethanol Facilities Necessary to Generate Select Proportions of Baltimore Metropolitan Area

2006-2025	**10% Proportion**	**20% Proportion**	**30% Proportion**
Employment	28,245	58,786	90,552
Wages & Salaries*	$841.1	$1,750.6	$2,696.6
State & Local Tax Revenues*	$12.6	$26.2	$40.4
Gross Metro Product(GMP)*	$3,665.7	$7,629.4	$11,752.0

*millions of dollars

Construction Impacts of a Hypothetical Maryland Ethanol Plant
To further illustrate the impacts of investment in alternative fuels, the analysis estimated the construction impacts associated with a hypothetical 50 million gallons per year ethanol plant in Maryland. It should be noted that construction impacts are temporary in nature and span the build-out period of the construction project.

The estimates presented in this analysis were calculated using the following steps:

1. According to a 2006 study produced by the University of Missouri, 14 construction jobs are created for every gallon of ethanol refining capacity.
2. The resulting number of direct construction employees (577) was then entered into our IMPLAN model to generate total economic impacts.

Summary of Results:
As shown in Figure L, below, annual construction jobs approach 1,000 and associated wages exceed $45 million. Tax revenues surpass $4.2 million, while the impact on GSP exceeds $105 million.

Figure L: Annual Economic Impacts of a Hypothetical, 50 Million Gallon, Maryland Ethanol Facility

Annual	**Direct**	**Indirect**	**Induced**	**Total**
Employment	577	134	282	993
Wages & Salaries*	$29.0	$6.6	$9.8	$45.4
State & Local Tax Revenues*	$2.5	$0.6	$1.1	$4.2
Gross State Product(GSP)*	$62.3	$15.6	$28.0	$105.8

*millions of dollars

Firm Attraction, Expansion & Start Ups
The analysis considered published research detailing the experiences other states have had in leveraging clean energy policies to attract firms to start up, expand and/or locate within their state. While many states have enjoyed success in these activities, it was difficult to isolate the effect of the implementation of clean energy policies on commercial location. In fact, much of the available literature does not distinguish between firm attraction, expansion and start up activity and, as a consequence, the analysis' estimates incorporate all of these.

While the analysis estimated the total economic impacts associated with potential firm attraction, expansion and start up activity Maryland's clean energy sector, firm attraction, retention and start up activity estimates were limited to energy efficiency and renewable energy development only. The analysis did not include impacts of investment in alternative fuels or other areas and relied primarily on the experience of Massachusetts as detailed in the report entitled *"Energy Efficiency and Renewable Energy A Growing Opportunity for Massachusetts"*. The study was conducted in 2002 by the Massachusetts Technology Renewable Energy Trust.

The above-mentioned report determined (via survey) that Massachusetts' energy efficiency sector employed 8,000 persons in 2002 and that the State's renewable energy sector employed 2,000 persons.

Firms surveyed include firms deriving all or a portion of their business from:

1. creation and implementation of energy efficiency equipment and techniques;
2. design and execution of energy conservation measures, including integrated designs such as green buildings;
3. design, manufacture, construction and operation of technologies which generate electricity and energy using renewable resources and;
4. installation and management of distributed energy resources and programs on both the supply- and demand-side of the market.

The analysis scaled down Massachusetts' jobs to better reflect the size of Maryland's economy. It then calculated estimates of job creation within the renewable and energy efficiency sectors for four scenarios:

1. assuming that Maryland will achieve 25% of Massachusetts's job creation,

2. assuming that we will achieve 50% of Massachusetts's job creation,
3. assuming we will achieve 75% and
4. assuming we will achieve 100% of Massachusetts's job creation.

As shown in Figure M, estimates of potential renewable and energy efficiency job creation in Maryland (based on the above-mentioned assumptions) range from 1,864 to 7,454.

Figure M: Estimated Jobs Impacts for Maryland (Using the Experience of Massachusetts)

	MD Jobs
25% Scenario	1,864
50% Scenario	3,727
75% Scenario	5,591
100% Scenario	7,454

The analysis then entered these direct employment numbers into our IMPLAN model to derive the total economic impacts. It should be noted, however, that the Massachusetts study does not specify the time horizon over which renewable and energy efficiency employment was created. Consequently, the firms listed in the report were contacted to determine the year each firm began its Massachusetts operations. Responses were received from nine firms, as shown in Figure N. The time horizon indicated by these firms ranges from 1978 through 2002 (the year that the Massachusetts Technology Renewable Energy Trust conducted its survey). The analysis assumes that this time span of 24 years is applicable to the results of the Massachusetts study.

Figure N: Renewable & Energy Efficiency Firms

Firm Name	Location	Year MA Operations Began
Conservation Services Group	Westborough, MA	1984
Lanthorn Technologies, Inc.	Boston, MA	2001
Solar Power		
Evergreen Solar	Marlboro, MA	1994
Wind Energy		
Second Wind	Somerville, MA	1980
Fuel Cell Energy		
Acumentrics	Westwood, MA	1994
Ballard Material Products	Lowell, MA	1978
CellTech Power	Westborough, MA	1998
Nuvera Fuels Cells	Cambridge, MA	2000
Hydro and Ocean Power		
Enel North America	Andover, MA	1985 (Renamed Enel in 2003)
Beacon Power	Wilmington, MA	1997

Summary of Results:

The analysis assumes a 24 year time horizon for these results (as determined above). Figure O, below, details total jobs impacts for Maryland ranging from 3,750 to nearly 15,000. Associated wages and salaries for these jobs range from $177 million to over $708 million, while expected state and local tax revenues exceed $18 million in the low proportion scenario (25%) and surpass $72 million in the high proportion scenario (100%). The estimated impact on Maryland's GSP ranges from nearly $455 million to more than $1.8 billion. For Baltimore, job impacts range from 1,863 to 7,450, and associated wages and salaries for these jobs range from $81 million to over $325 million. Expected state and local tax revenues range from over $8 million to over $33 million, and the estimated impact on Baltimore GSP ranges from over $209 million to more than $837 million.

Figure O: Economic Impacts Associated with Firm Attraction, Expansion & Start Up Activity in Maryland and the Baltimore Metropolitan Region

24 Year Time Horizon	**25%**	**50%**	**75%**	**100%**
MD Employment	3,750	7,500	11,250	14,999
MD Wages & Salaries*	$177.00	$354.00	$531.10	$708.10
MD State & Local Tax Revenues*	$18.10	$36.10	$54.20	$72.20
MD Gross State Product(GSP)*	$455.30	$910.70	$1,366.00	$1,821.30
BM Employment	1,863	3,725	5,588	7,450
BM Wages & Salaries*	$81.41	$162.81	$244.26	$325.67
BM State & Local Tax Revenues*	$8.32	$16.60	$24.93	$33.21
BM Gross State Product(GSP)*	$209.40	$418.85	$628.25	$837.65

*millions of dollars

Business Incubation

To determine the economic impact of the incubation of energy firms in Maryland, the analysis examined other states' experience regarding energy-related incubated firms. From these data, we extracted the industrial distribution of firms likely to be incubated in Maryland. We assumed that firms would be distributed in four areas

(1) Specialized Construction
(2) Environmental Manufacturing
(3) Architectural and Engineering Services
(4) Specialized Design Services

Within these fairly broad categories, numerous types of firms are represented. We further assumed a predetermined level of funding support for the incubator of $10 million per year. We then entered these expenditures into our IMPLAN model to derive total, annual economic impacts. In essence, we do not speculate as to the number of firms that would be served by a Maryland energy incubator.

Summary of Results:

As detailed in Figure P, below, the Maryland yearly employment impacts total 159 jobs, while associated wages and salaries for these jobs for a year exceed $7 million. Yearly estimated state and local tax revenues approaches $1 million and the estimated yearly impact on Maryland's GSP exceeds $18 million. These impacts are expected to happen wherever the incubator is located. For Baltimore, the estimated employment impacts total 79 jobs, and the associated wages and salaries for these jobs total to $3.4 million. Annual estimated state and local tax revenues in Baltimore are $320,000 and the estimated annual impact on Baltimore' GSP is over $8.3 million.

Figure P: Economic Impacts Associated with Incubated Energy Firms in Maryland and the Baltimore Metropolitan Region

Annual	Direct	Indirect	Induced	Total
MD Employment	81	32	46	159
MD Wages & Salaries*	$4.30	$1.50	$1.60	$7.40
MD State & Local Tax Revenues*	$0.40	$0.10	$0.20	$0.70
MD Gross State Product(GSP)*	$10.00	$3.60	$4.50	$18.10
BM Employment	40	16	23	79
BM Wages & Salaries*	$1.98	$0.69	$0.74	$3.40
BM State & Local Tax Revenues*	$0.18	$0.05	$0.09	$0.32
BM Gross State Product(GSP)*	$4.60	$1.66	$2.07	$8.32

* millions of dollars

Cumulative Results (Energy Efficiency, Renewable Energy, Alternative Fuels)

Since a reduction in electricity consumption translates into a reduction in natural gas, renewable energy and alternative energy consumption (which each comprise a portion of Maryland's electricity consumption), cumulative impacts cannot be summed directly but need to be discounted. The analysis discounts cumulative impacts by 20 percent. This discount rate is conservative due to the fact that currently, renewable energy, natural gas and alternative fuels comprise roughly 15-20 percent of Maryland's energy use. However, this proportion is expected to increase over the time horizon considered in this study. Cumulative impacts for Maryland and Baltimore are detailed in Figure Q, below.

Figure Q: Cumulative Economic Impacts (Efficiency, Renewable & Alternative Fuels Scenarios), 2006-2025, for Maryland and Baltimore

Scenario	Employment	Wages & Salaries*	State & Local Tax Revenues*	Gross State Product (GSP)*
MD Baseline	94,883	$3,804.9	$633.3	$10,559.5
MD High	212,262	$8,441.5	$1,370.7	$23,322.4
BM Baseline	47,128	$1,750.0	$291.3	$4,856.5
BM High	105,429	$3,882.4	$630.4	$10,726.4

*millions of dollars

The results presented in the economic impact analysis discussed above have been conservatively estimated. In a real sense, however, the economic benefits of renewable energy consumption enumerated above are too much understated. The reason is that, if the renewable energy-based electricity consumed in Maryland is also generated in Maryland, the amount of money paid for this electricity does not leave the State. By remaining in Maryland, this money will have additional secondary multiplicative impacts in the State similar to that of the money that is saved as a result of electricity energy efficiency. This money paid for renewable energy will also become someone's income and will eventually be spent again on other goods and services.

Money that is paid for fossil fuel- based electricity, on the other hand, will soon leave the state, because it is mostly used to pay for the cost of the fossil fuels used to generate this electricity, and these fuels are mostly produced outside of Maryland. The same can be said for nuclear materials. As pointed out in our analysis of Maryland energy use, only 6.4 % of the coal used to generate electricity is mined in Maryland. The estimated economic benefits associated with the three renewable energy scenarios (10, 20, and 30% renewables) can, therefore, be legitimately increased by amounts that are equal to the benefits associated with similar (10, 20 and 30%) improvements in electricity energy efficiency. These additional secondary economic impacts for Maryland and Baltimore can be found in Figures R and S, below. As was the case with the previous cumulative results shown in Figure M, these numbers have been discounted by 20 percent. The same reasoning can, of course, be applied to alternative fuels (ethanol, biodiesel, and hydrogen), if they are produced and used within the State. An estimate of the additional secondary impacts for biofuels, however, requires extensive analysis and will need to be conducted in the future.

Figure R: Additional Secondary Economic Impacts of Renewables-Based Electricity Consumption in Maryland

2006-2025	**10% Renewables**	**20% Renewables**	**30% Renewables**
Employment	48,836	74,720	114,252
Wages & Salaries*	$ 1,924.80	$ 2,945.06	$ 4,503.30
State & Local Tax Revenues*	$ 340.00	$ 520.05	$ 795.23
Gross State Product (GSP)*	$ 5,421.44	$ 8,294.80	$ 12,684.50

*millions of dollars

Figure S: Additional Secondary Economic Impacts of Renewables-Based Electricity Consumption in Baltimore

2006-2025	**10% Renewables**	**20% Renewables**	**30% Renewables**
Employment	19,418	37,113	56,748
Wages & Salaries*	$ 686.99	$ 1,313.05	$ 2,007.78
State & Local Tax Revenues*	$ 121.31	$ 231.86	$ 354.55
Gross State Product (GSP)*	$ 1,995.98	$ 3,814.94	$ 5,833.84

*millions of dollars

If the additional secondary economic impacts of renewables-based electricity consumption are included, the estimated overall cumulative economic impacts of efficiency, renewables and alternative fuels are as detailed in Figure T, below.

Figure T: Cumulative Economic Impacts (Efficiency, Renewable & Alternative Fuels Scenarios), 2006-2025, for Maryland and Baltimore

Scenario	Employment	Wages & Salaries*	State & Local Tax Revenues*	Gross State Product (GSP)*
MD Baseline	143,719	$5,729.7	$973.3	$15,980.9
MD High	326,514	$12,944.8	$2,165.9	$36,006.9
BM Baseline	66,546	$2,437.0	$412.6	$6,852.5
BM High	162,177	$5,890.2	$985.0	$16,560.2

*millions of dollars

Maryland's Clean Energy Competitive Position

For a number of reasons, Maryland is in a good competitive position to capture the growth of the clean energy sector and avail itself of some of the employment and other benefits identified above by establishing a clean energy center. A study done by the Jacob France Institute of the University of Baltimore, as part of this feasibility study, has highlighted several of these reasons. In addition, ICSD conducted a large number of interviews with universities, institutes, NGOs, companies and other organizations regarding their interests in clean energy and participation in a Maryland Clean energy Center.

Renewable Energy:
While the State's installed base of clean energy projects is currently limited, renewable energy is starting to receive more attention in Maryland. There are a several renewable energy projects currently being considered in the State, including a number of wind, ethanol, biodiesel, and biomass projects. Below is a listing of some of these projects.

Ethanol

- Atlantic Ethanol, $100 million, 54-100 MG plant in Baltimore City;
- Chesapeake Renewable Energy, LLC, $120 million, 50 MG facility in Somerset County;
- Ecron, $150 million, 100 MG facility in Baltimore City;
- Greenstock , 30 MG facility in Dorchester County; and
- Maryland Grain Producers Board, 50 MG facility.

Bio Diesel

- Cropper/Maryland Biodiesel, $1.2 million 5 MG facility in Worcester County;
- Windridge Farms/Chesapeake Green Fuels $4 million, 30 MG facility;
- Valley Proteins project under consideration in Curtis Bay; and
- Perdue, $15-18 million, 15 MG facility.

Biomass

- Allen Family Foods/JCR Facility in Dorchester County;
- Antilles, poultry litter to electric power in Somerset County;
- FibroShore, poultry litter to electric power;
- Pogo Tree Experts, wood waste to electric power, in Montgomery County;
- Capstone/Waschmuth, poultry litter to electric power; and
- Sudley Landfill, biomass and methane to electric power in Anne Arundel County.

Wind Power

- Clipper Windpower, 100 MW facility in Garrett County;
- U.S. Windforce, 40 MW in Allegany and Garrett County; and
- Synergics, 40 MW in Garrett County

Maryland has recently instituted a renewable portfolio standard, which requires 3.5% of the state's electricity be generated from renewable resources in 2006, increasing to 10% by 2018 and dropping to 7.5% by 2019 and thereafter. Good to excellent renewable energy resources have recently been identified in the State. Maryland's strategic emphasis on farmland preservation is starting to focus more and more attention on bio-based energy sources, including ethanol, biodiesel and poultry waste. With regard to wind energy, Maryland has 142 businesses with 8,355 employees that are either involved - or that could potentially become involved - in wind-related production. The Renewable Energy Policy Project list Maryland as also having 105 businesses with 5,120 employees that could potentially benefit from expanded manufacturing of solar cells. Given the losses in manufacturing activity and employment in the State, promoting the development of wind and solar power component production, and other renewable-energy technology equipment production, could assist in efforts to stabilize Maryland's declining manufacturing sector.

Clean Energy Research:

Maryland's strong position in technology research and business activity creates a comparative advantage for the State if it decides to effectively promote the development of alternative and clean energy technologies and businesses. Maryland is a technology-driven state. The Milken Institute ranks Maryland fourth nationally in its State Science and Technology Index. The strength of Maryland's high technology sector has also been a key driver in the State's recent economic performance. Maryland is also a leader in university and federal research and development activities as well as high technology business activity. As a national leader in technology research and development activities, Maryland's base of university and federal research can and should play a major role in the development of the alternative and clean energy industry in Maryland. Many of Maryland's leading high technology companies have directly spun out of or have been created by entrepreneurs with links to Maryland's substantial base of university and federal research programs. Similarly, Maryland's university and federal research programs present a clear opportunity for the generation of new spin-off alternative and clean energy technology companies.

There are two major research universities in Maryland; the University of Maryland, College Park (UMCP) and Johns Hopkins University (JHU). Both of these universities have extensive research centers and are currently very interested in clean energy development. Both Universities are also interested in partnering with a potential Maryland Clean Energy Center. Described below are some of their current research and other interests related to clean energy.

University of Maryland, College Park (UMCP)

The University of Maryland has extensive involvement with clean energy-related research. UMCP's Center for Environmental Energy Engineering (CEEE) is a leader in research and education in "environmentally-responsible and economically-feasible" distributed energy conversion and thermal management systems for buildings, transportation, and electronic cooling. Research in CEEE is conducted with support from government and various industrial sponsors and contains shared projects that are organized in four research consortia:

- Alternative Cooling Technologies and Application
- Integrated Systems Optimization
- Cooling, Heating and Power; and
- Advance Heat Transfer/Advanced Heat Exchangers

The Reacting Flow Lab and Center for Fuel Cell Research also operates within CEEE. The research in this Lab is focused on several areas, including (1) catalytic oxidation for combustion and hydrogen production applications, (2) solid oxide fuel cells, (3) catalytic reduction of NO in exhaust after treatment, (4) lean-premixed combustion, (5) fuel cell system integration, (6) large-scale chemical releases, detonations or fire scenarios, and (7) power generation from thermoelectrics. This research is being conducted in collaboration with faculty located in the Engineering College and the Department of Chemistry and Biochemistry at UMCP, as well as with colleagues at other universities and government laboratories.

The University of Maryland's Clark School of Engineering has designated energy research as a priority across engineering disciplines. Clark School researchers have long been involved in a wide range of energy research projects which they will continue to pursue. At the same time, the school focuses special attention on developing new energy sources, and improving existing ones for electric power, transportation and new generations of mobile systems for communications, computing, national security and medical applications. The Clark School of Engineering also oversees the newly established Maryland Energy Research Center (MERC) which serves as a multidisciplinary center focused on alternative energy and affiliated issues. A key goal of the Center is to bring new directions and unity to the university's many energy-related programs. The Center will initially focus on seven principal areas of energy technology research: hydrogen fuel-cell systems; small-scale power systems for mobile electronics and small-scale propulsion systems; advanced nano-film solar energy conversion; next-generation nuclear reactors for power and transportation applications; bioprocesses for fuel production; fusion; and oil recovery, transport and processing. In addition, the Center will undertake research initiatives in energy policy and economics. These research areas will also form the basis for education and training programs, in which many colleges may participate, to develop next generation practitioners and outreach programs around energy issues and options.

UMCP's College of Agriculture and Natural Resources is also involved in bioenergy research. One of their research projects is evaluating the use of hybrid poplars and switch grass for ethanol production. The University also created an incubation program, the Technology Advancement Program (TAP), as part of the Maryland Technology Enterprise Institute (MTECH). The University of Maryland Biotechnology Institute (UMBI) has played a key role in advancing biotechnology in Maryland and throughout the world. It is internationally recognized for its work in human virology and AIDS, marine biotechnology, medical biotechnology, structural and systems biology. UMBI is also very interested in the production of biofuels, such as cellulosic-based ethanol, algae-based biodiesel, and biohydrogen. UMBI has also expressed a strong interest in becoming a strategic partner of a potential Maryland Clean Energy Center.

Johns Hopkins University (JHU)

According to the JHU's Vice Provost for Research, Dr. Theodore Poehler, there is significant interest at this University in problems related to the environment and energy, as well as the related policy issues. He identified the programs of the Institute for Policy Studies, the Center for a Livable Future, and the School of Advanced International Studies as most relevant to the operation of a Maryland Clean Energy Center. Three professors located at JHU were identified as having research interests that include clean energy. These faculty members are Dr. Benjamin Hobbs, Dr. Hugh Ellis, and Dr. Joseph Katz.

- Dr. Hobbs is a Professor in the Department of Geography and Environmental Engineering. His research interests include environmental and energy systems analysis and economics, multi-objective and risk analysis, ecosystem management, mathematical programming models of imperfect energy markets, and stochastic electric power planning models.
- Dr. Ellis is the Chair of the Department of Civil Engineering. His research interests include environmental systems analysis, including air quality simulation and meterologic modeling, along with optimization of bridge inspection and maintenance policies, and with parameter identification for ambient vibration studies.
- Dr. Katz is the William F. Ward Sr. Distinguished Professor in the Department of Mechanical Engineering. His research interests include cavitation phenomena, attached partial cavitation, cavitation in turbulent shear flows, jets and wakes, multiphase flows, development of optical flow diagnostic techniques, complex flow structure and turbulence within turbomachines, and flow-induced vibrations and noise, mechanisms of noise generation in turbulent separated flows and in turbomachines.

The Applied Physics Lab (APL) operated by Johns Hopkins University is a not-for-profit center for engineering, research and development. APL provides a very broad set of capabilities spanning a number of disciplines considered essential to solving problems of critical importance to various US Government agencies. In its work, APL has complete program responsibility from concept development to implementation, installation, test, and evaluation. In addition to more than 130 specialized research and test laboratories, APL houses large-scale computing facilities. Whereas APL is also not currently focused on clean/alternative energy research, it has provided extensive assistance to the United States Department of Energy (DOE) in areas related to the development of expertise in the clean/alternative energy field. These projects have included developing a natural gas fueled car with a 300 mile range and the development of a gas storage system with a supplemental tank, as well as hydrogen storage components. To develop the natural gas vehicle, APL partnered with Chrysler. Currently, APL owns four patents regarding the clean/alternative energy products that they developed in conducting their research for the DOE.

In addition to the above mentioned capabilities in the area of technology development, APL has one of the strongest capabilities in the country for addressing energy issues from a systems engineering perspective. After discussions with APL's director Dr. Richard Roca and his business coordinator, Dr. Sam Seymour, it was suggested to ICSD that a potential area of cooperation between APL and a Maryland Clean Energy Center might be the development of a "Maryland Real-Time Regional Energy Monitoring and Alerting System (RREMAS)." Such a System would be modeled after a comparable health care system called ESSENCE, which was developed by APL It is envisioned that 24/7/365 data would be assimilated from multiple sources to characterize the available and potential energy supply. Concurrently, environmental factors of weather, transportation and distribution networks and extra-regional supply would be collected. Combined with generation and user demand, a real-time statistical steady-state picture would be obtained for the regional energy system. Any real or perceived disruption would lead to generation of alerts to the energy network to provide a balance and re-optimize delivery systematically from all sources. RREMAS could also serve as a Maryland energy crisis and terrorist response system to allow efficient and effective use of multiple energy sources, alternative delivery networks, and energy user guidance and assistance. Another outcome is public education and awareness of energy alternatives and conservation, not only on a routine basis, but especially in terms of crisis and limited availability. The system would be designed by APL engineers and run on APL computers

Federal Laboratory-Based Research

Maryland has a large number of federal research laboratories located within the State and has the second highest concentration of federally performed research in the nation. Our research identified four labs involved in some aspects of alternative and clean energy research within Maryland. These federal labs were: the National Institute of Standards and Technology (NIST); the Henry A. Wallace Beltsville Agriculture Research Center (BARC); the Aberdeen Proving Ground (APG); and the Army Research Laboratory (ARL) in Adelphia, Maryland. Through our discussions with NIST and BARC, researchers at both expressed interest in working to develop an alternative and clean energy research center located within Maryland. The research efforts focusing on alternative energy of these laboratories are described below.

National Institute of Standards and Technology (NIST)

The National Institute of Standards and Technology, located in Gaithersburg, Maryland is involved in wide range of programs that help industry improve energy use and conservation. In addition to this, NIST supports technological innovation involving alternative energy systems, including solar energy and fuel cells. These efforts regarding alternative power include:

- Solar Energy – NIST is developing computer simulation tools to predict the performance of photovoltaics that have been integrated into building systems. NIST also is working with four solar energy equipment manufacturers to develop and validate computer tools that can be used to predict the electrical performance of building materials used to collect solar radiation.
- Fuel Cells – NIST has developed a test facility to measure the performance of residential fuel cell systems. The test facility will be used to create a test procedure and a rating methodology that will determine the annual performance of these systems on a seasonal basis. Certain NIST facilities are available to qualified industrial researchers for energy-related projects. For instance, the NIST Center for Neutron Research is being used in a study of operational characteristics of a working fuel cell.
- Physical Chemical and Properties Division – develops measurements, data, and models for the thermo physical and thermo chemical properties of gasses, liquids, and solids. In research applicable to fuel cell and hydrogen systems, the Division is developing data to provide industry with high-quality thermo physical properties for mixtures of hydrogen and methane over broad ranges of temperature, pressure, and composition.

Beltsville Agriculture Research Center (BARC)

The Beltsville Agriculture Research Center, located in Beltsville, Maryland is part of the United States Department of Agriculture Agricultural Research Service. While BARC's research primarily focuses on areas other than clean/alternative energy, they have begun to focus research into the use of both animal byproducts and biomass such as cornstalks, manure, grasses, etc. as not only a fuel source but also for the development of other products, such as plastics. The poultry industry of Maryland's Eastern shore has been viewed as an important partner in conducting research into the potential to use poultry waste as a fuel source. The development of animal byproducts and biomass as a fuel source will also address problems regarding the environmental impacts associated with poultry waste. BARC is working with the United States Department of Energy to set up and begin this research. Roughly one year ago, BARC established the Biomass Gasification Center to create "behind the gate" technologies. These technologies are designed to allow farmers to become more energy self sufficient.

Aberdeen Proving Ground (APG)

The Aberdeen Proving ground is a major center for research, development and testing for the United States Army. While there is R&D being conducted at this location, none of it involves the development of clean/alternative energy sources. However, after speaking to Dr. James Cross, Co-Chair Power and Energy IPT at Fort Belvoir, Virginia, APG will be a national test site for fuel cell use. The testing of fuel cells at APG will assist the Army in further developing and expanding its research, development, and use of fuel cells in their vehicles.

Army Research Laboratory (ARL)

The Army Research Laboratory (ARL), located in Adelphia, Maryland, is the Army's corporate basic and applied research laboratory. The Army relies on the ARL for scientific discoveries, technologic advances, and analyses to enable full spectrum operations. Within the Laboratory are six Directorates - Weapons and Materials, Sensors and Electron Devices, Human Research and Engineering, Computational and Information Sciences, Vehicle Technology, and Survivability and Lethality Analysis. The Laboratory currently provides nine Research and Analysis Programs with three in the Power and Energy field. These include: the development of advanced directed energy technology; providing power sources for soldier and auxiliary power; and providing power components for hybrid electric vehicles and pulse power. Power components and pulse power investigates mature technologies to provide high temperature, high frequency power converters and generators; high power batteries operating over a large temperature range; high energy density fast/medium current rise time storage capacitors; and Micro-Electronic Mechanical Systems for improved efficiency and reliability.

Private Sector Research

Maryland is home to one of the leading solar power companies in the nation, BP Solar. This company is in the early stage of discussions with Frederick County to work with its incubator to promote the development of technologies and, potentially, companies out of the company's own internal research efforts.

Promoting Clean Energy Technology-Based Start-ups and Technology Commercialization:

As mentioned above, Maryland is a national leader in technology development activities. One of the reasons for this is the work of Maryland's Technology Development Corporation (TEDCO) in funding technology transfer and development programs and providing entrepreneurial business assistance. Among several programs, TEDCO's business incubator program has facilitated the establishment and operations of Maryland's 15 incubators. TEDCO also provides funding for technology start-up companies in the area of technology development, business planning and technical management assistance. In ICSD's discussions with TEDCO, it became apparent that TEDCO recognizes the potential for clean energy technology development and clean energy business incubation. TEDCO also suggested a willingness to dedicate a rather substantial portion of its budget to working with clean energy start-ups. ICSD also entered into discussions with two of Maryland's incubators: the Emerging Technology Center (ETC) in Baltimore and the Frederick Innovative Technology Center. Both incubators are interested in developing strategic partnerships with a Maryland Clean Energy Center, and ETC signed a MOU with ICSD to create a Clean Energy Business Incubator at ETC.

Maryland has spent a lot of time, money and effort in developing its biotechnology industry through research, technology transfer, incubation, technology development, financial assistance, and attracting new businesses to Maryland. As a result, Maryland has the fourth highest concentration of biotechnology companies in the nation. Biotechnology applications in alternative and clean energy technology are seen by many as the next major technological frontier in the biotechnology sector. With its strong base of biotechnology companies, researchers, entrepreneurs and historical ties between the Maryland biotechnology sector and the federal research establishment, Maryland is well positioned to become a leader in this field. For example, J. Craig Venter, the founder of Celera Genomics and one of Maryland's leading biotechnology entrepreneurs, created a new business, Synthetic Genomics, to explore the potential of biotechnology in alternative and clean energy technology. Just as UMBI supported the development of biotechnology research and businesses in several areas, a Maryland Clean Energy Center could work to catalyze the application of biotechnology in this emerging area in Maryland.

Maryland Clean Energy Companies:

Maryland has an existing base of clean energy companies around which the operations of a Maryland Clean Energy Center can be built. In the State, there are 503 businesses with 4,456 employees in the alternative and clean energy sector. A data base containing the addresses, contact names, and industry classification for these companies was commissioned by ICSD from JFI is available from ICSD. More than half of these businesses and employees (339 businesses and 2,519 employees) are in the environmental consulting field. This sector is part of Maryland's important and growing business and professional services sector. Maryland has long been a leader in this field based both on our proximity to the Washington D.C. and our highly educated workforce. It is highly likely that a large share of these businesses is part of Maryland's large number of federal government contractors. These businesses may have strategic relationships with core energy (DOE), technology (DOD, ARPA), or regulatory (EPA) agencies that could either benefit from or contribute to the operation of the proposed Maryland Clean Energy Center

Maryland is also home to BP Solar, one of the largest solar cell producers in the world, This company alone accounts for 8% of alternative and clean energy sector employment in Maryland. BP Solar completed a major expansion in its Frederick County, Maryland facility last year. The presence of one of the leading solar companies in the world in the state presents an opportunity to develop an industry cluster around this new and growing technology. The Renewable Energy

Policy Project list Maryland as having 105 businesses with 5,120 employees that could potentially benefit from expanded manufacturing of solar cells.

The remainder of Maryland alternative and clean energy companies is highly concentrated in construction, contracting and installation. These companies will benefit from efforts to enhance energy efficiency in Maryland. Maryland lacks significant employment (outside of BP Solar) in the manufacturing of products related to alternative and clean energy technologies. This will present a significant barrier to the development of clusters related to the production of alternative and clean energy technologies.

In addition to the first tier businesses identified above, that represent the core industries recognized in other studies as centrally and directly involved in the alternative and clean energy sector, there are a large number of other industries that can benefit from the development of both new alternative and clean energy power projects and, more importantly, from efforts to improve energy efficiency in Maryland. For example, in the area of businesses that can benefit from the development of both new alternative and clean energy power projects, the Renewable Energy Policy Project identified 142 business establishments with 8,355 employees that could potentially be involved in the construction of wind power projects as Maryland begins to develop wind power on a scale comparable to its neighboring states. The proposed Maryland Clean Energy Center could work with DBED and state or regional manufacturing organizations, such as Regional Manufacturing Institute (RMI) or the Maryland Technology Extension Service (MTES) to create a consortium of manufacturing firms to serve as suppliers to the major wind power developers.

Workforce and Location:
Clean energy development and deployment requires a workforce with high levels of skill and education. Maryland's strong position in technology research and technology business activity has given the State this type of high quality workforce. According to Maryland DBED, Maryland is first among states (24%) in professional and technical positions. The State is second among the states in the percentage of the population 25 and older with a graduate or professional degree (13.4%). Maryland is also one of the top states (3^{rd}) in the nation in the percentage of population (31.4%) 25 years and over with a BA or higher degree.

With regard to location, according to JFI, many of Maryland high technology businesses did not spin directly out of the state's research universities or federal labs, but were attracted into the State because of its proximity to federal funding agencies or regulators. Therefore, Maryland may have a comparative advantage in attracting companies based on our proximity to federal agencies (DOD, DOE, ARPA) involved in alternative and clean energy research, the presence of federal testing capacity (APG and BARC), our strong base of biotechnology companies, or our university resources. Maryland also ranks 1^{st} per capita in federal R&D obligations ($8.7 billion).

According to Maryland DBED, Maryland's atmosphere of creative innovation provides many opportunities for technology transfer and/or commercial partnerships between the academic, government and commercial communities. This atmosphere of innovation is fostered by a framework of financing, training, and incentives designed to support and nurture creativity, entrepreneurship, business formation, expansion and growth. This type of atmosphere is what is needed for Maryland to be able to capture a large share of the projected growth of the clean energy sector.

Summary:

The economic impact analysis discussed above showed that the largest potential job creation impacts and other economic benefits resulting from the operation of a Maryland Clean Energy Center can be derived from the Center's promotion of electricity energy efficiency improvement (20,30, or 40%) in Maryland and Baltimore. The second largest opportunity involves a 10, 20, or 30% increase in renewable energy utilization The third largest impact is associated with promoting the operations of ethanol facilities with the capacity to produce enough fuel to replace select proportions (10, 20, or 30%) of current and projected gasoline consumption in Maryland and the Baltimore metropolitan area. The fourth largest impact involves a 10, 15, or 20% improvement in natural gas utilization. Other economic impacts identified were those associated with the attraction, expansion and start-up activities of clean energy companies and with the incubation-related activities of these companies. Finally, the construction of a 50 mgpy ethanol plant was estimated to have about 5 times the economic impact of building a 50 MW wind facility.

As shown in the Table below, the cumulative economic impacts of the promotion of energy efficiency, renewable energy and alternative fuels to the State of Maryland, over a twenty year period, are huge. At the lowest level of effort (20% energy-efficiency improvement, 10% renewable-energy increase, and 10% ethanol production increase), the employment benefits over 20 years are approximately 144 thousand jobs for Maryland, of which approximately 67 thousand will be created in Baltimore. At the same level of effort, and over a twenty-year time period, wages & salaries will go up by $5.7 billion in Maryland and over $2.4 billion in Baltimore; state & local tax revenues will increase by $973 million in Maryland and $412 million in Baltimore; and gross state product (GSP) will increase by $16 billion in Maryland and almost $7 billion in Baltimore. At the highest level of effort (40% energy-efficiency improvement, 30% renewable-energy increase, and 30% ethanol production increase), the economic impacts more than double.

Cumulative Economic Impacts (Efficiency, Renewable & Alternative Fuels Scenarios), 2006-2025, for Maryland and Baltimore

Scenario	Employment	Wages & Salaries*	State & Local Tax Revenues*	Gross State Product (GSP)*
MD Baseline	143,719	$5,729.7	$973.3	$15,980.9
MD High	326,514	$12,944.8	$2,165.9	$36,006.9
BM Baseline	66,546	$2,437.0	$412.6	$6,852.5
BM High	162,177	$5,890.2	$985.0	$16,560.2

*millions of dollars

The numbers associated with the economic impacts of firm attraction, expansion and start-up activities, over a 24 year time period, are lower, but significant. For these activities, total jobs impacts for Maryland range from 3,750 to nearly 15,000. Associated wages and salaries for these jobs range from $177 to over $708 million, while expected state and local tax revenues exceed $18 million in the low scenario and surpass $72 million in the high scenario. The estimated impact on Maryland's GSP ranges from nearly $455 million to more than $1.8 billion. For

Baltimore, job impacts range from 1,863 to 7,450, and associated wages and salaries for these jobs range from $81 million to over $325 million. Expected state and local tax revenues range from over $8 million to over $33 million, and the estimated impact on Baltimore GSP ranges from over $209 million to more than $837 million.

In the case of business incubations, for every $10 million, the Maryland yearly employment impacts total 159 jobs, while associated wages and salaries for these jobs for a year exceed $7 million. Yearly estimated state and local tax revenues approaches $1 million and the estimated yearly impact on Maryland's GSP exceeds $18 million. These impacts are expected to happen wherever the incubator is located. For Baltimore, the estimated employment impacts total 79 jobs, and the associated wages and salaries for these jobs total to $3.4 million. Annual estimated state and local tax revenues in Baltimore are $320,000 and the estimated annual impact on Baltimore' GSP is over $8.3 million. Over a 20 year time period, these numbers might be expected to be several times larger, but nowhere near the cumulative estimated impacts of energy efficiency, renewable energy, and alternative fuel improvements.

To the extent that attracting, expanding, starting-up, and incubating clean-energy companies, over time, lead to improvement of energy efficiency and increased use of renewable energy and alternative fuels in Maryland, the actual economic impact of these activities will be much larger. The greatest economic benefit from growing the clean energy business sector comes not just from the jobs created and economic investment in the companies, but from the energy services they provide to Marylanders. The greatest economic benefit comes from the energy savings to people and businesses, which increases disposable income and increases profit, stimulating economic activity in all sectors. In addition, every dollar not spent in imported energy (all Maryland's energy is imported), stays in the community and generates approximately $3 in economic activity locally.

Nationally, the alternative and clean energy sector is poised for a new period of growth and activity based on increasing energy prices, scarcity and environmental impacts. There is the potential for significant business, employment and economic development benefits accruing to states that have or can develop a comparative advantage in this sector. Maryland is in a good competitive position to capture the growth of the clean energy sector and avail itself of some of the employment and other benefits identified above. In order to be able to do this, Maryland should consider (1) facilitating the development of an industry involved in the production of renewable energy power components and balance of systems, (2) developing a detailed assessment of its position in clean energy research, (3) identifying how to better link its clean energy sector to federal government programs, (4) identifying how to best utilize the strength of its biotechnology sector in clean energy development, (5) identifying how to better use the capabilities of Johns Hopkins Applied Physics Laboratory in developing its clean energy sector, (6) organizing a Maryland Clean Energy Business Council, (7) how to best promote linkages between existing incubators, research parks and clean energy companies, and (8) conducting an accurate assessment of what the clean energy industry in the State looks like.

6. Maryland Clean Energy Center- Business Plan

Background
The concept for the MCEC has been based on the experience of the many States that have renewable energy or clean energy centers or programs that supplement the work of the State energy offices. They are a combination of non profits, universities and utility run programs. The majority of programs are focused on public education, outreach and public interest lobbying. Fourteen States fund direct investment programs and financing programs for clean energy. The Maryland Clean Energy Center is envisioned as an effort to primarily stimulate economic development and job creation in the clean energy sector. State and regional programs that focus on economic development fall into two groups; clean energy funds and clean energy incubators.

Clean Energy Funds
Fourteen states across the U.S. have established funds to promote the development and commercialization of renewable energy technologies. Most often financed by a small surcharge on retail electricity rates, these funds currently collect more than $500 million per year in aggregate in support of renewables and efficiency. At this funding level, state clean energy funds are a major driver of renewable energy development. Though state clean energy funds have pursued a variety of approaches in the use of their funds, support for the deployment of utility-scale renewable energy projects, such as commercial wind, biomass, and geothermal projects, has been a principal target of most funds.

