

CURRENT MEANS OF ELECTRICITY PRODUCTION IN MARYLAND AND POTENTIAL ALTERNATIVES

INTRODUCTION

The League of Women Voters of Maryland adopted the study: *Current Means of Electricity Production* at the 2009 Convention. The study committee researched current electrical generation methods in Maryland and their environmental and economic impacts. Basic facts of electricity generation are presented. The committee reported current trends and legislation regarding other electric generation options. The goals set by the Maryland government and the new laws to attain them are presented. The committee found the LWVUS positions on energy, natural resources and the environment to be appropriate for lobbying on this topic. We supply this study as a brief study of the present and future of electric power generation in Maryland.

WHAT IS ELECTRICITY?

Electricity is the “accumulation or movement of a number of electrons” according to the Encyclopedia Britannica. It is basically involves electrons detaching from their shells around an atom of matter. If the detached electrons move in one direction, they produce a current. An electrical current can be induced by moving a wire of copper or similar material in a magnetic field. It can also be induced by sunlight (photons) making electrons move from their atoms in a crystal. The most common method of producing or generating electricity is moving a copper wire through a magnetic field--electromagnetic induction. **A force needs to do the moving.** On a commercial scale, this can be accomplished by a turbine powered by falling water or steam that is connected to the electric generator. Hydroelectric power plants were once common; today, the steam driven turbogenerator predominates. Steam can be produced by the heat of burning, less commonly by heat from geothermal formations, or by the heat of nuclear reactions. An alternative method uses wind to move huge wind turbines that power turbo generators. Solar power generation most commonly relies on directly causing electrons to move in an array of crystals. Thomas Alva Edison built the first commercial electricity generating station in New York in 1882, two years after he and a partner developed a practical incandescent light bulb.

HOW IS ELECTRICITY GENERATED IN MARYLAND?

Maryland imports about 30 per cent of its electricity from out of state. In-state generation is primarily by coal fired power plants and the two nuclear plants at Calvert Cliffs. The percentages for all types of generation in Maryland are: coal, 59.4%; nuclear energy, 29%; natural gas, 4 %; oil, 2 %; hydroelectric, 3.3 %; renewables, 1.2 %, other gases, .8 %; other, .6 %. There are 37 power plants in Maryland with generation capacity greater than 2 megawatts. These include independent power producers (the commercial utilities), publicly owned utilities (municipal producers or co-ops) and self-generators (industrial plants that supply their own electricity, transmitting excess to the grid.)

Fossil fuel and carbon-based fuel for power generation by burning (combustion)

Coal, oil, gas (methane), the major fossil fuels, are hydrocarbons or “carbon-based” fuels. So is waste plant material, wood and any organic material, also used in small amounts as fuel in power plants. (Non-fossil plant materials and animal waste are referred to as biomass, and categorized as renewables.) The energy from burning these fuels is transferred into electrical energy in a generator. Coal, oil and natural gas are not found in significant amounts in Maryland, so they are imported.

Coal Maryland produces a small amount of coal in the western part of the state but only one plant uses Maryland coal. More than 50% of the coal used in Maryland is mined in West Virginia, transported generally via train. Pennsylvania supplies most of the rest, with a small amount imported from Russia. Some of the coal plants can use oil or gas, according to the relative price and availability. The five largest coal power plants listed with their owners are Brandon Shores (Constellation), Morgantown (Mirant), Chalk Point (Mirant), H.A. Wagner (Constellation) and Dickerson (Mirant) , burning more than 80% of the coal used for electricity generation.) These five plants have a capacity of 7,470 megawatts (MW). Coal is easily available and relatively cheap. The capital investment in the plants is in place, although some plants are aging and cannot accommodate pollution-curbing measures.

Petroleum There is no petroleum (oil) produced in Maryland so all petroleum is imported through the Port of Baltimore. A small amount of petroleum is used for electricity generation, but most of the petroleum in the state is used for transportation, secondarily for heating. Petroleum is used in eight small power plants, and in two of the larger ones alternatively with coal and gas, but is not a chief fuel for generating electricity in Maryland. The technology for its use is in place. The cost for the fuel is higher than coal and unstable, with the future of the supply uncertain.

