A STUDY OF INCREASED USE OF RENEWABLE ENERGY RESOURCES IN VIRGINIA

Performed by:

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VIRGINIA CENTER FOR COAL AND ENERGY RESEARCH

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- Coordination of coal and energy research at Virginia Tech
- Dissemination of coal and energy research information and data to users in the Commonwealth
- Examination of socio-economic implications related to energy and coal development and associated environmental impacts

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Basic Energy Definitions[1]

Ancillary Services: Services in addition to electrical energy required by the grid system operator to maintain proper functioning and reliability of the grid.

Availability Factor: A percentage representing the number of hours a generating unit is available to produce power (regardless of the amount of power) in a given period, compared to the number of hours in the period.

Avoided Cost: The cost a utility would incur to supply additional electricity were it not for the existence of an independent power source. Avoided cost rates have been used to establish the power purchase price utilities offered to independent suppliers (see Qualifying Facility).

Baseload Unit: A power generating facility that is intended to run at near full-load capacity levels, much of the time as possible. Typically these are the lowest cost generators, such as large coal and nuclear plants.

Biomass: Any material of recent biological origin.

British Thermal Unit (Btu): The standard unit for measuring quantity of heat energy, such as the heat content of fuel. It is the amount of heat energy necessary to raise the temperature of one pound of water one degree Fahrenheit.

Busbar: In electric utility operations, a busbar is a conductor that serves as a common connection for two or more circuits. It may be in the form of metal bars or high-tension cables. The busbar cost is often given as a standard cost of generating power at the interconnection point with the main electric grid.

Capacity: The load for which a generating unit, generating station, or other electrical apparatus rated either by the user or by the manufacturer.

Capacity Charge: The payment made to offset all costs associated with the total capital cost of a plant including equipment costs and other capitalized costs such as interest during construction.

Capacity Factor: The ratio of the electrical energy produced by a generating unit for the period of time considered to the electrical energy that could have been produced at continuous full-power operation during the same period.

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[1] The definitions in this section are expanded from those presented in the Black & Veatch report, "Economic Impact of Renewable Energy in Pennsylvania," 2004, available at: http://www.bv.com/energy/eec/renewPennStudy.htm.

Capital Cost: The cost of field development and plant construction and the equipment required for the generation of electricity.

Cogeneration: The production of electrical energy and another form of useful energy (such as heat or steam) through the sequential use of energy.

Combined Cycle: A combustion turbine installation using waste heat boilers to capture exhaust energy for steam generation.

Commercial Operation Date: The date at which a plant is substantially completed, has passed any required testing and is otherwise declared ready to delivery capacity and energy to the grid.

Concentrator: A reflective or refractive device that focuses incident insolation onto an area smaller than the reflective or refractive surface, resulting in increased insolation at the point of focus.

Debt Service Reserve Fund: An amount of money required to be set aside in a reserve account to cover debt payments in the event that the project and other revenues are insufficient to make debt payments.

Demand: The rate at which electric energy is delivered to or by a system, part of a system, or a piece of equipment. It is expressed in kilowatts, kilovoltamperes or other suitable unit at a given instant or averaged over any designated period of time. The primary source of "Demand" is the power-consuming equipment of the customers.

Demand Charge: The sum to be paid by a large electricity consumer for its peak usage level.

Deregulation: See Electric Utility Restructuring.

Direct Access: The ability of customers to purchase electricity from wholesale providers other than their default utility.

Dispatch: Direction for the plant to commence, continue, increase, decrease or cease the delivery of electricity supplied to the interconnection point.

Dispatchable Generation: A generation source that is controlled by a system operator or dispatcher who can increase or decrease the amount of power from that source as the system requirements change.

Distributed Generation: A distributed generation system involves small amounts of generation located on a utility's distribution system for the purpose of meeting local (substation level) peak loads and/or displacing the need to build additional (or upgrade) local distribution lines.