Summary of State Support for Utility-Scale Renewable Projects (as of March 2006)

Project Location	# of Projects	Obligated Funding ($)		Capacity (MW)			
		Original	Current	Original	Canceled	Pending	Online
CA	60	$243,573,376	$189,970,791	1,291.5	64.5	748.5	478.5
IL	5	$8,425,000	$8,425,000	112.5	0.0	6.0	106.5
MA*	5	$32,756,736	$32,756,736	52.3	0.0	49.0	3.3
ME*	1	$5,600,000	$5,600,000	19.0	0.0	19.0	0.0
MN	147	$107,679,545	$107,679,545	253.3	1.7	35.3	216.3
NH*	1	$2,720,000	$2,720,000	50.0	0.0	50.0	0.0
NJ	6	$17,782,026	$14,682,026	38.9	21.0	6.9	11.0
NY	11	$25,560,000	$10,460,000	316.1	266.5	8.0	41.6
OR	4	$3,800,000	$3,800,000	122.0	0.0	6.0	116.0
PA	10	$27,292,000	$21,442,000	386.6	39.6	204.5	142.5
Total	**250**	**$475,188,683**	**$397,536,097**	**2,642.2**	**393.3**	**1,133.2**	**1,115.6**

*Maine and New Hampshire do not currently have clean energy funds. The projects located in these two states have received support from Massachusetts' clean energy fund. Similarly, one wind project located in Massachusetts has received financial support from Rhode Island's renewable energy fund.

Source: Mark Bolinger and Ryan Wiser , LBL, The Impact of State Clean Energy Fund Support for Utility-Scale Renewable Energy Projects.

The Clean Energy States Alliance (CESA) is a nonprofit organization comprised of members from 16 clean energy funds and two state agencies; it provides information and technical services to its members and works with them to build and expand clean energy markets in the United States. "Clean Energy Funds" or "State Funds" refers to the growing number of funds in the United States whose objective is building markets for renewable energy and clean energy resources. At mid-2005, there were 17 such state-level funds in 13 states. State programs will make available nearly $3.5 billion to promote renewable and clean energy over the next decade. These funds are capitalized in a number of ways. Some funds receive payments through a non-bypassable charge assessed on each customer's electric bill, typically as a result of restructuring legislation. These are typically referred to as "system benefit charges" (SBCs) or "public purpose charges." Other funds receive their money in lump sums, either as a result of a settlement of a utility merger or sale of generation assets. The original seventeen organizations forming CESA are the following:

- California Energy Commission
- Connecticut Clean Energy Fund
- Energy Trust of Oregon
- Illinois Clean Energy Community Foundation
- Long Island Power Authority Clean Energy Initiative
- Massachusetts Renewable Energy Trust
- Pennsylvania Electric Company Sustainable Energy Fund of The Community Foundation for the Alleghenies
- Metropolitan Edison Company Sustainable Energy Fund of The Berks County Community Foundation
- New Jersey Clean Energy Program
- New York State Energy Research & Development Authority
- Ohio Energy Loan Fund
- Rhode Island Renewable Energy Fund
- Sustainable Development Fund (PA)
- Sustainable Energy Fund of Central Eastern Pennsylvania
- West Penn Power Sustainable Energy Fund
- Wisconsin Focus On Energy - Wisconsin Division of Administration
- Xcel Energy Renewable Development Fund (MN)

Massachusetts Renewable Energy Trust
As part of its 1997 electric utility restructuring legislation, Massachusetts created public benefit funds for renewables, energy-efficiency programs and low-income assistance programs. The Renewable Energy Trust Fund is supported through a system benefits charge with total funding of roughly $150 million over the initial five-year period, with approximately $25 million per year for each year thereafter. The charge established varies according to the following schedule:

- 1998: $0.00075 cents per kilowatt-hour (0.75 mill/kWh)
- 1999: $0.001 cents per kilowatt-hour (1.0 mill/kWh)
- 2000: $0.00125 cents per kilowatt-hour (1.25 mills/kWh)
- 2001: $0.00075 cents per kilowatt-hour (0.75 mill/kWh)
- 2002 and each year thereafter: $0.0005 cents per kilowatt-hour (0.5 mill/kWh)

Massachusetts' 1997 restructuring law also mandates five-year funding totaling roughly $500 million for energy-efficiency investments. The law created an energy-efficiency surcharge of 3.3 mills/kWh in 1998, declining to 2.5 mills/kWh by 2002 and 0.25 mill in subsequent years. The DOER is administering these energy-efficiency funds through the utilities. Of the energy-efficiency funds, 20% of the amount spent in any year is for low-income weatherization and education programs. A low-income weatherization and fuel assistance network will implement these programs. In addition, the restructuring law requires utilities to continue low-income financial assistance at current levels with the funds collected via a separate systems benefit charge.

In late 2004, the Massachusetts Technology Collaborative launched a program to double the benefit of contributions to green-power programs operating in Massachusetts. Under this program, when citizens choose to pay a premium to support qualifying clean-energy facilities, the MTC will match customers' contributions dollar-for-dollar with up to $2.5 million annually in funds.

The Renewable Energy Trust is administrated by the Massachusetts Technology Collaborative, which is the state's development agency for renewable energy and the innovation economy, which is responsible for one-quarter of all jobs in the state. The mission of the Massachusetts Renewable Energy Trust (RET) is to maximize environmental and economic benefits for the Commonwealth's citizens by pioneering and promoting clean energy technologies and fostering the emergence of sustainable markets for electricity generated from renewable sources. The RET has four primary program areas.

The Clean Energy Program seeks to increase both the supply of and demand for renewable energy. On the supply side, it supports both utility-scale and community-scale energy projects that harness the wind, sun, and bioenergy. On the demand side, it educates citizens, teachers, and students, and advances the green electricity market by giving consumers objective information and attractive choices.

Green Buildings and Infrastructure Program promotes the use of renewable energy technologies in all types of buildings and other distributed applications. It has provided funding to a wide range of green building projects, solar installations, and infrastructure improvements. It encourages efforts that help the marketplace to value and support green buildings and renewable energy installations.

Industry Investment and Development Program accelerates job growth, economic development, and technological innovation in the Massachusetts renewable energy industry. It makes direct investments to catalyze new product commercialization, builds networks and provides services that better enable companies to access capital and other vital resources, and strive to lower barriers to success for entrepreneurs in the state.

The Policy Unit of the Renewable Energy Trust collaborates with interested stakeholders to address market and regulatory barriers that block the increased availability, use, and affordability of renewable energy.

Clean Energy Business Incubators

The second group of economic development focused programs is the clean energy business incubators. The National Alliance of Clean Energy Business Incubators, established in 2000 by the National Renewable Energy Laboratory (NREL), is an alliance of leading business incubators dedicated to providing business and financial services tailored to the needs of the clean energy community. To assist clean energy entrepreneurs and support the Alliance, NREL has developed an impressive network of investors, energy experts, and industry leaders who stand ready to provide mentoring, financing, and introductions to the global energy community. The Alliance is composed of ten top business incubators from across the country.

Advanced Technology Development Center in Georgia.
Albany NanoTech in New York
BizTech in Alabama
Boston Technology Venture Center
Business Innovation Center in Mobile Alabama
Clean Energy Incubator in Austin Texas
Environmental Business Cluster in San Jose California
Florida/NASA Business Incubation Center
National Environmental Technology Incubator in Ohio
National Renewable Energy Laboratory in Colorado
Rensselaer Incubator Program in New York
Technologies Ventures Corporation with offices in California, New Mexico and Nevada

Austin Clean Energy Incubator
The Clean Energy Incubator (CEI) in Austin Texas is the first dedicated clean energy incubator. The CEI was launched in August 2001 and is a joint effort between the Austin Technology Incubator (ATI) and the National Renewable Energy Laboratory (NREL) to promote the development of viable businesses focusing on clean energy. Since 2002, CEI has served 18 companies within the renewable and energy efficiency sectors; more specifically, these companies range from geothermal power and biofuels, to wind energy and water conservation. With CEI's assistance, companies fill in knowledge gaps and build stronger business propositions, helping to increase their chance for success. Current member companies include: Abundant Renewable Energy, AccuWater, Austin Biofuels, e60 Vision, Effenergy, GeoTek Energy, MicroDynamo, RSET Inc. CEI is supported by the Texas State Energy Conservation Office (SECO) and has previously received funding from the U.S. Department of Energy (DOE). In 2006, CEI secured funding from a collaborative effort with the City of Austin and Austin Energy.

Maryland Clean Energy Center (MCEC)
The MCEC is modeled after the leading successful clean energy business development programs in the country with the mission to promote economic development in the clean energy sector by improving access to energy efficiency and renewable energy technologies and supporting the growth of clean energy businesses in Maryland. MCEC is a public /private partnership that brings together the diverse interests in the clean energy sector as a clearly defined business sector in Maryland and a forum for discussions about strategies and policies that will support the growth of the clean energy sector. The MCEC will be formed as a Maryland non profit 501c3 corporation.

Vision
The MCEC will strive to create the maximum economic, environmental and quality of life improvement in the State through the promotion of business development and growth in the clean energy industry sector. Through our efforts, MCEC will increase the number of businesses in Maryland that manufacture, sell and service energy efficiency and renewable energy

technologies. As a result, Marylanders will benefit by reducing energy cost, increased profits and disposable income, improved energy price and supply stability, improved environment and overall improved quality of life.

Clean Energy
For the purpose of the MCEC, we define clean energy as any technology that reduces environmental impact of energy generation and use. This includes technologies associated with cleaner sources of energy, more efficient uses of energy and better management of energy waste. MCEC will focus primarily on energy efficiency, green buildings and renewable energy sources, such as solar thermal, solar PV, wind, ethanol, biodiesel, land fill gas, hydrogen and biogas.

Core Values
MCEC is guided by the following set of core values or guiding principals.

1. Public Purpose. MCEC is focused on results that improve the quality of life for all Marylanders. We understand that economic development must benefit not only business but also the poor and disadvantaged by providing access to affordable energy services, new jobs and economic opportunities in the growing clean energy sector.
2. Innovation. MCEC recognizes the power of ideas and innovation to address our growing energy needs and responsibilities to the environment and the public. We will work to stimulate new ideas and support innovation.
3. Understanding. Good information and informed dialogue leads to good public policy. To be successful in an expanding, diverse, dynamic and highly technical economy, we need timely, accurate, complete and unbiased information. This requires a combination of data collection, data analysis, listening and an active engagement with a broad range of stake holders. MCEC will work to assure that policy makers have the best and latest data for making informed policy and facilitate short feed back loops on what's working and what's not.
4. Collaboration. No single organization can do it alone. We must establish long term relationships and partnerships that generate effective solutions. We must build public/ private partnerships and facilitate communication and collaboration between all stake holders including citizens, government, industry, researchers and academia.
5. Catalytic Action. The industry can not do it fast enough on its own. We need a dedicated, informed, articulate and credible champion for the cause. MCEC will act as a catalyst providing support to leaders in government, academia, and industry to accelerate economic development and job growth in the clean energy sector.

MCEC and Maryland Energy Administration
The Maryland Energy Administration (MEA) and the MCEC work hand in hand in a strategic partnership to promote energy efficiency and renewable energy. We each have a distinct role to play. MEA is charged by the Governor to carry out the policy of the administration. In that role, MEA has a diverse mix of programs to serve that mission. Being a State agency, MEA is limited in its ability to address specific business and industry needs that may support one business over another or to take on initiatives without the direction of the legislature and the Governor. MCEC can fill that gap by representing the unique and diverse interests of the clean energy industry in Maryland. MCEC will act in some ways like an industry association or chamber of commerce for the clean energy industry in the State. MCEC will organize the industry and provide a forum for discussions about strategies and policies that will support the growth of clean energy business in the State. Working with MEA and DBED, MCEC can provide advice to the legislature and the

governor on policies that would have the highest impact on business growth and provide feed back on the effectiveness of existing policy. MCEC will be a valuable resource to MEA, DBED and the administration when it comes to stimulating business development in Maryland.

MCEC Goals

The goals of the MCEC are centered around promoting the clean energy industry in Maryland:

1. Organize the clean energy sector in Maryland into a cohesive and recognized entity;
2. Give the clean energy industry a voice to the public and policy makers and be the public advocate for the industry;
3. Increase the number of clean energy companies in Maryland by attracting new companies to locate in Maryland and growing new ones through our clean energy incubators and business support resources;
4. Establish MCEC as the credible source of information on the clean energy industry, energy data and policy guidance in Maryland;
5. Increase the deployment and application of clean energy technologies in Maryland.

MCEC Objectives

To reach the above goals, MCEC will achieve the following objectives:

1. Organize a Maryland Clean Energy Business Council that will represent and speak for the Maryland clean energy industry and undertake key activities supportive of the industry's economic growth;
2. Increase the availability of clean energy-related services at all existing incubators throughout the State of Maryland;
3. Undertake outreach and technical assistance activities that will foster a general climate supportive of clean energy technology deployment and application in Maryland;
4. Undertake assessments and analyses to identify Maryland's strengths and weaknesses in growing the clean energy industry in Maryland;
5. Establish and maintain an energy data collection and tracking system in Maryland;
6. Develop procedures for promoting entry into domestic and international markets by Maryland clean energy businesses and organizations;
7. Increase the adoption and sales of clean energy technologies in Maryland

    - Increase use of renewable energy 15% by 2016 and 30% by 2026
    - Increase energy efficiency of electricity consumption 20% by 2016 and 40% by 2026
    - Increase energy efficiency of gas consumption 10% by 2016 and 20% by 2026
    - Increase the use of non-petroleum transportation fuel 20% by 2016 and 40% by 2026

Key Players and Strategic Partners

One of MCEC's core values is collaboration. The center will strive to develop long term relationships and partnerships that will effectively support the growth of clean energy in Maryland. The MCEC will build public/ private partnerships and facilitate communication and collaboration between all stake holders including citizens, government, industry, researchers and academia. Over the past year, ICSD has met with numerous groups in the State to discuss the feasibility and potential for a MCEC. We received unanimous agreement from every organization we met with that there is a tremendous opportunity for economic development in clean energy and the concept of the MCEC is a good one. The following is a partial list of the organizations we met with and voiced their support for the MCEC and a desire to form a strategic relationship with the center.

- Johns Hopkins University, Dr. Theodore Poehler
- Johns Hopkins Applied Physics Laboratory, Dr. Richard Roca
- University of Maryland College Park, Brian Darmody
- University of Maryland Biotech, Dr. Jennie Hunter-Cevera
- BGE, Kevin D. Ryan, Counsel, Alexander G. Nunez
- PEPCO, Richard Swink, Manager Strategic Planning
- TEDCO, Renee M. Winsky
- Emerging Technology Center, John Fini
- Jacob France Institute, University of Baltimore, Richard Clinch
- RESI, Towson University, Dr. Daraius Irani
- BEACON- Salisbury University, Dr. Memo Diriker
- Chesapeake Bay Region Technical Center (CBRTCE), John General
- Maryland Center for Environmental Training (MCET), College of Southern Maryland, Karen L. Brandt
- Tri County Council for western Maryland, LeAnne Mazer
- Frederick Innovative Technology Center, Michael Dailey

Activities of the MCEC
The MCEC activities in the short term are focused on pulling together a cohesive and visible clean energy industry in Maryland and giving the industry a voice to the public and policy makers. Based on the feedback from the industry and other stake holders, MCEC will expand its activities as needed to support the growth of the clean energy industry. The primary activities of the center for at least the first two years fall into 4 categories.

(1) **Maryland Clean Energy Incubator.** MCEC will support a Maryland Clean Energy Incubator (MCEI) at the Emerging Technology Center (ETC) in Baltimore and recruit companies to join the MCEI. MCEC will also establish strategic partnerships with the other incubators in Maryland, modeled after the ETC partnership, to create a network of clean energy incubators in the State.

(2) **Maryland Clean Energy Business Council and Clean Energy Business Development Collaboratives.** MCEC will organize **a** Clean Energy Business Council. MCEC will work with the Council to initially establish five Clean Energy Business Development Collaboratives for solar energy, energy efficiency and Green buildings, off- shore wind, biofuels and hydrogen. The Collaboratives are critical to creating a cohesive and visible clean energy industry that can interact with the public and policy makers to grow the industry. MCEC will recruit membership and participation in the Council and organize a series of forums to discuss issues common to the industry. The MCEC through the Council will create an annual assessment of the state of the industry and a legislative agenda to promote the growth and health of the industry in Maryland. MCEC will also work with its strategic partners or provide support to clean energy companies and to recruit start ups to join the Maryland Clean Energy Incubator.

(3) **Data Collection, Assessments and Analyses**. It was clear in the development of this study that there is a severe lack of good data and useful information on energy use, trends and the state of the energy industry in Maryland. Good information is needed to develop good public policy and to track the effectiveness of our activities. To be successful in its mission, MCEC will obtain timely, accurate, complete and unbiased clean energy-related information. Furthermore, in order to assist Maryland in capturing the growth of the clean energy sector and the associated benefits that come with the growth of this sector, MCEC will undertake several assessments and analyses to help identify Maryland's strengths, weaknesses and interests in growing this sector.

(4) **Outreach and Technical Support**. The clean energy industry needs a dedicated, informed, articulate and credible champion to promote clean energy development and utilization in the State. MCEC will act as a catalyst providing support to leaders in government, academia, and industry to accelerate economic development and job growth in the clean energy sector.

Maryland Clean Energy Incubator (MCEI) at the Emerging Technology Center:

As part of this study, ICSD has been exploring the potential of a Maryland Clean Energy Incubator as a key program of the MCEC. In September, ICSD, MCEC and the Emerging Technology Center (ETC) signed an MOU (appendix 5) to form a strategic partnership to promote the development of clean energy businesses through their business incubator.

The ETC is a Maryland-based Non-Profit incubator created to promote and develop high technology and biotechnology companies in the City of Baltimore, Maryland. Over the last seven years, the ETC has demonstrated a marked ability in assisting high technology and biotechnology companies in developing products for both domestic and international markets. It has also demonstrated expertise in technology transfer from local universities and government agencies. The ETC is one of the most successful incubator clusters in the United States, with 60 tenants in 93,000 sq. ft. of space in two buildings. Since its inception in 1999, the Emerging Technology Center has assisted 100 companies that have created over 1000 jobs. Ninety-two percent of the companies are still in business and have received in excess of $130 million in investments. The ETC charter of creating and developing high technology and biotechnology companies easily allows it to be involved in clean energy technology development.

As part of the MOU, ETC agreed to provide a home for the MCEC at their Baltimore location on Boston Street. Both organizations will jointly support the MCEC mission by providing services and subject matter expertise.

MCEC will support the Maryland Clean Energy Incubator by:

1. Providing subject matter expertise in the markets for sustainable development
2. Acting as a technical scout for promising clean energy technologies that could be developed by MCEI
3. Locating and promote companies to join MCEI
4. Serving as an early adopter for technologies developed by companies associated with MCEC
5. Actively participate in mentoring companies involved in MCEI
6. Assisting in admission decisions for companies seeking admission into MCEI

The ETC will assist MCEC by:

1. Incubator administration,
2. Real estate services,

3. Program assistance to ICSD & MCEC,
4. Program assistance to incubator clients,
5. Locating and promote companies to join MCEI.
6. Provide meeting rooms and conference capability for MCEC

Soon after initiating the various activities of the strategic partnership with ETC, MCEC intends to also establish similar partnerships with the other incubators in Maryland, modeled after the ETC partnership, to create a network of clean energy incubators in the State of Maryland. MCEC also intends to explore promoting further linkages between existing incubators and research parks and clean energy companies. For example, BP Solar has expressed interest in working with the Frederick County incubator. Also, as further discussed below, MCEC's activities will attract new start-up clean energy businesses and this will have the dual impact of enhancing incubator utilization and stimulating new research opportunities and linkages in Maryland.

Maryland Clean Energy Business Council and Clean Energy Business Developement Collaboratives:

The MCEC, working with DBED and the technology councils, intends to organize a Maryland Clean Energy Business Council among participating businesses to promote the needs and interests of the clean energy sector. ICSD has already taken the initial step of identifying what companies make up the existing base of the clean energy industry in Maryland. MCEC will further develop and refine this database, so that we have an accurate assessment of what the industry looks like from the perspective of each clean energy technology and the following general categories:

1. Services/Consultants
2. Manufacturers
3. Suppliers/Dealers
4. System integrators/Contractors
5. Researchers

Initially the work of the Council will focus on developing five Collaboratives:

Offshore Wind Energy Development Collaborative

MCEC will form an Offshore Wind Energy Development Collaborative to begin discussions on how to best tap into Maryland's best renewable energy resource, off shore wind. The NREL Renewable Energy Resource Assessment that ICSD commissioned for this study estimates that more than 19,000 megawatts of wind generation capacity exists within 30 miles off our coasts. That is 137% more power than was sold in Maryland in 2004. Of that, 1,700 megawatts are practical today given the limitations of the existing power grid and cost competitive with today's electric rates. The 1,700 megawatts of offshore wind represents 30% of the total electric sales in Maryland in 2004. The winds over deep waters off the Maryland coast represent a potentially inexhaustible source of clean energy and a tremendous economic development potential for Maryland.

In September, 2005, the U.S. Department of Energy (DOE) and GE unveiled *A Framework for Offshore Wind Energy Development in the United States*, an agenda aimed at tapping abundant offshore winds, especially over deep waters, to increase the nation's production of clean, sustainable energy. The *Framework* identifies the technical, environmental, economic and regulatory needs required for the responsible development of our nation's offshore wind energy potential, as well as strategies for addressing them. "Tapping into offshore wind energy, a free fuel source that is not impacted by fluctuating prices or volatile fuel import schedules, can offer long-term competitive electricity costs," said Jim Lyons, GE Chief Research Engineer. "At the same time, it will provide the U.S. with a means to add additional renewable energy into the Nation's electricity mix. Further technology development will be key to this effort, particularly in deep waters where conditions are beyond the reach of current technology. The Framework recognizes the need for a cost-effective evolution from today's near-shore, shallow water sites to the future's more remote, deeper water facilities."

The Framework is intended to help the United States develop its offshore wind energy industry through a highly collaborative, multi-sector approach. A major goal of this collaborative effort is to bring government, industry, and universities together to spur innovation in wind energy technologies. The document also recognizes the importance of considering this offshore energy source in the context of emerging national ocean conservation and management priorities.

MCEC will explore the opportunities to join with DOE and GE and other states like Massachusetts and New York to explore the potential for offshore wind development.

Maryland Biofuel Development Collaborative

One of the best opportunities for clean energy economic development in Maryland is in the biofuels sector. Ethanol is one of the fastest growing and hottest investment opportunities today with returns on investment of 27%-34% and an average investment of over $100 million. Currently one ethanol plant is starting construction in Baltimore and at least 5 others are in the planning stages with a potential investment of over $300 million. Biodiesel also has tremendous job creation and investment potential in Maryland. Currently there is one biodiesel plant in Berlin, Maryland, and at least 4 in the planning stages with over $30 million in potential investment.

In addition to the biofuel plant development potential, there are tremendous opportunities for research and development in the biofuels sector with funding available from the US DOE and the private sector.

MCEC will form a Maryland Biofuel Development Collaborative to facilitate the development of the biofuels industry in Maryland. MCEC will bring together industry leaders, researchers, government and other stake holders to discuss the potentials for Maryland and to chart a course for the rapid development of the biofuels industry in the State. Activities of the Collaborative may include:

1. Develop a road map and a set of comprehensive policies for the rapid development of the biofuels industry in Maryland.
2. Facilitate the construction of grain to ethanol plants in Maryland;

3. Facilitate the demonstration of biomass to ethanol and bioproducts production in biorefinery systems and eventually the construction of biorefineries in Maryland.
4. Facilitate proof of concept demonstrations of new technologies derived from GTL-based bioenergy research in Maryland and eventual commercialization of GTL-based bioenergy technologies. Included in this will be facilitation of innovative biomass feed stock development and incubation-facilitation of start-up companies in this field.
5. Facilitate the construction of biodiesel plants in Maryland.
6. Facilitate the demonstration of algae and other advanced feed stocks conversion to biodiesel production and biodiesel-byproducts production in biorefinery systems, and eventually the construction of biodiesel-based biorefineries in Maryland
7. Facilitate proof of concept demonstrations of new biodiesel technologies derived from GTL-based bioenergy research and eventual commercialization of GTL-based biodiesel technologies in Maryland. Included in this will be the facilitation of innovative biomass feed stock development and incubation-facilitation of start-up companies in this field.

Maryland Solar Development Collaborative
Solar PV and solar water heating are very big opportunities for economic development in Maryland. BP solar, one of the largest PV manufacturers in the world is located in Frederick. While there are currently only a handful of solar installers in Maryland, the growth potential is significant based on the experience in California, New Jersey and Pennsylvania. Solar water heating is also poised for rapid growth. Solar water heater manufacturing also has great potential in Maryland. One of the leading manufacturers of evacuated tube solar water heaters, Thermomax, has their US headquarters in Columbia, Md.

MCEC will partner with the two solar associations currently active in Maryland, the Maryland, DC, Virginia Solar Energy Industries Association and the Potomac Region Solar Energy Association to organize the Maryland Solar Development Collaborative. MCEC will recruit membership and participation in the Collaborative and organize a series of forums to discuss issues common to the industry. The MCEC through the Collaborative will create an annual assessment of the state of the industry and a legislative agenda to promote the growth and health of the solar industry in Maryland. MCEC will also work with its strategic partners to provide support to solar companies and recruit solar start ups to join the Maryland Clean Energy Incubator.

Maryland Green Building and Energy Efficiency Development Collaborative
The National Association of Home Builders recently released a report on residential green building. The study analyzed a representative sample of more than 75,000 builders and concluded that green building will reach its "tipping point" in late 2006 early 2007. In 2006, the growth in green home building is expected to rise by 20% over 2005, and in 2007, there is a projected growth of 30% over 2006 numbers. As a result, more than two-thirds of builders will be building green homes (more than 15% of their projects), with only one-third not yet engaged in this marketplace. Beyond 2007, the sheer number of participants in the green home building market will pull the rest of the market up to green standards in order to remain competitive.

The Green Building and Energy Efficiency Development Collaborative will create a strategic partnership with the major organizations that support the Green Building industry. This partnership will include the Maryland Chapters of the National Association of Home Builders, US Green Building Council, National Capitol and Baltimore Chapters and the many NGOs that support energy efficiency and green building. MCEC will recruit membership and participation in the Collaborative and organize a series of forums to discuss issues common to the industry. Through the Collaborative, the MCEC will create an annual assessment of the state of the industry and a legislative agenda to promote the growth and health of the energy efficiency and green building industry in Maryland. MCEC will also work with its strategic partners to provide support to energy efficiency and green building companies and recruit start ups to join the Maryland Clean Energy Incubator.

Maryland Hydrogen Development Collaborative

The economic and environmental benefits from developing and deploying hydrogen and fuel cell technologies are rather significant. Maryland can play a leadership role in the commercial development and application of these technologies in the State, and the corresponding infrastructure build-out that will be required, in order to capture the economic and environmental benefits from their utilization. In Maryland, the use of hydrogen as a fuel and the application of fuel cell technologies are still on the periphery of public understanding. The development of an informed public policy addressing hydrogen and fuel cell issues will require a detailed education and outreach effort targeted on policymakers, business leaders, consumers, public-interests groups, and foundations and other donor organizations. If Maryland is to be a leader in establishing a fully functioning commercial market for hydrogen and fuel cell technologies in the State by 2020, it must start laying the groundwork for such a market today.

The Maryland Hydrogen Development Collaborative will create a strategic partnership with the major organizations that support the hydrogen industry, including the Mid Atlantic Hydrogen Coalition, researchers, universities, and the 11 companies currently operating in Maryland in the hydrogen and fuel cell field. MCEC will recruit membership and participation in the Collaborative and organize a series of forums to discuss issues common to the industry. The MCEC through the Collaborative will create an annual assessment of the state of the industry and a legislative agenda to promote the growth and health of the hydrogen industry in Maryland. MCEC will also work with its strategic partners to provide support to hydrogen and fuel cell companies and recruit start ups to join the Maryland Clean Energy Incubator

Data Collection, Assements and Analyses:

In the area of data collection, MCEC will (1) undertake the tracking of energy consumption, energy sources, industry activity, sales of clean energy products and services, and the health of the clean energy industry in Maryland, (2) track the activities in other States, at the Federal level and in other countries, and (3) work to assure that policy makers have the best and latest data for making informed policy and facilitate short feed back loops on what’s working and what’s not.

As mentioned in the previous Section , the Johns Hopkins Applied Physics Lab (APL) has a very broad set of capabilities spanning a number of disciplines considered essential to solving problems of critical importance to various US Government agencies. It has more than 130 specialized research and test laboratories and houses large-scale computing facilities. MCEC intends to engage APL in Maryland clean-energy development, so as to demonstrate to the State how to use some of APL’s extensive capabilities for the benefit of Maryland. The mid-Atlantic Consortium mentioned earlier is already drawing on APL’s expertise in putting together its response to the USDOE Bioenergy Solicitation. MCEC will further explore with APL, MEA, and some of the Maryland Electric utilities, and perhaps other interested parties (such as the

Department of Homeland Security), the feasibility of developing a "Maryland Real-Time Regional Energy Monitoring and Alerting System (RREMAS)." Furthermore, just getting top APL scientists to think about Maryland clean energy development opportunities can have the most unexpected benefits for useful technology applications, as other civilian applications of NASA and DOD-developed technologies have so frequently demonstrated.

Maryland has a small but growing base of installed and planned renewable energy production capacity. Maryland offers incentives, but according to the Maryland-DC-Virginia Solar Energy Industries Association, these are considered too small to promote the full development of the sector. None-the-less, several projects are in the permitting or planning stage. MCEC will conduct an assessment of the extent to which promoting the development of renewable energy in Maryland, especially wind and solar power, could facilitate the development of an industry involved in the production of renewable-energy power components and balance-of-systems, and the extent to which this could assist the State in stabilizing or growing employment in its manufacturing sector. If warranted, MCEC could then work with DBED and state or regional manufacturing organizations, such as Regional Manufacturing Institute (RMI) or the Maryland Technology Extension Service (MTES), to create a consortium of manufacturing firms to serve as suppliers to the major renewable-energy power developers.

In view of Maryland's national leadership in both university and federal research activities, there is a need to assess the extent to which there is a critical mass of technology under development to support wider-scale commercialization activities of clean energy business incubation and business start-ups. There almost certainly will be near term opportunities to better link the federal, university, and private resources in place to promote growth in alternative and clean energy research. Furthermore, Maryland needs to assess its position in alternative and clean energy research in light of the likely future growth and importance of the sector. MCEC intends develop of a complete inventory of private, university and federal clean energy technology capabilities and activities in the State and then conduct thorough needs and potential applications analyses of these capabilities. Based on a complete inventory of clean energy technology capabilities, MCEC working with TEDCO could, then, promote opportunities for expanded interaction between the university, federal labs and private companies. This would further develop a critical mass of research activities and interactions in the field.

Maryland is competitive within the mid-Atlantic region in terms of the size of its clean energy sector. Its critical strength lies in its government contracting, consulting and research base which account for the overwhelming majority of businesses and jobs. The strength of this sector is presumably related to the State's close proximity to Washington, D.C. and the strong base of federal government contracting in the State. Exploring and expanding the linkages of this sector to federal government agency clients presents a clear near term opportunity for supporting the growth and development of this sector, and MCEC intends to undertake this effort. Maryland is also home to an international leader in solar cell production, BP Solar. MCEC also intends to explore the potential of developing an industry cluster of related businesses to support the growth of this business sector.

Because of the strength of the Maryland biotechnology sector and the strong potential for biotechnology applications in alternative and clean energy technology development, Maryland should explore the potential for creating a new biotechnology research institute for alternative and clean energy research. Such an institute would build on the existing success of UMBI in promoting the development of new biotechnology applications and sectors and exploit an area of existing comparative advantage in biotechnology research and business activity. For the past four months, ICSD has been assisting Maryland DBED in the formation of a mid-Atlantic Consortium to respond to an USDOE Solicitation for establishing two Bioenergy Research Centers to undertake systems biology research on plants and microbes necessary for the cost-effective, large-scale production of cellulosic ethanol and other renewable energy from biomass. DBED intends to have such a Center be established in Maryland in cooperation with several Maryland-based organizations (University of Maryland College Park, University of Maryland Biotech Institute, Johns Hopkins Applied Physics Laboratory, the Institute for Genomics Research, the International Center for Sustainable Development, BCS Inc, and several private-sector bioenergy companies), and several partners from other States in the mid-Atlantic region (Brook Haven National Laboratory, North Carolina State University, Rutgers University, Duke University, and several other research centers). Regardless of whether or not the mid-Atlantic Consortium is successful in winning the USDOE Solicitation, MCEC intends to work to catalyze the application of biotechnology in this emerging clean energy field in Maryland.

MCEC intends to work with DBED on developing a more complete inventory of the companies working with DOE and other federal agencies in the area of alternative and clean energy related consulting, research or other services to identify the needs of these businesses and their interest in working together to promote the development of the sector. MCEC also intends to work with MEA, the Maryland Interdepartmental Energy Group, and Maryland clean energy companies, to develop a complete analysis of the incentives available to support renewable energy in Maryland as compared to best practices across the country to determine the need for new or expanded incentives programs.

Outreach and Technical Support:

Working through the Collaboratives, MCEC will provide regular information to the media and support workshops and seminars for consumers. MCEC will also publish a Newsletter and an annual "State of the Maryland Clean Energy Industry." Furthermore, MCEC will provide technical assistance to the State, institutions and NGO's in Maryland on the application of energy efficiency and renewable energy technologies in their facilities. Through conference participation and its international contacts, MCEC will inform the national and international clean-energy community of Maryland's decision to pursue clean energy-driven economic development in the State and foster a general climate supportive of clean- energy technology deployment and application. This, and the afore-mentioned quality of the State's workforce, its locational benefits and atmosphere of creative innovation, will work to attract clean-energy start-up and mature businesses to Maryland.

MCEC Time Line

MCEC Year 1

The following are the priorities for the first year of the MCEC.

1. Establish the MCEC
    - Set up the MCEC at ETC and recruit and hire staff,
    - Set up bylaws, Board of Directors and Board of Advisors,
    - Apply for 501c3 tax exempt status with the IRS
2. Establish MOUs with Strategic partners
3. Further develop and refine the Maryland Clean-Energy Industry Database

4. Create and manage the Maryland Clean Energy Business Council and establish the above-mentioned Clean Energy Business Development Collaboratives
5. Begin developing other core activities of Center
    - track State and National activities
    - Publish a Newsletter and an annual State of the Maryland Clean Energy Industry
    - Establish and maintain an energy data collection and tracking systems
    - Conduct an Energy Policy Study and develop policy recommendations
    - Provide technical assistance to businesses, home owners, state and local governments, NGOs and the Maryland legislature
6. Establish and support the Clean Energy Incubator at ETC
7. Begin developing projects with MCEC Strategic partners

MCEC Year 2

1. Continue working with the Clean Energy Business Council, and supporting the Clean Energy Collaboratives and other core activities
2. Hold the first Annual Clean Energy Conference and workshops
3. Explore the feasibility of creating a Clean Energy Fund for Maryland
4. Launch projects with MCEC Strategic Partners
5. Launch Green Home Pro Weatherization Program

Potential Projects to be undertaken in year 1 or 2 with MCEC Partners:

- Feasibility study for developing a "Maryland Real-Time Regional Energy Monitoring and Alerting System (RREMAS)"
- Assessment of potential renewable-energy power component and balance-of-systems industrial development in Maryland
- Assessment, inventory and needs-and-applications analysis of private, university and federal clean-energy technology capabilities, research and activities in the State
- Assessment and inventory of the linkages of the Maryland clean-energy sector to federal agency programs
- Analysis of potential biotechnology applications in the clean energy field in Maryland
- Analysis of available renewable energy production and utilization incentives in Maryland
- Feasibility studies for ethanol and biodiesel plants, and wind farms in Maryland
- Clean energy demonstration projects
- Zero Energy Building for MCEC
- Vocational development projects
- Sustainable Cities Program

Proposed Budget

- Core Budget year 1- $820,000
- Core Budget year 2- $1,060,000
- Year 2 and beyond- Core budget plus project budgets. $2-5 million per year through Strategic Partners
- Technical assistance and commercial weatherization program is self supporting

Staffing and Management
The MCEC will be managed and staffed in the beginning by the ICSD, until full time staff can be hired. MCEC will seek full time staff positions to include:

- Executive Director
- Chief Technology Officer
- Solar, energy efficiency and Green buildings Collaborative Manager
- Biofuel and Hydrogen Collaborative Manager
- Wind Collaborative Manager
- Outreach Manager
- Data and Policy Analyst
- Project Managers (as needed to work with Strategic Partners)

MCEC will have a Board of Directors that will oversee the operations of the Center. The Board of Directors will consist of representatives from DBED, MEA, Abell Foundation, ETC and industry. MCEC will be guided by a Board of Advisors that will be named by the Board of Directors and consist of leaders in industry, research, educators and policy makers.

Potential funding methods
The majority of State Clean Energy Centers are funded by the State or local government with additional support from foundations. The most effective economic development programs are funded by a very small public benefit surcharge on consumer's electric bills. These funds currently collect more than $500 million per year in 14 States in support of renewables and efficiency. The Massachusetts Renewable Energy Trust Fund is supported through a system benefits charge with total funding of roughly $150 million over the initial five-year period, with approximately $25 million per year for each year thereafter. The New Jersey fund is about $18 million per year, New York $25.5 million per year and Pennsylvania $27.3 million per year. The States that have made this kind of investment have seen significant economic development benefits for the State. Clearly, Maryland needs to look at how the State can fund Clean Energy investments at a level of at least $25 million per year in order to see significant growth the clean energy sector. MCEC expects to start small and build statewide support for a more aggressive program. If Maryland chooses to impose a very small public benefit tax on consumers' utility bills of $0.0004 cents per kilowatt-hour or less than $0.50 per household per month, as 14 states currently do, this would raise $25 million per year for clean energy programs.

At least for the first two years, we think an annual operating budget of approximately $1 million can be funded by a combination of State funds and foundation support with the majority of the funds coming from the State. As the MCEC starts to develop projects, these projects will seek project specific funding that can come from a variety of sources, including the Federal government, foundations, industry and private investment. MCEC will always seek to leverage existing programs and funding when ever possible. During the first two years of the MCEC, we will work closely with the State, utilities and others to find a way to fund a Maryland Clean Energy Fund.