Natural Gas Natural gas is predominantly methane gas (CH₄). While natural gas is not used to a large extent in Maryland, there are signs that it will be used more extensively in the near future. Natural gas has been imported through pipes and in a liquefied state through the Port of Baltimore and the liquefied natural gas facility (LNG) at Cove Point in Calvert County.

Future capacity increases: No new coal fired-generating plants have applied for permits recently. One new oil-fired plant has applied, producing 9 megawatts of electricity. Six new natural gas-fired generating plants capable of producing 3342 megawatts of electricity have applied to the Public Service Commission for permission to build.

Biomass-Waste Materials: Waste materials that are organic carbon-based materials can be used as fuel to generate electricity. Landfill, poultry litter, manure, waste plant materials are examples of biomass. It can be burned directly, or the methane gas it gives off under bacterial decomposition can be burned. In gaseous form with modern technological methods, biomass can be very efficient. Biomass is classified as a renewable fuel, although, as organic material it is a carbon-based fuel that gives off CO₂.

Fossil Fuels-- Environmental Concerns: Coal is a cheap fuel for power generation because it is widely available and there is a plentiful supply near Maryland. Investment is already sunk into vast mining operations, train transportation, and generating plants. However, there are external costs to using coal, oil and gas as fuel. Economists call these costs externalities--costs not paid for by the industry, but paid for by someone else in environmental degradation, health dangers, and worldwide effects like global warming, for example. (External costs can be social and economic, also.)

Mountain Top Removal: Most coal mining in West Virginia and to a lesser extent in Pennsylvania involves mountain top removal where as much as 1500 feet of the mountain top is removed to expose the coal layer. The soil and rock of the mountain top are pushed into nearby stream valleys. Streams are often stopped up completely; remaining streams and flows of water are polluted with dangerous chemicals like arsenic and mercury. The tailings are also deposited into huge piles that endanger communities near them.

Burning coal results in the emission of problem gases. Nitrogen oxides, sulfur dioxide and mercury are emitted by coal and oil power plants as well as carbon dioxide and carbon monoxide. Nitrogen oxides (NO_x) settle in bodies of water, like the Chesapeake Bay and rivers, indirectly causing the algal booms that create the infamous dead zones of the Bay. Sulfur dioxide (SO₂) and Nitrogen oxides (NO_x) are responsible for Acid Rain, as they combine with moisture in the air and fall to earth as mild acids. Dry deposits of acid mixed with dust fall on the land also, and when rain does occur, this acid dust washes into streams and lakes. These deposits change the acid balance of water and land, potentially affecting plants and animals. For instance, acid rain can kill trees, decimating forests.

Human health is affected by coal-burning gases. Sulfur dioxide can trigger asthma attacks after even brief exposure to relatively low levels in the air. Nitrogen oxides are a major component of ozone smog, dangerous to many people. High levels of nitrogen oxides in the air are linked to increased susceptibility of respiratory illness, especially among children, according to the American Lung Association. Both substances contribute to fine particle formation, another health hazard. Mercury (Hg) present in coal is emitted as a gas. It is poisonous to living things and can be deposited on land and water.

Solids are produced from coal burning--fly ash and sludge. Fly ash, an air pollutant, is fine particles that contain dangerous materials like arsenic and selenium and go into the air from the plant. Fly ash can be trapped to a large extent at the plant and then become a problem for disposal. Solids remaining in the bottom of the burners or precipitated out of smoke are called sludge, contain poisonous elements and are a similar disposal problem. Fly ash and sludge can be used as filler in concrete or used as landfill. Since it contains poisonous materials, leaching out of unlined fly ash landfills has caused poisoning of nearby drinking water wells. Such damage has been done in Gambrills, Anne Arundel County, Maryland.

According to the Maryland Energy Administration progress has been made by Maryland's power plants to reduce three gases--SO₂, NO₂ and mercury. Constellation Energy says that in a billion dollar installation at its Brandon Shores plant, it has reduced SO₂ emissions by 95% , reduced mercury emissions by 90% and significantly reduced acid gases and now meets standards for 2010 that were required in the MD Healthy Air Act of 2006. At Brandon Shores scrubbers remove SO₂ by spraying lime water into the emission gas, creating solid gypsum that falls to the bottom and can be used in wallboard. Fly ash is collected in bags, sprays combine with mercury and some other acid gases to precipitate them out of the emissions gas. Some of the plants in Maryland belonging to Constellation and Mirant are aging or on limited sites, and not amenable to the latest environmental safeguards.

Burning petroleum oil produces the same pollutants as coal. Offshore oil drilling can result in catastrophic harm to the environment, as can spills from damaged transports and pipes. Mining tar sands is harmful to the environment. Tar, technically called bitumen, is mined in huge quantities in the province of Alberta, Canada. Both mining and processing of tar sands involve a variety of environmental impacts, such as global warming and greenhouse gas emissions, disturbance of mined land; impacts on wildlife and air and water quality.

Environmental Effects of Natural Gas: Natural gas is methane gas, CH₄, a carbon-based fuel. Burning it at the power plant produces nitrogen oxides (NO_x) and CO₂ in lower quantities than in burning coal or oil. SO₂ and mercury compounds emitted are considered as negligible amounts. Methane can be emitted through incomplete burning or leaks during transportation. It contributes to global warming, as does CO₂. Natural gas produces 1/2 as much carbon dioxide as the average air emissions from coal-fired power plants, 1/3 as much NO_x, 1% as much SO₂. However, emissions into the air may occur in the extraction, treatment and transport. Unwanted hydrocarbons, hydrogen sulfide, helium, CO₂ and moisture are extracted at treatment plants after the gas is removed from the ground. Even so, the total emissions of burning natural gas are less than those from burning coal. There are no solid wastes from gas to deal with.

Hydraulic Fracturing is a new technique that has made it possible to get quantities of gas from sandstone formations once impractical to mine. The Marcellus Shale formation is an example. It spreads from New York, over western Pennsylvania, the very far western tip of Maryland, Ohio and West Virginia. Hydraulic fracturing or “fracking” is a method of injecting sand, water and chemicals under high pressure into sandstone layers, causing a myriad of tiny cracks to form through which the gas can flow to the well.

Residents near gas “fracking” sites have experienced contaminated wells, even finding methane gas in the water. Under the U.S. Energy Act of 2005 hydraulic fracturing is exempt from federal regulation under the Safe Drinking Water. As a result, drillers are not required to disclose the chemicals that make up fracking fluids.

Greenhouse Gases (GHG): Carbon Dioxide (CO₂) the byproduct of all combustion, and methane (CH₄) from natural gas, coal fields, and decomposition of plant and animal materials are referred to as Greenhouse Gases (GHG). They accumulate in a layer high in the earth’s atmosphere that traps sunlight reflected from the earth’s surface, turning solar energy into heat energy that warms the earth. Even though Maryland is small if compared with the entire world, the State is accountable for almost as many GHG emissions as Sweden and Norway combined. In addition, Maryland’s per capita and statewide GHG emissions are growing faster than those of the U.S. as a whole according to the Maryland Commission on Climate Change 2008 report.

Electricity Generation by Nuclear Energy: Twenty-nine per cent of Maryland’s electricity produced in-state is from the nuclear power plant at Calvert Cliffs, the only nuclear powered plant in Maryland. The splitting of atoms (nuclear fission) produces heat energy. In a thermonuclear reactor, this energy is controlled and used to heat water into steam to turn a turbogenerator that produces electricity. Uranium 235 is a form of uranium that can be induced to split. When hit by a neutron, the atom splits giving off energy and releasing a neutron. In a nuclear reactor, pellets of U 235 are formed into bundles, and submerged in water. There must be enough uranium to keep fission going. Rods of neutron absorbing material are lowered into the water to control the speed of the nuclear reaction. Raising them hastens the reaction, and lowering them slows the reaction. In case of emergency, the rods can be lowered enough to stop reaction entirely. Layers of concrete and steel shield the reactor and equipment so radiation does not leak. A secondary concrete structure houses the whole plant. This structure is designed to be strong enough to withstand earthquakes and collisions with airplanes. The disaster at Chernobyl is laid to the lack of a secondary protective structure.