7. Conclusions

The overall conclusion of the study is that creating a Clean Energy Center for Maryland would have tremendous benefits to the State in terms of economic development, stable energy prices and supply, and environmental improvement. Additional conclusions are as follows:

1. **The economic development potential of clean energy development in Maryland is very significant in terms of jobs, wages and salaries, state and local tax revenues, and gross state product.** The estimated cumulative economic impacts of the promotion of energy efficiency, renewable energy and alternative fuels to the State of Maryland, over a twenty year period, are huge. At the lowest level of effort (20 percent energy-efficiency improvement, 10 percent renewable-energy increase, and 10 percent ethanol production increase), the employment benefits over 20 years are approximately 144 thousand jobs for Maryland, of which approximately 67 thousand will be created in Baltimore. At the same level of effort, and over a twenty-year time period, wages & salaries will go up by $5.7 billion in Maryland and over $2.4 billion in Baltimore; state & local tax revenues will increase by $973 million in Maryland and $412 million in Baltimore; and gross state product (GSP) will increase by $16 billion in Maryland and almost $7 billion in Baltimore. At the highest level of effort (40 percent energy-efficiency improvement, 30 percent renewable-energy increase, and 30 percent ethanol production increase), the economic impacts more than double.
2. **The estimated economic development potential of attracting, expanding and starting-up clean-energy companies, over a 24 year time period, is lower, but still significant.** For these activities, estimated total jobs impacts for Maryland range from 3,750 to nearly 15,000. Associated wages and salaries for these jobs range from $177 million to over $708 million, while expected state and local tax revenues exceed $18 million in the low scenario and surpass $72 million in the high scenario. The estimated impact on Maryland's GSP ranges from nearly $455 million to more than $1.8 billion. For Baltimore, job impacts range from 1,863 to 7,450, and associated wages and salaries for these jobs range from $81 million to over $325 million. Expected state and local tax revenues range from over $8 million to over $33 million, and the estimated impact on Baltimore's GSP ranges from over $209 million to more than $837 million.
3. **The estimated economic development potential of clean energy business incubation is also significant.** For every $10 million spent on business incubation, the Maryland yearly employment impacts total 159 jobs, while associated wages and salaries for these jobs for a year exceed $7 million. Yearly estimated state and local tax revenues approaches $1 million and the estimated yearly impact on Maryland's GSP exceeds $18 million. These impacts are expected to happen wherever the incubator is located. For Baltimore, the estimated employment impacts total 79 jobs, and the associated wages and salaries for these jobs total to $3.4 million. Annual estimated state and local tax revenues in Baltimore are $320,000 and the estimated annual impact on Baltimore' GSP is over $8.3 million. Over a 20 year time period, these numbers will be several times larger, but nowhere near the cumulative estimated impacts of energy efficiency, renewable energy, and alternative fuel improvements.
4. **The greatest economic benefit from growing the clean energy business sector comes not just from the jobs created and economic investment in the companies, but from the energy services they provide to Marylanders.** The greatest economic benefit comes from the energy savings to people and businesses, which increases disposable income and

increases profit, stimulating economic activity in all sectors. In addition, every dollar not spent on imported energy (all Maryland's energy is imported), stays in the community and generates approximately $3 in economic activity locally.

5. **Maryland needs to assess its strengths, weaknesses and interest in participating in the expected growth of this sector, and if it decides to participate, how to best capture this growth.** ICSD is suggesting that the best way for this assessment to take place is to (1) give Maryland's clean energy industry an identity and a voice in the process of identifying how to best grow the clean energy sector in Maryland, and (2) establish a Maryland Clean Energy Center to help identify, organize, and grow this industry, and bring all of Maryland's private and public resources into play in a coordinated way so that the State can avail itself of the economic benefits of clean energy growth in the most cost-effective way.
6. **There is strong support for promoting clean energy in Maryland.** We received unanimous agreement from every organization we met with that there is a tremendous opportunity for economic development in clean energy and the concept of the MCEC is a good one. As a result, we have begun to develop strong collaborative relationships with the major institutions in the State, including TEDCO, UMBI, UMD, JHU, JHU-APL, ETC, PEPCO, BGE and many others.
7. **Energy costs are rising and we need a more stable energy supply and costs.** Energy efficiency and renewable costs and supplies are much more stable and entail lower costs in the long term than conventional energy. In addition, we need to provide better access to stable affordable energy services for the low income and disadvantaged segment of the population in Maryland.
8. **Maryland has good to excellent renewable energy resources in wind, solar, and biomass with off-shore wind and solar PV having the greatest potential.** Renewable energy resource potential exceeds current electric sales. Renewable energy technology can provide 30 percent to over 136 percent of the State's electric energy needs**.** PV could provide 17-25 percent and off-shore wind could provide 8 percent to almost 100 percent of the power needs of the State.
9. **The potential clean energy market is large and growing rapidly, over 30 percent per year.** In 2006, the growth in green home building is expected to rise by 20 percent over 2005, and in 2007, there is a projected a growth of 30 percent over 2006 numbers. This means that more than two-thirds of all the home builders will be building green homes. The sheer number of participants in the green-home building market will pull the rest of the market up to green-building standards in order to remain competitive. The market potential for solar water heaters in Maryland is $2 billion for retrofit applications alone. Solar PV is a $12 billion global industry. The PV equipment market is projected to be $30.8 billion by 2013. Renewable-energy project finance is up from $10.8 billion in 2004 to $18.2 billion last year. The preponderance of financing is in wind (72%), with the U.S. leading the world with $3.9 billion invested in 2005.
10. **Maryland is well-positioned to take advantage of the growth in the energy efficiency and renewable energy market.** Maryland has a rich landscape of services and capabilities to support new business growth. Maryland has real strength in the biotechnology sector, which positions the State well to be a leader in the biofuels sector.
11. **While Maryland has some pro clean-energy policies, it lags behind the States that have been reaping the benefits of the rapidly growing clean energy market. T**he solar industry has shown explosive growth in California and New Jersey, where they have aggressive tax incentives, buy down programs, good interconnection policy and

aggressive Renewable Portfolio Standards (RPS). New Jersey's solar industry has experienced a 500 percent growth rate in the past three years as a result of its aggressive policies.

12. **Maryland's Renewable Portfolio Standard (RPS) will do little to grow the clean energy industry in Maryland.** According to the Maryland Power Plant Research Program, barring unforeseen levels of renewable energy generation retirements, increases in demand in the state, or widespread difficulties certifying resources in states adjacent to PJM, it is likely that new renewable energy projects will not have to be developed to meet Maryland's RPS requirement. The Maryland RPS legislation, therefore, may fall short of its expectations.
13. **A reduction is needed in the environmental impacts from fossil fuel-based energy production in Maryland.** Maryland struggles to maintain good air quality and protect the Bay. Because of our heavy coal use, power plants in Maryland contribute significantly to health threatening air pollution. These plants currently contribute nearly 80 percent of the total sulfur dioxide (SO2) emissions and 30 percent of the total nitrogen oxides (NOx) emissions. Currently, coal-fired plants are also significant sources of mercury, a neurological toxicant that contaminates the fish in our rivers, lakes and oceans. Energy efficiency and renewable energy can significantly mitigate the environmental impact of electricity generation in Maryland. The Maryland Healthy Air Act of 2006, with some of the toughest restrictions in the country for emissions of NOx, SO2 and mercury, is a good start, but doesn't take effect till 2009/2010, and much more remains to be done.
14. **Clean energy development in Maryland will allow the State to reduce greenhouse gas emissions that contribute to global climate change.** The Maryland Healthy Air Act also requires that, in 2007, Maryland will join the Regional Greenhouse Gas Initiative, which is a regional consortium of Northeast states committed to reducing greenhouse gas emissions. The Initiative establishes a cap-and-trade mechanism for reducing emissions of greenhouse gases. Maryland will thus join seven other states in the Northeast - Connecticut, Delaware, Maine, New Jersey, New York, New Hampshire, and Vermont - that have agreed to reduce carbon dioxide emissions by10% in 2019. During negotiations about the bill in the Maryland Legislature, the Maryland Governor and Maryland utility companies expressed concerns about the effects of this legislation on electricity prices. As a result, it was amended to require a comprehensive study of reliability and cost issues in 2008. Depending on the outcome of this study, the State can withdraw from the Regional Greenhouse Gas Initiative in 2009.
15. **Performance based incentive programs could be used to encourage local growth of renewable manufacturing.** The best example of this is Washington State, who rejected the RPS mechanism in favor of a feed-in tariff program, similar to the one implemented in Germany. Washington State's program pays producers of renewable electricity a feed-in tariff of up $0.15 kWh or up to $2000 per year for nine years. Larger tariffs are paid, if products are produced in-state. If, for example, the inverter was made locally, the rate jumps to 18 cents. If the system uses a locally-made inverter and modules, the rate jumps to 54 cents. The customer also receives the net metered value of the power and the renewable energy credits. This is the first state end-user incentive program to encourage local growth of renewable manufacturing.
16. **Energy efficiency is the most cost effective energy saving investment.** The potential to reduce energy consumption and cost through energy efficiency is significant. Through a modest set of programs, Maryland can reduce anticipated total electricity demand by 6

percent by 2010. Studies have shown that a broader set of measures could yield cost-effective savings of five times this amount in a similar time frame. In addition, energy efficiency is 60-70 percent cheaper than new generating capacity.

17. **One of the best opportunities for clean energy economic development in Maryland is in the biofuels sector**. Ethanol is one of the fastest growing and hottest investment opportunities today with returns on investment of 27-34 percent on an average investment of over $100 million.
18. **Maryland has excellent technical resources particularly in biotechnology and therefore is well positioned to be a leader in the biofuels market.** MCEC intends to catalyze the application of biotechnology in the biofuels field.
19. **Stable and progressive energy policy is needed to stimulate the clean energy market.** The most effective policies have been performance based incentives, such as the feed-in tariff adopted in Washington State. California and New Jersey have seen explosive growth in the clean energy sector due to their stable and progressive policies.
20. **Maryland needs a focal point to realize the potential of clean energy in Maryland.** Currently the clean energy industry has no identity or voice in Maryland. MCEC proposes to be the champion of the clean energy industry.
21. **Policy makers need accurate data in order to make sound, informed policy that maximizes the potential of clean energy in Maryland.** In addition, they need timely feedback on policy decisions and how well their programs and policies are working.
22. **The public and businesses need to be informed of the potential and benefits of energy efficiency and renewable energy.** The benefits are great but generally unknown to the average consumer. In order to create the market demand for clean energy products and services and grow the clean energy industry in Maryland, the message needs to be broadcast loud and clear across the whole State.
23. **Doing everything we can to promote clean energy in Maryland is good for the economy, good for the people, good for the environment, and is good policy.** This has been clearly demonstrated in many States.
24. **Effective policy and programs can only be developed and managed through a collaborative process.** The MCEC will build public/ private partnerships and facilitate communication and collaboration between all stake holders, including citizens, government, industry, researchers and academia.
25. **Long-term stable funding for the MCEC should be secured through a small public benefit charge on the utility bills.** Fourteen States currently fund their clean energy investment programs through some sort of public benefit charge on the utility bills. The average funding level is $25 million per year. Every State has found a significantly-positive return on their investment in clean energy for their State.
26. **For the MCEC to be effective, it needs to do the following:**
    a. Identify and organize the clean energy industry in Maryland;
    b. Coordinate the industry's interests and provide a forum for collaboration;
    c. Be a technology resource to the State, institutions, businesses and citizens;
    d. Be a resource for the State legislature and local governments;
    e. Help coordinate all the State's resources to support the clean energy industry;
    f. Categorize and coordinate the work of the university, federal and private-sector research community;
    g. Expand the linkages between the Maryland clean energy sector and the federal agencies;

h. Catalyze the application of biotechnology to the emerging clean energy field in Maryland;
i. Promote linkages between existing incubators and research parks and clean energy companies;
j. Conduct an assessment of the extent to which promoting the development of renewable energy in Maryland, especially wind and solar power, could facilitate the development of an industry involved in the production of renewable-energy power components and balance-of-systems products, and the extent to which this could assist the State in stabilizing or growing employment in its manufacturing sector;
k. Broadly promote the benefits of clean energy throughout the State;
l. Coordinate the development of a Maryland "Real-Time Regional Energy Monitoring and Alerting System (RREMAS)."

Appendix 1 Energy Data

Table R1: Maryland Renewable-Eneregy Consumption by Sector: 1960-2004 Trillion Btu							
Year	Residential	Commercial	Industrial	Transportation	Electric Power - Hydro	Electric Power - Biomass	Total
1960	8.1	0.2	15.6	0.0	14.6	0.0	39
1961	7.8	0.1	15.7	0.0	12.1	0.0	36
1962	7.5	0.1	16.3	0.0	12.1	0.0	36
1963	7.2	0.1	18.0	0.0	10.2	0.0	36
1964	6.7	0.1	18.9	0.0	11.6	0.0	37
1965	6.6	0.1	20.4	0.0	11.9	0.0	39
1966	6.7	0.1	21.5	0.0	13.8	0.0	42
1967	6.8	0.1	22.5	0.0	20.1	0.0	50
1968	7.0	0.1	23.9	0.0	16.7	0.0	48
1969	7.3	0.1	23.9	0.0	14.2	0.0	46
1970	7.5	0.1	24.1	0.0	20.0	0.0	52
1971	7.4	0.1	23.1	0.0	18.6	0.0	49
1972	7.7	0.1	24.6	0.0	23.7	0.0	56
1973	7.8	0.1	24.6	0.0	22.5	0.0	55
1974	8.2	0.2	23.5	0.0	20.6	0.0	53
1975	9.0	0.2	22.6	0.0	24.0	0.0	56
1976	10.0	0.2	24.5	0.0	21.7	0.0	56
1977	11.1	0.2	27.2	0.0	21.1	0.0	60
1978	13.1	0.3	27.9	0.0	18.0	0.0	59
1979	14.9	0.3	28.4	0.0	22.7	0.0	66
1980	15.9	0.4	16.4	0.0	13.2	0.0	46
1981	11.3	0.3	17.3	0.1	14.9	0.0	44
1982	12.2	0.3	16.7	0.0	14.0	0.0	43
1983	12.0	0.3	18.9	0.0	18.6	0.0	50
1984	17.7	0.4	19.2	0.0	21.1	0.4	59
1985	19.4	0.5	19.2	0.0	15.9	0.2	55
1986	16.8	0.5	16.4	0.0	19.6	0.4	54
1987	13.8	0.5	16.1	0.0	16.8	0.5	48
1988	14.3	0.5	16.7	0.0	13.7	0.6	46
1989	15.0	0.6	13.3	0.0	18.5	7.4	55
1990	8.0	1.6	9.7	0.0	23.9	7.3	51
1991	8.3	1.1	10.2	0.0	14.7	7.3	42
1992	8.7	1.7	9.9	0.0	18.9	7.5	47
1993	12.6	2.4	10.0	0.0	17.1	7.3	49
1994	12.0	2.3	10.4	0.0	20.7	7.6	53
1995	12.0	3.6	11.3	0.3	14.9	10.1	52
1996	12.4	3.8	12.3	0.2	25.4	12.1	66
1997	9.4	3.9	11.8	0.3	16.2	11.7	53
1998	8.3	3.3	11.1	0.2	17.7	12.1	53
1999	8.7	3.2	11.7	0.2	14.6	12.7	51
2000	9.3	3.4	11.3	0.2	17.7	12.3	54
2001	5.9	2.9	5.8	0.0	12.2	12.2	39
2002	6.0	2.5	5.9	3.1	16.9	13.0	47
2003	6.4	3.0	11.6	0.0	27.1	12.9	61
2004	6.4	3.0	11.6	0.0	25.7	12.6	59
2005	6.4	3.0	11.7	0.0	39.3		60
2006	6.4	3.0	11.9	0.0	40.2		62
2007	6.4	3.0	12.0	0.0	41.2		63
2008	6.4	3.0	12.2	0.0	42.3		64
2009	6.4	3.0	12.3	0.0	43.3		65
2010	6.4	3.0	12.5	0.0	44.4		66
2011	6.5	3.0	12.6	0.0	45.5		68
2012	6.5	3.0	12.8	0.0	46.7		69
2013	6.5	3.0	12.9	0.0	47.8		70
2014	6.5	3.0	13.1	0.0	49.0		72
2015	6.5	3.0	13.2	0.0	50.3		73
2016	6.5	3.0	13.4	0.0	51.5		74
2017	6.5	3.0	13.5	0.0	52.8		76
2018	6.5	3.0	13.7	0.0	54.1		77
2019	6.5	3.0	13.9	0.0	55.5		79
2020	6.5	3.0	14.0	0.0	56.9		80
2021	6.5	3.0	14.2	0.0	58.3		82
2022	6.5	3.0	14.4	0.0	59.7		84
2023	6.5	3.0	14.6	0.0	61.2		85
2024	6.5	3.0	14.7	0.0	62.8		87
2025	6.5	3.0	14.9	0.0	64.3		89
2026	6.5	3.0	15.1	0.0	65.9		91
2027	6.6	3.0	15.3	0.0	67.6		92
2028	6.6	3.0	15.4	0.0	69.3		94
2029	6.6	3.0	15.6	0.0	71.0		96
2030	6.6	3.0	15.8	0.0	72.8		98

Table P1: Maryland Petroleum Consumption by Sector: 1960-2004 Trillion Btu						
Year	Residential	Commercial	Industrial	Transportation	Electric Power	Total
1960	50.4	30.3	102.0	169.6	1.1	353
1961	56.0	27.8	92.5	170.8	1.3	348
1962	58.0	26.9	87.6	196.2	1.3	370
1963	58.8	27.8	91.1	197.8	1.5	377
1964	58.2	29.4	100.3	205.4	1.7	395
1965	57.8	29.9	108.5	215.4	1.8	413
1966	58.4	31.8	117.6	227.2	1.8	437
1967	61.0	29.5	101.2	223.3	2.5	418
1968	63.3	28.6	96.4	246.5	9.4	444
1969	61.7	29.2	100.0	253.1	26.4	470
1970	64.0	29.7	101.8	270.8	68.0	534
1971	64.1	35.8	124.5	271.3	92.3	588
1972	62.4	36.3	125.1	286.0	141.1	651
1973	60.7	37.5	135.2	300.8	161.0	695
1974	57.6	31.9	110.7	295.1	176.2	672
1975	59.6	28.2	93.7	295.1	117.0	594
1976	58.3	29.1	101.5	308.0	110.4	607
1977	58.5	29.0	104.0	319.0	107.1	618
1978	56.5	27.0	96.6	323.8	123.5	627
1979	61.2	29.0	102.7	315.9	92.1	601
1980	58.7	25.2	76.9	314.5	57.6	533
1981	46.3	11.8	71.4	320.9	46.1	497
1982	42.6	14.9	62.9	310.0	41.7	472
1983	41.8	21.5	79.3	303.2	40.3	486
1984	47.4	25.5	98.4	305.4	35.9	513
1985	42.5	16.2	74.1	314.5	37.1	484
1986	38.7	17.1	80.1	322.9	31.1	490
1987	46.6	26.1	79.9	335.4	32.1	520
1988	50.2	18.8	78.6	347.4	42.8	538
1989	41.9	23.3	76.5	357.3	76.8	576
1990	35.8	20.1	79.8	327.7	47.1	511
1991	34.8	18.0	65.1	332.8	50.5	501
1992	36.9	22.1	69.7	340.4	34.6	504
1993	40.4	19.4	75.7	340.1	51.9	528
1994	39.7	23.5	75.4	340.0	50.4	529
1995	37.7	21.2	68.3	345.1	18.3	491
1996	43.9	21.9	72.2	354.0	19.0	511
1997	39.8	17.5	78.1	364.2	20.1	520
1998	35.8	18.2	82.7	374.9	40.2	552
1999	36.2	15.9	81.1	395.4	50.0	579
2000	36.1	19.1	77.4	397.9	26.9	557
2001	36.5	18.0	79.2	400.2	34.5	568
2002	33.5	17.2	75.9	397.1	25.5	549
2003	35.9	18.4	78.7	404.9	29.4	567
2004	37.3	19.1	81.7	420.1	30.5	589
2005	37.0	19.2	82.0	428.1	30.1	514
2006	36.8	19.3	82.4	436.2	29.8	522
2007	36.5	19.4	82.7	444.5	29.4	530
2008	36.3	19.5	83.0	452.9	29.1	538
2009	36.0	19.6	83.3	461.6	28.7	546
2010	35.8	19.7	83.7	470.3	28.4	554
2011	35.5	19.8	84.0	479.3	28.0	563
2012	35.3	19.9	84.4	488.4	27.7	571
2013	35.0	20.0	84.7	497.6	27.4	580
2014	34.8	20.1	85.0	507.1	27.0	589
2015	34.5	20.2	85.4	516.7	26.7	598
2016	34.3	20.3	85.7	526.6	26.4	608
2017	34.0	20.4	86.1	536.6	26.1	617
2018	33.8	20.5	86.4	546.8	25.8	627
2019	33.6	20.6	86.7	557.1	25.4	637
2020	33.3	20.7	87.1	567.7	25.1	647
2021	33.1	20.8	87.4	578.5	24.8	657
2022	32.9	20.9	87.8	589.5	24.5	668
2023	32.6	21.0	88.1	600.7	24.2	679
2024	32.4	21.1	88.5	612.1	24.0	690
2025	32.2	21.2	88.8	623.7	23.7	701
2026	32.0	21.3	89.2	635.6	23.4	712
2027	31.7	21.4	89.6	647.7	23.1	724
2028	31.5	21.5	89.9	660.0	22.8	736
2029	31.3	21.6	90.3	672.5	22.6	748
2030	31.1	21.7	90.6	685.3	22.3	760

Table C1: Maryland Coal Consumption by Sector: 1960-2004 Trillion Btu						
Year	Residential	Commercial	Industrial	Transportation	Electric Power	Total
1960	4.2	2.9	135.0	2.3	82.2	226.6
1961	3.9	2.7	135.9	0.6	87.1	230.2
1962	4.3	3.0	146.4	0.6	98.1	252.3
1963	5.2	3.8	151.9	0.5	113.8	275.3
1964	5.1	3.7	164.1	0.6	127.1	300.6
1965	3.3	2.5	162.4	0.5	158.7	327.4
1966	2.0	1.5	159.7	0.5	175.3	339.0
1967	1.6	1.2	161.1	0.4	186.4	350.7
1968	1.5	1.2	164.4	0.3	195.4	362.8
1969	1.4	1.1	176.4	0.3	176.2	355.4
1970	1.1	0.9	162.7	0.2	146.4	311.3
1971	0.8	0.8	140.1	0.2	132.1	274.0
1972	0.5	0.6	113.5	0.1	111.8	226.4
1973	0.4	0.8	158.4	0.1	97.1	256.8
1974	0.4	0.9	119.0	0.1	97.1	217.5
1975	0.2	0.5	102.2	(s)	94.2	197.2
1976	0.2	0.5	119.9	(s)	124.8	245.3
1977	0.3	0.8	80.7	(s)	107.9	189.7
1978	0.2	0.6	90.7	0.0	118.2	209.7
1979	0.9	3.8	106.1	0.0	129.9	240.7
1980	0.2	0.7	88.6	0.0	146.3	235.7
1981	0.2	0.8	82.0	0.0	127.4	210.4
1982	0.4	2.1	71.6	0.0	143.1	217.3
1983	0.4	2.1	72.5	0.0	157.6	232.6
1984	0.4	1.6	78.9	0.0	189.3	270.2
1985	0.7	2.3	74.8	0.0	178.4	256.2
1986	0.7	2.4	69.9	0.0	202.0	275.0
1987	1.0	3.4	75.9	0.0	208.6	288.9
1988	0.7	2.4	68.6	0.0	229.6	301.2
1989	0.3	1.1	63.3	0.0	231.2	295.8
1990	0.2	1.0	57.4	0.0	227.9	286.5
1991	0.2	0.9	52.8	0.0	220.9	274.8
1992	0.1	0.3	17.8	0.0	229.4	247.5
1993	0.1	0.3	18.5	0.0	242.9	261.7
1994	0.1	0.8	18.8	0.0	249.2	268.9
1995	1.0	6.4	19.2	0.0	262.9	289.6
1996	0.1	0.9	19.7	0.0	271.7	292.5
1997	0.2	1.2	19.3	0.0	269.0	289.7
1998	0.1	1.2	19.2	0.0	283.3	303.9
1999	0.1	1.0	19.9	0.0	284.1	305.2
2000	0.2	1.9	20.3	0.0	289.7	312.2
2001	0.2	1.7	33.6	0.0	283.3	318.9
2002	0.0	0.1	34.1	0.0	291.7	325.8
2003	0.0	0.1	31.8	0.0	297.6	329.6
2004	0.0	0.1	34.3	0.0	292.3	326.7
2005	0.0	0.1	34.7	0.0	295.8	330.6
2006	0.0	0.1	35.1	0.0	299.4	334.6
2007	0.0	0.1	35.5	0.0	302.9	338.6
2008	0.0	0.1	36.0	0.0	306.6	342.7
2009	0.0	0.1	36.4	0.0	310.3	346.8
2010	0.0	0.1	36.8	0.0	314.0	350.9
2011	0.0	0.1	37.3	0.0	317.8	355.1
2012	0.0	0.1	37.7	0.0	321.6	359.4
2013	0.0	0.1	38.2	0.0	325.4	363.7
2014	0.0	0.1	38.6	0.0	329.3	368.1
2015	0.0	0.1	39.1	0.0	333.3	372.5
2016	0.0	0.1	39.6	0.0	337.3	377.0
2017	0.0	0.1	40.1	0.0	341.3	381.5
2018	0.0	0.1	40.5	0.0	345.4	386.1
2019	0.0	0.1	41.0	0.0	349.6	390.7
2020	0.0	0.1	41.5	0.0	353.8	395.4
2021	0.0	0.1	42.0	0.0	358.0	400.1
2022	0.0	0.1	42.5	0.0	362.3	404.9
2023	0.0	0.1	43.0	0.0	366.7	409.8
2024	0.0	0.1	43.5	0.0	371.1	414.7
2025	0.0	0.1	44.1	0.0	375.5	419.7
2026	0.0	0.1	44.6	0.0	380.0	424.7
2027	0.0	0.1	45.1	0.0	384.6	429.8
2028	0.0	0.1	45.7	0.0	389.2	435.0
2029	0.0	0.1	46.2	0.0	393.9	440.2
2030	0.0	0.1	46.8	0.0	398.6	445.5

Table G1: Maryland Gas Consumption by Sector: 1960-2004 Trillion Btu						
Year	Residential	Commercial	Industrial	Transportation	Electric Power	Total
1960	47.5	8.3	16.6	0.9	0.1	73.3
1961	49.6	9.1	16.7	1.0	0.1	76.5
1962	52.7	10.0	20.8	1.2	0.1	84.8
1963	54.2	10.8	22.8	1.2	0.1	89.0
1964	56.5	11.8	24.7	1.2	0.1	94.3
1965	58.1	13.3	28.3	1.2	0.1	101.0
1966	58.6	13.8	28.8	1.5	0.2	102.8
1967	66.3	19.9	32.8	1.9	0.4	121.3
1968	68.0	21.5	38.3	1.5	0.4	129.7
1969	72.6	24.5	41.9	2.0	6.7	147.7
1970	74.5	26.5	44.9	2.1	11.7	159.6
1971	75.2	28.9	48.8	2.1	9.6	164.7
1972	76.5	31.0	62.1	3.6	7.0	180.3
1973	74.4	30.3	61.8	2.4	8.8	177.6
1974	71.3	30.4	58.7	1.8	13.4	175.5
1975	70.1	25.5	43.6	2.2	0.4	141.9
1976	74.5	28.6	44.1	2.3	0.2	149.6
1977	66.2	28.0	38.5	2.1	0.3	135.2
1978	72.1	28.2	36.8	1.9	0.6	139.6
1979	72.5	32.9	61.3	2.4	10.6	179.6
1980	69.4	29.1	55.5	4.0	5.4	163.4
1981	71.4	32.5	65.3	2.4	6.1	177.7
1982	68.7	31.4	57.2	2.5	1.0	160.8
1983	66.1	31.4	47.2	2.1	1.8	148.7
1984	74.9	26.0	58.8	2.2	1.3	163.1
1985	70.7	25.0	56.5	2.3	1.4	156.0
1986	74.5	24.7	54.4	2.1	2.3	158.0
1987	73.0	26.4	60.4	2.2	12.3	174.3
1988	77.3	26.7	66.2	2.7	5.6	178.4
1989	77.5	27.8	68.4	2.3	23.7	199.6
1990	68.2	24.7	63.5	2.5	21.7	180.6
1991	71.0	39.1	48.3	2.6	22.1	183.0
1992	77.1	43.6	51.1	2.5	15.8	190.1
1993	79.0	44.8	50.2	2.5	10.5	187.0
1994	79.0	45.5	49.1	2.6	15.8	192.0
1995	78.5	48.0	50.2	3.0	19.5	199.2
1996	88.0	47.2	51.5	2.8	12.3	201.7
1997	80.1	51.5	68.2	3.3	16.1	219.2
1998	70.6	59.5	40.0	3.2	22.3	195.5
1999	77.4	60.1	38.5	3.5	23.7	203.0
2000	86.8	57.5	41.4	3.5	30.1	219.4
2001	73.3	62.0	28.4	3.1	18.1	185.0
2002	82.2	65.7	27.9	2.8	23.2	201.8
2003	93.3	72.6	22.5	3.1	11.4	202.9
2004	88.4	71.7	23.4	2.8	12.4	198.7
2005	90.0	71.2	23.6	2.8	12.5	200.1
2006	91.6	72.6	23.8	2.9	12.6	203.5
2007	93.3	74.1	24.0	2.9	12.7	207.0
2008	94.9	75.6	24.3	2.9	12.8	210.5
2009	96.6	77.1	24.5	2.9	12.9	214.0
2010	98.4	78.6	24.7	3.0	13.0	217.7
2011	100.2	80.2	24.9	3.0	13.1	221.4
2012	102.0	81.8	25.1	3.0	13.2	225.1
2013	103.8	83.4	25.4	3.1	13.3	229.0
2014	105.7	85.1	25.6	3.1	13.4	232.9
2015	107.6	86.8	25.8	3.1	13.5	236.8
2016	109.5	88.5	26.1	3.2	13.6	240.9
2017	111.5	90.3	26.3	3.2	13.8	245.0
2018	113.5	92.1	26.5	3.2	13.9	249.2
2019	115.5	93.9	26.8	3.3	14.0	253.5
2020	117.6	95.8	27.0	3.3	14.1	257.8
2021	119.7	97.7	27.2	3.3	14.2	262.2
2022	121.9	99.7	27.5	3.3	14.3	266.7
2023	124.1	101.7	27.7	3.4	14.4	271.3
2024	126.3	103.7	28.0	3.4	14.5	276.0
2025	128.6	105.8	28.2	3.5	14.7	280.7
2026	130.9	107.9	28.5	3.5	14.8	285.6
2027	133.2	110.1	28.8	3.5	14.9	290.5
2028	135.6	112.3	29.0	3.6	15.0	295.5
2029	138.1	114.5	29.3	3.6	15.1	300.6
2030	140.6	116.8	29.5	3.6	15.3	305.8

Table S1: Maryland Energy Consumption by Sector: 1960-2004 Trillion Btu					
Year	Residential	Commercial	Industrial	Transportation	Total Consumption
1960	143.1	73.6	307.8	172.9	697.5
1961	153.1	72.4	302	172.7	700.1
1962	160.4	74.6	315.5	198.2	748.6
1963	166.5	79.7	332.6	199.6	778.4
1964	171.8	85.7	362.5	207.2	827.2
1965	176.4	91.3	378.2	217.1	863.1
1966	183.2	98.4	393.9	229.1	904.6
1967	197.8	106.5	390.4	225.5	920.2
1968	211.2	112.6	402.2	248.3	974.3
1969	222.8	122.1	429.1	255.4	1,029.30
1970	237.0	131.2	432.3	273.1	1,073.60
1971	241.9	144.7	444.4	273.6	1,104.60
1972	246.5	152.2	434.5	289.7	1,123.00
1973	254.7	160.3	496.7	303.3	1,215.00
1974	247.4	152.8	426.4	297.0	1,123.50
1975	251.2	154	367.4	297.3	1,069.90
1976	260.3	162.9	415.4	310.2	1,148.80
1977	261.3	160.6	387.4	321.1	1,130.50
1978	272.6	161.8	395	325.8	1,155.20
1979	279.4	172	450.2	318.5	1,220.10
1980	285.2	164.7	389.3	318.8	1,158.00
1981	270.0	154.9	392.3	323.6	1,140.80
1982	267.4	160.2	355.2	312.8	1,095.60
1983	275.0	171.3	367.6	305.6	1,119.50
1984	297.3	159.7	422.5	308.2	1,187.60
1985	294.8	152.4	397.2	317.6	1,162.00
1986	306.5	158.7	396.6	325.9	1,187.70
1987	324.1	175.9	416.8	338.5	1,255.40
1988	346.1	175.4	422.2	351.2	1,294.80
1989	351.2	173.5	442.3	360.6	1,327.60
1990	328.2	172	428.7	331.3	1,260.10
1991	342.5	185.6	395.1	336.6	1,259.80
1992	344.0	194.7	369.5	344.0	1,252.20
1993	373.3	201.4	380.5	343.9	1,299.10
1994	371.3	226.5	365.1	344.0	1,306.90
1995	377.2	344.2	261.3	349.5	1,332.20
1996	401.2	339.5	268.5	358.2	1,367.40
1997	373.8	342.3	290.2	369.0	1,375.40
1998	364.6	360.5	268.3	379.6	1,373.00
1999	384.3	368	262.7	400.5	1,415.50
2000	400.1	378.1	262.9	403.2	1,444.30
2001	384.9	383.4	259.7	405.2	1,433.20
2002	403.6	327.0	374.5	401.7	1,506.80
2003	430.4	281.4	444.9	413.2	1,569.70
2004	441.2	284.7	385.3	428.1	1,539.30
2005	444.6	287.3	386.0	436.1	1553.9
2006	448.0	291.8	386.7	444.3	1570.8
2007	451.5	296.4	387.4	452.6	1588.0
2008	455.1	301.2	388.2	461.1	1605.5
2009	458.7	306.0	388.9	469.7	1623.4
2010	462.4	310.9	389.7	478.6	1641.6
2011	466.2	315.9	390.6	487.5	1660.2
2012	470.0	321.1	391.4	496.7	1679.2
2013	473.9	326.3	392.3	506.0	1698.5
2014	477.9	331.6	393.2	515.5	1718.2
2015	482.0	337.0	394.1	525.2	1738.3
2016	486.1	342.6	395.1	535.1	1758.9
2017	490.4	348.2	396.1	545.1	1779.8
2018	494.7	354.0	397.1	555.4	1801.1
2019	499.0	359.9	398.1	565.8	1822.9
2020	503.5	365.9	399.2	576.4	1845.0
2021	508.1	372.0	400.3	587.3	1867.7
2022	512.7	378.3	401.4	598.3	1890.7
2023	517.4	384.7	402.6	609.6	1914.2
2024	522.3	391.2	403.7	621.0	1938.2
2025	527.2	397.9	404.9	632.7	1962.7
2026	532.2	404.6	406.2	644.6	1987.6
2027	537.3	411.6	407.4	656.7	2013.0
2028	542.5	418.7	408.7	669.1	2039.0
2029	547.8	425.9	410.0	681.7	2065.4
2030	553.2	433.3	411.4	694.5	2092.3

Table 7. Energy Consumption Estimates by Source, 1960-2030, Maryland							
Trillion Btu							
Year	Coal	Natural Gas	Total Petroleum	Nuclear Power	Total Renewable Energy	Net Interstate flow / Losses	Total
1960	226.6	73.3	353.4	0.0	38.4	5.8	697.50
1961	230.2	76.5	348.4	0.0	35.7	9.3	700.10
1962	252.3	84.8	369.9	0.0	36.0	5.6	748.60
1963	275.3	89.0	377.1	0.0	35.5	1.5	778.40
1964	300.6	94.3	395.0	0.0	37.4	-0.1	827.20
1965	327.4	101.0	413.4	0.0	39.0	-17.7	863.10
1966	339.0	102.8	436.8	0.0	42.1	-16.2	904.60
1967	350.7	121.3	417.6	0.0	49.5	-18.9	920.20
1968	362.8	129.7	444.3	0.0	47.7	-10.3	974.30
1969	355.4	147.7	470.4	0.0	45.5	10.3	1029.30
1970	311.3	159.6	534.4	0.0	51.8	16.5	1073.60
1971	274.0	164.7	587.9	0.0	49.3	28.9	1104.60
1972	226.4	180.3	650.9	0.0	56.1	9.3	1123.00
1973	256.8	177.6	695.3	0.0	55.1	30.2	1215.00
1974	217.5	175.5	671.7	0.0	52.4	6.4	1123.50
1975	197.2	141.9	593.6	48.3	55.8	33.2	1069.90
1976	245.3	149.6	607.3	70.9	56.4	19.2	1148.80
1977	189.7	135.2	617.7	117.2	59.6	11.1	1130.50
1978	209.7	139.6	627.4	108.3	59.3	10.9	1155.20
1979	240.7	179.6	601.0	105.2	66.3	27.2	1220.10
1980	235.7	163.4	533.0	119.4	45.8	60.7	1158.00
1981	210.4	177.7	496.6	127.1	43.7	85.3	1140.80
1982	217.3	160.8	472.0	114.6	43.2	87.8	1095.60
1983	232.6	148.7	486.1	127.3	49.8	75.0	1119.50
1984	270.2	163.1	512.5	126.3	58.9	56.6	1187.60
1985	256.2	156.0	484.4	105.4	55.1	104.8	1162.00
1986	275.0	158.0	490.0	135.7	53.7	75.3	1187.70
1987	288.9	174.3	520.2	105.1	47.7	119.1	1255.40
1988	301.2	178.4	537.8	124.4	45.8	107.1	1294.80
1989	295.8	199.6	575.8	28.8	54.7	172.8	1327.60
1990	286.5	180.6	510.5	13.2	50.5	218.8	1260.10
1991	274.8	183.0	501.2	94.7	41.7	164.3	1259.80
1992	247.5	190.1	503.6	111.7	46.7	152.6	1252.20
1993	261.7	187.0	527.6	129.2	49.2	144.4	1299.10
1994	268.9	192.0	529.0	117.4	52.9	146.6	1306.90
1995	289.6	199.2	490.6	135.9	51.8	165.2	1332.20
1996	292.5	201.7	511.0	127.0	66.0	169.2	1367.40
1997	289.7	219.2	519.8	138.7	52.9	155.2	1375.40
1998	303.9	195.5	551.8	139.9	52.5	129.4	1373.00
1999	305.2	203.0	578.6	139.1	51.0	138.6	1415.50
2000	312.2	219.4	557.3	144.2	54.2	157.1	1444.30
2001	318.9	185.0	568.4	142.7	39.2	179.1	1433.20
2002	325.8	201.8	549.1	126.6	44.5	259.0	1506.80
2003	329.6	202.9	567.2	142.7	61.0	266.3	1569.70
2004	326.7	198.7	588.7	151.9	59.3	214.0	1539.30
2005	330.6	200.1	596.5	153.3	60.4	213.0	1553.92
2006	334.6	203.5	604.4	154.6	61.5	212.1	1570.77
2007	338.6	207.0	612.5	156.0	62.7	211.2	1587.96
2008	342.7	210.5	620.8	157.4	63.9	210.3	1605.49
2009	346.8	214.0	629.2	158.9	65.1	209.4	1623.37
2010	350.9	217.7	637.8	160.3	66.3	208.6	1641.60
2011	355.2	221.4	646.6	161.7	67.6	207.8	1660.20
2012	359.4	225.1	655.5	163.2	68.9	207.0	1679.16
2013	363.7	229.0	664.7	164.7	70.2	206.3	1698.51
2014	368.1	232.9	674.0	166.1	71.6	205.6	1718.23
2015	372.5	236.8	683.5	167.6	73.0	204.9	1738.35
2016	377.0	240.9	693.2	169.1	74.4	204.3	1758.86
2017	381.5	245.0	703.1	170.7	75.8	203.7	1779.78
2018	386.1	249.2	713.2	172.2	77.3	203.1	1801.11
2019	390.7	253.5	723.5	173.8	78.8	202.6	1822.86
2020	395.4	257.8	734.0	175.3	80.4	202.1	1845.04
2021	400.1	262.2	744.7	176.9	82.0	201.7	1867.66
2022	404.9	266.7	755.6	178.5	83.6	201.3	1890.72
2023	409.8	271.3	766.7	180.1	85.3	201.0	1914.24
2024	414.7	276.0	778.1	181.7	87.0	200.7	1938.22
2025	419.7	280.7	789.7	183.3	88.8	200.5	1962.67
2026	424.7	285.6	801.5	185.0	90.6	200.3	1987.61
2027	429.8	290.5	813.5	186.7	92.4	200.1	2013.03
2028	435.0	295.5	825.8	188.3	94.3	200.1	2038.95
2029	440.2	300.6	838.3	190.0	96.2	200.0	2065.38
2030	445.5	305.8	851.0	191.7	98.2	200.1	2092.33