Built on the western shores of the Chesapeake Bay in southern Calvert County at Lusby, the Calvert Cliffs Nuclear Power Plant is owned and operated by Constellation Energy and receives federal oversight from the U.S. Nuclear Regulatory Commission, (NRC) as do all nuclear power generation plants constructed in the United States. The plant consists of two reactors, Unit I and Unit II that provide 1,735 MW of capacity for Maryland. Calvert Cliffs Nuclear Power Plant Unit I began operation in 1973, and is licensed for operation until 2034. Unit II was licensed in 1976 and its license is in force until 2036. Both nuclear reactors at the Calvert Cliffs nuclear power plant have a Pressurized Water Reactor (PWR). Many reactors in the US are Boiling Water Reactors (BWR). By using a PWR, pressurized water around the core reactor goes to a steam generator where the superhot water transfers its heat to the water that heats into steam. There is no direct contact of the steam with the water that is picking up more radiation near the core.

Environmental Effects of Nuclear Power Generation: Production of nuclear power in the United States is licensed, monitored, and regulated by the NRC. Provisions in the operating licenses of each plant allow utilities to discharge very low levels of radioactive material to the environment. The kind and quantity of releases are strictly regulated and must fall within limits defined in federal law as protective of human health and the environment. Calvert Cliffs routinely releases small levels of gaseous, particulate, and liquid radioactive material into the atmosphere and the Chesapeake Bay. Releases of radioactivity to the environment from Calvert Cliffs have been well within the regulatory limits since the beginning of its operation. Natural radiation sources account for nearly 50 percent of the average radiation dose to human beings. Of the remaining approximately 50 percent of the radiation dose to human beings arising from man-made sources, less than 0.05 percent is attributed to commercial nuclear power production. Spent nuclear fuel is used fuel from a reactor that is no

longer efficient in creating electricity, because its fission process has slowed. However, it is still thermally hot, highly radioactive, and potentially harmful. Until a permanent disposal repository for spent nuclear fuel is built, licensees must safely store this fuel at their reactors, under strict NRC guidelines. Non-nuclear material contaminated by radiation is typically stored on-site by licensees, either until it has decayed away and can be disposed of as ordinary trash, or until amounts are large enough for shipment to a low-level waste site in containers approved by the Department of Transportation. A plume of heated water from cooling can affect the local ecology of the Bay, although it has not been found to have a profound effect and is very localized. The radioactivity in the water is monitored in close studies of oysters by the PPRP. The presence of the radioactive uptake by them is recently lower than detectable amounts. Since there is no burning of carbon-based fuel, none of the products associated with burning coal, gas, oil or other organic material are discharged into the air or water, making nuclear energy a carbon free source of electricity.

Future of Nuclear Energy in Maryland: Since 2005 Constellation Energy has planned for building an “advanced design” third reactor at Calvert Cliffs. Because of the very high cost of construction, Constellation partnered with Electricite de France (EDF), a leader in Europe in nuclear power to form a joint venture company, Unistar Nuclear Energy (UNE). In 2008, the NRC accepted applications involving environment and safety from Unistar Nuclear Energy, Inc. also known as UNE. UNE also envisioned building other new nuclear plants in other states. Constellation found the loan guarantee offered by the US Department of Energy to have terms too burdensome for their size corporation and on November 3, 2010 sold their interest in the partnership to EDF for what they described as far below market value. At issue now is whether a US law against foreign ownership of the power plant will prohibit UNE from building Calvert Cliffs 3. The NRC held a meeting to hear testimony on this issue Dec. 8, 2010.

ALTERNATIVE ENERGY

Alternative energy is an umbrella term that includes renewables and technology other than fossil fuels and nuclear generation plants. Renewable energy is derived sources that are naturally replenished. Primarily considered in Maryland are: solar, wind, geothermal, small hydroelectric, biomass. Renewable Energy Portfolio Standard (RPS) has been adopted by Maryland that mandates the state’s energy consumption be from 20% renewable energy sources by 2022. Included in that mandate is a set-aside for solar energy to increase incrementally from .005% of the state’s power consumption in 2008 to 2% by 2022, with the remainder of the mandate to be made up from other renewable sources, including wind and biomass.

Solar energy: Except for nuclear and geothermal energy, all the earth’s energy comes from the sun. But for convenience we usually limit what we call solar energy to that converted directly from the incoming solar radiation. That energy is collected by two methods: photovoltaic (PV), which is a direct conversion of the incoming solar radiation into electricity; and concentrated solar thermal, which uses the heat from the sun to drive either a turbine generator, using steam or a Stirling engine which turns a generator.

Solar thermal: Concentrated solar thermal power (CSTP) requires a large array of receivers which can be driven to follow the sun across the sky and focus the sun’s rays to concentrate the energy to heat a thermal fluid. It is not practical in Maryland.

Solar PV: Photovoltaic materials are semiconductors in which the incoming solar energy is absorbed by the bound electrons in the material and the energy increase of those electrons allows them to break the bonds holding them to the atoms and to move more or less freely, thus becoming “conduction” electrons. The electricity thus produced is direct current, which must be converted to alternating current for most practical uses, and the voltage at a single junction is usually on the order of one volt, more or less, so several junctions are typically connected in series to boost the output voltage to a more practical level—one that can be relatively efficiently converted to alternating current. Then many of these arrays are connected in parallel in order to accumulate a useable current. Panels of interconnected cells create a useable current of electricity.

Drawbacks of solar PV units are that they are expensive (to be addressed below), capture only about one seventh of the solar radiation that reaches them, and (obviously) do not operate when the sun is not out. A typical solar panel is rated at one to two kilowatts at maximum output. There must be either a backup system to produce needed electricity when the panels are not operating at sufficient output or a system to store any excess energy produced for use later when it is needed, or both.

On the positive side, once installed the panels have the potential to replace a significant fraction of the electricity we now get from fossil-fuel generation. They are virtually maintenance-free, provide their electricity

at no further cost to the user and have a useful lifetime of at least 30 years. In addition many regions have mandated that the local power companies purchase the excess power produced by privately-owned solar panels at a rate higher than the customer will pay for electricity received from the providers' conventionally-generated sources. This is called a Feed-In Tariff.

Actual data from 2009 and 2010 is not available, so the figures presented here are estimates from various sources. There is no CSTP presently located in Maryland, but estimated Solar PV power capacity was 4 MW at the end 2009 and is projected to be about 14 MW by the end of 2010. Energy production from this source amounts to 110 million kWh in 2009 and 210 million kWh in 2010. Almost all of this was produced by end users, both residential and commercial, consisting mostly of rooftop installations. Generating capability from installations not connected to the grid was unavailable.

Renewable Energy Portfolio Standard (RPS) and EmPOWER Maryland: Maryland has enacted a renewable energy portfolio standard (RPS) that mandates that the state's energy consumption be from 20% renewable energy sources by 2022. Included in that mandate is a set-aside for solar energy to increase incrementally from .005% of the state's power consumption in 2008 to 2% by 2022, with the remainder of the mandate to be made up from other renewable sources, including wind and biomass. When combined with the reduction in total energy usage mandated by the EmPOWER Maryland Clean Energy Programs, this will require that solar power capacity be increased from the present value of about 4 MW to about 1290 MW by 2022. Involved in this increase will be extensive use of commercial rooftops for solar PV panel installations, as well as installations on state buildings, and parking lots of all types—commercial, government-owned and private non-commercial lots. Tax incentives will be provided for non-governmental installations to provide incentives for individuals and business to join this program.

Pollution or non-pollution effects: From the local producer's point of view, solar PV is virtually pollution-free, however, the manufacturing process is not, and it is important that the pollution generated in the manufacturing process be accounted for.

Efficiency: Recent developments in the efficiency and types of solar PV panels are encouraging. Experimental panels have been able to recover over 40% of the solar energy incident upon the panels, and the efficiency of panels currently on the market has grown to mostly more than 15%, up from a typical 10-13% only a short time ago. New types of thin-film panels that can be attached directly to roofing shingles promise to provide electricity without the large panels that many consider unsightly on residential roofs. Costs of the newer systems are steadily decreasing, which promises to make the economics of solar power more in line with current energy costs.