Table 8. Residential Sector Energy Consumption Estimates, 1960-2030, Maryland - Trillion Btu							
	Coal	Natural Gas	Petroleum	Renewables	Electricty	Electric Losses	Total
1960	4.2	47.5	50.4	8.1	9.5	23.4	143.1
1961	3.9	49.6	56.0	7.8	10.4	25.4	153.1
1962	4.3	52.7	58.0	7.5	11.1	26.8	160.4
1963	5.2	54.2	58.8	7.2	12.1	29.0	166.5
1964	5.1	56.5	58.2	6.7	13.4	31.8	171.8
1965	3.3	58.1	57.8	6.6	15.0	35.7	176.4
1966	2.0	58.6	58.4	6.7	16.9	40.5	183.2
1967	1.6	66.3	61.0	6.8	18.3	43.7	197.8
1968	1.5	68.0	63.3	7.0	21.1	50.3	211.2
1969	1.4	72.6	61.7	7.3	23.6	56.2	222.8
1970	1.1	74.5	64.0	7.5	26.2	63.5	237.0
1971	0.8	75.2	64.1	7.4	27.7	66.7	241.9
1972	0.5	76.5	62.4	7.7	29.3	70.2	246.5
1973	0.4	74.4	60.7	7.8	33.0	78.4	254.7
1974	0.4	71.3	57.6	8.2	32.1	77.8	247.4
1975	0.2	70.1	59.6	9.0	33.0	79.3	251.2
1976	0.2	74.5	58.3	10.0	34.5	82.8	260.3
1977	0.3	66.2	58.5	11.1	36.9	88.3	261.3
1978	0.2	72.1	56.5	13.1	38.1	92.5	272.6
1979	0.9	72.5	61.2	14.9	38.2	91.5	279.4
1980	0.2	69.4	58.7	15.9	41.4	99.7	285.2
1981	0.2	71.4	46.3	11.3	42.0	98.7	270.0
1982	0.4	68.7	42.6	12.2	42.6	101.0	267.4
1983	0.4	66.1	41.8	12.0	46.0	108.7	275.0
1984	0.4	74.9	47.4	17.7	47.7	109.3	297.3
1985	0.7	70.7	42.5	19.4	48.9	112.5	294.8
1986	0.7	74.5	38.7	16.8	54.0	121.9	306.5
1987	1.0	73.0	46.6	13.8	58.7	130.9	324.1
1988	0.7	77.3	50.2	14.3	63.1	140.5	346.1
1989	0.3	77.5	41.9	15.0	65.1	151.4	351.2
1990	0.2	68.2	35.8	8.0	65.2	150.8	328.2
1991	0.2	71.0	34.8	8.3	69.2	158.9	342.5
1992	0.1	77.1	36.9	8.7	67.4	153.6	344.0
1993	0.1	79.0	40.4	12.6	73.5	167.7	373.3
1994	0.1	79.0	39.7	12.0	73.9	166.6	371.3
1995	1.0	78.5	37.7	12.0	75.9	172.3	377.2
1996	0.1	88.0	43.9	12.4	78.4	178.4	401.2
1997	0.2	80.1	39.8	9.4	74.8	169.6	373.8
1998	0.1	70.6	35.8	8.3	76.5	173.4	364.6
1999	0.1	77.4	36.2	8.7	79.6	182.2	384.3
2000	0.2	86.8	36.1	9.3	81.7	185.9	400.1
2001	0.2	73.3	36.5	5.9	82.9	186.0	384.9
2002	0.0	82.2	33.5	6.0	87.0	194.8	403.6
2003	0.0	93.3	35.9	6.4	91.0	203.8	430.4
2004	0.0	88.4	37.3	6.4	95.4	213.7	441.2
2005	0.0	90.0	37.0	6.4	97.2	213.9	444.6
2006	0.0	91.6	36.8	6.4	99.1	214.1	448.0
2007	0.0	93.3	36.5	6.4	100.9	214.3	451.5
2008	0.0	94.9	36.3	6.4	102.9	214.6	455.1
2009	0.0	96.6	36.0	6.4	104.8	214.8	458.7
2010	0.0	98.4	35.8	6.4	106.8	215.0	462.4
2011	0.0	100.2	35.5	6.5	108.8	215.2	466.2
2012	0.0	102.0	35.3	6.5	110.9	215.4	470.0
2013	0.0	103.8	35.0	6.5	113.0	215.6	473.9
2014	0.0	105.7	34.8	6.5	115.2	215.8	477.9
2015	0.0	107.6	34.5	6.5	117.3	216.1	482.0
2016	0.0	109.5	34.3	6.5	119.6	216.3	486.1
2017	0.0	111.5	34.0	6.5	121.8	216.5	490.4
2018	0.0	113.5	33.8	6.5	124.2	216.7	494.7
2019	0.0	115.5	33.6	6.5	126.5	216.9	499.0
2020	0.0	117.6	33.3	6.5	128.9	217.1	503.5
2021	0.0	119.7	33.1	6.5	131.4	217.4	508.1
2022	0.0	121.9	32.9	6.5	133.9	217.6	512.7
2023	0.0	124.1	32.6	6.5	136.4	217.8	517.4
2024	0.0	126.3	32.4	6.5	139.0	218.0	522.3
2025	0.0	128.6	32.2	6.5	141.6	218.2	527.2
2026	0.0	130.9	32.0	6.5	144.3	218.5	532.2
2027	0.0	133.2	31.7	6.6	147.1	218.7	537.3
2028	0.0	135.6	31.5	6.6	149.9	218.9	542.5
2029	0.0	138.1	31.3	6.6	152.7	219.1	547.8
2030	0.0	140.6	31.1	6.6	155.6	219.3	553.2

Table 9. Commercial Sector Energy Consumption Estimates, 1960-2030, Maryland Trillion Btu							
	Coal	Natural Gas	Petroleum	Renewables	Electricity	Electric Losses	Total
1960	2.9	8.3	30.3	0.2	9.2	22.7	73.6
1961	2.7	9.1	27.8	0.1	9.5	23.1	72.4
1962	3.0	10.0	26.9	0.1	10.2	24.4	74.6
1963	3.8	10.8	27.8	0.1	10.9	26.2	79.7
1964	3.7	11.8	29.4	0.1	12.0	28.6	85.7
1965	2.5	13.3	29.9	0.1	13.4	32.1	91.3
1966	1.5	13.8	31.8	0.1	15.1	36.1	98.4
1967	1.2	19.9	29.5	0.1	16.4	39.3	106.5
1968	1.2	21.5	28.6	0.1	18.1	43.1	112.6
1969	1.1	24.5	29.2	0.1	19.8	47.3	122.1
1970	0.9	26.5	29.7	0.1	21.7	52.4	131.2
1971	0.8	28.9	35.8	0.1	23.2	55.9	144.7
1972	0.6	31.0	36.3	0.1	24.8	59.4	152.2
1973	0.8	30.3	37.5	0.1	27.1	64.4	160.3
1974	0.9	30.4	31.9	0.2	26.1	63.3	152.8
1975	0.5	25.5	28.2	0.2	29.3	70.3	154.0
1976	0.5	28.6	29.1	0.2	30.7	73.8	162.9
1977	0.8	28.0	29.0	0.2	30.2	72.3	160.6
1978	0.6	28.2	27.0	0.3	30.9	74.9	161.8
1979	3.8	32.9	29.0	0.3	31.2	74.8	172.0
1980	0.7	29.1	25.2	0.4	32.0	77.2	164.7
1981	0.8	32.5	11.8	0.3	32.7	76.8	154.9
1982	2.1	31.4	14.9	0.3	33.1	78.5	160.2
1983	2.1	31.4	21.5	0.3	34.5	81.5	171.3
1984	1.6	26.0	25.5	0.4	32.3	73.9	159.7
1985	2.3	25.0	16.2	0.5	32.8	75.6	152.4
1986	2.4	24.7	17.1	0.5	35.0	79.0	158.7
1987	3.4	26.4	26.1	0.5	37.1	82.6	175.9
1988	2.4	26.7	18.8	0.5	39.4	87.7	175.4
1989	1.1	27.8	23.3	0.6	36.3	84.5	173.5
1990	1.0	24.7	20.1	1.6	37.6	87.0	172.0
1991	0.9	39.1	18.0	1.1	38.4	88.2	185.6
1992	0.3	43.6	22.1	1.7	38.7	88.3	194.7
1993	0.3	44.8	19.4	2.4	41.0	93.5	201.4
1994	0.8	45.5	23.5	2.3	47.5	107.0	226.5
1995	6.4	48.0	21.2	3.6	81.0	183.9	344.2
1996	0.9	47.2	21.9	3.8	81.1	184.6	339.5
1997	1.2	51.5	17.5	3.9	82.1	186.1	342.3
1998	1.2	59.5	18.2	3.3	85.1	193.1	360.5
1999	1.0	60.1	15.9	3.2	87.6	200.3	368.0
2000	1.9	57.5	19.1	3.4	90.4	205.8	378.1
2001	1.7	62.0	18.0	2.9	92.1	206.7	383.4
2002	0.1	65.7	17.2	2.5	74.5	167.0	327.0
2003	0.1	72.6	18.4	3.0	57.8	129.5	281.4
2004	0.1	71.7	19.1	3.0	58.9	131.9	284.7
2005	0.1	71.2	19.2	3.0	60.5	133.2	287.3
2006	0.1	72.6	19.3	3.0	62.2	134.6	291.8
2007	0.1	74.1	19.4	3.0	64.0	135.9	296.4
2008	0.1	75.6	19.5	3.0	65.8	137.3	301.2
2009	0.1	77.1	19.6	3.0	67.6	138.6	306.0
2010	0.1	78.6	19.7	3.0	69.5	140.0	310.9
2011	0.1	80.2	19.8	3.0	71.5	141.4	315.9
2012	0.1	81.8	19.9	3.0	73.5	142.8	321.1
2013	0.1	83.4	20.0	3.0	75.5	144.3	326.3
2014	0.1	85.1	20.1	3.0	77.6	145.7	331.6
2015	0.1	86.8	20.2	3.0	79.8	147.2	337.0
2016	0.1	88.5	20.3	3.0	82.0	148.6	342.6
2017	0.1	90.3	20.4	3.0	84.3	150.1	348.2
2018	0.1	92.1	20.5	3.0	86.7	151.6	354.0
2019	0.1	93.9	20.6	3.0	89.1	153.1	359.9
2020	0.1	95.8	20.7	3.0	91.6	154.7	365.9
2021	0.1	97.7	20.8	3.0	94.2	156.2	372.0
2022	0.1	99.7	20.9	3.0	96.8	157.8	378.3
2023	0.1	101.7	21.0	3.0	99.5	159.3	384.7
2024	0.1	103.7	21.1	3.0	102.3	160.9	391.2
2025	0.1	105.8	21.2	3.0	105.2	162.6	397.9
2026	0.1	107.9	21.3	3.0	108.1	164.2	404.6
2027	0.1	110.1	21.4	3.0	111.2	165.8	411.6
2028	0.1	112.3	21.5	3.0	114.3	167.5	418.7
2029	0.1	114.5	21.6	3.0	117.5	169.2	425.9
2030	0.1	116.8	21.7	3.0	120.8	170.8	433.3

Table 10. Industrial Sector Energy Consumption Estimates, 1960-2030, Maryland Trillion Btu							
	Coal	Natural Gas	Petroleum	Renewables	Electricity	Electricity Losses	Total
1960	135	16.6	102	15.6	11.2	27.6	307.8
1961	135.9	16.7	92.5	15.7	12	29.2	302
1962	146.4	20.8	87.6	16.3	13.1	31.4	315.5
1963	151.9	22.8	91.1	18	14.4	34.3	332.6
1964	164.1	24.7	100.3	18.9	16.1	38.3	362.5
1965	162.4	28.3	108.5	20.4	17.3	41.3	378.2
1966	159.7	28.8	117.6	21.5	19.5	46.8	393.9
1967	161.1	32.8	101.2	22.5	21.4	51.2	390.4
1968	164.4	38.3	96.4	23.9	23.4	55.8	402.2
1969	176.4	41.9	100	23.9	25.7	61.3	429.1
1970	162.7	44.9	101.8	24.1	28.9	69.9	432.3
1971	140.1	48.8	124.5	23.1	31.6	76.3	444.4
1972	113.5	62.1	125.1	24.6	32.2	77.1	434.5
1973	158.4	61.8	135.2	24.6	34.5	82.1	496.7
1974	119	58.7	110.7	23.5	33.4	81	426.4
1975	102.2	43.6	93.7	22.6	30.9	74.4	367.4
1976	119.9	44.1	101.5	24.5	36.9	88.4	415.4
1977	80.7	38.5	104	27.2	40.4	96.7	387.4
1978	90.7	36.8	96.6	27.9	41.7	101.3	395
1979	106.1	61.3	102.7	28.4	44.7	107	450.2
1980	88.6	55.5	76.9	16.4	44.6	107.4	389.3
1981	82	65.3	71.4	17.3	46.6	109.7	392.3
1982	71.6	57.2	62.9	16.7	43.5	103.3	355.2
1983	72.5	47.2	79.3	18.9	44.5	105.1	367.6
1984	78.9	58.8	98.4	19.2	50.8	116.5	422.5
1985	74.8	56.5	74.1	19.2	52.2	120.4	397.2
1986	69.9	54.4	80.1	16.4	53.9	121.8	396.6
1987	75.9	60.4	79.9	16.1	57.1	127.3	416.8
1988	68.6	66.2	78.6	16.7	59.5	132.6	422.2
1989	63.3	68.4	76.5	13.3	66.4	154.4	442.3
1990	57.4	63.5	79.8	9.7	65.9	152.4	428.7
1991	52.8	48.3	65.1	10.2	66.4	152.3	395.1
1992	17.8	51.1	69.7	9.9	67.4	153.7	369.5
1993	18.5	50.2	75.7	10	68.9	157.3	380.5
1994	18.8	49.1	75.4	10.4	65	146.4	365.1
1995	19.2	50.2	68.3	11.3	34.3	78	261.3
1996	19.7	51.5	72.2	12.3	34.5	78.4	268.5
1997	19.3	68.2	78.1	11.8	34.6	78.3	290.2
1998	19.2	40	82.7	11.1	35.3	80.1	268.3
1999	19.9	38.5	81.1	11.7	33.9	77.6	262.7
2000	20.3	41.4	77.4	11.3	34.3	78.1	262.9
2001	33.6	28.4	79.2	5.8	34.7	77.9	259.7
2002	34.1	27.9	75.9	5.9	71.2	159.6	374.5
2003	31.8	22.5	78.7	11.6	92.7	207.6	444.9
2004	34.3	23.4	81.7	11.6	72.3	162.0	385.3
2005	34.7	23.6	82.0	11.7	73.0	160.9	386.0
2006	35.1	23.8	82.4	11.9	73.8	159.7	386.7
2007	35.5	24.0	82.7	12.0	74.5	158.6	387.4
2008	36.0	24.3	83.0	12.2	75.2	157.5	388.2
2009	36.4	24.5	83.3	12.3	76.0	156.4	388.9
2010	36.8	24.7	83.7	12.5	76.7	155.3	389.7
2011	37.3	24.9	84.0	12.6	77.5	154.2	390.6
2012	37.7	25.1	84.4	12.8	78.3	153.1	391.4
2013	38.2	25.4	84.7	12.9	79.1	152.1	392.3
2014	38.6	25.6	85.0	13.1	79.9	151.0	393.2
2015	39.1	25.8	85.4	13.2	80.7	150.0	394.1
2016	39.6	26.1	85.7	13.4	81.5	148.9	395.1
2017	40.1	26.3	86.1	13.5	82.3	147.9	396.1
2018	40.5	26.5	86.4	13.7	83.1	146.8	397.1
2019	41.0	26.8	86.7	13.9	83.9	145.8	398.1
2020	41.5	27.0	87.1	14.0	84.8	144.8	399.2
2021	42.0	27.2	87.4	14.2	85.6	143.8	400.3
2022	42.5	27.5	87.8	14.4	86.5	142.8	401.4
2023	43.0	27.7	88.1	14.6	87.3	141.8	402.6
2024	43.5	28.0	88.5	14.7	88.2	140.8	403.7
2025	44.1	28.2	88.8	14.9	89.1	139.8	404.9
2026	44.6	28.5	89.2	15.1	90.0	138.8	406.2
2027	45.1	28.8	89.6	15.3	90.9	137.8	407.4
2028	45.7	29.0	89.9	15.4	91.8	136.9	408.7
2029	46.2	29.3	90.3	15.6	92.7	135.9	410.0
2030	46.8	29.5	90.6	15.8	93.6	135.0	411.4

Table 11. Transportation Sector Energy Consumption Estimates, 1960-2030, Maryland, Trillion Btu							
	Coal	Natural Gas	Petroleum	Ethanol	Electricity	Electric Losses	Total
1960	2.3	0.9	169.6	0.0	0.1	0.2	172.9
1961	0.6	1.0	170.8	0.0	0.1	0.2	172.7
1962	0.6	1.2	196.2	0.0	0.1	0.2	198.2
1963	0.5	1.2	197.8	0.0	0.1	0.1	199.6
1964	0.6	1.2	205.4	0.0	0.0	0.0	207.2
1965	0.5	1.2	215.4	0.0	0.0	0.0	217.1
1966	0.5	1.5	227.2	0.0	0.0	0.0	229.1
1967	0.4	1.9	223.3	0.0	0.0	0.0	225.5
1968	0.3	1.5	246.5	0.0	0.0	0.0	248.3
1969	0.3	2.0	253.1	0.0	0.0	0.0	255.4
1970	0.2	2.1	270.8	0.0	0.0	0.0	273.1
1971	0.2	2.1	271.3	0.0	0.0	0.0	273.6
1972	0.1	3.6	286.0	0.0	0.0	0.0	289.7
1973	0.1	2.4	300.8	0.0	0.0	0.0	303.3
1974	0.1	1.8	295.1	0.0	0.0	0.0	297.0
1975	(s)	2.2	295.1	0.0	0.0	0.0	297.3
1976	(s)	2.3	308.0	0.0	0.0	0.0	310.2
1977	(s)	2.1	319.0	0.0	0.0	0.0	321.1
1978	0.0	1.9	323.8	0.0	0.0	0.1	325.8
1979	0.0	2.4	315.9	0.0	0.0	0.1	318.5
1980	0.0	4.0	314.5	0.0	0.1	0.2	318.8
1981	0.0	2.4	320.9	0.1	0.1	0.2	323.6
1982	0.0	2.5	310.0	0.0	0.1	0.2	312.8
1983	0.0	2.1	303.2	0.0	0.1	0.2	305.6
1984	0.0	2.2	305.4	0.0	0.2	0.4	308.2
1985	0.0	2.3	314.5	0.0	0.3	0.6	317.6
1986	0.0	2.1	322.9	0.0	0.3	0.6	325.9
1987	0.0	2.2	335.4	0.0	0.3	0.6	338.5
1988	0.0	2.7	347.4	0.0	0.3	0.8	351.2
1989	0.0	2.3	357.3	0.0	0.3	0.7	360.6
1990	0.0	2.5	327.7	0.0	0.3	0.8	331.3
1991	0.0	2.6	332.8	0.0	0.4	0.8	336.6
1992	0.0	2.5	340.4	0.0	0.4	0.8	344.0
1993	0.0	2.5	340.1	0.0	0.4	0.9	343.9
1994	0.0	2.6	340.0	0.0	0.5	1.0	344.0
1995	0.0	3.0	345.1	0.3	0.5	1.1	349.5
1996	0.0	2.8	354.0	0.2	0.5	1.0	358.2
1997	0.0	3.3	364.2	0.3	0.4	1.0	369.0
1998	0.0	3.2	374.9	0.2	0.5	1.0	379.6
1999	0.0	3.5	395.4	0.2	0.5	1.1	400.5
2000	0.0	3.5	397.9	0.2	0.5	1.2	403.2
2001	0.0	3.1	400.2	0.0	0.6	1.3	405.2
2002	0.0	2.8	397.1	3.1	0.6	1.3	401.7
2003	0.0	3.1	404.9	0.0	1.6	3.6	413.2
2004	0.0	2.8	420.1	0.0	1.6	3.6	428.1
2005	0.0	2.8	428.1	0.0	1.6	3.6	436.1
2006	0.0	2.9	436.2	0.0	1.6	3.6	444.3
2007	0.0	2.9	444.5	0.0	1.6	3.6	452.6
2008	0.0	2.9	452.9	0.0	1.7	3.6	461.1
2009	0.0	2.9	461.6	0.0	1.7	3.6	469.7
2010	0.0	3.0	470.3	0.0	1.7	3.5	478.6
2011	0.0	3.0	479.3	0.0	1.7	3.5	487.5
2012	0.0	3.0	488.4	0.0	1.8	3.5	496.7
2013	0.0	3.1	497.6	0.0	1.8	3.5	506.0
2014	0.0	3.1	507.1	0.0	1.8	3.5	515.5
2015	0.0	3.1	516.7	0.0	1.8	3.5	525.2
2016	0.0	3.2	526.6	0.0	1.9	3.5	535.1
2017	0.0	3.2	536.6	0.0	1.9	3.5	545.1
2018	0.0	3.2	546.8	0.0	1.9	3.5	555.4
2019	0.0	3.3	557.1	0.0	1.9	3.5	565.8
2020	0.0	3.3	567.7	0.0	2.0	3.4	576.4
2021	0.0	3.3	578.5	0.0	2.0	3.4	587.3
2022	0.0	3.3	589.5	0.0	2.0	3.4	598.3
2023	0.0	3.4	600.7	0.0	2.1	3.4	609.6
2024	0.0	3.4	612.1	0.0	2.1	3.4	621.0
2025	0.0	3.5	623.7	0.0	2.1	3.4	632.7
2026	0.0	3.5	635.6	0.0	2.1	3.4	644.6
2027	0.0	3.5	647.7	0.0	2.2	3.4	656.7
2028	0.0	3.6	660.0	0.0	2.2	3.4	669.1
2029	0.0	3.6	672.5	0.0	2.2	3.3	681.7
2030	0.0	3.6	685.3	0.0	2.3	3.3	694.5

Table 12. Electric Power Sector Consumption Estimates, 1960-2030, Maryland - Trillion Btu											
	Coal	Natural Gas	Petroleum	Nuclear	Hydroelectric	Biomass	Geothermal	Solar	Wind	Total Renewables	Total
1960	82.2	0.1	1.1	0.0	14.6	0.0	0.0	0.0	0.0	14.6	98.0
1961	87.1	0.1	1.3	0.0	12.1	0.0	0.0	0.0	0.0	12.1	100.6
1962	98.1	0.1	1.3	0.0	12.1	0.0	0.0	0.0	0.0	12.1	111.6
1963	113.8	0.1	1.5	0.0	10.2	0.0	0.0	0.0	0.0	10.2	125.6
1964	127.1	0.1	1.7	0.0	11.6	0.0	0.0	0.0	0.0	11.6	140.5
1965	158.7	0.1	1.8	0.0	11.9	0.0	0.0	0.0	0.0	11.9	172.5
1966	175.3	0.2	1.8	0.0	13.8	0.0	0.0	0.0	0.0	13.8	191.1
1967	186.4	0.4	2.5	0.0	20.1	0.0	0.0	0.0	0.0	20.1	209.4
1968	195.4	0.4	9.4	0.0	16.7	0.0	0.0	0.0	0.0	16.7	221.9
1969	176.2	6.7	26.4	0.0	14.2	0.0	0.0	0.0	0.0	14.2	223.5
1970	146.4	11.7	68.0	0.0	20.0	0.0	0.0	0.0	0.0	20.0	246.1
1971	132.1	9.6	92.3	0.0	18.6	0.0	0.0	0.0	0.0	18.6	252.6
1972	111.8	7.0	141.1	0.0	23.7	0.0	0.0	0.0	0.0	23.7	283.6
1973	97.1	8.8	161.0	0.0	22.5	0.0	0.0	0.0	0.0	22.5	289.4
1974	97.1	13.4	176.2	0.0	20.6	0.0	0.0	0.0	0.0	20.6	307.3
1975	94.2	0.4	117.0	48.3	24.0	0.0	0.0	0.0	0.0	24.0	283.9
1976	124.8	0.2	110.4	70.9	21.7	0.0	0.0	0.0	0.0	21.7	328.0
1977	107.9	0.3	107.1	117.2	21.1	0.0	0.0	0.0	0.0	21.1	353.6
1978	118.2	0.6	123.5	108.3	18.0	0.0	0.0	0.0	0.0	18.0	368.6
1979	129.9	10.6	92.1	105.2	22.7	0.0	0.0	0.0	0.0	22.7	360.5
1980	146.3	5.4	57.6	119.4	13.2	0.0	0.0	0.0	0.0	13.2	341.9
1981	127.4	6.1	46.1	127.1	14.9	0.0	0.0	0.0	0.0	14.9	321.6
1982	143.1	1.0	41.7	114.6	14.0	0.0	0.0	0.0	0.0	14.0	314.4
1983	157.6	1.8	40.3	127.3	18.6	0.0	0.0	0.0	0.0	18.6	345.6
1984	189.3	1.3	35.9	126.3	21.1	0.4	0.0	0.0	0.0	21.5	374.3
1985	178.4	1.4	37.1	105.4	15.9	0.2	0.0	0.0	0.0	16.1	338.4
1986	202.0	2.3	31.1	135.7	19.6	0.4	0.0	0.0	0.0	20.0	391.1
1987	208.6	12.3	32.1	105.1	16.8	0.5	0.0	0.0	0.0	17.3	375.4
1988	229.6	5.6	42.8	124.4	13.7	0.6	0.0	0.0	0.0	14.3	416.7
1989	231.2	23.7	76.8	28.8	18.5	7.4	0.0	0.0	0.0	25.9	386.4
1990	227.9	21.7	47.1	13.2	23.9	7.3	0.0	0.0	0.0	31.2	341.1
1991	220.9	22.1	50.5	94.7	14.7	7.3	0.0	0.0	0.0	22.0	410.2
1992	229.4	15.8	34.6	111.7	18.9	7.5	0.0	0.0	0.0	26.4	417.9
1993	242.9	10.5	51.9	129.2	17.1	7.3	0.0	0.0	0.0	24.4	458.9
1994	249.2	15.8	50.4	117.4	20.7	7.6	0.0	0.0	0.0	28.3	461.1
1995	262.9	19.5	18.3	135.9	14.9	10.1	0.0	0.0	0.0	25.0	461.6
1996	271.7	12.3	19.0	127.0	25.4	12.1	0.0	0.0	0.0	37.5	467.5
1997	269.0	16.1	20.1	138.7	16.2	11.7	0.0	0.0	0.0	27.9	471.8
1998	283.3	22.3	40.2	139.9	17.7	12.1	0.0	0.0	0.0	29.8	515.5
1999	284.1	23.7	50.0	139.1	14.6	12.7	0.0	0.0	0.0	27.3	524.2
2000	289.7	30.1	26.9	144.2	17.7	12.3	0.0	0.0	0.0	30.0	520.9
2001	283.3	18.1	34.5	142.7	12.2	12.2	0.0	0.0	0.0	24.4	503.0
2002	291.7	23.2	25.5	126.6	16.9	13.0	0.0	0.0	0.0	29.9	496.9
2003	297.6	11.4	29.4	142.7	27.1	12.9	0.0	0.0	0.0	40.0	521.1
2004	292.3	12.4	30.5	151.9	25.7	12.6	0.0	0.0	0.0	38.3	525.4
2005	295.8	12.5	30.1	153.3						39.3	531.0
2006	299.4	12.6	29.8	154.6						40.2	536.6
2007	302.9	12.7	29.4	156.0						41.2	542.3
2008	306.6	12.8	29.1	157.4						42.3	548.2
2009	310.3	12.9	28.7	158.9						43.3	554.1
2010	314.0	13.0	28.4	160.3						44.4	560.1
2011	317.8	13.1	28.0	161.7						45.5	566.2
2012	321.6	13.2	27.7	163.2						46.7	572.3
2013	325.4	13.3	27.4	164.7						47.8	578.6
2014	329.3	13.4	27.0	166.1						49.0	585.0
2015	333.3	13.5	26.7	167.6						50.3	591.4
2016	337.3	13.6	26.4	169.1						51.5	598.0
2017	341.3	13.8	26.1	170.7						52.8	604.6
2018	345.4	13.9	25.8	172.2						54.1	611.4
2019	349.6	14.0	25.4	173.8						55.5	618.2
2020	353.8	14.1	25.1	175.3						56.9	625.2
2021	358.0	14.2	24.8	176.9						58.3	632.2
2022	362.3	14.3	24.5	178.5						59.7	639.4
2023	366.7	14.4	24.2	180.1						61.2	646.6
2024	371.1	14.5	24.0	181.7						62.8	654.0
2025	375.5	14.7	23.7	183.3						64.3	661.5
2026	380.0	14.8	23.4	185.0						65.9	669.1
2027	384.6	14.9	23.1	186.7						67.6	676.8
2028	389.2	15.0	22.8	188.3						69.3	684.6
2029	393.9	15.1	22.6	190.0						71.0	692.6
2030	398.6	15.3	22.3	191.7						72.8	700.7

Maryland Electric Power Consumption 1960-2030 Trillion BTU							
	Residential	Commercial	Industrial	Transportation	TOTAL	Electric Losses	TOTAL
1960	9.5	9.2	11.2	0.1	30.0	73.9	103.9
1961	10.4	9.5	12.0	0.1	32.0	77.9	109.9
1962	11.1	10.2	13.1	0.1	34.5	82.8	117.3
1963	12.1	10.9	14.4	0.1	37.5	89.6	127.1
1964	13.4	12.0	16.1	0.0	41.5	98.7	140.2
1965	15.0	13.4	17.3	0.0	45.7	109.1	154.8
1966	16.9	15.1	19.5	0.0	51.5	123.4	174.9
1967	18.3	16.4	21.4	0.0	56.1	134.2	190.3
1968	21.1	18.1	23.4	0.0	62.6	149.2	211.8
1969	23.6	19.8	25.7	0.0	69.1	164.8	233.9
1970	26.2	21.7	28.9	0.0	76.8	185.8	262.6
1971	27.7	23.2	31.6	0.0	82.5	198.9	281.4
1972	29.3	24.8	32.2	0.0	86.3	206.7	293.0
1973	33.0	27.1	34.5	0.0	94.6	224.9	319.5
1974	32.1	26.1	33.4	0.0	91.6	222.1	313.7
1975	33.0	29.3	30.9	0.0	93.2	224.0	317.2
1976	34.5	30.7	36.9	0.0	102.1	245.0	347.1
1977	36.9	30.2	40.4	0.0	107.5	257.3	364.8
1978	38.1	30.9	41.7	0.0	110.7	268.8	379.5
1979	38.2	31.2	44.7	0.0	114.1	273.4	387.5
1980	41.4	32.0	44.6	0.1	118.1	284.5	402.6
1981	42.0	32.7	46.6	0.1	121.4	285.4	406.8
1982	42.6	33.1	43.5	0.1	119.3	283.0	402.3
1983	46.0	34.5	44.5	0.1	125.1	295.5	420.6
1984	47.7	32.3	50.8	0.2	131.0	300.1	431.1
1985	48.9	32.8	52.2	0.3	134.2	309.1	443.3
1986	54.0	35.0	53.9	0.3	143.2	323.3	466.5
1987	58.7	37.1	57.1	0.3	153.2	341.4	494.6
1988	63.1	39.4	59.5	0.3	162.3	361.6	523.9
1989	65.1	36.3	66.4	0.3	168.1	391.0	559.1
1990	65.2	37.6	65.9	0.3	169.0	391.0	560.0
1991	69.2	38.4	66.4	0.4	174.4	400.2	574.6
1992	67.4	38.7	67.4	0.4	173.9	396.4	570.3
1993	73.5	41.0	68.9	0.4	183.8	419.4	603.2
1994	73.9	47.5	65.0	0.5	186.9	421.0	607.9
1995	75.9	81.0	34.3	0.5	191.7	435.3	627.0
1996	78.4	81.1	34.5	0.5	194.5	442.4	636.9
1997	74.8	82.1	34.6	0.4	191.9	435.0	626.9
1998	76.5	85.1	35.3	0.5	197.4	447.6	645.0
1999	79.6	87.6	33.9	0.5	201.6	461.2	662.8
2000	81.7	90.4	34.3	0.5	206.9	471.0	677.9
2001	82.9	92.1	34.7	0.6	210.3	471.9	682.2
2002	87.0	74.5	71.2	0.6	233.3	522.7	756.0
2003	91.0	57.8	92.7	1.6	243.1	544.5	787.6
2004	95.4	58.9	72.3	1.6	228.2	511.2	739.4
2005	97.2	60.5	73.0	1.6	232.4	511.6	744.0
2006	99.1	62.2	73.8	1.6	236.7	512.0	748.7
2007	100.9	64.0	74.5	1.6	241.1	512.4	753.5
2008	102.9	65.8	75.2	1.7	245.5	512.9	758.4
2009	104.8	67.6	76.0	1.7	250.1	513.4	763.5
2010	106.8	69.5	76.7	1.7	254.8	513.9	768.6
2011	108.8	71.5	77.5	1.7	259.6	514.4	773.9
2012	110.9	73.5	78.3	1.8	264.4	514.9	779.3
2013	113.0	75.5	79.1	1.8	269.4	515.5	784.9
2014	115.2	77.6	79.9	1.8	274.5	516.1	790.5
2015	117.3	79.8	80.7	1.8	279.7	516.7	796.3
2016	119.6	82.0	81.5	1.9	284.9	517.3	802.2
2017	121.8	84.3	82.3	1.9	290.4	517.9	808.3
2018	124.2	86.7	83.1	1.9	295.9	518.6	814.5
2019	126.5	89.1	83.9	1.9	301.5	519.3	820.8
2020	128.9	91.6	84.8	2.0	307.3	520.0	827.3
2021	131.4	94.2	85.6	2.0	313.2	520.8	834.0
2022	133.9	96.8	86.5	2.0	319.2	521.5	840.7
2023	136.4	99.5	87.3	2.1	325.4	522.3	847.7
2024	139.0	102.3	88.2	2.1	331.6	523.1	854.8
2025	141.6	105.2	89.1	2.1	338.1	524.0	862.0
2026	144.3	108.1	90.0	2.1	344.6	524.8	869.4
2027	147.1	111.2	90.9	2.2	351.3	525.7	877.0
2028	149.9	114.3	91.8	2.2	358.2	526.6	884.7
2029	152.7	117.5	92.7	2.2	365.2	527.5	892.7
2030	155.6	120.8	93.6	2.3	372.3	528.5	900.8

Appendix 2 National Renewable Energy Laboratory Report

Maryland Renewable Energy Resources and Costs

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Prepared under the U.S. Department of Energy, TAP program.

August 2006

At the request of the Maryland Department of Business & Economic Development, NREL has prepared a brief assessment of renewable resources in Maryland that could potentially be developed for electricity generation. This is an assessment of technical potential, not an economic assessment. However, the last section includes information on the costs of renewable generation sources in comparison to fossil and nuclear technologies.

1.0 Existing Renewable Energy Capacity and Generation

Table 1 presents 2003 renewable energy capacity and generation data for Maryland from NREL and the Department of Energy's Energy Information Administration (EIA).[69] EIA reports 127 MW of non-hydro renewable energy capacity, including 125 MW of landfill gas and municipal solid waste generation and 2 MW of wood or waste wood-fired plants. EIA reports 566 MW of conventional hydropower. EIA does not track small installations under 1 MW in size and does not report any wind or solar photovoltaics (PV).

NREL's REPIS database reports 140 MW of non-hydro renewable energy capacity as of 2003, including 136 MW of landfill gas generation or other municipal solid waste (MSW) facilities. According to the U.S. Environmental Protection Agency's (EPA) Landfill Methane Outreach program[70], only about 5 MW of landfill gas generation is operational in Maryland; therefore, much of this is MSW combustion. REPIS also reports 0.3 MW of photovoltaics, 0.004 MW of wind generation capacity, and 4 MW of wood or wood waste-fired facilities. REPIS reports photovoltaic and wind capacity, while EIA does not, because REPIS gathers data for installations under 1 MW in size. REPIS reports 475 MW of conventional hydropower. Of this, 20 MW are projects that are less than 30 MW in size, which is a common definition for small hydro.

Table 1: Maryland Renewable Energy Capacity and Generation[1,2]

	Capacity				Generation	
	REPIS 2003 MW	REPIS % of Total Capacity	EIA 2003 MW	EIA % of Total Capacity	EIA 2002 MWh	EIA % of Total Generation
MSW/Landfill Gas	136	1.02%	125	1%	629,254	1.2%
Conventional Hydro	475	3.55%	566	4.2%	2,646,984	5.07%
Photovoltaic	.3[3]	<1%	NA	NA	NA	NA
Wind	.004[3]	<1%	NA	NA	NA	NA
Wood/Wood Waste	4	<1%	2	<1%	NA	NA
Total	**615**	**4.6%**	**693**	**5.2%**	**3,276,238**	**6.3%**
Non-hydro Total	**140**	**1.1%**	**127**	**1.0%**	**629,254**	**1.2%**

[1] EIA reports total Maryland nameplate capacity in 2003 of 13,362 MW and total generation of 52,244,237 MWh.
[2] REPIS does not report generation.
[3] REPIS includes small wind and PV systems not counted by EIA.

[69] NREL data is from the Renewable Electric Plant Information System (REPIS) database http://www.nrel.gov/analysis/repis/ and EIA data is from the 2003 Renewable Energy Trends http://www.eia.doe.gov/cneaf/solar.renewables/page/rea_data/rea.pdf. Total capacity and generation data are from EIA State Electricity Profiles 2002 http://www.eia.doe.gov.
[70] U.S. EPA Landfill Methane Outreach Program, Energy Projects and Candidate Landfills http://www.epa.gov/lmop/proj/index.htm#1

2.0 Renewable Energy Resources in Maryland

2.1 Wind Resources

For our analysis of wind resource potential, we use annual wind power data that were produced by TrueWind Solutions, using their Mesomap system and historical weather data. It was validated with available surface data by NREL and wind meteorological consultants. The resource is represented as annual average wind power class at 50 meters above ground. The wind resource data have been screened to eliminate areas that may not be compatible with wind development, such as urban areas, airfields, steep slopes, parks, wetlands, and wildlife refuges. These exclusions are detailed in Table 2.[71] The Maryland wind resource map with transmission lines overlaid is presented in Appendix A.

We used two methodologies to determine available wind resources with access to transmission. First, because transmission costs generally increase with distance to transmission, we calculate wind resources within 5, 10, 15, and 20 miles of transmission.

Second, because existing transmission lines may not be fully available to carry wind generation, we restrict the wind resources to that which can be supported by 20% of the capacity of existing transmission lines. This algorithm, which has been used in other NREL analyses, competes the best wind resources against each other to a total that is equivalent to 20% of the capacity of the available transmission lines. Because of the potential for double counting of transmission lines, particularly when large transmission lines split into smaller lines, we further restrict the available transmission lines to include only the lines that supply in-state load areas or cross power control areas (and therefore could export power to other regions). For both of the methodologies, we consider only wind resources and transmission lines in Maryland.

Table 3 summarizes the results of our assessment of the technical potential for onshore wind energy generating capacity with consideration of distance to transmission. It assumes 5 MW of wind capacity per square kilometer. Typically, utility scale wind projects require wind resources of Class 4 or higher. The analysis shows that onshore Class 4 through Class 6 wind resources in Maryland located within 20 miles of transmission could support about 185 MW of wind energy capacity. If Class 3 resources are included, nearly 1,570 MW of wind capacity could be supported within 20 miles of transmission.