Wind energy: Wind turbines are simply ordinary airplane propellers scaled up to a very large size. Modern wind turbine blades can be 50 meters or more in length, but they are subject to the same laws of fluid motion that apply to any airfoil. Because the electricity is generated in a rotating system, the electricity produced is normally alternating current, which allows it to be increased in voltage easily and efficiently in order to make it compatible with the transmission and distribution systems. For structural reasons, the blades rotate rather slowly—usually no more than about eight revolutions per minute. The propellers drive a generator through a transmission that increases the frequency of the alternating current generated to match the frequency of the transmission line. The turbine output is also adjusted to match the phase of the electric wave to that of the line. Like an ordinary windmill, the hub is on a pivot so that it can turn to be always facing directly into the wind. Blade speed is maintained by changing the angle of the blades so that the wind forces will drive them at a nearly constant speed, again similar to the process that keeps an airplane propeller turning at a constant speed, called automatic pitch control.

The wind turbine requires a minimum wind speed for the blade to turn at all; it reaches its maximum output (rated power) at some higher speed, and then, when the wind reaches a speed that threatens the structural limits of the turbine system, the blades are turned so that the wind cannot turn them, called feathering, and locked to prevent further turning until the wind speed drops below this structural maximum. The theoretical maximum fraction of the energy contained in the wind passing through the plane of the blades that can be recovered by the

turbine is just under 60%. Most wind turbines achieve about two thirds of this limit in actual practice. The rated output of a wind turbine is taken to be its maximum output.

Because of the intermittency of the wind, wind turbines do not operate at their rated power all the time. Typically, over a period of time, they produce an average output of from 30-40% of their rated power, with the higher number more applicable to offshore turbines. This average fraction of the rated power produced is called the performance factor.

ENVIRONMENTAL EFFECTS

Taking up Land. On shore wind towers take up land, but are spaced to prevent interference with each other from the turbulence created by their rotating blades. A wind farm could be extensive, but only about 10% of that land is actually used for the wind turbines, support structures and access roads. The rest of the land can be used for cultivating crops or grazing cattle, meaning that the effective footprint of a wind farm is much smaller than it would seem if only the overall extent of the installation were considered.

Turbulence can affect the efficiency of the wind turbine “downstream” and can also create vibrations that could weaken the tower structure. Typically, wind turbine spacing is between 6 to 10 blade diameters, depending on the prevailing wind speed and the turbine design.

Birds and Marine Life: Environmentalists are worried about the danger to birds of the large blades, whose tips can be moving at speeds of almost 200 mph, especially to migrating birds and raptors. Several of the principal migratory flyways are also areas with high potential for wind power exploitation. A study by the Audubon Society indicates that bird casualties from wind turbines are very small compared to those from automobiles, but the study only looked at total numbers and the effects of a large increase in wind turbines on raptors or migratory birds remains a problem of unknown magnitude. Studies are being done on the effect of wind tower installations off the Atlantic coast. Preliminary indications are that marine life movement adapts and the the underwater platforms serve like manmade reefs for habitat for marine life. The construction itself results in noises that can temporarily confuse dolphins and whales.

Radar Another potential issue has to do with the interference of the wind turbines with radars. The moving blades produce a large return signal for radars used for air traffic control, especially in several military training areas where wind farm installations have been proposed. Concerns have been expressed that the wind turbines will impair the safety of the air combat training maneuvers that are conducted in some of those areas if a large number of them are built.

Visual and Noise: There is very little pollution associated with wind turbines once installed. The main issue that has been raised is visual. Another issue raised has been that of the noise from the turbines. Claims have been made that the low-frequency noise from the sweeping blades can induce a form of depression, but they have not been verified.

Pollution in Wind Tower Production: However, the installation of wind turbines uses a large volume of cement to construct the pads that support the turbines, both in on-shore installations and shallow-water offshore installations. Worldwide, cement production releases about 4% of the world’s output of carbon dioxide into the atmosphere. Options are available for reduction of these emissions. Steel manufacturing also needs to be considered in reducing air and water pollution.

Safety. Wind turbines are large devices, with blades weighing several tons each, and a nacelle which contains the transmission and generator and which, in the larger turbines, is large enough to house several people for maintenance purposes. Several failures of blades have occurred in Europe, and fires have occurred in the nacelles. Some of the accidents have caused the entire structure to collapse. These events have caused injuries and deaths, but, fortunately they are rare, and the damage to the turbines is usually limited to the one machine where the failure occurred and perhaps its nearest neighbor.

PRESENT UTILIZATION AND CURRENT PLANS

Maryland does not utilize a significant amount of wind-generated energy. It purchases about 55 MW per year from Delaware’s off-shore wind power. NRG Bluewater Wind wants to build a wind farm off Ocean City and has already plans to build off Rehoboth Beach, Delaware. Financing and federal licensing is awaited. U.S.

Secretary of the Interior Ken Salazar announced in Baltimore in November that he would expedite permits for Atlantic off-shore wind power. Some permits could come through by 2012.

According to a study by the Abell Foundation and the University of Delaware, the potential for electricity production off the coast of Maryland is quite large. Using conservative estimates and careful exclusions of waters that are either not appropriate for wind power generation or are reserved for other use (principally the shipping lanes and migratory bird flyways that pass through the region studied for the wind turbine installations), they concluded that the area off the Maryland shore and out to a water depth of 100 m, is capable of producing about 1.5 times the electrical requirements of the state—about 98,000 GWh/yr.

Additional wind-power resources exist in the Chesapeake Bay area and in the western mountains, and a study from NREL has estimated a total maximum capacity for Maryland, excluding the Atlantic off-shore area, based on wind turbines of 100 m hub height, located on land not restricted from wind power development and with wind intensity allowing them to operate at or above a 30% performance factor, of about 2800 MW, which translates into about 7360 GWh/year of electrical energy, or about 11% of the state's average electric power demand. Combining these two figures shows that the potential availability of wind power in Maryland is nearly twice the state's electrical energy needs.

Maryland's current renewable energy goal is for 18% of the state's electrical energy supply to be provided by non-solar renewable energy by 2022 (the remainder of the 20% goal to be from solar power), and it is expected that most of this power will come from wind. and about one-third of the contribution to the total by wind power is expected to come from on-shore wind sources. It appears that the renewable resources available for exploitation in Maryland are more than enough to meet the electrical needs of the state for the foreseeable future, assuming that the consumer efficiency goals envisioned in the EmPOWERing Maryland Act are achieved.

Future developments are likely to be in the area of improved effectiveness of the blades, allowing the turbine to operate at near rated power over a wider range of wind speeds, and allowing more of the theoretical maximum amount of energy to be captured. Other improvements could enable them to be made lighter, and to reduce downstream turbulence, thus enabling the turbines to be placed closer together. But future improvements are more likely to be marginal than “breakthroughs.”

Solar & Wind Combination: Solar and wind power enjoy a degree of complementarity that will make them able to provide most of our electricity without the necessity of relying on the so-called “base-load” systems—coal or nuclear power. The times when solar power is least available tend to be the times when wind power is most available. The overlap is not complete, so there will remain, at least for a while, the necessity to provide “peaking” power sources. However, with the development of efficient high-capacity electric energy storage systems the peaking power systems can be replaced and ultimately all electric power can be provided by renewable resources.

Potential for use of Combined Wind and Solar Power in Maryland: Maryland's wind energy potential is about twice as large as it's solar energy potential, due mainly to its lack of resources suitable for CSTP installations. But North Carolina is in much the same position, and yet study has shown that the combined use of wind and solar power is a viable option, even when the disparity between the two sources is significant. Similar results are shown in a Minnesota study, as yet unpublished. If Maryland were to develop only half of its total potential it could produce 120% of its electrical energy needs from these two sources alone, which would reduce its need for energy storage to meet peak demand to well within achievable levels with present technology.

The effectiveness of the combined wind and solar effort will be more effective if both sources are more widely distributed over the state. This should not be an issue with solar PV since it is an inherently distributed source, but wind turbines will need to be located in all three potentially fruitful locations (offshore of Delmarva, in and

near the Chesapeake Bay, and in the Western mountains) in order to take advantage of the smoothing of wind power generation caused by geographically distributed sources.