[71] Note that some of these restrictions, such as excluding 50% of all USDA lands and 50% of all non-ridge crest forestlands, may be conservative and limit resource estimates.

Table 2: Criteria for Defining Available Windy Land

Environmental Criteria	*Data/Comments:*
2) 100% exclusion of National Park Service and Fish and Wildlife Service managed lands	USGS Federal and Indian Lands shapefile, Feb 2003
3) 100% exclusion of federal lands designated as park, wilderness, wilderness study area, national monument, national battlefield, recreation area, national conservation area, wildlife refuge, wildlife area or wild and scenic river.	USGS Federal and Indian Lands shapefile, Feb 2003
4) 100% exclusion of state and private lands equivalent to criteria 2 and 3, where GIS data is available.	State/GAP land stewardship data management status 1, available for the 48 conterminous states from the Conservation Biology Institute Protected Areas Database, Version 2 (2003). Status 1 lands have the greatest protection from disturbance or conversion.
8) 50% exclusion of remaining USDA Forest Service (FS) lands (incl. National Grasslands)	USGS Federal and Indian Lands shapefile, Feb 2003
9) 50% exclusion of remaining Dept. of Defense lands	USGS Federal and Indian Lands shapefile, Feb 2003
10) 50% exclusion of state forest land, where GIS data is available	State/GAP land stewardship data management status 2, available for the 48 conterminous states from the Conservation Biology Institute Protected Areas Database, Version 2 (2003). Status 2 lands are protection from disturbance or conversion, but allow some extractive uses.
Land Use Criteria	
5) 100% exclusion of airfields, urban, wetland and water areas.	USGS North America Land Use Land Cover (LULC), version 2.0, 1993; ESRI airports and airfields (2003)
11) 50% exclusion of non-ridgecrest forest	Ridge-crest areas defined using a terrain definition script, overlaid with USGS LULC data screened for the forest categories.
Other Criteria	
1) Exclude areas of slope > 20%	Derived from elevation data used in the wind resource model.
6) 100% exclude 3 km surrounding criteria 2-5 (except water)	Merged datasets and buffer 3 km
7) Exclude resource areas that do not meet a density of 5 km^2 of class 3 or better resource within the surrounding 100 km^2 area.	Focalsum function of class 3+ areas (not applied to 1987 PNL resource data)
Note – Criteria are numbered in the order they are applied. 50% exclusions are not cumulative. If an area is non-ridgecrest forest on FS land, it is just excluded at the 50% level one time.	

Table 3: Potential Wind Generating Capacity by Distance to Transmission (Onshore only)

Distance to Transmission	**Class 3 Area (MW)**	**Class 4 Area (MW)**	**Class 5 Area (MW)**	**Class 6 Area (MW)**	**Total**
0 - 5 miles	534.1	117.1	37.4	8.7	697.3
5 - 10 miles	170.4	11.4	1.9	0.0	183.7
10 - 20 miles	678.3	8.9	0.0	0.0	687.2
> 20 miles	44.1	0.0	0.0	0.0	44.1
Total	*1,426.9*	*137.4*	*39.3*	*8.7*	1,612.3

Maryland has considerable potential offshore wind resources, using the same methodologies described above. Table 4 presents the potential for wind energy generating capacity for offshore resources within 5, 10 and 20 miles of transmission. Maryland's Class 5 and Class 6 offshore wind resources have the technical potential to collectively support a total of about 19,400 MW of wind energy generating capacity and, of this, about 2,100 MW is within 20 miles of transmission. Note that costs are higher for the development of offshore wind resources than onshore resources.

Table 4: Wind Energy Resource and Generation Potential by Distance to Transmission for Offshore Resources

Distance to Transmission	**Class 4 Area (MW)**	**Class 5 Area (MW)**	**Class 6 Area (MW)**	**Total**
0 - 5 miles	0.0	0.0	0.0	0.0
5 - 10 miles	9.9	371.4	0.0	381.3
10 - 20 miles	1.1	1,755.1	0.0	1,756.3
> 20 miles	276.4	2,006.9	15,300.7	17,584.0
Total	*287.4*	*4,133.5*	*15,300.7*	19,721.6

In the analysis that assumes that only 20% of the capacity of existing transmission lines would be available for wind, the estimated capacity that could technically be supported by onshore resources of class 4 and higher is still 185 MW. If class 3 resources are included, the total is about 1420 MW, which is a little lower than the 1,570 MW potential within 20 miles of transmission lines. The potential offshore wind capacity drops further. The analysis shows that there are adequate Class 5 and Class 6 offshore resources to support about 1670 MW of capacity, with about 750 MW of potential in Class 6 resource area (Table 5).

Table 5: Potential Wind Energy Capacity Assuming 20% Availability of Existing Transmission Lines (MW)

	Class 3	***Class 4***	***Class 5***	***Class 6***	***Total***
On-shore	1235.9	137.4	39.3	8.7	1421.3
Off-shore	N/a	2.2	926.0	746.0	1674.2
Total	1235.9	139.6	965.3	754.7	3095.5

The estimates of technical potential presented above do not attempt to evaluate the operating costs of grid generators due to wind variability or to evaluate reliability implications of high levels of penetration of wind generation. The integration of about 1,400 MW of onshore wind generation in an approximately 13,000 MW system should be manageable and result in ancillary costs similar to those experienced in other regions. Offshore resources have been developed in Europe, but have yet to be developed in the U.S.; therefore, there is less experience with actual operating costs.

2.2 Biomass Resources

According to the U.S. EPA Landfill Gas Methane Outreach Program, there are 11 landfills in Maryland that are candidates for electric generation and could potentially support about 28 MW of electric generating capacity collectively (Table 6).[72] EPA defines candidate landfills as those with more than one million tons of waste in place and either still accepting waste or closed within the past 5 years. In addition, EPA reports another 5 landfills that may have the potential to support electric generation projects, although limited data are available on these projects, so it is not known if they are viable for electricity generation. If these potential projects could be developed, Maryland's landfills could support a total of about 34 MW of electric generating capacity.

Table 6: Maryland Landfills with Potential for Electricity Generation

	Number of Landfills	Estimated Capacity (MW)
Candidate Landfills	11	28
Potential Landfills	5	6
Total Landfills w/o LFGE Projects	16	34

Source: Goldstein, Rachel. EPA Landfill Methane Outreach Program.

Additional information on biomass resources in Maryland is available from the National Renewable Energy Laboratory's biomass resource assessment[73], which is based on county-level data from the U.S. Department of Agriculture and other sources (Table 7). Table 7 presents total available feedstocks, but does not account for those already being used, except in the case of mill residues. Biomass residues may be used for mulch, bedding or other products, as well as electricity generation, with the end-use typically determined by economics. According to the NREL data, urban wood and crop residues present the largest opportunity for electricity production, with a potential to support about 250 MW of electric generating capacity. Collectively, biomass resources could support about 340 MW of generating capacity. Again this represents the technical potential and does not take into consideration the economic viability of using these resources for electricity generation. Maryland-specific research on biomass resource availability and usage would be useful for refining these estimates.

[72] U.S. EPA Landfill Methane Operating Program, Energy Projects and Candidate Landfills http://www.epa.gov/lmop/proj/index.htm#1

[73] Milbrandt, A. 2005, A Geographic Perspective on the Current Biomass Resource Availability in the United States, National Renewable Energy Laboratory, Golden, CO. NREL/TP-560-39181, December. http://www.nrel.gov/docs/fy06osti/39181.pdf

Table 7: Biomass Residues in Maryland

Resource	**Available Resource dry metric tons/year**	**Potential MWh/yr**	**Potential MW**
Urban Wood Residues	624,245	966,888	138.0
Un-utilized Mill Residues	137,995	213,739	30.5
Forest Residues	262,960	407,297	58.1
Crop Residues	584,439	803,029	114.6
Switch Grass	270,837	419,498	59.9
Animal Manure (methane)	5,673	23,665	3.0
Wastewater	8,758	36,538	4.6
Total		2,390,953	341.2

*Assumes heat content of fuels of 18.6 GJ/ton for woods, 16.5 GJ/ton for crop residues, and 50 GJ/ton for methane and a thermal conversion efficiency of 30%.

2.3 Solar Resources

Solar energy can be used for a variety of end uses, including hot water, space heating, daylighting, and production of electricity via solar photovoltaics (PV) and solar thermal generators. Of these five technologies, thermal concentrating solar is not considered viable in Maryland. While space heating and daylighting are considered viable, and may be quite practical, this assessment is limited to electricity generation via distributed PV and residential solar hot water heating.

Maryland's solar resource potential is described as "good" with the majority of the state receiving about 4.5 kWhr/sq meter of solar insolation per day.[74] This can be compared to the "best" locations in the U.S. at 7-7.5 kWhr/sq meter in the southwest, and 3-3.5 kWhr/sq meter in the "worst" locations in the northwest.

2.3.1 Photovoltaics

Solar photovoltaics can be used to produce electricity on buildings and offset centralized generation. Expected solar PV output can be quantified using previously recorded ground station data. Ground station hourly weather data collected from 1961 through 1990 was compiled and used to generate a "typical meteorological year" (TMY) for each of 216 sites in the lower 48 U.S. states.[75] This TMY data includes solar insolation, which can be placed into a solar PV simulation tool to generate an expected hourly output for a typical year.

[74] Solar Radiation Data Manual for Flat-Plate and Concentration Collectors NREL/TP-463-5607 1994.
[75] http://rredc.nrel.gov/solar/old_data/nsrdb/tmy2/

There are 5 TMY sites (1 each in MD, DE, NJ, VA and WV) representative of weather conditions in Maryland.

For each of these sites, we ran a PV simulation tool to derive the expected hourly output for a rooftop mounted PV system.[76] We simulated the output of two system types: a flat roof system and a pitched, south facing roof system.

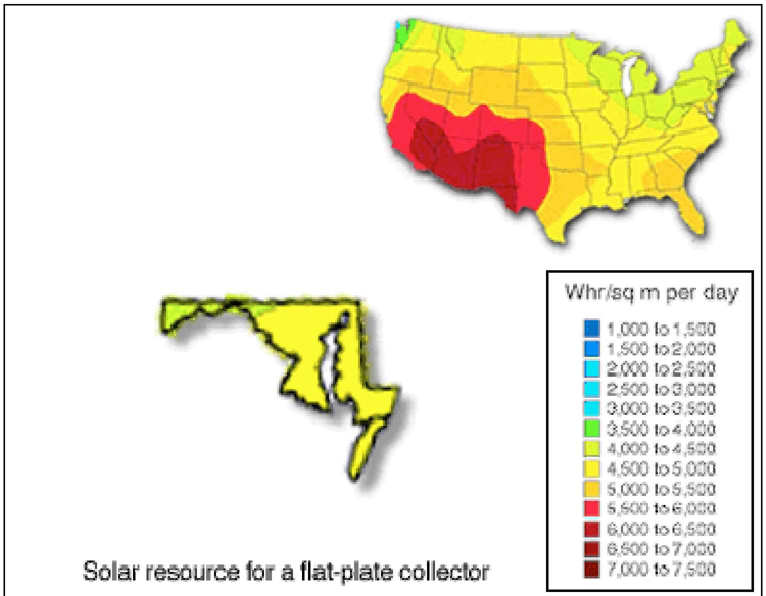


Figure 1: Solar Resources in Maryland.[77]

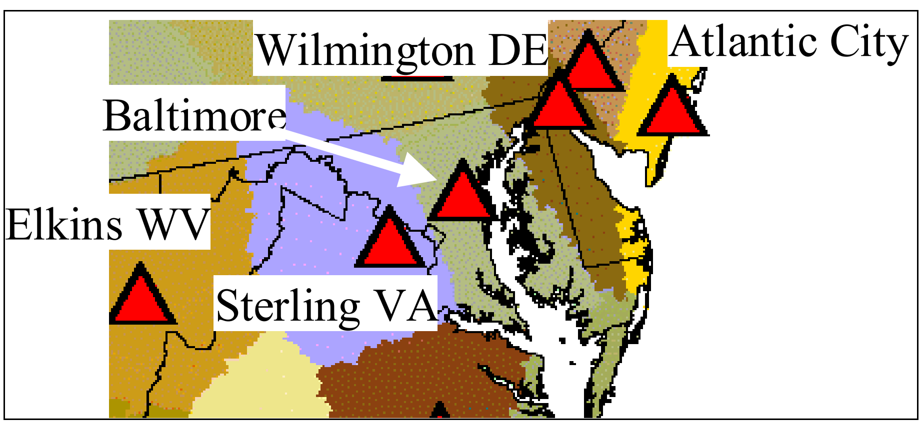


Figure 2: TMY Sites Used for PV evaluation

Table 8 provides the estimated capacity factor for each of the five sites. Also provided is a population allocation, indicating the fraction of the states population that could be assigned to that particular site, based on the states 2000 census.

[76] http://rredc.nrel.gov/solar/codes_algs/PVWATTS/version1/

[77] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy "Alternative Energy Resources by State" http://www.eere.energy.gov/states/alternatives/resources_md.cfm

Table 8: Relevant Maryland TMY Ground Stations, Population Allocation and PV System Capacity Factors[78]

TMY Site	% Population Allocated to Site	System Capacity Factor	
		South Facing, Latitude Tilt	Flat
Baltimore	72.7%	17.7	15.0
Sterling (VA)	20.5%	17.8	15.2
Wilmington (DE)	4.3%	17.7	15.0
Elkins (WV)	1.9%	15.7	14.0
Atlantic City (NJ)	0.6%	18.0	15.2
Population Weighted Average		17.7	15.0

2.3.2 Solar Hot Water

Solar hot water (SHW) heat is an alternative use for solar energy, and currently more cost competitive, particularly with current high natural gas prices.

This analysis used a previous study of domestic solar hot water heating to derive the potential performance in Maryland.[79] This previous study analyzed system performance in the same sites used in the PV analysis, and found that a normally sized solar hot water heater in most sites in Maryland can reduce total water heating energy demand by about 40-70% for a 60-80 gallon/day demand. The roof space required for this level of performance is around 40-64 square feet of collector area.

Solar hot water systems are considerably more efficient that PV systems, with roughly 40% of the incident solar energy being converted into useful energy. However, there is a limit to the usefulness of solar hot water, since excess solar energy cannot be used for other uses, or shipped to a neighbor like PV generated electricity. Table 9 illustrates the simulated performance for a solar hot water heating system in three Maryland cities.

Table 9: Solar Hot Water System Performance in Maryland

System Size (gallons/day)	Approximate Solar Fraction*	Efficiency
40	60-70%	34%
60	50-60%	40%
80	40-50%	43%

*Solar fraction is the fraction of hot water heating energy derived from solar energy. The remainder is derived from traditional heating sources.

[78] Capacity Factor is defined as expected annual energy from a 1 kW **AC** rated PV system / 8760.
[79] Christensen, C.; Barker, G. (1998). Annual System Efficiencies for Solar Water Heating. Campbell-Howe, R.; Cortez, T.; Wilkins-Crowder, B., eds. Proceedings of the 1998 American Solar Energy Society Annual Conference, 14-17 June 1998, Albuquerque, New Mexico. Boulder, CO: American Solar Energy Society pp. 291-296; NREL Report No. 25569

Commercial buildings are also suitable for solar hot water heaters, with overall performance at least comparable to residential systems in their ability to reduce water heating demand by 50% or more.

2.3.3 Total State Rooftop Solar Resource

Solar PV or hot water systems may be deployed on existing rooftops, having minimal impact on land use. Both solar technologies requires rooftops that are unshaded, able to bear the additional load of the PV or SHW system, and if pitched, the pitch of the roof cannot be too great (perhaps less than 45%). Total roof area in the state of Maryland can be estimated using a variety of sources including census data, and the EIA's building surveys.[80] However, these sources provide no information on orientation, pitch, or shading. Two prior studies do provide some estimates of rooftop availability on a national basis.[81,82]

Table 10 provides an estimate for roof availability in the state of Maryland for solar energy utilization. The values in the table are base on the following assumptions:

3) Of all residential building types, including attached homes, and apartment buildings 22% of the total roof area is suitable for solar PV.
4) Of commercial buildings 50% of the roof area is suitable for solar PV.

Table 10: Estimated Rooftop Area Available for Solar Energy Systems in 2005 (million square feet)

Building Class	Roofspace
Residential	640
Commercial (Small/Medium)	396
Commercial (Large)	49
Total	**1086**

For SHW we assumed that 25% of all single-family homes have suitable roof availability. According to Census estimates, there were about 1.6 million single-family homes in the state of Maryland in 2005, resulting in 400,000 homes suitable for SHW using the 25% estimate.[83]

These available roofspace estimates can be used to estimate the total potential contribution of Solar PV and solar hot water systems (SHW) on rooftops in the state of Maryland. Rooftop area may converted to PV peak capacity by applying the typical peak efficiency (AC Watts per square foot.) This assessment uses a system efficiency of 8.7 peak W_{AC}/ sq. foot, which is equivalent to a 10.8 W_{DC}/sq. foot and a derate factor of 0.81. A state-average 15.5% capacity factor was

[80] http://www.eia.doe.gov/emeu/consumption/index.html
[81] PV Grid Connected Market Potential in 2010 under a Cost Breakthrough Scenario Prepared by Navigant Consulting for The Energy Foundation, March 2005.
[82] Building-Integrated Photovoltaics (BI-PV)—Analysis and US Market Potential, Prepared by Arthur D. Little, Inc. for the US Department of Energy Office of Building Technologies, NREL/TP-472-7850, DE95004055, February 1995.
[83] U.S.Census Bureau, Population Division, Interim State Population Projections, 2005.

assumed, based on an equal distribution of flat and tilted orientation, with an additional 0.9 derate factor applied for non-optimum orientation of tilted systems.

SHW systems were assumed to be used only on single family homes. This conservative assumption eliminates the use of SHW on apartment buildings and commercial buildings. We assumed that SHW systems have a 40% efficiency, a 60% solar fraction, and occupy 50 square feet of roof area. (The roof area used for SHW was subtracted from the roof availability for solar PV to avoid double counting.)

Table 11 illustrates the rooftop solar energy potential in Maryland using the above assumptions. As indicated by **Table 11**, the assumptions used in this analysis produce a potential electricity reduction in the state of Maryland from rooftop solar systems of around 19%. Assuming building stock grows at the same rate as electricity demand, this fraction could be expected to remain nearly constant. However, if PV efficiency increases at a rate faster than building energy intensity as expected, this fraction could significantly increase.

Table 11: Estimated Potential for Solar Energy on Rooftop Deployed PV and SHW in Maryland

Building Class	**Residential Buildings**	**Commercial Buildings**	**State Total**
Potential PV Capacity (Peak MW_{AC})	5600	3900	9500
Annual Potential from PV on Rooftops (GWh)	7580	5290	12,860
Estimated Total State Electricity Demand in 2005 (GWh)	28,550	17,830	68.430
Potential Fraction of Total Electricity from PV in 2005 (%)	**25.7**	**29.7**	**18.8**
Annual Potential from SHW (billion BTU)	**4456**	Not Evaluated	Not Evaluated

The use of SHW would reduce both electricity use and natural gas use. A large fraction of energy for domestic water heating is derived from electricity, which itself is derived from a mix of coal, natural gas, and nuclear energy. In 2004 Maryland consumed about 190 BCF (billion cubic feet) of natural gas.[84] Of this about 86 BCF was delivered to residential customers, with about 30% of residential natural gas consumption used for water heating.[85]

This analysis excludes the use of SHW on non-residential buildings, and also the significant rooftop potential of industrial buildings, parking lot awnings, or other non-occupied structures. Solar PV systems may also be deployed on ground-based systems including PV tracking arrays, which features increased technical performance.

3.0 Levelized Cost of Renewable Technologies for Electricity Generation

[84] http://tonto.eia.doe.gov/dnav/ng/ng_cons_sum_a_EPG0_veu_mmcf_a.htm
[85] 2001 Residential Energy Consumption Survey

In this section, we provide estimates of the levelized cost of energy (LCOE) of various renewable energy technologies. The use of levelized costs enables direct comparison of alternatives utilizing different technologies, scales of operation, and operating lifetimes, and accounts for the initial capital investment in a system, fixed and variable costs associated with operating and maintaining a system over its life, and fuel costs required to produce energy.[86]

Technology-specific cost and performance assumptions used to calculate levelized costs are sourced primarily from the Energy Information Administration (EIA) 2006 Annual Energy Outlook (AEO). Table 12 displays the AEO cost assumptions.[87] The capacity factors used for biomass and municipal solid waste (landfill gas) represent AEO expected national averages for 2010. The capacity factors for wind and solar technologies are estimates based on the levels of wind and solar resource available within the state. The biomass fuel price is based on the AEO forecast for the Mid-Atlantic Area Council generation region and varies from $1.11 to $2.13 (constant 2006 $/MBTU) from 2006 to 2030.

Table 12: AEO 2006 Renewable Technology Cost Assumptions

	Renewable Technology				
	Biomass	MSW - Landfill Gas	Wind Onshore	Wind Offshore	Solar, PV
Plant Capital Cost (including contingency) (2006 $/kW)	1910	1629	1231	2313	4850
Fixed O&M Cost (2006 $/kW-yr)	51.23	109.74	29.10	49.03	10.91
Variable O&M Cost (2006 $/kWh)	0.00330	0.00001	0.00000	0.00000	0.00000

Federal level credits are those specified in the Energy Policy Act of 2005:

- Investment Tax Credit: Two versions applied to the solar (photovoltaic) technology are provided: a 30% credit is available for facilities in service prior to January 1, 2008; a 10% credit is available to facilities in service on that date or later.
- Production Tax Credit: $.020/kWh for wind (10 years duration), $.0094/kWh for biomass and municipal solid waste (both 10 years duration).[88]

No other technology-specific credits or incentives are assumed for the renewable energy and fossil and nuclear cost calculations, including those available through the state.

The following additional assumptions are made for <u>all</u> technologies (renewable as well as fossil and nuclear):

- 25-year system life
- 5-year accelerated depreciation with half-year convention (MACRS)

[86] The levelized cost is the cost that, if assigned to every unit of energy produced over a system's life, equals the total life cycle cost of the system discounted to the base year.

[87] Cost and capacity factors for offshore wind are taken from DOE Wind and Hydropower Technologies Program input to the FY2007 Projected Benefits of Federal Energy Efficiency and Renewable Energy Programs report.

[88] Credit amounts are inflated to 2006$. The actual amounts in 2005$ specified in EPACT 2005 are $.019 and $.009, respectively.

- Discounting via a nominal weighted cost of capital of 9.6% (based on 55%/45% split of debt/equity financing with 6.5%/16.7% nominal returns). The corresponding real weighted cost of capital is 6.9%
- Current costs and capacity factors (no cost and performance improvements over time)
- Inflation rate of 2.5%/yr
- Federal corporate tax rate of 35%
- Maryland state corporate tax rate of 7%
- Combined property tax and insurance rate of 2% of initial investment
- Fixed and variable O&M costs escalate at inflation rate (i.e., stay constant in real terms)
- Capital costs associated with the connection of centralized systems to the electricity grid not included
- Fixed and variables costs associated with electricity distribution and transmission not included

Table 13 identifies the LCOE, in 2006 $/kWh associated with several renewable technologies used for electricity generation for a range of capacity factors.[89] Nominal and real (inflation-adjusted) forms of levelized costs are included both with and without the federal production tax credit (PTC). For comparison, Tables 14 and 15 identify the levelized costs associated with several fossil and nuclear technologies used for electricity generation for a range of capacity factors, without and with federal tax credits available under the Energy Policy Act of 2005.

[89] The levelized cost of energy is calculated according to the methodology outlined in: Short, W., D. Packey, and T. Holt. 1995. *A Manual for the Economic Evaluation of Energy Efficiency and Renewable Energy Technologies*, National Renewable Energy Laboratory, Golden, Colorado. NREL/TP-462-5173.

Table 13: Levelized Cost of Renewable Energy by Capacity Factor (2006 $/kWh)
(Credits Under Energy Policy Act of 2005)

		Renewable Technology											
		Biomass		MSW - Landfill Gas		Wind Onshore		Wind Offshore		Solar, PV (ITC 10%)		Solar, PV (ITC 30%)	
		No PTC	PTC	No PTC	PTC	No PTC	PTC	No PTC	PTC	No PTC	PTC	No PTC 1	PTC
Low	Capacity Factor - Low	83.0%		90.0%		32.0%		35.0%		14.0%		14.0%	
	Nominal LCOE ($/kWh)	0.079	0.067	0.051	0.040	0.085	0.060	0.144	0.119	0.591	NA	0.450	NA
	Real LCOE ($/kWh)	0.062	0.053	0.040	0.031	0.067	0.047	0.113	0.093	0.460	NA	0.348	NA
Mid	Capacity Factor - Mid	83.0%		90.0%		35.0%		38.0%		17.0%		17.0%	
	Nominal LCOE ($/kWh)	0.079	0.067	0.051	0.040	0.078	0.053	0.133	0.108	0.487	NA	0.371	NA
	Real LCOE ($/kWh)	0.062	0.053	0.040	0.031	0.061	0.041	0.104	0.084	0.379	NA	0.287	NA
High	Capacity Factor - High	83.0%		90.0%		40.0%		40.0%		20.0%		20.0%	
	Nominal LCOE ($/kWh)	0.079	0.067	0.051	0.040	0.068	0.043	0.126	0.101	0.414	NA	0.315	NA
	Real LCOE ($/kWh)	0.062	0.053	0.040	0.031	0.053	0.033	0.099	0.079	0.322	NA	0.244	NA

Table 14. Levelized Cost of Fossil and Nuclear Energy by Capacity Factor
(Assuming No Federal Tax Credit)

		Fossil and Nuclear Technology								
		Scrubbed Coal	IGCC	IGCC with CS	Conv Gas/Oil CC	Adv Gas/Oil CC	Adv CC with CS	Conv. Combust. Turbine	Adv. Combust. Turbine	Adv. Nuclear
Low	Capacity Factor - Low	54.0%	75.0%	75.0%	10.0%	10.0%	10.0%	1.0%	1.0%	88.0%
	Nominal LCOE ($/kWh)	0.085	0.073	0.098	0.200	0.194	0.346	1.143	1.060	0.069
	Real LCOE ($/kWh)	0.066	0.057	0.076	0.157	0.152	0.269	0.888	0.824	0.054
Mid	Capacity Factor - Mid	70.0%	80.0%	80.0%	45.0%	45.0%	45.0%	4.0%	4.0%	92.0%
	Nominal LCOE ($/kWh)	0.071	0.070	0.093	0.087	0.083	0.129	0.348	0.319	0.066
	Real LCOE ($/kWh)	0.056	0.055	0.073	0.069	0.066	0.101	0.272	0.249	0.052
High	Capacity Factor - High	90.0%	90.0%	90.0%	88.0%	88.0%	88.0%	40.0%	40.0%	92.0%
	Nominal LCOE ($/kWh)	0.061	0.065	0.086	0.072	0.068	0.098	0.110	0.096	0.066
	Real LCOE ($/kWh)	0.048	0.051	0.067	0.057	0.054	0.078	0.087	0.076	0.052

As with the renewable energy LCOE calculations, technology-specific cost and performance assumptions used to calculate levelized costs for the fossil and nuclear technologies are sourced primarily from the Energy Information Administration (EIA) 2006 Annual Energy Outlook (AEO). Table 16 displays these assumptions. Coal and natural gas fuel prices are based on the AEO forecast for the Mid-Atlantic Area Council generation region. The nuclear fuel price is based on the AEO US value. Additional technology-specific finance assumptions are listed in Table 16.

Table 15. Levelized Cost of Fossil and Nuclear Energy by Capacity Factor (Assuming Federal Tax Credit Under 2005 Energy Policy Act)

		Fossil and Nuclear Technology								
		Scrubbed Coal	**IGCC**	**IGCC with CS**	**Conv Gas/Oil CC**	**Adv Gas/Oil CC**	**Adv CC with CS**	**Conv. Combust. Turbine**	**Adv. Combust. Turbine**	**Adv. Nuclear**
Low	Capacity Factor - Low	54.0%	75.0%	75.0%	10.0%	10.0%	10.0%	1.0%	1.0%	88.0%
	Nominal LCOE ($/kWh)	0.085	0.069	0.092	0.200	0.194	0.346	1.143	1.060	0.049
	Real LCOE ($/kWh)	0.066	0.054	0.072	0.157	0.152	0.269	0.888	0.824	0.038
Mid	Capacity Factor - Mid	70.0%	80.0%	80.0%	45.0%	45.0%	45.0%	4.0%	4.0%	92.0%
	Nominal LCOE ($/kWh)	0.071	0.066	0.088	0.087	0.083	0.129	0.348	0.319	0.047
	Real LCOE ($/kWh)	0.056	0.052	0.069	0.069	0.066	0.101	0.272	0.249	0.036
High	Capacity Factor - High	90.0%	90.0%	90.0%	88.0%	88.0%	88.0%	40.0%	40.0%	92.0%
	Nominal LCOE ($/kWh)	0.061	0.061	0.081	0.072	0.068	0.098	0.110	0.096	0.047
	Real LCOE ($/kWh)	0.048	0.048	0.063	0.057	0.054	0.078	0.087	0.076	0.036

Table 16: AEO 2006 Fossil and Nuclear Technology Cost Assumptions

	Costs [2]				Capacity Factor			
Technology [1]	**Capital Cost (2006 $/kW)**	**Fixed O&M (2006 $/kW-yr)**	**Variable O&M (2006 $/kWh)**	**Heatrate (Btu/kWh)** [3]	**Low** [4]	**Med** [5]	**High** [6]	**Fuel Price Forecast** [7]
Scrubbed Coal	1318	26.45	0.00441	8844	54.0%	70.0%	90.0%	Coal
Integrated Gasification Combined Cycle (IGCC)	1522	37.14	0.00280	8309	75.0%	80.0%	90.0%	Coal
IGCC with Carbon Sequestration (IGCC with CS)	2177	43.71	0.00426	9713	75.0%	80.0%	90.0%	Coal
Conventional Gas/Oil Combined Cycle (Conv Gas/Oil CC)	616	11.99	0.00198	7196	10.0%	45.0%	88.0%	Gas
Advanced Gas/Oil Combined Cycle (Adv Gas/Oil CC)	607	11.23	0.00192	6752	10.0%	45.0%	88.0%	Gas
Advanced Gas/Oil Combined Cycle with Carbon Sequestration (Adv CC with CS)	1210	19.11	0.00283	8613	10.0%	45.0%	88.0%	Gas
Conventional Combustion Turbine (Conv. Combust. Turbine)	429	11.64	0.00343	10842	1.0%	4.0%	40.0%	Gas
Advanced Combustion Turbine (Adv. Combust. Turbine)	406	10.12	0.00305	9227	1.0%	4.0%	40.0%	Gas
Advanced Nuclear (Adv. Nuclear)	2125	65.21	0.00047	10400	88.0%	92.0%	92.0%	Nuclear

Notes
1 Fossil and nuclear technologies from AEO 2006 Assumptions, Table 38
2 Costs from AEO 2006 Table 38 (inflated to 2006 $)
3 Heatrate in 2005 from AEO 2006 Table 38
4 Not seen in AEO; 20th percentile of fleet availability from NERC/GADS database 1999-2003
5 Not seen in AEO; average fleet availability from NERC/GADS database 1999-2003
6 Not seen in AEO; highest projected in some recent PUC filings except coal (highest historical)

- AEO 2006 fuel prices to electricity generators, 1990-2030, Mid-Atlantic Area Council generation region, except Nuclear (US)

Table 17: Fossil and Nuclear Technology-Specific Finance Assumptions

	Finance Assumptions		
Technology	**Tax Life - MACRS (yr) 1**	**Invest-ment Tax Credit 2 (%)**	**Production Tax Credit 3 ($/kWh,yr)**
Scrubbed Coal	20	NA	NA
Integrated Gasification Combined Cycle (IGCC)	20	10.0%	NA
IGCC with Carbon Sequestration (IGCC with CS)	20	10.0%	NA
Conventional Gas/Oil Combined Cycle (Conv Gas/Oil CC)	15	NA	NA
Advanced Gas/Oil Combined Cycle (Adv Gas/Oil CC)	15	NA	NA
Advanced Gas/Oil Combined Cycle with Carbon Sequestration (Adv CC with CS)	15	NA	NA
Conventional Combustion Turbine (Conv. Combust. Turbine)	15	NA	NA
Advanced Combustion Turbine (Adv. Combust. Turbine)	15	NA	NA
Advanced Nuclear (Adv. Nuclear)	15	NA	.0184, 8

Notes
1 Based on interpretation of IRS guidelines
2 IGCC values are consistent with amounts specified under Energy Policy Act of 2005
under the following conditions: IGCC project falls within overall credit limit, and 50% of capital expenditures are gasification-related. (Act calls for 20% credit applicable only to equipment associated with the gasification of coal with limit of $800 million in total credits for IGCC projects)
3 Consistent with amounts specified under Energy Policy Act of 2005 inflated to 2006$

Table 18 summarizes major Maryland state incentive programs currently in place for renewable technologies for electricity generation.[90]

Table 18: Maryland State Incentive Programs for Renewable Technologies

Program	Eligible Renewables	Type	Applicable Sectors	Maximum Amount	Description
Clean Energy Production Tax Credit	Solar Thermal Electric, PV, Landfill Gas, Wind, Biomass, Hydroelectric, Geothermal Electric, MSW, Co-firing, Anaerobic Digestion	State Corporate or Personal Income Tax Credit	Commercial, Industrial, Residential, Utility, Agricultural	0.85¢/kWh (0.5¢/kWh for co-fired electricity)	Credits available for 5 years for electricity from facilities in service (or initiating co-firing with coal) on or after January 1, 2006 but before January 1, 2011. The maximum credit per entity is based on estimated annual energy production during a five-year period, or $2.5 million. The sum of all state credits limited to $25 million. Excess credits may be carried forward up to 10 taxable years.
Income Tax Credit for Green Buildings	Photovoltaics, Wind, Fuel Cells	State Corporate or Personal Income Tax Credit	Commercial, Industrial, Multi-Family Residential	6-8% Green Bldg; 20-25% PV; 25% Wind; 30% Fuel Cell (incremental cost) Allowable costs cannot exceed $120/sq. ft. (whole/base building), $60/sq. ft. (tenant space)	Applies to buildings of at least 20,000 square feet constructed or rehabilitated to meet criteria set forth by the U.S. Green Building Council and located on a qualified brownfields site or in a priority funding area (some rehabilitation projects also eligible). Tax credits can only be claimed if the eligible technology serves a green whole building or similar. Some restrictions exist on eligibility and number of credits allowed annually. Provisions expire on December 31, 2011.
Local Option Corporate Property Tax Credit	Solar (Water Heat, Space Heat, Thermal Electric, Thermal Process Heat, Pool Heating, Photovoltaics) Geothermal Heat Pumps	Property Tax Exemption	Commercial, Industrial	Varies (local option)	Optional property tax credit for corporations allowing counties to provide a credit (not an exemption) against the corporate property tax for buildings equipped with a solar, geothermal, or qualifying energy conservation device used to heat or cool a structure. Counties determine the amount of the credit, the duration (up to three years), and the specific definitions of eligible devices. The state's code also provides that solar heating and cooling be assessed at not more than the value of a conventional system for property tax purposes.
Wood Heating Fuel Exemption	Biomass	Sales Tax Exemption	Residential	100%	Exempts from state sales tax all wood or "refuse-derived" fuel used for residential heating purposes.
Solar Energy Grant Program	Solar Water Heat, Solar Thermal Process Heat, Photovoltaics	State Rebate Program	Commercial, Residential, Nonprofit, Local Government	20% of system cost up to $3,000 (res. PV), $5,000 (com. PV), $2,000 (solar water heating)	Provides grants to eligible entities that install solar water-heating systems or solar-electric (PV) systems, subject to overall budget limits (FY06: $75,000, FY07: $1.5 million). Minimum eligible system size requirements are consistent with U.S. Department of Energy's Million Solar Roofs Initiative guidelines.
Community Energy Loan Program	Energy Efficiency, Solar (Passive Space Heat, Water Heat, Space Heat, Thermal Electric, Photovoltaics)	State Loan Program	Nonprofit, Schools, Local Government, Hospitals	Varies, up to a maximum of $600,000	Provides financing for entities to identify and implement energy conservation, allowing borrowers to use cost savings for repaying the loans. Currently, program funds ~ $1.5 million in new projects each fiscal year. All costs for implementing an energy efficiency project can be considered for funding.

[90] The information in Table 3 is summarized from the Database of State Incentives for Renewable Energy (DSIRE), an ongoing project of the Interstate Renewable Energy Council (IREC) managed by the North Carolina Solar Center (North Carolina State University). Source: Database of State Incentives for Renewable Energy (DSIRE)

4.0 Summary

Maryland has significant untapped renewable energy resources. To date, there is about 140 MW of operational non-hydro renewable energy capacity in Maryland**. Maryland has the technical potential to develop from 12,000 MW to 30,000 MW of renewable energy generating capacity** (**Table 19**). However, it is important to note that this figure does not take into consideration the economic viability of developing these resources. According to our analysis, Maryland has about 185 MW of Class 4 or higher onshore wind resources, with another 1,400 MW of Class 3 resources. Nearly all of this is within 20 miles of existing transmission lines. In addition, Maryland has significant offshore wind resources; Class 5 and Class 6 offshore wind resources, which are typically required for offshore utility scale projects, could support about 19,000 MW of generating capacity, with about 2,100 MW of this (all Class 5) within 20 miles of transmission. Further, our analysis shows that nearly 1,700 MW of offshore wind energy capacity could be developed assuming 20% availability of transmission lines. Available biomass resources could potentially support about 340 MW of electric generation. Finally, Maryland could support up to 9,500 MW of solar electric generation on existing rooftops.