If these characteristics can be included, along with the requisite short-term storage capability, it is very likely that a combined wind and solar power supply can provide all or very nearly all of Maryland's electricity needs for the foreseeable future.

Geothermal Energy: Geothermal energy has been used to generate electricity since 1913 in areas where hot springs are available such as Italy and at Geysers in California. Superhot water underground transfers heat to produce steam and power a generator. It is a non carbon emitting form of energy that has great potential as Engineered Geothermal Systems (EGS) can theoretically be built anywhere, but are not common in Maryland as yet.

ECONOMICS OF ELECTRICAL ENERGY GENERATION

Electricity Needs for Maryland: According to the latest data from the U.S. Department of Energy (DOE), overall energy demand in Maryland totaled 1,489 trillion British thermal units (Btus) in 2007, or approximately 1.5% of all energy demand in the United States. Per capita consumption was down from 12,325 kWh in 2007 to 12,059 kWh per person in 2008, a 2.2% reduction. In 2008, retail electricity sales in Maryland were 216.1 trillion Btus, ranked 24th in the nation.

Source of Electricity for Maryland: Only about 70 % of Maryland's present electricity needs are generated in the state. The rest is imported. The State is part of the Pennsylvania-New Jersey- Maryland (PJM) Interconnection, or power grid. PJM Interconnection is a regional transmission organization (RTO) that coordinates the movement of wholesale electricity in all or parts of 13 states and the District of Columbia and manages the high-voltage electric grid and the wholesale electricity market that serves 13 states and the District of Columbia.

Maryland distributing companies can get power from the grid and Maryland generating stations can contribute power to the grid. Customers can choose the source of their wholesale electricity through their retail distributor, such as BGE and PEPCO.

Relative Costs of Electricity Generation: The costs of electricity generation have usually been measured in direct cost of generation, not the indirect costs of environmental degradation or health cost. Coal is the cheapest generating method. Coal is the cheapest generating method, presently, but retrofitting coal plants to meet new emissions standards in Maryland is costly and most of Maryland's coal plants are aging, becoming less efficient and many don't have space for retrofitting. Nuclear power's operating costs are low. Base load electric power is supplied by coal and nuclear power plants since these plants are relatively inexpensive to operate. Peak load power, added to the grid when demand is especially high, is more expensive as it is usually generated by oil and natural gas fuel. With the costs of construction, estimated costs of power compare as follows: nuclear power, \$59.30/MKH; wind power, \$55.60/MWh; coal, \$53.10/MWh; and natural gas, \$52.50/MWh. Government incentives will make a difference in choices for electricity generation. Federal loan and insurance guaranties are afforded nuclear power and Maryland has incentives for distributed renewable generation.

Green Jobs: Maryland's goal is 100,000 new jobs in clean energy by 2025. Maryland has been awarded a \$5.8 million grant by the Federal government to help prepare Marylanders for green jobs.

Controlling Demand Through Efficiency: Controlling demand can make it less urgent to build new generating facilities, can limit the use of more expensive peak electricity, and result in less pollution. The EmPOWER Maryland legislation adopted in 2008 provides incentives and goals for reducing energy usage.

Externalities (Indirect Costs): Environmental pollution and degradation costs by power plant emission and mining practices are not figured into the cost of generation usually. Yet they are a cost to all of us, in effects on human health and the loss of livelihoods related to clean bodies of water and healthy forests, and a healthy ecosystem in general.

MARYLAND'S ENERGY FUTURE

In accordance with the programs and goals of Governor O'Malley and the Maryland General Assembly, the Maryland Energy Administration has formulated the following objectives: Reduce Energy consumption; Improve the market for renewable energy; Reduce GHG emissions; Grow a green economy with a robust workforce; Promote energy independence through alternative transportation policies and use of alternative fuels for vehicles.

This fact sheet was prepared by Susan Cochran, Chair, Hugh Haskell, Carol Filipczak, Tracy Miller and Kathy Riley. Sources and references upon request.