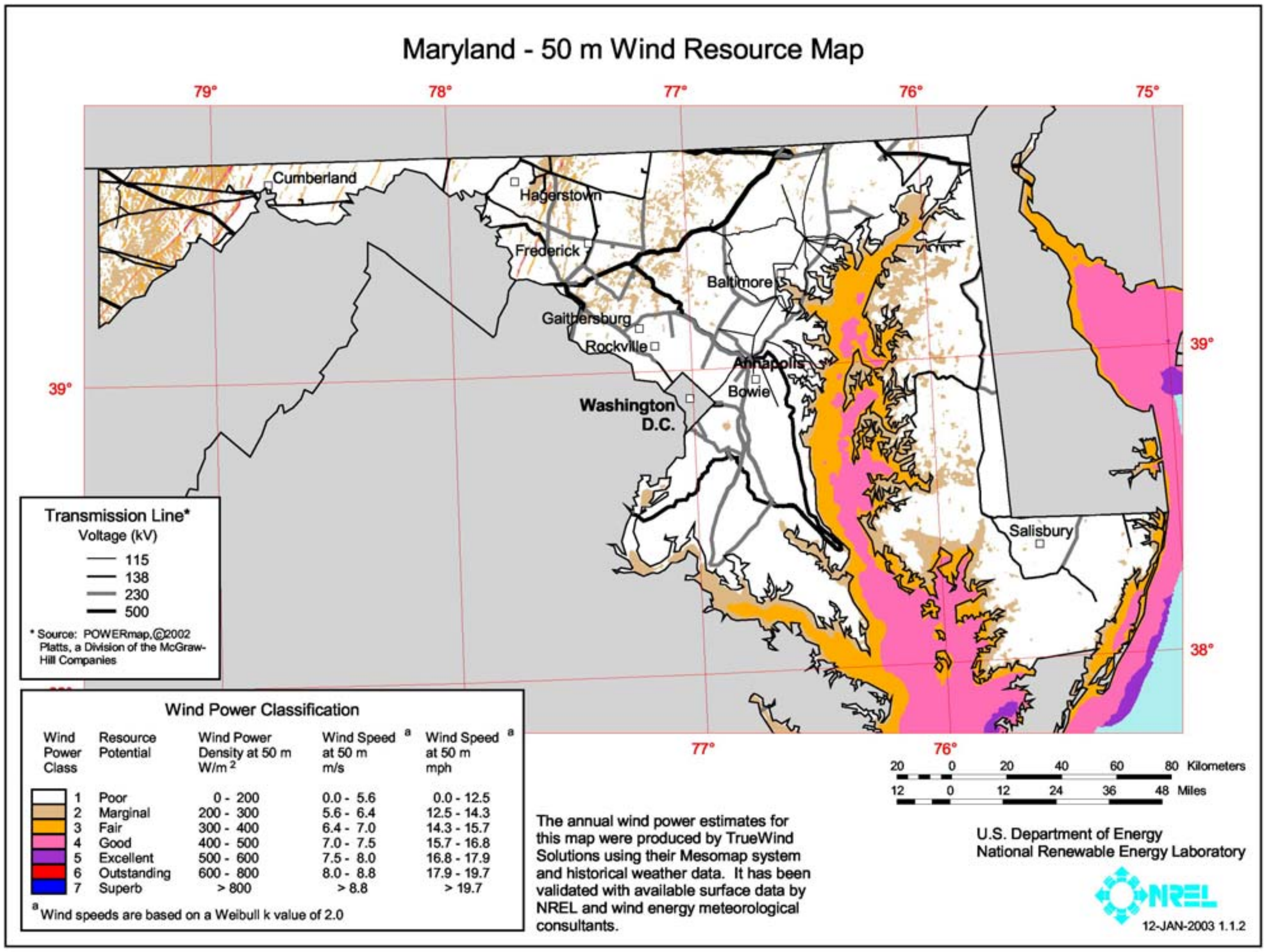
Table 19 also summarizes data on the capital and levelized costs of renewable energy generation facilities. Onshore wind and landfill gas generating facilities are among the most economic, followed by other biomass. In fact, these technologies are competitive with fossil technologies on a levelized cost basis, using current EIA assumptions regarding capital and operating costs. Thus, Maryland has the greatest near term potential to develop onshore wind, landfill gas and other biomass resources, in light of resource availability and cost. The state also has ample offshore wind and solar resources to support significant levels of PV and offshore wind generation, but at a higher cost than the other renewables.

Table 19: Summary of Maryland Renewable Resource Potential and Costs

Technology	2002 Installed Maryland	Maryland Technical Potential MW	Capacity Factor	Capital Cost $/kW	Real LCOE $/MWh
Wind (onshore)	0.004	200-1,600	32-40%	1231	28-69
Wind (offshore)	0.0	1,700-19,000	35-40%	2313	79-144
Solar PV	0.30	9,500	14-20%	4850	244-591
Biomass (direct)	4	340	83%	1910	53-79
MSW/Landfill gas	136*	35	90%	1629	31-51

* Includes municipal solid waste combustion. All other data presented here is for landfill gas generation facilities.

Appendix A
Map of Maryland Wind Resources and Transmission Lines



Appendix 3 University of Baltimore Report

Economic Development Potential
Of the Proposed Maryland Clean Energy Center
Introduction

The Jacob France Institute of the Merrick School of Business at the University of Baltimore (The JFI) was requested to prepare an analysis of the potential economic development impacts of the establishment of the proposed Maryland Clean Energy Center (MCEC) in the area of promoting the development of new technologies and businesses in this important and growing market. Recent increases in both electricity and gasoline prices are indicative of the potential social and economic disruptions in a future of expected increasing scarcity of traditional energy resources. Maryland is a leader in high technology businesses, but its strength has traditionally been in the areas of life sciences, information technology, and defense technologies. While Maryland is home to leading clean energy companies, like BP Solar in Frederick, it lags other states in both the use of alternative and clean technologies and in the basic research and development of these technologies. The likely expansion in both national research activities and interest in the field of alternative and clean energy technologies will present an opportunity for the State to benefit from the targeting of this sector for both an expansion of research and business development activities. This will augment the State's success and reputation in high technology and research in general.

Economic Development and Alternative and Clean Power Generation/Production

There are existing business and economic development opportunities in the use of alternative and clean energy for power generation. As presented in Table 1, Maryland is generally competitive with other Middle Atlantic States in the installed base of biomass, hydroelectric and photovoltaic energy capacity. In the area of wind power, Maryland's (2003) installed and planned capacity is well below neighboring states.

Table 1
Renewable Energy Installed and Planned Capacity
(kW)

	Operational Renewable Energy Capacity by				Planned Renewable Energy		
	Biomass	Hydro	Photovoltaic	Wind	Biomass	Photovoltaic	Wind
Middle Atlantic	**1,253,200**	**6,108,607**	**1,686**	**160,606**	**38,500**	**370**	**3,656,600**
Delaware	600	500	324	2	1,500		
Maryland	139,250	475,350	323	4		87	
New Jersey	212,100	393,313	585				
Pennsylvania	361,730	1,919,018	231	94,580	1,000	68	271,200
Virgina	539,520	3,087,306	220	10		215	3,125,400
West Virginia		233,120	3	66,010	36,000		260,000

Source: REPiS - 2002 Data

Maryland is lagging behind other states in the deployment of renewable energy generation capacity. For example, since 2002 (the date of the REPiS data in the above table), New Jersey, which has passed legislation to promote renewable energy production, has deployed three wind power projects with 30 kW of capacity; four biomass projects with 2,000 kW of capacity; and 1,072 solar projects with 12,136 kW of capacity.

According to the U.S. Department of Energy, Energy and Renewable Energy Program, Maryland is well suited to promote increased generation of alternative and clean energy . According to the DOE-EERE (http://www.eere.energy.gov/states/alternatives/resources_md.cfm) Maryland has the following potential in each of the five main areas of renewable energy:

- Biomass – good resource potential;
- Geothermal – has vast low-temperature resources suitable for geothermal heat pumps;
- Hydropower – low hydropower use as a percentage of electricity generation;
- Solar – good and useful solar resources photovoltaic and hot water; and
- Wind – wind resources consistent with utility scale production.

While Maryland's installed base of alternative and clean energy projection is currently limited, there are a large number of projects under consideration. According to draft materials provided by the Maryland Interdepartmental Energy Working Group, there are a large number of alternative and clean energy projects in either the planning or permitting stage in all areas of the State. These are as follows:

Ethanol

- Atlantic Ethanol, $100 million, 54-100 MG plant in Baltimore City;
- Chesapeake Renewable Energy, LLC, $120 million, 50 MG facility in Somerset County;
- Ecron, $150 million, 100 MG facility in Baltimore City;
- Greenstock , 30 MG facility in Dorchester County; and
- Maryland Grain Producers Board, 50 MG facility.

Bio Diesel

- Cropper/Maryland Biodiesel, $1.2 million 5 MG facility in Worcester County;
- Windridge Farms/Chesapeake Green Fuels $4 million, 30 MG facility;
- Valley Proteins project under consideration in Curtis Bay; and
- Perdue, $15-18 million, 15 MG facility.

Bio Mass

- Allen Family Foods/JCR Facility in Dorchester County;
- Antilles, poultry litter to electric power in Somerset County;
- FibroShore, poultry litter to electric power;
- Pogo Tree Experts, wood waste to electric power, in Montgomery County;
- Capstone/Waschmuth, poultry litter to electric power; and
- Sudley Landfill, biomass and methane to electric power in Anne Arundel County.

Wind Power

- Clipper Windpower, 100 MW facility in Garrett County;
- U.S. Windforce, 40 MW in Allegany and Garrett County; and
- Synergics, 40 MW in Garrett County.

The proposed MCEC can play a major role in assisting the developers and the State in facilitating the development of these projects.

Maryland offers financial incentives in most major areas to support renewable energy development, however, the amounts available are not considered to be sufficient to stimulate large-scale new investment in renewable energy. In the area of financial incentives, according to the Database of State Incentives for Renewable Energy (DSIRE), Maryland has developed incentives in most of the major areas (Table 2). However, according to the Maryland Energy Association, while Maryland offers numerous types of financial incentives for renewable energy projects, either the amount of incentives available or the percentage of project costs covered by the incentive are low relative to the incentives existing in other states. The inadequacy of Maryland incentives is also suggested by the lack of growth in renewable energy production in comparison to other states. One potential activity for the proposed MCEC is a more complete analysis of the types, structure and amount available to support renewable energy projects and a comparison to best practice incentives existing in other states.

Table 2
Database of State Incentives for Renewable Energy
Financial Incentives in the Middle Atlantic

State/Territory	Personal Tax	Corporate Tax	Sales Tax	Property Tax	Rebates	Grants	Loans	Industry Recruit.	Leasing/ Sales	Production Incentive*
Delaware					X	X				
Maryland	X	X	X	X	X		X			
New Jersey			X		X	X	X			X
Pennsylvania					X	X	X			
Virginia				X		X		X		
West Virginia		X		X						

Source: Database of State Incentives for Renewable Energy (DSIRE)

Maryland also passed renewable portfolio standards (RPS) in 2004. According to State Renewable Energy News (http://www.nrel.gov/analysis/sren/sren38.html) consisting of:

Maryland Legislature Establishes RPS:

Gov. Robert L. Ehrlich, Jr. signed a bill (SB 869), which establishes a RPS for the state's electricity supply. The bill creates two tiers of renewable energy sources. Tier 1 sources include solar, wind, geothermal, qualifying biomass, small hydropower (less than 30 MW), and landfill methane. Tier 2 sources include larger hydropower plants, poultry litter incineration, and other waste-to-energy projects. Eligibility of hydropower and waste-to-energy is limited to existing projects.

The law requires that, in 2006, 3.5% of the state's electricity be generated from renewable resources, with 1% from Tier 1 sources and 2.5% from Tier 2 sources. Between 2007 and 2018, the Tier 2 source requirement remains at 2.5%, but the Tier 1 requirement increases by 1% every other year. Beginning in 2019 and in all subsequent years, the RPS requirement is 7.5% and consists entirely of Tier 1 sources.

The law institutes an Alternative Compliance Fee (ACF) that suppliers must pay if they fail to meet the RPS requirements—the ACF is 2¢/kWh for Tier 1 resources and 1.5¢/kWh for Tier 2 resources. The law also creates the Maryland Renewable Energy Fund, which will be funded from ACF payments. The fund will be administered by the Maryland Energy Administration and will be used to make loans and grants to support the development of new Tier 1 renewable energy sources within the state. The law also establishes a renewable energy credit trading system to facilitate RPS compliance among suppliers. (http://www.nrel.gov/analysis/sren/sren38.html).

Maryland appears to have an immediate comparative advantage in wind power and biomass power development. Based on the U.S. Department of Energy, Energy and Renewable Energy Program (EERE) analysis and the activities of neighboring states, Maryland has the best near term potential to promote the development of wind power resources. According to the EERE, several areas in the state are considered to have "good" to "excellent" wind resources available. These include the barrier islands along the Atlantic coast, the southeastern shore of Chesapeake Bay, and ridge crests in the western part of the state, west of Cumberland. As presented in Table 1, Pennsylvania had 105 MW of wind power capacity installed and another 186 MW planned as of 2003 and West Virginia had 260 MW of planned capacity. According to the Maryland Interdepartmental Energy Working Group, there is a total of 180 MW of wind power capacity currently planned for development in Western Maryland.

The development of Wind Power projects in Maryland could yield substantial economic benefits. According to an analysis prepared for the ICSD, Maryland has 1,862 MW in developable land based wind power capacity. According to the NREL's JEDI wind power economic impact modeling software[91], the development of a 10MW wind power facility would create 21 jobs and generate $2.3 million in economic output activity in Maryland over the construction period and annually support 4 jobs and $260,000 in economic output activity. Because much of the area suitable for wind power development is in economically depressed Western Maryland, wind power development would have the added benefit of creating jobs and economic activity in an area suffering from job losses, higher unemployment, and lower incomes than the rest of the State. Maryland also has substantial opportunities for the development of offshore wind power generation. Studies prepared for New Jersey estimate offshore wind power potential of 3,000 MW and studies of Virginia estimate a range of 1,300 to 32,000 MW.

Maryland could also benefit from the retention or attraction of companies involved in the production of wind power components. Research conducted by the Renewable Energy Policy Project[92] has mapped the location of companies involved in the production of the various components required for wind power development. While Maryland is not ranked as one of the top 20 states for the manufacturing of wind power components, it does have 142 business establishments with 8,355 employees either involved or that could potentially be involved in production activities. Given the losses in manufacturing activity and employment in the state, promoting the development of wind power component production could assist in efforts to stabilize the manufacturing sector.

Maryland also appears to have a need for and, a potential comparative advantage in, the development of biomass energy from both agricultural by-products. Maryland is a leading poultry producer. Poultry waste has been linked to environmental problems in the Chesapeake Bay. Maryland is now in the process of examining the potential of several projects to use poultry waste as a feedstock for biomass energy production. Furthermore, Maryland has also placed a strategic emphasis on farmland preservation. As a result, the development of new uses, such as in ethanol or bio diesel production and biomass power generation, create an opportunity to combine agricultural preservation through the creation of new or higher value-added products with reducing dependence on fossil fuels. Thus, biomass energy appears to be an area where

[91] http://www.eere.energy.gov/windandhydro/windpoweringamerica/docs/jedi_wind_model_100604.xls
[92] http://www.crest.org/articles/static/1/binaries/WindLocator.pdf

future development activities may yield results in both reducing dependence on fossil fuels and yield both environmental (reductions in pollution associated with poultry waste) and policy (support for farmland preservation through new market creation) benefits.

There are no methods of generating similar economic impact estimates for the other renewable energy development projects proposed for development in Maryland, however other states have analyzed the potential impacts of increasing the use of renewable energy in general. Some findings from these analyses are as follows:

- UC-Berkley study found that each MW of solar power capacity installed would create 6.52 local installation/operations jobs and 31 manufacturing jobs (in the location where the photovoltaic cells are produced). Maryland, with BP solar in Frederick and a substantial base of high technology manufacturing activity would be in a position to capture both the production and installation jobs associated with solar power development.
- The Renewable Energy Policy Project[93] estimates the following national job impacts for the development of renewable energy:
    - Wind – 3.5 jobs/MW
    - Solar photovoltaic – 15.2 jobs/MW
    - Geothermal – 4.8 jobs/MW
    - Biomass/Dedicated Steam -- 4.3 jobs/MW
- California has developed a weighed average employment impact estimate for new renewable energy plants. This analysis found that for each MW of renewable energy capacity developed 4.8 one-time construction jobs and 0.5 annual operations and maintenance jobs are created (CALPIRG Charitable Trust Renewables Work).

It is outside of the scope of this analysis to estimate the actual job and economic development impacts that could be achieved by the increase in the development of renewable energy capacity and production required to meet the renewable portfolio standards goals. However, the establishment of these goals and the public and private efforts and investments required to meet them clearly have the potential to create jobs and stimulate new economic development opportunities. In order to ensure that the State derives the largest possible economic benefit from these activities, state-wide planning is necessary. The proposed MCEC can play an important role in facilitating this planning.

[93] Quoted in Generating Electricity, Generating Jobs – http://www.policymattersohio.org/generating.htm .

Economic Development Status and Opportunities
Clean Alternative and Clean Energy Technology Research
And Start-up Businesses Opportunities in Maryland

Maryland is a technology driven state. The Milken Institute ranks Maryland fourth nationally in its State Science and Technology Index. The strength of Maryland's high technology sector has been a key driver in the State's recent economic performance. The development of the proposed MCEC will create a means to focus the diverse federal, university, State and private technology business and research capabilities existing in Maryland on this important and growing sector.

Maryland is a leader in university and federal research and development activities as well as in high technology business activity. The Milken Institute ranks Maryland fourth nationally in research and development activities and sixth nationally in the concentration of high technology business activity. Maryland's strong position in technology research and business activity creates a comparative advantage for the state in its efforts to promote the development of alternative and clean energy technologies and businesses.

Research Driven Economic Development

As a national leader in technology research and development activities, Maryland's base of university and federal research can and should play a major role in the development of the alternative and clean energy industry in Maryland. Many of Maryland's leading high technology companies have directly spun out of or have been created by entrepreneurs with links to Maryland's substantial base of university and federal research programs. Similarly, Maryland's university and federal research programs present a clear opportunity for the generation of new spin-off alternative and clean energy technology companies.

Unfortunately, as a result of the lack of national databases on alternative and clean energy research activities, the JFI was unable to develop a complete inventory of the potential university and federal research and development capabilities in the state that can serve as drivers for the development of the alternative and clean energy sector. The JFI reviewed national R&D databases and conducted a limited number of interviews with staff, deans and faculty and leading universities and federal labs. Additionally, the Rand Corporation RaDiUS database and the United States Department of Energy research databases were examined for any research being conducted by Maryland universities. RaDiUS stands for Research and Development in the United States and is the most comprehensive database of information on federally-funded research and development. Both databases identified no federally-funded research for clean/renewable/alternative energy being conducted at Maryland universities. However, the JFI's inability to find such funded may be due to our lack of a full understanding of the relevant technologies and the lack of clear database search terms for alternative and clean energy technologies. As a result, further research is necessary.

While the list of available resources below is incomplete, it represents a good start for an inventory of the university and federal R&D resources supporting the alternative and clean energy sector. Should the MCEC be established, a recommended first task would be to develop a more complete list of available university and federal research capacity in the state.

University-Based Research

There are two major research universities in Maryland, the University of Maryland, College Park (UMCP) and Johns Hopkins University (JHU). While each of these universities has extensive research centers and ongoing research involving energy underway, alternative energy was not identified as a major focus of their research efforts. Described below are the current research and faculty members at two of the major research universities involved in alternative energy research.

University of Maryland, College Park (UMCP)

UMCP has one research laboratory currently involved in clean/renewable/alternative energy research. This is the Center for Environmental Energy Engineering. The Center for Environmental Energy Engineering is a leader in research and education in Environmentally Responsible, Economically Feasible distributed energy conversion and thermal management systems for buildings, transportation and electronic cooling. Research in CEEE is constructed with support from government and industrial sponsors and contains shared projects that are organized in four research consortia:

- Alternative Cooling Technologies and Application
- Integrated Systems Optimization
- Cooling, Heating and Power; and
- Advance Heat Transfer/Advanced Heat Exchangers

The Reacting Flow Lab and Center for Fuel Cell Research also operates within CEEE. The Research of the Flow Lab is focused in several areas. These areas include: catalytic oxidation for combustion and hydrogen production applications; solid oxide fuel cells; catalytic reduction of NO in exhaust after treatment; lean-premixed combustion; fuel cell system integration; large-scale chemical releases, detonations or fire scenarios; and power generation from thermoelectrics. This research is being conducted in collaboration with faculty located in the Engineering College and the Department of Chemistry and Biochemistry at UMCP, as well as with colleagues at other universities and government laboratories.

Additionally, the University is currently in the process of establishing a multi-disciplinary Energy Research Center, focusing on a broad set of alternative energy solutions.

There are five faculty members identified located at UMCP currently involved in clean energy research. These faculty members are Dr. Greg Jackson, Dr. Michael Ohadi, Dr. Reinhard Radermacher, and Dr. Bryan Eichhorn. Brief information regarding each of these faculty members is included below.

- Dr. Jackson is an Associate Professor in the Department of Mechanical Engineering. Dr. Jackson's research focuses on energy conversion with an emphasis on model development and experimental validation of combustion, catalytic, and electrochemical processes for power generation solid oxide fuel cells, H_2 production, and ultra-low emissions combustion.
- Dr. Ohadi is a Professor in the Department of Mechanical Engineering. Dr. Ohadi's research focuses on heat and mass transfer at the meso, micro and nano-scales with applications to thermal/fluid system miniaturization, smart heat exchangers, electronic cooling, and innovative energy systems.
- Dr. Radermacher is a Professor in the Department of Mechanical Engineering and the Director of the Center for Environmental Energy Engineering at UMCP. The Center is taking the lead in developing energy conversion systems that meet environmental and

economic concerns. Dr. Radermacher is an internationally recognized expert in heat transfer and working fluids for energy conversion systems, including heat pumps, air-conditioners, and refrigeration systems. He introduced ternary working fluid mixtures for absorption heat pumps and contributed to the use of working fluid mixtures in vapor compression systems developing advanced cycles with new degrees of freedom for special applications. In domestic refrigerators, energy savings of over fifty percent were demonstrated. His research grew to range from environmentally safe refrigerants in residential air-conditioners and heat pumps to combined heating, cooling and power systems for buildings and campuses. His work has resulted in over one hundred publications, as well as numerous invention records and eight patents, and he co-authored three books.

- Bryan Eichhorn is a Professor in the Department of Chemistry and Biochemistry. Dr. Eichhorn's research focuses on Inorganic materials and nanochemistry, Heterogeneous catalysis and fuel cells. Further research and extensive publications include Electrochemical Oxidation, enhanced CO tolerance for Hydrogen activation, and the study of Nanoscale materials that are revolutionizing the ways in which energy is managed and environmental toxins are processed and detected.

<u>Johns Hopkins University (JHU)</u>

As with UMCP, the JFI was only able to identify a limited amount of research being conducted into clean/renewable/alternative energy at Johns Hopkins University. Our review of the various research centers and programs at JHU was unable to identify any specifically focused on alternative or clean energy research. However, many of the centers identified cover research areas related to the subject. Three professors located at JHU were identified by the University as having research interests that include clean energy. These faculty members are Dr. Benjamin Hobbs, Dr. Hugh Ellis, and Dr. Joseph Katz.

- Dr. Hobbs is a Professor in the Department of Geography and Environmental Engineering. His research interests include environmental and energy systems analysis and economics, multi-objective and risk analysis, ecosystem management, mathematical programming models of imperfect energy markets, and stochastic electric power planning models.
- Dr. Ellis is the Chair of the Department of Civil Engineering. His research interests include environmental systems analysis, including air quality simulation and meterologic modeling, along with optimization of bridge inspection and maintenance policies, and with parameter identification for ambient vibration studies.
- Dr. Katz is the William F. Ward Sr. Distinguished Professor in the Department of Mechanical Engineering. His research interests include cavitation phenomena, attached partial cavitation, cavitation in turbulent shear flows, jets and wakes, multiphase flows, development of optical flow diagnostic techniques, complex flow structure and turbulence within turbomachines, and flow-induced vibrations and noise, mechanisms of noise generation in turbulent separated flows and in turbomachines.

The Applied Physics Lab (APL) operated by Johns Hopkins University is a not-for-profit center for engineering, research and development. APL provides a very broad set of capabilities spanning a number of disciplines considered essential and has complete program responsibility from concept development to implementation, installation, test, and evaluation. Whereas APL is also not currently focused on clean/alternative energy research, it has provided extensive assistance to the United States Department of Energy (DOE) in areas related to the development of expertise in the clean/alternative energy field. These projects have included developing a natural gas fueled car with a 300 mile range and the development of a gas storage system with a supplemental tank as well as hydrogen storage components. To develop the natural gas vehicle, APL partnered with Chrysler. Currently, APL owns four patents regarding the clean/alternative energy products that they developed in conducting their research for the DOE.

Federal Laboratory-Based Research

Maryland has a large number of federal research laboratories located within the State and has the second highest concentration of federally performed research in the nation. Our research identified four labs involved in some aspects of alternative and clean energy research within Maryland. These federal labs were: the National Institute of Standards and Technology (NIST); the Henry A. Wallace Beltsville Agriculture Research Center (BARC); the Aberdeen Proving Ground (APG); and the Army Research Laboratory (ARL) in Adelphia, Maryland. Through our discussions with NIST and BARC, researchers at both expressed interest in working to develop a alternative and clean energy research center located within Maryland. The research efforts focusing on alternative energy of these laboratories are described below.

National Institute of Standards and Technology (NIST)

The National Institute of Standards and Technology, located in Gaithersburg, Maryland is involved in wide range of programs that help industry improve energy use and conservation. In addition to this, NIST supports technological innovation involving alternative energy systems involving alternative power including solar energy and fuel cells. These efforts regarding alternative power include:

- Solar Energy – NIST is developing computer simulation tools to predict the performance of photovoltaics that have been integrated into building systems. NIST also is working with four solar energy equipment manufacturers to develop and validate computer tools that can be used to predict the electrical performance of building materials used to collect solar radiation.
- Fuel Cells – NIST has developed a test facility to measure the performance of residential fuel cell systems. The test facility will be used to create a test procedure and rating methodology that will determine the annual performance of these systems on a seasonal basis. Certain NIST facilities are available to qualified industrial researchers for energy-related projects. For instance, the NIST Center for Neutron Research is being used in a study of operational characteristics of a working fuel cell.
- Physical Chemical and Properties Division – develops measurements, data, and models for the thermophysical and thermochemical properties of gasses, liquids, and solids. In research applicable to fuel cell and hydrogen systems, the division is developing data to provide industry with high-quality thermophysical properties for mixtures of hydrogen and methane over broad ranges of temperature, pressure, and composition.

Beltsville Agriculture Research Center (BARC)

The Beltsville Agriculture Research Center, located in Beltsville, Maryland is part of the United States Department of Agriculture Agricultural Research Service. While BARC's research primarily focuses on areas other than clean/alternative energy, they have begun to focus research into the use of both animal byproducts and biomass such as cornstalks, manure, grasses, etc. as not only a fuel source but also for the development of other products, such as plastics. The poultry industry of Maryland's Eastern shore has been viewed as an important partner in conducting research into the potential to use poultry waste as a fuel source. The development of animal byproducts and biomass as a fuel source will also address problems regarding the environmental impacts associated with poultry waste. BARC is working with the United States Department of Energy to set up and begin this research. Roughly one year ago, BARC established the Biomass Gasification Center to create "behind the gate" technologies. These technologies are designed to allow farmers to become more energy self sufficient.

Aberdeen Proving Ground (APG)

The Aberdeen Proving ground is a major center for research, development and testing for the United States Army. While there is R&D being conducted at this location, none of it involves the development of clean/alternative energy sources. However, after speaking to Dr. James Cross, Co-Chair Power and Energy IPT at Fort Belvoir, Virginia, APG will be a national test site for fuel cell use. The testing of fuel cells at APG will assist the Army in further developing and expanding its research, development, and use of fuel cells in their vehicles.

Army Research Laboratory (ARL)

The Army Research Laboratory (ARL), located in Adelphia, Maryland, is the Army's corporate basic and applied research laboratory. The Army relies on the ARL for scientific discoveries, technologic advances, and analyses to enable full spectrum operations. Within the Laboratory are six Directorates - Weapons and Materials, Sensors and Electron Devices, Human Research and Engineering, Computational and Information Sciences, Vehicle Technology, and Survivability and Lethality Analysis. The Laboratory currently provides nine Research and Analysis Programs with three in the Power and Energy field. These include: the development of advanced directed energy technology; providing power sources for soldier and auxiliary power; and providing power components for hybrid electric vehicles and pulse power. Power components and pulse power investigates mature technologies to provide high temperature, high frequency power converters and generators; high power batteries operating over a large temperature range; high energy density fast/medium current rise time storage capacitors; and Micro-Electronic Mechanical Systems for improved efficiency and reliability.

Private Sector Research

Maryland is home to one of the leading solar power companies in the nation, BP Solar. This company is in the early stage of discussions with Frederick County to work with its incubator to promote the development of technologies and, potentially, companies out of the company's own internal research efforts.

Existing Efforts to Promote Alternative and Clean Energy Technology-based Start-ups

As described above, this initial scan of Maryland R&D activities has identified only a limited base of alternative and clean energy technologies being generated within Maryland universities or federal labs. While a more complete inventory of existing R&D resources at both universities and federal labs is needed, there exists immediate opportunities in working with federal labs in this area. This finding was validated through discussions with the Maryland Technology Development Corporation (TEDCO), which has had only limited success in identifying alternative and clean energy technologies for development at Maryland universities, but is in early stage discussions (on which only limited information on which can be revealed at this time) with many of Maryland's federal research facilities. TEDCO has reported efforts to work with the Beltsville Agricultural Research Center, the Aberdeen Proving Ground (APG), the Army Research Lab (ARL), and Pax River. Two technology transfer driven efforts are underway. TEDCO has assisted Spiralcat Innovations in working with APG on a Field Sanitation Unit with possible energy conversion potential and provided Maryland Technology Transfer Fund support to Atlantic Biomass Conversions, Inc., a company working on biomass generation based on sugar beet waste. TEDCO sees strong interest among both the universities and federal labs working on alternative and clean energy technologies and a very strong potential for it to work with the proposed MCEC in coordinating cooperative research opportunities between the private companies, universities, and federal labs that it currently works with.

Maryland also has the fourth highest concentration on biotechnology companies in the nation. Biotechnology applications in alternative and clean energy technology are seen by many as the next major technological frontier in the biotechnology sector. With its strong base of biotechnology companies, researchers, entrepreneurs and historical ties between the Maryland biotechnology sector and the federal research establishment, Maryland is well positioned to become a leader in this field. For example, J. Craig Venter, the founder of Celera Genomics and one of Maryland's leading biotechnology entrepreneurs, created a new business, Synthetic Genomics, to explore the potential of biotechnology in alternative and clean energy technology. Just as UMBI supported the development of biotechnology research and businesses in several areas, MCEC could work to catalyze the application of biotechnology in this emerging area in Maryland.

Maryland is also investing heavily in the development of its technology and business incubation capacity. Efforts to target small, start-up alternative and clean energy companies as tenants for existing incubators would have the combined effect of increasing incubator utilization and attracting new companies with new technology interests and capabilities into the State. This would augment efforts to enhance private and university research efforts in these new technologies. A key selling point for Maryland would be proximity to the Washington D.C. based federal agencies funding innovative research as well as the strong base of technology companies already existing in the State.

Summary

Near term opportunities exist to better coordinate and link the existing base of university, federal and private sector efforts in this area. Many of Maryland high technology businesses did not spin directly out of the state's research universities or federal labs, but were attracted into the State because of its proximity to federal funding agencies or regulators. Therefore, Maryland may have a comparative advantage in attracting companies based on our proximity to federal agencies (DOD, DOE, ARPA) involved in alternative and clean energy research, the presence of federal testing capacity (APG and BARC), our strong base of biotechnology companies, or our university resources. The Maryland Technology and Economic Development Corporation (TEDCO) is interested in linking the diverse research capabilities of Maryland's university and federal research programs with potential private sector clients. This effort would benefit from more through inventory of both university and federal research capabilities and interests in alternative and clean energy technologies. Furthermore, once a more complete inventory exists, it will enable Maryland to compare its research capabilities to those of competing states in this important area of future technology development. This may prompt investments in extending our research capabilities in this potentially important area.

Economic Development Status and Opportunities
Maryland's Existing Base of Alternative and Clean Energy Companies

Maryland has an existing base of alternative and clean energy on which to build. This analysis of the existing base of alternative and clean energy technology companies consists of two parts. In the first analysis, the JFI conducted a review of available reports analyzing the alternative and clean energy sector in other states to develop a list of key target business sectors. This analysis was based on older Standard Industrial Classification (SIC) codes rather than current NAICs codes because of the need to rely on commercial databases (Dun & Bradstreet's iMarket database was used) for company information.[94] In the second analysis, the JFI analyzed sectors not considered directly involved in alternative or clean energy activities, but in industries, such as heat pump manufacturers, that could benefit from an increased emphasis on energy efficiency.

First Tier Business Opportunities – The Traditional Alternative and Clean Energy Sector

The JFI reviewed the available reports defining and measuring the size of the alternative and clean energy sector in other states, most importantly the *Energy Efficiency Renewable Energy, and Jobs in Massachusetts* report produced by the Maryland Technology Collaborative but also including other measurement efforts in other states. The alternative and clean energy industry definitions developed in these efforts were used to develop a list of target industries to analyze in Maryland using the Dun & Bradstreet iMarket database.

Maryland's base of alternative and clean energy businesses is presented in Table 3. Based on this analysis, there are 503 businesses with 4,456 employees in the alternative and clean energy sector. More than half of these businesses and employees (339 businesses and 2,519 employees) are in the environmental consulting field. This sector is part of Maryland's important and growing business and professional services sector. Maryland has long been a leader in this field based both on our proximity to the Washington D.C. and our highly educated workforce. It is highly likely that a large share of these businesses is part of Maryland's large number of federal government contractors. These businesses may have strategic relationships with core energy (DOE), technology (DOD, ARPA), or regulatory (EPA) agencies that could either benefit from or contribute to the operation of the proposed MCEC.

Maryland is also home to BP Solar, one of the largest solar cell producers in the world, this company alone accounts for 8% of alternative and clean energy sector employment in Maryland. BP Solar completed a major expansion in its Frederick County, Maryland facility last year. The presence of one of the leading solar companies in the world in the state presents an opportunity to develop an industry cluster around this new and growing technology. The Renewable Energy Policy Project list Maryland as having 105 businesses with 5,120 employees that could potentially benefit from expanded manufacturing of solar cells.

The remainder of Maryland alternative and clean energy companies is highly concentrated in construction, contracting and installation. These companies will benefit from efforts to enhance energy efficiency in Maryland. Maryland lacks significant employment (outside of BP Solar) in the manufacturing of products related to alternative and clean energy

[94] The JFI maintains administrative record based databases of Maryland companies. However, as a result of confidentiality restrictions, we would be unable to release employment data on many sectors in which there are few or a few dominant firms. Furthermore, the use of a commercial database allows for the development of a clean energy database of companies for future use in research or targeting efforts.

technologies. This will present a significant barrier to the development of clusters related to the production of alternative and clean energy technologies.

Table 4 presents total alternative and clean energy sector employment for the five Middle Atlantic states. While Maryland is ranked third of the five states in the number of businesses and level of employment, adjusting for the smaller size of the state, we are competitive within the region in this sector. The most important gap between Maryland and the other states is in our low level of manufacturing activity relative to either Pennsylvania or Virginia.

Table 3
The Maryland Alternative and Clean Energy Sector

SIC Code	SIC Code Name	# of Businesses	# of Employees
Total - All Industries		**503**	**4,456**
1711-0403	Solar energy contractor	10	31
1731-0102	Computer power conditioning	1	2
1731-0201	Computerized controls installation	4	224
1731-0202	Energy management controls	10	125
1731-0203	Environmental system control installation	6	96
1742-0204	Solar reflecting insulation film	2	22
1781-9901	Geothermal drilling	1	2
1796-9907	Power generating equipment installation	5	34
2296-0300	Cord and fabric for reinforcing fuel cells	--	--
2296-0302	Fabric for reinforcing fuel cells	--	--
2679-0902	Fuel cell forms, cardboard: made from purchased material	--	--
2869-0104	Ethyl alcohol, ethanol	--	--
3086-9904	Insulation or cushioning material, foamed plastics	2	12
3211-0302	Insulating glass, sealed units	1	30
3433-9904	Solar heaters and collectors	1	4
3511-0000	Turbines and turbine generator sets	1	3
3511-0100	Turbines and turbine generator set units, complete	--	--
3511-0101	Gas turbine generator set units, complete	--	--
3511-0102	Hydraulic turbine generator set units, complete	--	--
3511-0103	Steam turbine generator set units, complete	--	--
3511-0200	Turbines and turbine generator sets and parts	1	3
3511-0201	Gas turbines, mechanical drive	--	--
3511-0202	Hydraulic turbines	--	--
3511-0203	Steam engines	--	--
3511-0205	Steam turbines	--	--
3511-0206	Turbo-generators	--	--
3511-0207	Wheels, water	--	--
3613-0209	Power switching equipment	--	--
3621-9909	Windmills, electric generating	--	--
3629-0102	Electrochemical generators (fuel cells)	--	--
3629-0105	Power conversion units, a.c. to d.c.: static-electric	1	5
3674-0305	Photovoltaic devices, solid state	--	--
3674-0306	Solar cells	1	375
3674-9901	Fuel cells, solid state	1	3
3822-0206	Temperature controls, automatic	2	7
3822-9901	Building services monitoring controls, automatic	1	5
3829-0218	Solarimeters	--	--
5033-0200	Insulation materials	7	143
5074-0208	Heating equipment and panels, solar	3	13
5211-0300	Insulation and energy conservation products	1	4
5211-0301	Energy conservation products	2	2
5211-0302	Insulation material, building	3	28
5211-0303	Solar heating equipment	2	4
8711-9906	Energy conservation engineering	11	126
8731-0301	Energy research	9	49
8731-0302	Environmental research	31	363
8748-9904	Energy conservation consultant	44	222
8748-9905	Environmental consultant	339	2,519

Source: D&B iMarket

Table 4
Middle Atlantic
Alternative and Clean Energy Sector

State	# of Businesses	# of Employees
Total United States	21,692	230,426
Middle Atlantic	2,053	20,679
Delaware	70	771
Maryland	503	4,456
Pennsylvania	826	7,945
Virgina	587	7,064
West Virginia	67	443

Source: D&B iMarket

Second Tier Business Opportunities – Industries that Could Benefit from Alternative and Clean Energy Development

In addition to the first tier businesses analyzed above that represent the core industries recognized in other studies as centrally and directly involved in the alternative and clean energy sector, there are a large number of other industries that can benefit from the development of both new alternative and clean energy power projects and, more importantly, from efforts to improve energy efficiency in Maryland. For example, in the area of businesses that can benefit from the development of both new alternative and clean energy power projects, the Renewable Energy Policy Project identified 142 business establishments with 8,355 employees that could potentially be involved in the construction of wind power projects as Maryland begins to develop wind power on a scale comparable to its neighboring states. The proposed MCEC could work with DBED and state or regional manufacturing organizations, such as Regional Manufacturing Institute (RMI) or the Maryland Technology Extension Service (MTES) to create a consortium of manufacturing firms to serve as suppliers to the major wind power developers.

Some of the largest potential economic development impacts, however, may come from efforts to improve energy efficiency in Maryland. There is no generally accepted list of the types of businesses that can benefit from efforts to promote energy efficiency. For example, based on existing general business databases or state employment information, it is impossible to differentiate between construction or engineering firms that specialize in green or energy efficient buildings versus traditional buildings. In order to identify the existing base of Maryland companies in this second tier of businesses that could benefit from an increased emphasis on energy efficiency, the JFI collected information on the Maryland member companies from the Sustainable Buildings Industry Council (http://www.sbicouncil.org) and the Renewable Energy Sources Guides (http://www.sourceguides.com/index.html). The JFI attempted to remove all overlap between these databases and the primary impact industries analyzed above, however, some duplication may occur. Furthermore, these databases would by definition exclude non-member firms that may become active in energy efficiency efforts as the state market grows. Thus, it is an imperfect first cut of the available businesses. The results of this analysis are as follows:

- The Sustainable Buildings Industry Council lists twelve Maryland members, including three A/E firms, one builder, and two manufacturers nor included in the first tier analysis.
- The Renewable Energy Sources Guides list fifty-six Maryland companies involved in renewable energy.

Businesses Development Policy Options

Nationally, the alternative and clean energy sector is poised for a new period of growth and activity based on increasing energy prices, scarcity and environmental impacts. There is the potential for significant business, employment and economic development benefits accruing to states that have or can develop a comparative advantage in this sector. Maryland needs to assess it strengths, weaknesses and interest in participating in the expected growth of this sector. The proposed MCEC can play a leading role in this assessment. This preliminary analysis examined conditions in Maryland in three main areas:

- The existing and planned base of capacity in renewable energy power generation and the regulations in place to support it;
- The existing base of university, federal and private alternative and clean energy research to support technology development and commercialization; and
- The existing base of alternative and clean energy business activity in Maryland.

Some summary conclusions are as follows:

1. Maryland has a small but growing base of installed and planned renewable energy production capacity. Maryland offers incentives, but these are considered too small to promote the full development of the sector. None-the-less, several projects are in the permitting or planning stage.
2. Despite Maryland's national leadership in both university and federal research activities, the State does not appear (based on the preliminary analysis conducted) to have a critical mass of technology under development to support wide-scale commercialization activities. However, near term opportunities exist to better link the federal, university, and private resources in place to promote growth in alternative and clean energy research. Furthermore, Maryland needs to assess its position in alternative and clean energy research in light of the likely future growth and importance of the sector.
3. Maryland is competitive within the Middle Atlantic in terms of the size of its alternative and clean energy sector. Its critical strength lies in its government contracting, consulting and research base which account for the overwhelming majority of businesses and jobs. The strength of this sector is presumably related to the State's close proximity to Washington, D.C. and the strong base of federal government contracting in the State. Exploring and expanding the linkages of this sector to federal government agency clients presents a clear near term opportunity for supporting the growth and development of this sector. Maryland is also home to an international leader in solar cell production. The state should explore the potential of developing an industry cluster of related businesses

to support the growth of this business sector, however, the lack of related manufacturing activity may limit the near-term potential of this opportunity.

Maryland has come late to planning for the growth and development of this sector. Maryland's economic development strategy does not officially recognize or call for the development of alternative and clean energy businesses; however, this sector is implicitly recognized as part of the State promotion of high technology businesses in general. The Maryland Department of Business and Economic Development (DBED)'s Resource Based Industries Program however, is taking the lead in promoting the development of the sector. According to Katherine Magruder, the Director of this program, DBED has organized the Maryland Interdepartmental Energy Group to bring together the various state agencies impacting the development of alternative and clean energy to coordinate the various efforts underway to promote the sector. The Working Group includes DBED, the Maryland Energy Administration; The Maryland Environmental Service; the Maryland Department of the Environment; the Maryland Department of Agriculture; the Department of General Services; and the Maryland Department of Natural Resources. This group began to work together in 2005.

The Maryland Interdepartmental Energy Group's goals are to promote alternative energy sources to reduce dependence on fossil fuels and natural gas; mitigate the rising costs of fuel and electricity; to catalyze economic growth; and mitigate the environmental impacts of economic activities. This group sees the development of alternative and clean energy as a "win-win-win" opportunity to promote economic development, reduce reliance on fossil fuels, and provide environmental benefits to the state. This group is working together to develop a more coordinated approach among the key state agencies to promote the growth and development of this sector. TEDCO is also beginning to recognize the potential of the sector and is working to integrate the various federal, university and private resources existing in the research and technology commercialization area. Private sector activity, however, is lacking. Neither the Maryland Technology Council nor the Greater Baltimore Technology Council have a current focus on alternative or clean energy companies because neither have a base of companies active or interested in the sector.

Other states are pursuing a much more active role in promoting the development of the alternative and clean energy sector. A thorough and complete analysis of the efforts underway across the fifty states is outside the scope of this limited project. Some highlights of state or national efforts identified in the research conducted are as follows:

- New York state has developed the New York State Energy Research and Development Authority (NYSERDA) a public benefit corporation funded by an assessment on the intrastate sales of New York State's investor-owned electric and gas utilities, federal grants, and voluntary annual contributions to fund renewable energy projects. NYSEDRA created the Saratoga Technology + Energy Park (STEP), a 280-acre site 1.25 million sq. ft., research and manufacturing park for alternative and clean energy companies.

- In Pennsylvania, four funds designed to promote the development of sustainable and renewable energy programs and clean-air technologies on both a regional and statewide basis were created as a result of the restructuring plans of five electric companies. The funds have provided more than $20 million in loans and $1.8 million in grants to over 100 projects. A Statewide Sustainable Energy Board was formed in 1999 to enhance communications among the four funds and state agencies. The board includes representatives from the Commission; the Department of Environmental Protection; the Department of Community and Economic Development; the Office of Consumer Advocate; the Pennsylvania Environmental Council; and regional boards.

- Connecticut created the Connecticut Clean Energy Fund (CCEF) to promote the development and commercialization of clean energy technologies and is stimulating markets for electricity from clean renewable sources. Its main goals are to create clean energy supply for Connecticut; develop clean energy technologies; and to educate residents about clean energy's importance for the state's energy future. CCEF's funding comes from a surcharge on electric ratepayers' utility bills.
- Research conducted by the Clean Energy States Alliance identified that ten state clean energy funds have invested in the early stage research and development of new alternative and clean energy technologies.[95]
- Texas has developed a clean energy incubator to promote the commercialization of new technologies and start-up companies in alternative and clean energy. NYSERDA funded the development of RENEW NY, a collaborative effort focused on identifying, incubating and creating renewable energy companies in Western New York. The University of Toledo has created the Clean & Alternative Energy Center to foster the creation and growth of clean and alternative energy companies through the use of business start-up and technology commercialization programs and help create a new industry cluster in the region. Nationally, NREL works with seven incubators that work with clean energy companies.
- Many states have developed economic analyses or plans to support the development of individual alternative or clean energy technologies. As an example, New Jersey has studied the opportunities in the development of hydrogen fuel cells.
- Many states have developed comprehensive energy strategies that include efforts to promote increased renewable, alternative and clean energy development.

Potential MCEC/Alternative and Clean Energy Development Policy Options

In order to determine the potential of Maryland to develop and the proposed MCEC to facilitate economic development through the expanded research, commercialization of alternative and clean energy technology, and renewable energy production a number of policy options could be explored. These include:

- Maryland/the MCEC should develop of a complete inventory of private, university and federal alternative and clean energy technology capabilities and activities in the State and then conduct thorough needs and potential applications analysis of these capabilities.
- Based on a more complete inventory of alternative and clean energy technology capabilities, the proposed MCEC working with TEDCO could promote opportunities for expanded interaction between the university, federal labs and private companies. This would help build a critical mass of research activities and interactions in the field.
- Because of the strength of the Maryland biotechnology sector and the strong potential for biotechnology applications in alternative and clean energy technology development, Maryland should explore the potential for creating a new biotechnology research institute

[95] http://www.cleanenergystates.org/CaseStudies/LBNL-PUB-918_Support_for_R&D.pdf

for alternative and clean energy research. Such an institute would build on the existing success of UMBI in promoting the development of new biotechnology applications and sectors and exploit an area of existing comparative advantage in biotechnology research and business activity.

- Opportunities may exist to promote linkages between existing (or proposed) incubators and research parks and alternative and clean energy companies. For example, BP Solar has expressed interest in working with the Frederick County incubator. Attracting new start-up alternative and clean energy businesses will have the dual impact of enhancing incubator utilization in Maryland and stimulating new research opportunities and linkages.
- The MCEC working with DBED could develop a more complete inventory of the companies working with DOE and other federal agencies in the area of alternative and clean energy related consulting, research or other services to identify the needs of these businesses and their interest in working together to promote the development of the sector.
- The MCEC, working with MEA and Maryland Interdepartmental Energy Group, could develop a complete analysis of the incentives available to support renewable energy in Maryland compared to best practices across the country to determine the need for new or expanded incentives programs.
- The MCEC, working with DBED or the technology councils, could organize a clean energy sector working group, the Maryland Clean Energy Business Council, among participating businesses to promote the needs and interests of the sector.

The development of the alternative and clean energy sector is cyclical and largely dependent on national and international trends in energy prices. The sector is characterized by a 'Boom or Bust" cycle based on costs relative to traditional fossil fuels. The development of this sector is fragmented in Maryland and could benefit from the development of clear and concise industry guidelines and policies by the proposed MCEC.

Appendix 4   Towson University Study

RESI

RESEARCH & CONSULTING

TOWSON UNIVERSITY

An Economic Impact Analysis of Energy Efficiency and Renewable Energy in Maryland

Prepared by
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On behalf of

International Center for Sustainable Development

February 28, 2007

Contents

Introduction

Scope of Work

In 2006 RESI of Towson University spent some time investigating the potential economic benefits associated with a proposed clean energy and renewable research center in Maryland. The economic benefits associated with the operations of such a center are primarily derived from its ancillary effects of encouraging energy efficiency throughout various segments of Maryland's economy (i.e., commercial, residential, industrial, etc.) as well as through the incubation of energy firms. The proposed center would also encourage the development of and investment in renewable energy and alternative fuels. Collectively, these efforts would likely spur the attraction of related energy firms to the State, the expansion of existing Maryland energy firms as well as encourage growth of start-up firms. This study provides economic impact estimates for all of these activities. In addition, we also identify areas for future research.

Economic Impact Analysis Defined

About Economic Impact Analyses & Input/Output Models:

Input/output models are the primary tool used by economists to measure the total economic impact of a policy, business or event. For example, input/output models are used to measure the total economic impacts associated with the relocation of a firm to an area. The theory behind economic impact analysis is that the total economic impact of a new firm entering a region is not merely limited to the number of employees the firm hires or to the payroll associated with these employees. Rather, the total economic impact includes these impacts as well as additional, multiplicative impacts. Multiplicative impacts occur as the new firm spends money in the region on goods and services and as the wages of employees trickle through the local economy.

Specifically, there are three types of impacts captured by input/output models:

- ***Direct impacts:*** these impacts are generated when the new business creates new jobs and hires workers to fill those jobs.
- ***Indirect impacts:*** these impacts accrue as the new firm purchases goods and services from other locally situated businesses.
- ***Induced impacts:*** both the direct and indirect impacts result in an increase in area household income. This increase allows local households to ramp up their spending at local area businesses. The increase in local spending is referred to as the induced impacts.

For this analysis, RESI quantifies total economic impacts for the following:

1. Energy Efficiency – Electricity
2. Energy Efficiency – Natural Gas
3. Renewable Energy – Wind Power, Solar Photovoltaic and Biomass
4. Alternative Energy – Ethanol
5. Firm Attraction, Expansion & Start Up Activity
6. Business Incubation.

The direct, indirect and induced impacts are defined as follows for each of these areas:

- ***Energy Efficiency - Electricity***

For the purpose of this analysis, the direct impacts are considered to be equal to the value of electricity savings as they accrue to existing businesses (as savings are recycled through the economy). The indirect impacts accrue to additional supporting businesses (through purchases of goods and services by businesses that receive the direct impacts). The induced impacts result from increased household income and related spending which is driven by the direct and indirect impacts.

- ***Energy Efficiency – Natural Gas***

The direct impacts are considered to be equal to the value of natural gas savings as they accrue to existing businesses (as savings are recycled through the economy). The indirect impacts accrue to additional supporting businesses (through purchases of goods and services by businesses that receive the direct impacts). The induced impacts result from increased household income and related spending which is driven by the direct and indirect impacts.

- ***Renewable Energy – Wind Power, Solar Photovoltaic and Biomass***

In the case of this analysis, the direct impacts result from employees working in the wind power, solar photovoltaic and biomass facilities, the indirect impacts are driven by the facilities themselves as they purchase local goods and services and the induced impacts are derived from increases in area household spending due to both the direct and indirect impacts. Total economic impacts referenced in this study refer to the sum of all three of these impacts.

- ***Alternative Energy - Ethanol***

Direct impacts result from employees working in the ethanol facilities, the indirect impacts are driven by the facilities themselves as they purchase local goods and services and the induced impacts are derived from increases in area household income and spending due to both the direct and indirect impacts. Total economic impacts referenced in this study refer to the sum of all three of these impacts.

- ***Firm Attraction, Expansion & Start Up Activity***

In the case of this analysis, the direct impacts result from employees working at estimated Maryland renewable energy firms, the indirect impacts are driven by the firms themselves as they purchase local goods and services and the induced impacts are derived from increases in area household income and spending due to both the direct and indirect impacts. Total economic impacts referenced in this study refer to the sum of all three of these impacts.

- ***Business Incubation***

Direct impacts are equal to the incubator investment, the indirect impacts are driven by the incubated firms as they purchase local goods and services from local support firms and the induced impacts are derived from increases in area household income and spending due to both the direct and indirect impacts. Total economic impacts referenced in this study refer to the sum of all three of these impacts.

About the IMPLAN Model:

To estimate total economic impacts, RESI relies upon IMPLAN, a standard input/output software package. A significant feature of the IMPLAN model is that it is customizable to better reflect individual economies, and in the case of this study, RESI has calibrated the model to reflect the economies of Maryland and the Baltimore Metropolitan Area.

Report Layout

RESI divides study results into the following sections:

2.0 Energy Efficiency – Electricity and Natural Gas
3.0 Renewable Energy – Wind Power, Solar Photovoltaic and Biomass
4.0 Alternative Energy – Ethanol
5.0 Cumulative Results (Energy Efficiency, Renewable Energy, Alternative Fuels)
6.0 Firm Attraction, Expansion & Startup Activity
7.0 Business Incubation

The study concludes with a summary of additional benefits not fully explored in this report including: (1) environmental benefits associated with increased energy efficiency as well as increased use of renewable energies and alternative fuels and (2) the development of sustainable communities.

Energy Efficiency

This analysis measures the savings that Maryland and the Baltimore metropolitan area could see due to increased energy efficiency. The term "energy efficiency" has been utilized frequently and often, inconsistently, in recent years. According to the World Energy Council (WEC), the term energy efficiency (from a policy standpoint): "encompasses all changes that result in decreasing the amount of energy used to produce one unit of economic activity or to meet the energy requirements for a given level of comfort. Energy efficiency is associated to economic efficiency and includes technological, behavioral and economic changes."[96]

This study agrees with the WEC definition of energy efficiency. For the purpose of this analysis, increased energy efficiency means the state and region will require less energy to generate economic activity through the implementation of "technological, behavioral and economic changes". This study estimates the economic impacts of energy efficiency on both (1) electricity and (2) natural gas consumption in both Maryland and the Baltimore metropolitan region.[97]

Energy Efficiency - Electricity

What We Are Measuring: Total economic impacts associated with cost savings of reduced electricity consumption (current and projected) in Maryland and the Baltimore metropolitan area. The idea is that as the State and region achieve increased energy efficiency, electricity consumption will decline. Dollar savings associated with three scenarios of reduced electricity consumption between 2006 and 2025 are estimated:

(4) 20% reduction in electricity consumption (baseline scenario);
(5) 30% reduction (mid-range scenario); and
(6) 40% reduction (high scenario).

[96] "Energy Efficiency Policies and Indicators", World Energy Council.
[97] This study defines the Baltimore metropolitan region to consist of the following Maryland jurisdictions: Anne Arundel County, Baltimore County, Baltimore City, Carroll County, Harford County and Howard County. This definition corresponds to the Maryland Office of Planning's definition of the Baltimore metropolitan region.

Using our economic input/output model, we then calculate the economic benefits the State and region could see were these savings to be cycled back through local economies.

It should be noted that the impacts considered in this analysis do not include:

- Jobs and related economic impacts associated with implementing energy efficiency.

<u>About the Scenarios:</u>

The following excerpts from published research provide some context to the savings scenarios considered in this analysis:

- In 2004, the American Council for an Energy Efficient Economy (ACEEE) conducted a review of published literature assessing the potential for energy efficiency in the United States.[98] ACEEE looked at eleven studies focusing on various geographies (California, New York, Massachusetts, the entire U.S., etc.). The results of ACEEE's review determined that the median ***achievable***[99] savings potential for electricity is ***24 percent*** over a 20 year horizon or 1.2 percent per year.

- A 2004 report produced by Synapse Energy Economics, Inc. conducted a review of four nation-wide studies and four regional studies on energy efficiency and determined the following: "These studies include forecasts of the amount and cost of energy efficiency available through 2010 and, in most cases, 2020. They find that there is enough cost-effective efficiency available to reduce electric demand in 2010 by as much as 11%-23% and in 2020 by as much as ***21-35 percent.***"[100]

- According to 2003 estimates produced by ACEEE[101], Maryland could realistically reduce its electricity consumption (through energy efficiency and conservation efforts) by 5.5 percent over a five year horizon. The 5.5 percent applied to the 20 year horizon considered in this analysis would yield electricity savings of ***22 percent***, which is greater than the baseline savings scenario considered in this analysis.

<u>Methodology & Assumptions:</u>

The estimates presented in this analysis were calculated using the following steps:

1. RESI utilized current and projected electricity consumption data for both Maryland and the Baltimore metro area[102].

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[98] The Technical, Economic and Achievable Potential for Energy-Efficiency in the U.S. – A Meta-Analysis of Recent Studies. Steven Nadel, Anna Shipley and R. Neal Elliott, 2004.

[99] The study defines achievable potential as the potential that is "contained by the rate at which homes and businesses will actually adopt energy saving technologies and practices" and further notes that the achievable potential figures are always less than the economic and technical potentials determined in such studies.

[100] Synapse Energy Economics Inc. A Responsible Electricity Future: An Efficient, Cleaner and Balanced Scenario for the US Electricity System, June 11, 2004. Page 13.

[101] ACEEE Estimates of Near-Term Electricity and Gas Savings, R. Neal Elliott, Anna Monis Shipley, Steven Nadel and Elizabeth Brown, August 15, 2003.

[102] RESI utilized two sets of electricity consumption forecasts (broken out by residential, commercial, industrial and transportation sectors). The first is produced by the International Center for Sustainable Development (ICSD) and the second by the Mid-Atlantic Area Council. To adjust for the difference in electricity growth rates projected by these two sources, RESI discounted the electricity rates such that the estimated dollar value of the Delta would be equivalent to a Delta calculated using the Mid-Atlantic Area Council's electricity growth rates

2. To determine the value of reduced electricity consumption (i.e., the cost of natural gas) RESI rates produced by the Energy Information Administration.

3. RESI disaggregated savings to households using household income distribution data produced by the U.S. Census Bureau (2005 American Community Survey estimates).

4. RESI disaggregated savings to industry using industrial distribution data produced by the U.S. Census Bureau (2003 American Community Survey estimates).

5. Direct savings were inputted into RESI's IMPLAN model to derive the total economic impacts including employment, wage, tax revenue and GSP/GMP estimates.[103]

The following assumptions should be noted:

- We assume that energy prices will keep pace with inflation (in other words, prices are assumed to remain constant over the time horizon considered in this analysis). This assumption errs on the conservative side.

- There is a cost associated with implementing energy efficiency. RESI assumes a 30% implementation cost evenly spread across the 20 year time horizon. The 30% implementation cost estimate is taken from a 2005 study produced by the Ernest Orlando Lawrence Berkeley National Laboratory.[104] Our estimate of dollar savings due to decreased electricity consumption are discounted by the estimated implementation costs of increased energy efficiency.

Summary of Results:

As detailed in the following figure, reduction in electricity consumption over the 20 year horizon considered in this analysis (2006-2025) is estimated to yield significant economic benefits including an increase in Maryland job creation ranging between 93,400 and 194,562 jobs. Associated wages and salaries for these jobs range from $3.7 billion to nearly $7.7 billion, while expected state and local tax revenues exceed $650 million in the low reduction scenario (20%) and surpass $1.3 billion in the high reduction scenario (40%). The impact on Maryland's GSP is estimated to be quite substantial and ranges from $10.3 to $21.6 billion.

Figure A: Total Economic Impacts of Reduced Electricity Consumption in Maryland (Due to Increased Energy Efficiency)

2006-2025	**20% Reduction**	**30% Reduction**	**40% Reduction**
Employment	93,400	142,815	194,562
Wages & Salaries*	$ 3,681.33	$ 5,629.13	$ 7,669.00
State & Local Tax Revenues*	$ 650.06	$ 994.04	$ 1,354.28

[103] A more detailed description of IMPLAN and economic impact analyses in general is provided in the Introduction section of this analysis.

[104] Ernest Orlando Lawrence Berkeley National Laboratory. Easing the Natural Gas Crisis: Reducing Natural Gas Prices through Increased Deployment of Renewable Energy and Energy Efficiency.

Gross State Product(GSP)*	$ 10,368.51	$ 15,855.63	$ 21,603.05
2006-2015			
Employment	21,053	32,922	45,985
Wages & Salaries*	$ 831.92	$ 1,300.93	$ 1,817.14
State & Local Tax Revenues*	$ 147.17	$ 230.14	$ 321.46
Gross State Product(GSP)*	$ 2,359.42	$ 3,689.68	$ 5,153.82
2016-2025			
Employment	72,347	109,893	148,577
Wages & Salaries*	$ 2,849.42	$ 4,328.20	$ 5,851.86
State & Local Tax Revenues*	$ 502.90	$ 763.90	$ 1,032.82
Gross State Product(GSP)*	$ 8,009.09	$ 12,165.95	$ 16,449.22

*millions of dollars

Regional impacts are also quite significant and are detailed in Figure B. Job creation ranges between roughly 46,000 and 97,000 jobs. Associated wages and salaries for these jobs range from $1.6 billion to $3.4 billion, while expected state and local tax revenues exceed $289 million in the low reduction scenario (20%) and surpass $603 million in the high reduction scenario (40%). The impact on the Baltimore Metropolitan region's GSP is estimated to be quite substantial and ranges from $4.8 to $9.9 billion.

Figure B: Total Economic Impacts of Reduced Electricity Consumption in the Baltimore Metropolitan Area (Due to Increased Energy Efficiency)

2006-2025	**20% Reduction**	**30% Reduction**	**40% Reduction**
Employment	46,391	70,935	96,637
Wages & Salaries*	$ 1,641.31	$ 2,509.73	$ 3,419.20
State & Local Tax Revenues*	$ 289.83	$ 443.19	$ 603.80
Gross State Product(GSP)*	$ 4,768.67	$ 7,292.30	$ 9,935.65
2006-2015			
Employment	10,457	16,352	22,840
Wages & Salaries*	$ 370.91	$ 580.02	$ 810.17
State & Local Tax Revenues*	$ 65.61	$ 102.61	$ 143.32
Gross State Product(GSP)*	$ 1,085.14	$ 1,696.95	$ 2,370.34
2016-2025			
Employment	35,934	54,583	73,797
Wages & Salaries*	$ 1,270.40	$ 1,929.71	$ 2,609.03
State & Local Tax Revenues*	$ 224.21	$ 340.58	$ 460.48
Gross State Product(GSP)*	$ 3,683.53	$ 5,595.35	$ 7,565.31

*millions of dollars

Energy Efficiency – Natural Gas

What We Are Measuring: Total economic impacts associated with savings due to reduced natural gas consumption in Maryland and the Baltimore metropolitan area. The idea is that as the State and region achieve increased energy efficiency, natural gas consumption will decline. Dollar savings associated with three scenarios of reduced natural gas consumption are estimated:

(4) 10% reduction in natural gas consumption (baseline scenario);
(5) 15% reduction (mid-range scenario); and
(6) 20% reduction (high scenario).

Using our economic input/output model, we then calculate the total economic benefits the State and region could see were these savings to be cycled back through local economies.

It should be noted that the impacts considered in this analysis do not include:

- Potential cost savings to Maryland and Baltimore metro consumers due to lower natural gas prices (reduced natural gas demand has been found to lower prices).[105]

- Jobs and related economic impacts associated with implementing energy efficiency.

About the Scenarios:

The following excerpts from published research on the subject of natural gas savings due to increased energy efficiency provide some context to the savings scenarios considered in this analysis:

- In 2004, the American Council for an Energy Efficient Economy (ACEEE) conducted a review of published literature assessing the potential for energy efficiency in the United States.[106] ACEEE looked at eleven studies focusing on various geographies (California, New York, Massachusetts, the entire U.S., etc.). The results of ACEEE's review determined that the median ***achievable***[107] savings potential for natural gas is ***9 percent*** over a 20 year horizon or 0.5 percent per year.

- According to 2003 estimates produced by ACEEE[108], Maryland could realistically reduce its natural gas consumption (through energy efficiency and conservation efforts) by 4.2 percent over a five year horizon. The 5.6 percent applied to the 20 year horizon considered in this analysis would yield electricity savings of ***16.8 percent,*** which is greater than the mid-range savings scenario considered in this analysis.

Methodology & Assumptions:

The estimates presented in this analysis were calculated using the following steps:

[105] The Ernest Orlando Lawrence Berkeley National Laboratory finds that the "displacement of gas-fired electricity generation reduces natural gas demand and thus puts downward pressure on gas prices. Many recent modeling studies of increased renewable energy and energy efficiency deployment have demonstrated this 'secondary' effect of lowering natural gas prices could be significant.", Easing the Natural Gas Crisis, January 2005, Page vii

[106] The Technical, Economic and Achievable Potential for Energy-Efficiency in the U.S. – A Meta-Analysis of Recent Studies. Steven Nadel, Anna Shipley and R. Neal Elliott, 2004.

[107] The study defines achievable potential as the potential that is "contained by the rate at which homes and businesses will actually adopt energy saving technologies and practices" and further notes that the achievable potential figures are always less than the economic and technical potentials determined in such studies.

[108] ACEEE Estimates of Near-Term Electricity and Gas Savings, R. Neal Elliott, Anna Monis Shipley, Steven Nadel and Elizabeth Brown, August 15, 2003.

1. RESI utilized current and projected natural gas consumption data for both Maryland and the Baltimore metro area.[109]

2. To determine the value of reduced natural gas consumption (i.e., the cost of natural gas) RESI rates produced by the Energy Information Administration.

3. RESI disaggregated savings to households using household income distribution data produced by the U.S. Census Bureau (2005 American Community Survey estimates).

4. RESI disaggregated savings to industry using industrial distribution data produced by the U.S. Census Bureau (2003 American Community Survey estimates).

5. Direct savings were inputted into RESI's IMPLAN model to derive the total economic impacts including employment, wage, tax revenue and GSP/GMP estimates.[110]

The following assumptions should be noted:

- We assume that energy prices will keep pace with inflation (in other words, prices are assumed to remain constant over the time horizon considered in this analysis). This assumption errs on the conservative side.

- There is a cost associated with implementing energy efficiency. RESI assumes a 30% implementation cost evenly spread across the 20 year time horizon. The 30% implementation cost estimate is taken from a 2005 study produced by the Ernest Orlando Lawrence Berkeley National Laboratory.[111] Our estimate of dollar savings due to decreased electricity consumption are discounted by the estimated implementation costs of increased energy efficiency.

Summary of Results:

As detailed in the following figure, reduction in natural gas consumption over the 20 year horizon considered in this analysis (2006-2025) is estimated to yield significant economic benefits including an increase in Maryland job creation ranging between approximately 11,500 and 28,300 jobs. Associated wages and salaries for these jobs range from $430 to nearly $879 million, while expected state and local tax revenues exceed $75 million in the low reduction scenario (10%) and approach $155 million in the high reduction scenario (20%). The impact on Maryland's GSP is estimated to be quite substantial and ranges from $1.2 to $2.4 billion.

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[109] RESI utilized natural gas consumption forecasts (broken out by residential, commercial, industrial and transportation sectors produced by the International Center for Sustainable Development (ICSD.

[110] A more detailed description of IMPLAN and economic impact analyses in general is provided in the Introduction section of this analysis.

[111] Ernest Orlando Lawrence Berkeley National Laboratory. Easing the Natural Gas Crisis: Reducing Natural Gas Prices through Increased Deployment of Renewable Energy and Energy Efficiency.

Figure C: Total Economic Impacts of Reduced Natural Gas Consumption in Maryland (Due to Increased Energy Efficiency)

2006-2025	**10% Reduction**	**15% Reduction**	**20% Reduction**
Employment	11,551	17,496	28,319
Wages & Salaries*	$ 430.29	$ 651.66	$ 878.97
State & Local Tax Revenues*	$ 75.79	$ 114.76	$ 154.72
Gross State Product(GSP)*	$ 1,173.05	$ 1,776.45	$ 2,395.64
2006-2015			
Employment	3,574	5,461	12,149
Wages & Salaries*	$ 133.06	$ 203.34	$ 276.47
State & Local Tax Revenues*	$ 23.41	$ 35.77	$ 48.63
Gross State Product(GSP)*	$ 363.40	$ 555.36	$ 755.09
2016-2025			
Employment	7,978	12,034	16,170
Wages & Salaries*	$ 297.23	$ 448.32	$ 602.50
State & Local Tax Revenues*	$ 52.39	$ 78.99	$ 106.09
Gross State Product(GSP)*	$ 809.65	$ 1,221.09	$ 1,640.55

*millions of dollars

Regional impacts are also quite significant and are detailed in Figure D. Job creation ranges between roughly 6,000 and 14,000 jobs. Associated wages and salaries for these jobs range from $191 million to $391 million, while expected state and local tax revenues exceed $33 million in the low reduction scenario (10%) and amount to $69.0 million in the high reduction scenario (20%). The impact on the Baltimore Metropolitan region's Gross Metro Product (GMP) is estimated to be quite substantial and ranges from nearly $540 million to $1.1 billion.

Figure D: Total Economic Impacts of Reduced Natural Gas Consumption in the Baltimore Metropolitan Area (Due to Increased Energy Efficiency)

2006-2025	**10% Reduction**	**15% Reduction**	**20% Reduction**
Employment	5,737	8,690	14,066
Wages & Salaries*	$ 191.84	$ 290.54	$ 391.89
State & Local Tax Revenues*	$ 33.79	$ 51.16	$ 68.98
Gross State Product(GSP)*	$ 539.51	$ 817.02	$ 1,101.80
2006-2015			
Employment	1,775	2,713	6,034
Wages & Salaries*	$ 59.32	$ 90.66	$ 123.26
State & Local Tax Revenues*	$ 10.44	$ 15.95	$ 21.68
Gross State Product(GSP)*	$ 167.13	$ 255.42	$ 347.28
2016-2025			
Employment	3,962	5,977	8,031
Wages & Salaries*	$ 132.52	$ 199.88	$ 268.62
State & Local Tax Revenues*	$ 23.36	$ 35.22	$ 47.30
Gross State Product(GSP)*	$ 372.37	$ 561.60	$ 754.52

*millions of dollars

Renewable Energy

Renewable energy (also referred to as clean energy or sustainable energy) is derived from energy sources, which when harnessed, are not destroyed. Renewable energy originates from natural sources of energy such as geothermal heat, water, wind and sunlight. Some examples of renewable energy sectors include: wind, solar thermal, photovoltaics, biomass and geothermal.

Because the renewable energy industry is relatively young, industry investments result in significant job creation (especially relative to established segments of the energy sector such as natural gas). This analysis measures the economic impacts associated with harnessing three types of renewable energy: wind, solar photovoltaics and biomass.

What We Are Measuring: Total economic impacts attributable to the operations of onshore wind facilities, solar photovoltaics and biomass facilities with the capacity to power enough renewable energy to replace select proportions of current and projected electricity consumption in Maryland and the Baltimore metropolitan area. Specifically, this analysis considers the following scenarios of renewable power generation over 20 year horizon:

(1) 10% of current and projected electricity consumption;
(2) 20% of current and projected electricity consumption; and
(3) 30% of current and projected electricity consumption.

In addition, the analysis considers the following scenarios of renewable power generation over a 10 year horizon:

(1) 5% of current and projected electricity consumption;
(2) 10% of current and projected electricity consumption; and
(3) 15% of current and projected electricity consumption.

It should be noted that the impacts considered in this analysis do not include:

- Potential cost savings to consumers due to the introduction of a competitive energy source (wind power, solar power or biomass).

<u>About the Scenarios:</u>

It should be noted that the results of RESI's renewable energy analysis are highly dependant on two assumptions in particular:

(5) *Maryland analysis*: the wind, solar and biomass power capacity considered in this analysis would be generated entirely by Maryland-based renewable power facilities;
(6) *Baltimore metro analysis*: the wind, solar and biomass power capacity considered in this analysis would be generated entirely by Baltimore metro-based renewable power facilities.

The first assumption, which calls for a range of MW of generating capacity (roughly 9,000 MW for the low scenario and roughly 37,000 MW for the high) to be located in Maryland. This assumption appears eminently plausible. According to a 2006 report produced by the Jacob France Center[112], Maryland has the potential to house wind power facilities with a collective capacity of 1.8 million MW, while according to an NJPIRG 2004 study, the National Renewable Energy Laboratory (NREL) estimates that Maryland has 2.2 million MW potential capacity for wind. As of the writing of this study, there are several wind facilities already being planned in Maryland and all are located in Western Maryland. These include:

- Clipper Windpower Facility, 100 MW
- U.S. Windforce Facility, 40 MW
- Synergics Facility, 40 MW

Since the location of onshore wind power facilities is dictated by specific environmental conditions (i.e., wind and other resources) as well as by socio-political constraints (most wind facilities are situated in rural, less populated areas), the feasibility of the second assumption is questionable with respect to wind power facilities and not an issue with regard to solar photovoltaic or biomass facilities. Consequently, the Baltimore metro area results for the wind portion of the analysis should be viewed in a hypothetical rather than a realistic context. However, the results for solar photovoltaic and biomass are not burden by this.

If Maryland adopted a building code to install solar on at least 10% of the rooftops in Maryland, Maryland has the potential for 235,000MW according to the National Renewable Energy Laboratory. Moreover, according to this same laboratory, Biomass could potentially supply at least 6% of the total electricity needs.

[112] Economic Development Potential of the Proposed Maryland Clean Energy Center, Jacob France Center 2006.

Methodology & Assumptions:

The estimates presented in this analysis were calculated using the following steps:

1. RESI utilized current and projected electricity consumption data for both Maryland and the Baltimore metro area.[113]

2. For each of the six scenarios, RESI converted the appropriate proportion of electricity consumption from trillions of British thermal units (BTUs) to megawatt hours (MW).

3. Once the annual MW generating capacity was established for each scenario (previous step), RESI estimated the number of operational jobs necessary to staff renewable power facilities by applying an operational jobs per MW ratio of 0.79 to each scenario's generating capacity.[114]

4. The number of jobs per scenario was then run through RESI's IMPLAN model to derive the total economic impacts including employment, wage, tax revenue and GSP/GMP estimates.[115]

The following assumptions should be noted:

- The impacts for each region (the State and Baltimore metro area) assume that all necessary renewable facilities will be located within each region.

- According to published research, the renewable sector creates a larger jobs impact than other fossil fuel sectors. This factor is partially attributed to the fact that wind and solar are free resources while biomass is renewable. The relative youth of the sector is a contributing factor as well. As industry investments rise and economies of scale are increasingly realized, it can be expected that the jobs impact for renewable facilities will decline beyond a 5 to 10 year period. According to a 2002 CALPIRG Charitable Trust study, conservative jobs per MW estimates would register a decline of roughly 5 percent per year (beyond a 10 year horizon).[116] ***RESI has discounted the total economic impacts in each scenario by 5 percent per year beyond the first 10 years of the time horizon considered in this analysis (i.e., for years 2016-2025).***

Summary of Results:

The operational impacts of annual MW renewable capacity generation considered in this analysis are substantial and include an increase in Maryland job creation ranging between nearly 15,000

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[113] RESI utilized two sets of electricity consumption forecasts (broken out by residential, commercial, industrial and transportation sectors). The first is produced by the International Center for Sustainable Development (ICSD) and the second by the Mid-Atlantic Area Council. To adjust for the difference in electricity growth rates projected by these two sources, RESI discounted the electricity rates such that the estimated dollar value of the Delta would be equivalent to a Delta calculated using the Mid-Atlantic Area Council's electricity growth rates

[114] The jobs per MW ratio was obtained from a 2004 NJPIRG study entitled "Renewables Work, Job Growth from Renewable Energy Development in the Mid-Atlantic".

[115] A more detailed description of IMPLAN and economic impact analyses in general is provided in the introduction of this analysis.

[116] Renewables Work Job Growth from Renewable Energy Development in California. CALPIRG Charitable Trust, June 2002, page 9.

and more than 46,000 jobs over the 20 year horizon. Associated wages and salaries for these jobs range from $700 million to more than $2.24 billion, while expected state and local tax revenues exceed $72 million in the low proportion scenario (10%) and are $224 million in the high proportion scenario (30%). The impact on Maryland's GSP is estimated to be quite substantial and ranges from $1.8 billion to $5.6 billion.

Figure E: Total Economic Impacts of Renewable Facilities with the Collective Capacity to Generate Select Proportions of Maryland Electricity Consumption

2006-2025	10% Proportion	20% Proportion	30% Proportion
Employment	15,030	30,552	46,723
Wind	11,569	23,516	35,963
Solar PV	189	383	586
Biomass	3,273	6,652	10,173
Wages & Salaries*	$ 707.11	$1,439.86	$ 2,203.28
Wind	$544.27	$1,108.27	$1,695.88
Solar PV	$ 8.87	$ 18.07	$ 27.65
Biomass	$ 153.97	$ 313.51	$ 479.74
State & Local Tax Revenues*	$ 72.11	$ 146.84	$ 224.70
Wind	$55.51	$113.03	$172.95
Solar PV	$ 0.91	$ 1.84	$ 2.82
Biomass	$ 15.70	$ 31.97	$ 48.93
Gross State Product(GSP)*	$1,818.81	$3,703.58	$ 5,667.25
Wind	$1,399.96	$2,850.68	$4,362.14
Solar PV	$ 22.83	$ 46.48	$ 71.13
Biomass	$ 396.03	$ 806.42	$ 1,233.98

*millions of dollars

Ten Year Impacts

The operational impacts of annual MW renewable capacity generation considered in this analysis are substantial and include an increase in Maryland job creation ranging between nearly 4,000 and more than 11,000 jobs over the 10 year horizon. Associated wages and salaries for these jobs range from $182 million to more than $550 million, while expected state and local tax revenues exceed $18 million in the low proportion scenario (5%) and are $56 million in the high proportion scenario (15%). The impact on Maryland's GSP is estimated to be quite substantial and ranges from $460 billion to $1.4 billion.

Figure F: Total Economic Impacts of Renewable Facilities with the Collective Capacity to Generate Select Proportions of Maryland Electricity Consumption over ten year horizon

2006-2015	5% Proportion	10% Proportion	15% Proportion
Employment	3,869	7,797	11,790

Wind	2,978	6,001	9,075
Solar PV	49	98	148
Biomass	842	1,698	2,567
Wages & Salaries*	$ 182.64	$ 368.08	$ 556.56
Wind	$140.58	$283.31	$428.39
Solar PV	$ 2.29	$ 4.62	$ 6.99
Biomass	$ 39.77	$ 80.15	$ 121.19
State & Local Tax Revenues*	$ 18.63	$ 37.54	$ 56.76
Wind	$14.34	$28.89	$43.69
Solar PV	$ 0.23	$ 0.47	$ 0.71
Biomass	$ 4.06	$ 8.17	$ 12.36
Gross State Product(GSP)*	$ 469.78	$ 946.77	$ 1,431.58
Wind	$361.59	$728.74	$1,101.90
Solar PV	$ 5.90	$ 11.88	$ 17.97
Biomass	$ 102.29	$ 206.15	$ 311.71

*millions of dollars

Regional impacts are also quite significant and are detailed in Figure F. Job creation approaches 7,500 in the low scenario to more than 23,000 jobs in the high scenario. Associated wages and salaries for these jobs range from $315 million to more than $1.3 billion, while expected state and local tax revenues exceed $32 million in the low proportion scenario (10%) and surpass $100 million in the high proportion scenario (30%). The impact on the Baltimore Metropolitan region's GMP is estimated to be quite substantial and ranges from nearly $840 million to nearly $1.9 billion.

Figure G: Total Economic Impacts of Renewable Facilities with the Collective Capacity to Generate Select Proportions of Baltimore Metropolitan Area Electricity Consumption

2006-2025	**10% Proportion**	**20% Proportion**	**30% Proportion**
Employment	7,491	15,201	23,233
Wind	5,766	11,700	17,883
Solar PV	94	191	292
Biomass	1,631	3,310	5,059
Wages & Salaries*	$ 315.26	$ 846.56	$ 1,302.24
Wind	$242.66	$651.61	$1,002.35
Solar PV	$ 3.96	$ 10.63	$ 16.34
Biomass	$ 68.64	$ 184.33	$ 283.55
State & Local Tax Revenues*	$ 32.15	$ 65.47	$ 100.18
Wind	$24.75	$50.39	$77.11
Solar PV	$ 0.40	$ 0.82	$ 1.26
Biomass	$ 7.00	$ 14.26	$ 21.81
Gross State Product(GSP)*	$ 836.51	$ 1,703.35	$ 1,949.78
Wind	$643.87	$1,311.08	$1,500.76
Solar PV	$ 10.50	$ 21.38	$ 24.47
Biomass	$ 182.14	$ 370.89	$ 424.54

*millions of dollars

Ten Year Impact

Regional impacts are also quite significant and are detailed in Figure F. Job creation approaches 2,000 in the low scenario to more than 5,800 jobs in the high scenario over the ten year horizon. Associated wages and salaries for these jobs range from $81 million to more than $248 million, while expected state and local tax revenues exceed $8.3 million in the low proportion scenario (5%) and surpass $25 million in the high proportion scenario (30%). The impact on the Baltimore Metropolitan region's GMP is estimated to be quite substantial and ranges from nearly $216 million to $500 million.

Figure H: Total Economic Impacts of Renewable Facilities with the Collective Capacity to Generate Select Proportions of Baltimore Metropolitan Area Electricity Consumption over a ten year horizon

2006-2015	5% Proportion	10% Proportion	15% Proportion
Employment	1,922	3,873	5,856
Wind	1,479	2,981	4,507
Solar PV	24	49	73
Biomass	418	843	1,275
Wages & Salaries*	$ 81.43	$ 164.11	$ 248.14
Wind	$62.68	$126.31	$191.00
Solar PV	$ 1.02	$ 2.06	$ 3.11
Biomass	$ 17.73	$ 35.73	$ 54.03
State & Local Tax Revenues*	$ 8.30	$ 16.74	$ 25.31
Wind	$6.39	$12.88	$194.79
Solar PV	$ 0.10	$ 0.21	$ 3.18
Biomass	$ 1.81	$ 3.64	$ 55.10
Gross State Product(GSP)*	$ 216.06	$ 435.44	$ 658.41
Wind	$166.30	$335.16	$506.79
Solar PV	$ 2.71	$ 5.47	$ 8.26
Biomass	$ 47.04	$ 94.81	$ 143.36

Construction Impacts of a Hypothetical Maryland Wind Farm

To further illustrate the impacts of investment in the renewable industry could have on Maryland's economy, RESI estimates the construction impacts associated with a hypothetical wind facility. It should be noted that construction impacts are temporary in nature and span the build-out period of the construction project.

What We Are Measuring: Total economic impacts attributable to the operations of a hypothetical, 50MW wind facility in Maryland.

Methodology & Assumptions:

The estimates presented in this analysis were calculated using the following steps:

1. According to a 2006 study published by the Jacob France Center, 21 construction jobs are created for every 10MW of wind power generating capacity. RESI applied this number to the 180MW of wind facilities currently being planned or proposed in Maryland.

4. The resulting number of direct construction employees (378) was then inputted into our IMPLAN model to generate total economic impacts.

5. Results were then scaled down to a 50MW basis.

Summary of Results:

Annual construction jobs total 181 and associated wages exceed $8 million. Tax revenues surpass $19 million while the impact on GSP approaches $1 million.

Figure I: Annual Economic Impacts of a Hypothetical, 50MW Maryland Wind Facility

Annual	**Direct**	**Indirect**	**Induced**	**Total**
Employment	105	24	51	181
Wages & Salaries*	$5.3	$1.2	$1.8	$8.3
State & Local Tax Revenues*	$0.4	$0.1	$0.2	$0.8
Gross State Product(GSP)*	$11.3	$2.8	$5.1	$19.3

*millions of dollars

Alternative Fuels

For the purpose of this analysis, the term alternative fuel refers to biofuels such as ethanol (grain based fuel) and biodiesel. Again, the focus of this portion of the analysis is limited to one type of alternative fuel in particular: ethanol.

What We Are Measuring: Total economic impacts attributable to the operations of ethanol facilities with the capacity to generate enough alternative fuel to replace select proportions of current and projected gasoline consumption in Maryland and the Baltimore metropolitan area. Specifically, this analysis considers the following ethanol power generation scenarios:

(1) 10% of gasoline consumption;
(2) 20% of gasoline consumption; and
(3) 30% of gasoline consumption.

It should be noted that the impacts considered in this analysis do not include:

- Potential cost savings to consumers due to the introduction of a competitive energy source (ethanol).

Methodology & Assumptions:

The estimates presented in this analysis were calculated using the following steps:

1. RESI utilized current and projected petroleum consumption data for both Maryland and the Baltimore metro area.[117]

2. For each of the three scenarios, RESI converted the appropriate proportion of petroleum consumption from trillions of British thermal units (BTUs) to gallons of ethanol.

3. Once the annual amount of ethanol (in gallons) was established for each scenario (previous step), RESI estimated the number of operational jobs necessary to staff ethanol facilities by applying an operational jobs per million of gallons ratio (18:1) to each scenario's generating capacity.[118]

[117] RESI utilized petroleum forecasts (broken out by residential, commercial, industrial and transportation sectors). produced by the International Center for Sustainable Development (ICSD)

[118] The jobs per MW ratio was obtained from a 2004 NJPIRG study entitled "Renewables Work, Job Growth from Renewable Energy Development in the Mid-Atlantic".

4. The number of jobs per scenario was then run through RESI's IMPLAN model to derive the total economic impacts including employment, wage, tax revenue and GSP/GMP estimates.[119]

The following assumptions should be noted:

- The impacts for each region (the State and Baltimore metro area) assume that all necessary ethanol facilities will be located within each region.

Summary of Results:

As detailed in the following figure, the impacts of ethanol facilities necessary to generate sufficient for the scenarios considered in this analysis are substantial and include an increase in Maryland job creation ranging between 56,867 and more than 182,000 jobs. Associated wages and salaries for these jobs range from $1.9 to nearly $6.0 billion, while expected state and local tax revenues exceed $28 million in the low proportion scenario (10%) and approach $90.6 million in the high proportion scenario (30%). The estimated impact on Maryland's GSP ranges from nearly $8 to more than $25 billion.

Figure J: Total Operating Impacts of Ethanol Facilities Necessary to Generate Select Proportions of Maryland Energy Consumption

2006-2025	**10% Proportion**	**20% Proportion**	**30% Proportion**
Employment	56,867	118,356	182,311
Wages & Salaries*	$1,886.6	$3,926.5	$6,048.2
State & Local Tax Revenues*	$28.3	$58.8	$90.6
Gross State Product(GSP)*	$7,970.3	$16,588.5	$25,552.3

*millions of dollars

Regional impacts are also quite significant and are detailed in Figure I. Job creation ranges between roughly 28,000 to more than 90,000 jobs. Associated wages and salaries for these jobs range from $841 million to nearly $2.7 billion, while expected state and local tax revenues exceed $12.6 million in the low proportion scenario (10%) and surpass $40 million in the high proportion scenario (30%). The estimated impact on the Baltimore Metropolitan region's GMP ranges from nearly $3.6 to $11.7 billion.

[119] A more detailed description of IMPLAN and economic impact analyses in general is provided in the introduction of this analysis.

Figure K: Total Operating Impacts of Ethanol Facilities Necessary to Generate Select Proportions of Baltimore Metropolitan Area

2006-2025	10% Proportion	20% Proportion	30% Proportion
Employment	28,245	58,786	90,552
Wages & Salaries*	$841.1	$1,750.6	$2,696.6
State & Local Tax Revenues*	$12.6	$26.2	$40.4
Gross Metro Product(GMP)*	$3,665.7	$7,629.4	$11,752.0

*millions of dollars

Construction Impacts of a Hypothetical Maryland Ethanol Plant

To further illustrate the impacts of investment in alternative fuels, RESI estimates the construction impacts associated with a hypothetical ethanol plant. It should be noted that construction impacts are temporary in nature and span the build-out period of the construction project.

What We Are Measuring: Total economic impacts attributable to the operations of a hypothetical, 50 million gallon ethanol facility in Maryland.

Methodology & Assumptions:

The estimates presented in this analysis were calculated using the following steps:

1. According to a 2006 study produced University of Missouri, 14 construction jobs are created for every gallon of ethanol refining capacity. RESI applied this number to each scenario's generating capacity (in gallons).[120]

3. The resulting number of direct construction employees (577) was then inputted into our IMPLAN model to generate total economic impacts.

4. Results were then scaled down to a 50 million gallon basis.

Summary of Results:

Annual construction jobs approach 1,000 and associated wages exceed $45 million. Tax revenues surpass $105 million while the impact on GSP exceeds $4.2 million.

Figure L: Annual Economic Impacts of a Hypothetical, 50 Million Gallon, Maryland Ethanol Facility

Annual	Direct	Indirect	Induced	Total
Employment	577	134	282	993
Wages & Salaries*	$29.0	$6.6	$9.8	$45.4
State & Local Tax Revenues*	$2.5	$0.6	$1.1	$4.2
Gross State Product(GSP)*	$62.3	$15.6	$28.0	$105.8

*millions of dollars

[120] Employment and Economic Benefits of Ethanol Production in Missouri: Missouri Corn Growers Association. Prepared by Vern Pierce, Joe Horner and Ryan Milhollin. Commercial Agriculture Program, University of Missouri. January 2006.

Cumulative Results (Energy Efficiency, Renewable Energy, Alternative Fuels)

Overall Results

Since a reduction in electricity consumption translates into a reduction in natural gas, renewable energy and alternative energy consumption (which each comprise a portion of Maryland's electricity consumption), cumulative impacts cannot be summed directly but need to be discounted. RESI discounts cumulative impacts by 20 percent. This discount rate is conservative due to the fact that currently, renewable energy, natural gas and alternative fuels comprise roughly 15-20 percent of Maryland's electricity generation, however, this proportion is expected to increase over the time horizon considered in this study. Cumulative impacts are detailed in the following figure.

Figure M: Cumulative Economic Impacts (Efficiency, Renewable & Alternative Energy Scenarios), 2006-2025

Scenario	Employment	Wages & Salaries*	State & Local Tax Revenues*	Gross State Product (GSP)*
MD Baseline	94,883	$3,804.9	$633.3	$10,559.5
MD High	212,262	$8,441.5	$1,370.7	$23,322.4
BM Baseline	47,128	$1,750.0	$291.3	$4,856.5
BM High	105,429	$3,882.4	$630.4	$10,726.4

*millions of dollars

Firm Attraction, Expansion & Start Ups

RESI reviewed published research detailing the experience other states have had in leveraging clean energy policies to attract firms to start up, expand and/or locate within their state. While many states have enjoyed success in these activities, it was difficult to isolate the effect of the implementation of clean energy policies on economic growth. In fact, much of the available literature does not distinguish between firm attraction, expansion and start up activity and as a consequence, RESI's estimates incorporate all of these.

What We Are Measuring: Total economic impacts associated with potential firm attraction, expansion and start up activity Maryland's renewable energy sector.

It should be noted that the impacts considered in this analysis do not include:

- Firm attraction, retention and start up activity estimates are limited to energy efficiency and renewable energy development only. They do not include impacts of investment in alternative fuels or other areas.

Methodology & Assumptions:

RESI relied on the experience of Massachusetts to produce estimates on potential firm attraction, expansion and start-up activity in Maryland.

Specifically, we utilized findings published in the following report: *"Energy Efficiency and Renewable Energy A Growing Opportunity for Massachusetts".* The study was conducted in 2002 by the Massachusetts Technology Renewable Energy Trust.

The above-mentioned report determined (via survey) that Massachusetts' energy efficiency sector employed 8,000 persons in 2002 and that the State's renewable energy sector employed 2,000 persons.

Firms surveyed include firms deriving all or a portion of their business from:

5. creation and implementation of energy efficiency equipment and techniques;
6. design and execution of energy conservation measures, including integrated designs such as green buildings;
7. design, manufacture, construction and operation of technologies which generate electricity and energy using renewable resources and;
8. installation and management of distributed energy resources and programs on both the supply- and demand-side of the market.

RESI scaled down Massachusetts jobs to better reflect the size of Maryland's economy.[121] We then calculated estimates of job creation within the renewable and energy efficiency sectors for four scenarios:

5. assuming that Maryland will achieve 25% of Massachusetts's job creation,
6. assuming that we will achieve 50% of Massachusetts's job creation,
7. assuming we will achieve 75% and
8. assuming we will achieve 100% of Massachusetts's job creation.

Estimates of potential renewable and energy efficiency job creation in Maryland (based on the above-mentioned assumptions) range from 1,864 to 7,454 and for the Baltimore Metropolitan region range from 926 to 3,702.

Figure N: Estimated Jobs Impacts for Maryland and Baltimore Metropolitan Region (Using the Experience of Massachusetts)

	MD Jobs	**BM Jobs**
25% Scenario	1,864	926
50% Scenario	3,727	1,851
75% Scenario	5,591	2,777
100% Scenario	7,454	3,702

We then inputted these direct employment numbers into our IMPLAN model to derive the total economic impacts.

The following assumption should be noted:
The Massachusetts study does not specify the time horizon over which renewable and energy efficiency employment was created. Consequently, RESI contacted the firms listed in the report to determine the year each firm began its Massachusetts operations.

We received responses from nine firms, as shown in Figure M. The time horizon indicated by these firms ranges from 1978 through 2002 (the year that the Massachusetts Technology Renewable Energy Trust conducted its survey). RESI assumes that this time span of 24 years is applicable to the results of the Massachusetts study.

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Figure O: Renewable & Energy Efficiency Firms

Firm Name	Location	Year MA Operations Began
Conservation Services Group	Westborough, MA	1984
Lanthorn Technologies, Inc.	Boston, MA	2001
Solar Power		
Evergreen Solar	Marlboro, MA	1994
Wind Energy		
Second Wind	Somerville, MA	1980
Fuel Cell Energy		
Acumentrics	Westwood, MA	1994
Ballard Material Products	Lowell, MA	1978
CellTech Power	Westborough, MA	1998
Nuvera Fuels Cells	Cambridge, MA	2000
Hydro and Ocean Power		
Enel North America	Andover, MA	1985 (Renamed Enel in 2003)
Beacon Power	Wilmington, MA	1997

Summary of Results:

RESI assumes a 24 time horizon for these results (as determined above). The following figure details total jobs impacts ranging from 3,750 to nearly 15,000. Associated wages and salaries for these jobs range from $177 to nearly $708 million, while expected state and local tax revenues exceed $18 million in the low proportion scenario (25%) and surpass $72 million in the high proportion scenario (100%). The estimated impact on Maryland's GSP ranges from nearly $455 million to more than $1.8 billion.

Figure P: Economic Impacts Associated with Firm Attraction, Expansion & Start Up Activity in Maryland and the Baltimore Metropolitan Region

24 Year Time Horizon	25%	50%	75%	100%
MD Employment	3,750	7,500	11,250	14,999
MD Wages & Salaries*	$177.00	$354.00	$531.10	$708.10
MD State & Local Tax Revenues*	$18.10	$36.10	$54.20	$72.20
MD Gross State Product(GSP)*	$455.30	$910.70	$1,366.00	$1,821.30
BM Employment	1,863	3,725	5,588	7,450
BM Wages & Salaries*	$81.41	$162.81	$244.26	$325.67
BM State & Local Tax Revenues*	$8.32	$16.60	$24.93	$33.21
BM Gross State Product(GSP)*	$209.40	$418.85	$628.25	$837.65

*millions of dollars

Business Incubations

To determine the economic impact of the incubation of energy firms in Maryland, RESI examined other states' experience regarding energy-related incubated firms. From these data, we extracted the industrial distribution of firms likely to be incubated in Maryland.
We assumed that firms would be distributed in these four areas

(1) Specialized Construction
(2) Environmental Manufacturing

(3) Architectural and Engineering Services
(4) Specialized Design Services

Within these fairly broad categories, numerous types of firms are represented. We further assumed a predetermined level of funding support for the incubator of $10 million per year. We then inputted these expenditures into our IMPLAN model to derive total, annual economic impacts. In essence, we do not speculate the number of firms that would be served by a Maryland energy incubator.

Summary of Results:
As detailed in the following figure, the jobs impacts total 159, while associated wages and salaries for these jobs exceed $7 million. Estimated state and local tax revenues exceed $18 million and the estimated impact on Maryland's GSP approaches $1 million.

Figure Q: Economic Impacts Associated with Incubated Energy Firms in Maryland and the Baltimore Metropolitan Region

Annual	Direct	Indirect	Induced	Total
MD Employment	81	32	46	159
MD Wages & Salaries*	$4.30	$1.50	$1.60	$7.40
MD State & Local Tax Revenues*	$0.40	$0.10	$0.20	$0.70
MD Gross State Product(GSP)*	$10.00	$3.60	$4.50	$18.10
BM Employment	40	16	23	79
BM Wages & Salaries*	$1.98	$0.69	$0.74	$3.40
BM State & Local Tax Revenues*	$0.18	$0.05	$0.09	$0.32
BM Gross State Product(GSP)*	$4.60	$1.66	$2.07	$8.32

*millions of dollars

Areas for Future Study

Environmental Impacts

Increased energy efficiency as well as increased substitution of renewable energy and alternative fuels in place of fossil fuels will undoubtedly reduce the amount of harmful pollutants released into our environment. Certainly, there are cost benefits associated with such pollution reduction and this study touches on but does not fully explore.

The following findings from published research indicate the magnitude of these benefits:

- Renewable energy is labor intensive, so they generally create more jobs per dollar invested than conventional electricity generating technologies[122]

Renewable energy can be used in a variety of ways, below is a brief description of three types of renewables:

- Biomass electricity is typically generated through boiler/steam turbine plants -- there is less than 0.1% sulfur (an acid rain ingredient) in biomass fuels, and less air pollutants are produced
- Geothermal energy comes from the residual heat of the Earth's formation and from radioactive decay. As a result, the use of geothermal energy helps keep our air and water

[122]US Department of Energy. Dollars from Sense: The Economic Benefits of Renewable Energy, September 1997.

clean. The use of geothermal energy also greatly minimizes the amount of resulting solid waste and land required for energy production.
- Wind energy is captured from the wind with wind turbines, these systems provide a cushion against electricity price increases. Wind energy systems reduce U.S. dependence on fossil fuels, and they don't emit greenhouse gases.

Quantifiable Benefits:

- Biomass currently accounts for around 1% of total U.S. electric generating capacity, or 8% of the country's renewable-source generating capacity. In Maine, the biomass power industry generates 25% of their electricity and supports 2780 jobs in wood harvesting and transport, power plant construction and operation, and associated retail and service sectors.
- Nevada's Geothermal plant produces 210 MW of electricity saving energy imports for the State equivalent to 800,000 tons of coal or three million barrels of oil each year.
- The U.S. government estimates that on a national level, new wind energy development alone will generate $60 billion in capital investment, $1.2 billion in new income for farmers and ranchers, and 80,000 new permanent jobs across the country[123]
-

Development of Sustainable Communities

The proposed clean energy center considered in this analysis would also help local communities towards achieving sustainability. Benefits of sustainable communities, while often difficult to quantify, are significant and are summarized in this analysis. It would be worthwhile to explore additional advantages related to sustainable communities that the Center could provide. Moreover, it might be worthwhile to investigate the real estate valuation impacts that characterize communities as they make the transition to increasing sustainability.

Sustainable Development is often defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs. Benefits of sustainable communities are environmental, economic and social. Growth is expected and encouraged but it is managed, sustainable growth. In other words, sustainable growth accommodates increases in population, while protecting natural resources, and encourages economic development for the benefit of the entire state.

The development of sustainable communities offers the following benefits[124]:

- Environmental Protection through the protection of air, land, water by:
    - Protecting Farm and Rural Lands
    - Promoting sustainable farming practices

[123] US Government Accountability Office. Renewable Energy: Wind Power's Contribution to Electric Power Generation and Impact on Farms and Rural Communities, September 2004.

[124] " Sustainable Development", Northeastern Illinois Planning Commission
"Wingspread Conference Report", Civil Practices Network
U.S. Environmental Protection Agency

  - Reducing air pollution
  - Providing Transportation alternatives

- Economic Growth through the attraction of commercial, residential and industrial development by:
  - Training the local workforce
  - Supporting local businesses
  - creating meaningful work
  - offering living wages

- Social Development through the enhancement of the social fabric by:
  - Protecting the unique character and qualities of communities
  - Preserving historical buildings and landmarks
  - Building community social capital

The case of Portland, Oregon provides an example of the successful growth and development of a sustainable community.

The Portland Office of Sustainable Development (OSD) was created in September 2000 by merging the Solid Waste & Recycling Division, previously part of the Bureau of Environmental Services, with the Energy Office, which housed the City's energy and green building programs and staffed the Sustainable Development Commission.

In 2004 OSD completed a strategic planning process to revise its mission and identify high-level goals, core service areas, a unifying vision and set of values. Below is a synopsis of the vision statement that was a result of the strategic planning process.

Vision

Our (Portland) choices and actions create a healthy and prosperous community where:

- Water and air are pure and clean
- Land is productive and used in ecologically sound ways
- Natural resources are used wisely
- Energy is renewable
- People, plants, salmon and other animals thrive in a healthy ecosystem
- Rewarding work supports families
- Neighborhoods are vibrant and green
- People participate in community life as active, responsible citizens
- Buildings are beautiful and efficient
- Food is healthy, plentiful and accessible
- Residents can easily walk, bicycle, carpool, or ride public transit as their first choice of transportation

In terms of policy and the implementation of programs to foster the development of the community, OSD focuses on the following:

- Solid waste
- Energy
- Greenhouse Gases
- Food Systems

To date, there have been significant successes in the following areas:
Recycling
Portland consistently ranks among the top U.S. cities for its recycling rate, which is currently at about 55%.

Recycling is required of Portland businesses and major construction projects, and the residential sector consistently recycles over half its waste as well.

Green Building
Portland has become a national leader in green building.

In 2005, more than 40 high-performance LEED buildings have been completed or are under construction. As a result, OSD has provided technical and financial assistance for projects through the Green Incentive Fund.

Energy
OSD has facilitated energy-efficiency improvements in 20,000 apartment units in the past 10 years, and efficiency projects in the City's own facilities now save $2 million annually in energy bills.

OSD pursues energy efficiency and renewable energy both as corporate policy and in efforts throughout the community. The City currently generates or buys 10 percent of its electricity from renewable sources, including a fuel cell and microturbines powered by waste sewage gas.

Furthermore, the State has been proactive in the advancement of careers and educational opportunities on the topic of sustainability. The State comprehends the significance of fostering new ideas as well as new leaders that will continue the sustainable community momentum. In partnership with universities, it has developed programs such as *Sustainability Leadership Academy* and the *Undergraduate, graduate, professional and certificate.*[125]

[125] "OSD Strategic Plan" City of Portland, Office of Sustainable Development
State of Oregon Sustainability Initiative

Appendix 5 MCEC/ ICSD/ ETC MOU

Memorandum of understanding
TO ESTABLISH THE MARYLAND CLEAN ENERGY CENTER (MCEC)

Overview

The Maryland Clean Energy Center (MCEC) is to be a strategic alliance between the International Center for Sustainable Development (ICSD) and the Emerging Technology Center (ETC). The goal of the MCEC is to establish the State of Maryland as a leader in the emerging field of clean energy and energy efficiency by creating and supporting Maryland-based companies that are developing and deploying these advanced technologies. MCEC will also be a clearing-house for individuals and corporations wishing to pursue clean energy opportunities in Maryland and throughout the United States and the world.

MCEC will promote and assist in the development of distributed power systems based on bio-fuels, wind power, solar power technologies, energy storage, ocean power, small hydroelectric systems. It will also promote and develop energy efficient housing designs and technologies as well as energy efficient building materials.

Background

The ICSD is a Maryland-based Non-Profit created to promote sustainable development. The mission of ICSD is to apply sustainable principles to development projects around the world in order to affect world development through practical projects that meet local needs and that are: community focused, environmentally friendly, financially healthy, and replicable. ICSD brings international financial resources as well as US technology and expertise to aid individual communities, cities, or national governments in designing and executing development projects. ICSD is committed to promoting sustainable technologies and methodologies. ICSD also offers technical assistance and training. With its great access to many U.S. sustainable technologies, ICSD acts as a broker for technology application. ICSD does not promote any individual technology but rather looks at the needs of a given project and uses a systems approach to find the best solution. Of late, it has become clear to the principals of ICSD that they could make a substantial impact on sustainable development by developing new technologies that address some of the limitations in current sustainable technologies.

The ETC is a Maryland-based Non-Profit incubator created to promote and develop high technology and biotechnology companies in the City of Baltimore, Maryland. Over the last seven years, the ETC has demonstrated a marked ability in assisting high technology and biotechnology companies in developing products for both domestic and international markets. It has also demonstrated expertise in technology transfer from local universities and government agencies. The ETC is one of the most successful incubator clusters in the United States, with 60 tenants in 93,000 sq. ft. of space in two buildings. Since its inception in 1999, the Emerging Technology Centers have assisted 100 companies that have created over 1000 jobs, of which 92% of the companies are still in business, and they have received in excess of $130 million in investments. The ETC charter of creating and developing high technology and biotechnology companies easily allows it to be involved in clean energy technology development.

Implementation Plan

MCEC will be incorporated in Maryland as a non-profit entity. Representatives of both ICSD and ETC will be will on the Board of Directors of MCEC, as well as other participants drawn from the local community. Neither organization will be involved in the operation of the other organization outside of the MCEC. MCEC will be located in Baltimore, MD and will be based at the Emerging Technologies Centers (ETC). Both organizations will jointly support the MCEC mission by providing services and subject matter expertise.

The ICSD will assist MCEC by:

1. Providing subject matter expertise in the markets for sustainable development
2. Acting as a technical scout for promising clean energy technologies that could be developed by MCEC
3. Locating and promote companies to join MCEC
4. Serving as an early adopter for technologies developed by companies associated with MCEC
5. Actively participate in mentoring companies involved in MCEC
6. Assisting in admission decisions for companies seeking admission into MCEC

The ETC will assist MCEC by:

1. Incubator administration,
2. Real estate services,
3. Program assistance to ICSD & MCEC,
4. Program assistance to incubator clients,
5. Locating and promote companies to join MCEC.
6. Provide meeting rooms and conference capability for MCEC

MCEC will not maintain a dedicated staff for the first year. Both the ICSD and the ETC will donate staff time on as needed basis, and will be assisted by virtual teams of subject matter experts drawn from business, academia, and government. ICSD and the ETC will develop a full strategic plan and operational budget for the MCEC within the first year of operations and will support fund raising for MCEC.

For its work, the MCEC will take an equity position in each MCEC company. When a firm is sold or goes public, proceeds to the Institute will be used to finance more company creation. The amount of equity that will be requested will be determined later. It is the goal of MCEC to be eventually self-funding through the use of these proceeds.

Appendix 6 Documents Reviewed

Benefits, barriers and policies relating to adoption of clean energy technologies and practices. Documents reviewed:

- Renewable Energy Policies and Markets in the United States (Martinot 2005)
- Easing the Natural Gas Crises: Reducing Natural Gas Prices through Increased Deployment of Renewable Energy and Energy efficiency (LBNL 2005)
- Achieving a New Energy Future: How States Can Lead America to a Clean, Sustainable Economy (National Association of State PIRGs 2005)
- An Energy Policy for the 21st Century (Kammen 2005)
- The Solar High-Impact National Energy (SHINE) Project (Solar Catalyst Group 2005)
- Redirecting America's Energy: The economic and Consumer Benefits of Clean Energy Policies (US PIRG Education Fund 2005)
- Renewable Energy Policies and Barriers (Beck 2004)
- Developments in State-Level Financial Incentives in the US, 2003-2004 (Haynes 2004)
- Financial Incentives for Stationary Fuel Cells: A report on State-Level Policy in the US (Haynes 2004)
- Northern Exposure: An Overview of Canadian Clean Energy Funds (LBNL 2004)
- Low-Income Renewable Energy Programs: A Survey of State Clean Energy Funds (LBNL 2004)
- New Energy for America: The Apollo Jobs Report For Goods Jobs & Energy Independence (Apollo Alliance 2004)
- Solar Opportunity Assessment Report (Solar Catalyst Group 2003)
- Issue Brief: Energy Efficiency (Business for social Responsibility 2003)
- Bringing Solar To Scale (Clean Edge 2002)
- Artic Refuge Drilling or Clean Energy (Wilderness Society 2002)
- Renewable Energy: Not Cheap, Not "Green" (Bradley 1997)

Energy-savings potential of energy-efficiency activities and programs – technical, economic and achievable potentials. Documents reviewed:

- Economically Achievable Energy Efficiency Potential in New England (Optimal Energy, Inc. 2005)
- Assessments of Energy Efficiency Potential in Georgia (ICF 2005)
- The Potential for More Efficient Electricity in the Western United States (Energy Efficiency Task Force (2005)
- Ontario Power Authority - Assessment of Energy Efficiency Potential: 2006-2025 (ICF 2005)
- Potential Long-Term Impacts of Changes in US Vehicle Fuel Efficiency Standards (Bezdek 2005)
- Meta-Analysis of Recent Studies (ACEEE 2004)
- The Maximum Achievable Cost effective Potential for Gas DSM in Utah (GDS Associates 2004)

- Energy Efficiency, Water and Waste-Water Reduction Guidebook for Manufacturers; Proven ways to Reduce Your Costs and Improve Operations (National Association of Manufacturers 2004)
- New Jersey Energy Efficiency and Distributed Generation Market Assessment (KEMA, Inc. 2004)
- Energy-Efficiency and Renewable Supply Potential in New York State and Five Load Zones (Optimal Energy 2003)
- Vermont Department of Public Service Electric and economic Impacts of Maximum Achievable Statewide Efficiency Savings, 2003-2012: Results and Analysis Summary (Optimal Energy 2003)
- California statewide Commercial Sector Natural Gas Energy Efficiency Potential Study (Kema-Xenergy 2003)
- Energy Efficiency and Conservation Measure resource Assessment for the Residential, Commercial, Industrial and Agricultural Sectors (Ecotope 2003)
- Natural Gas Efficiency and Conservation Measure Resource Assessment for the Residential and Commercial sectors (Ecotope 2003)
- The New Mother Lode: The Potential for More Efficient Electricity Use in the Southwest (SWEEP 2002)

Electricity-generation potential of renewable-energy technologies -- technical, economic and achievable potentials. Documents reviewed:

- Green Power Partnership (USEPA 2006)
- Wind Power Outlook 2005 (AWEA 2005)
- Our Solar Power Future (SEIA 2005)
- DoD Renewable Energy Assessment (Report to Congress 2005)
- Combined Heat and Power (USEPA 2005)
- New Jersey Renewable Energy Market Assessment (Navigant Consulting, Inc. 2004)
- PV Grid Connected Market Potential under a Cost Breakthrough Scenario (Navigant 2004)
- The Role of Solar in the Long-Term Outlook of Electric Power Generation in the U.S. (NREL 2004)
- Biomass resources: Trends and Possibilities (ORNL 2004)
- Solar Opportunity Assessment Report (Solar Catalyst Group 2003)
- Designing a Clean Energy Future (The Minnesota Project 2003)
- Clean Energy Solutions: Energy efficiency and Renewable Energy in Maryland (MaryPIRG 2002)
- The U.S. Small Wind Turbine Industry Roadmap (AWEA 2002)
- Roadmap for Biomass Technologies in the United States (USDOE 2002)

Market Potential for Alternative Fuels. Documents reviewed:

- Ethanol Can Contribute to Energy and Environmental Goal (Farrell 2006)
- Ethanol Fact Book (CFDC 2005)
- Roadmap on Manufacturing R&D for the Hydrogen Economy (USDOE 2005)
- Biomass as Feedstock for a Bioenergy and Bioproducts Industry (USDOE 2005)

- Ethanol Industry Outlook (RFA 2005)
- Feasibility Study for Co-Locating and Integrating Ethanol Production Plants from Corn Starch and Lignocellulosic Feedstocks (NREL 2005)
- Evaluating Progressive Technology Scenarios in the Development of the Advanced Dry Mill Biorefinery (NREL 2005
- Making Sense of Hydrogen (MaryPIRG 2004)
- Ethanol in Gasoline: Environmental Impacts and Sustainability Review Article (Niven 2004)
- Top Value Added Chemicals from Biomass (PNNL 2004)
- Stationary Fuel Cells: Future Promise, Current Hype (ACEEE 2004)
- Hydrogen Posture Plan (USDOE 2004)
- New Jersey: Opportunities and Options in the Hydrogen Economy (Center for Energy, Economic & Environmental Policy 2004)
- Industrial Bioproducts: Today and Tomorrow (Energetics 2003)
- Twenty Hydrogen Myths (Lovins 2003)
- National Hydrogen Roadmap (USDOE 2002)
- Cleaner Energy, Greener Profits: Fuel Cells as cost-Effective distributed Energy Resources. (Swisher 2002)

Environmental Improvements improvements. Documents reviewed:

- Protecting Water Resources with Higher-Density Development (USEPA 2006)
- Growing Toward More Efficient Water Use: Linking Development, Infrastructure, and Drinking Water Policies (USEPA 2006)
- Power Plants and Global Warming: Impacts on Maryland and Strategies for Reducing Emissions (MaryPIRG 2005)
- Climate Change Futures: Health, Ecological and Economic Dimensions (Center for Health and the Global Environment – Harvard Medical School 2005)
- Cleaner Air Through Energy Efficiency: Analysis and Recommendations for Multi-Pollutant Cap-and-Trade Policies (ACEEE 2005)
- Renewable Energy – Mitigating Global Warming (Union of Concerned Scientists 2005)
- Energy Efficiency: The Smart Way to Reduce Global Warming Pollution in the Northeast (National Association of State PIRGS 2005)
- Cleaning the Air and Improving Health with Hydrogen Fuel Cell Vehicles
- The Impact of CO2 and Climate Change on Public Health in the Inner City (Epstein 2004)

Best practices in Sustainable Community Development. Documents reviewed:

- Low-Cost Energy Efficiency Measures (SWEEP 2005)
- Solar City Report: How Los Angeles Can Gain the Economic and Environmental Competitive Edge (Global Green USA 2005)
- Low Carbon Leader Cities (The Climate Group 2005)
- High Performance Cities (Apollo Alliance 2004)

- A Tool Kit of Sustainable Development Decision Support Tools (USDOE 2000)

Economic impact analysis of clean energy. Documents reviewed:

- Impacts of Energy Efficiency and Renewable Energy on Natural Gas Markets (ACEE 2005)
- Electric energy Efficiency and Renewable Energy in New England : An Assessment of Existing Policies and Prospects for the Future (The Regulatory Assistance Project 2005)
- Comparing Statewide Economic Impacts of New Generation from Wind, Coal, and natural Gas in Arizona, Colorado, and Michigan (NREL 2005)
- Economic Impact Analysis of a Proposed LNG Facility Expansion and Associated Pipeline (RESI 2004)
- Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate (Kammen 2004)
- A Responsible Electricity Future: An Efficient, Cleaner and Balanced Scenario for the US Electrricity System (National Association of State PIRGs 2004)
- Renewables Work: Job Growth from Renewable Energy Development in the Mid-Atlantic (PennEnvironment research and Policy Center 2004)
- Impact of the FY 2005 Building technologies Program on US Employment and Earned Income (PNNL2004)
- Impact of the FY 2005 Weatherization and Intergovernmental Program on US Employment and Earned Income (PNNL 2004)
- Renewable Energy and Jobs: Employment Impacts of Developing Markets for Renewables in California (2003)
- Economic Impact Analysis of Energy Trust of Oregon Program Activities (ECONorthwest 2003)
- State of Wisconsin's Focus on Energy Statewide Evaluation (Sherman 2003)
- Clean Energy and Jobs (Economic Policy Institute 2002)
- Renewables Work: Job Growth from Renewable Energy Development in California (CalPIRG 2002)
- ImBuild II: Impact of technologies on Energy Efficiency Programs (PNNL 2002)
- Economic Impacts of the Fitzsimons Redevelopment Project (Hammer 2002)
- The Economic Impact on Maryland's Crabmeat processing Industry of proposed Regulations (Lipton 2002)
- Maryland Incubator Impact Analysis (RESI 2001)
- Clean Energy: Jobs for America's Future (World Wildlife Fund (2001)

Appendix 7 Summary of Recent Reports on Potential Technical, Economic and Achievable Energy Savings

Summary of Recent Reports on Potential Technical, Economic and Achievable Energy Savings

ACEEE Report 2004
(Review of 8 studies)

Region/State	Year	# Years	Technical	Economic	Achievable	Annual Achievable
			Electric Potential (%)			
California	2003	10	18%	13%	10%	1%
Massachusetts	2001	5		24%		
New York	2003	20	36%	27%		
Oregon	2003	10	31%			
Puget	2003	20	35%	19%	11%	0.55%
Southwest	2002	17			33%	1.94%
Vermont	2003	10			31%	3.10%
U.S.	2000					
Median Overall			33%		24%	1.20%
Median Residential			32%		26%	
Median Commercial			36%		22%	
Median Industrial			21%		14%	
			Gas Potential (%)			
California	2003	10		21%	10%	1%
Oregon	2003	10	47%	35%		
Puget	2003	20	40%	13%	9%	0.45%
Utah	2004	10	41%	22%		
U.S.	2000	20			8%	0.40%
Median Overall			41%	22%	9%	0.50%
Median Residential			48%	27%	9%	
Median Commercial			20%	14%	8%	
Median Industrial					9%	

Synapse Report 2004
(Review of 8 studies)

Region/State	Year	# Years	Electric Potential (%)	Annual
US-wide	1999-2003	10	11-23%	
US-wide	1999-2003	20	21-35%	
Average				1.60%
Forecast:	2004-2020			
Residential	2004	16		1.40%
Commercial	2004	16		1.80%
Industrial	2004	16		1.50%

NEEP Report 2005
(Review of 7 studies)

Region/State Electric Potential (%)

Vermont Residential	2003	10		29.90%	2.99%
Vermont Com/Industrial	2003	10		31.50%	3.15%
Maine Residential	2002	10		7%	0.70%
Maine Com/Industrial	2002	10		17%	1.70%
Connecticutt Residential	2004	10		13%	1.30%
Connecticutt Com/Indust	2004	10		14%	1.40%
Massachusetts Residen	2001	5	31%		
Massachusetts Com/Ind	2001	5	21%		
Forecast for Northeast	2004-2013				2.58%

<u>WGA Report 2006</u>
<u>(Review of 7 studies)</u>

Region/State			Electric Potential (%)		
Utah DSM Potential	2001	6		9%	1.50%
California Secret Surplus	2002	10		10%	1%
Energy Trust of Oregon	2003	10	31%		
Residential			27.80%		
Commercial			32.20%		
Industrial			35.10%		
Puget Sound Energy	2005	20		10%	0.50%
Residential				9%	0.46%
Commercial				9%	0.47%
Industrial				10%	0.50%
SWEEP	2002	18		33%	1.80%
Northwest Power Plan		20		10%	0.50%

<u>SWEEP Gas DSM 2006</u>
<u>(Survey of 10 utilities)</u>

			Estimated % of Gas Sales Saved		
Aquila (MN)	2004	1		0.50%	0.50%
Centerpoint Energy (MN)	2004	1		0.50%	0.50%
Keyspan (MA)	2004	1		0.40%	0.40%
Northwest Ntrl Gas (OR)	2004	1		0.10%	0.10%
NSTAR (MA)	2004	1		0.20%	0.20%
PG&E (CA)	2004	1		0.70%	0.70%
PSE (WA)	2004	1		0.50%	0.50%
So Cal Gas (CA)	2004	1		0.30%	0.30%
Vermont Gas (VT)	2004	1		1.00%	1.00%
Xcel (MN)	2004	1		0.90%	0.90%
Average Savings				0.50%	0.50%
Median Savings				0.50%	0.50%