Distribution System: The substations, transformers and lines that convey electricity from high-power transmission lines to ultimate consumers. See Grid.

Electric Utility Restructuring: With some notable exceptions, the electric power industry historically has been composed primarily of investor-owned utilities. These utilities have been predominantly vertically integrated monopolies (combining electricity generation, transmission, and distribution), whose prices have been regulated by State and Federal government agencies. Restructuring the industry entails the introduction of competition into at least the generation phase of electricity production, with a corresponding decrease in regulatory control. Restructuring may also modify or eliminate other traditional aspects of investor-owned utilities, including their exclusive franchise to serve a given geographical area, assured rates of return, and vertical integration of the production process.

Energy Charge: The amount of money owed by an electric customer for kilowatt-hours consumed.

Escalation: The rate of growth applied to a present value cost to determine the future cost of the item. It is equal to the expected inflation rate times any real price effects.

Federal Energy Regulatory Commission (FERC): An independent regulatory commission within the U.S. Department of Energy that has jurisdiction over energy producers that sell or transport fuels for resale in interstate commerce; the authority to set oil and gas pipeline transportation rates and to set the value of oil and gas pipelines for ratemaking purposes; and regulates wholesale electric rates and hydroelectric plant licenses.

Firm Energy: Power supplies that are guaranteed to be delivered under terms defined by contract.

Fixed O&M: Operating and maintenance costs associated with a generating facility that do not vary with the output of the facility. Such costs typically include staffing, insurance, rents, etc. For comparison purposes, these costs are often expressed as an annual expenditure per unit of capacity ($/yr-kW).

Fluidized Bed Combustion: A process for burning powdered coal (or other fuels) that is poured in a liquid-like stream with air or gases. The process reduces sulfur dioxide emissions from coal combustion.

Fossil Fuel: Oil, coal, natural gas or their byproducts. Fuel that was formed in the earth in prehistoric times from remains of living-cell organisms.

Fuel Cells: One or more cells capable of generating an electrical current by converting the chemical energy of a fuel directly into electrical energy. Fuel cells differ from conventional electrical cells in that the active materials such as fuel and oxygen are not contained within the cell but are supplied from outside.

Generation: The total amount of electric energy produced by the generating units in a generating station or stations measured at the generator terminals, usually expressed in terms of kilowatthours.

Geothermal Energy: As used at electric utilities, hot water or steam extracted from geothermal reservoirs in the Earth's crust that is supplied to steam turbines at electric utilities that drive generators to produce electricity.

Giga: One billion.

Green Pricing: In the case of renewable electricity, green pricing represents a market solution to the various problems associated with regulatory valuation of the nonmarket benefits of renewables. Green pricing programs allow electricity customers to express their willingness pay for renewable energy development through direct payments on their monthly utility bills.

Greenfield: Undeveloped land.

Grid: The layout of an electrical distribution system.

Gross Plant Output: The instantaneous electrical output of an electricity generating plant (e.g., electricity used to power pumps, fans, etc. needed to run the facility). Typically measured in kilowatts or megawatts.

Heat rate: A measure of generating station thermal efficiency, generally expressed in Btu per net kilowatt-hour. It is computed by dividing the Btu content of fuel burned for electric generation by the resulting net kilowatt-hour generation.

Heating value: The amount of heat produced the complete combustion of a given amount fuel. Can be expressed as higher heating value (HHV) or lower heating value (LHV).

Horsepower (HP): A unit for measuring the rate doing work. One horsepower equals about three-fourths of a kilowatt (745.7 watts).

Hot Start: A plant startup which occurs when facility has been off-line less than 4 hours and given a dispatch instruction to start up.

Hub Height: In a horizontal-axis wind turbine, distance from the turbine platform to the rotor shaft.

Independent Power Producer (IPP): A wholesale electricity producer (other than a qualifying facility under the Public Utility Regulatory Policies Act of 1978), that is unaffiliated with franchised utilities in the area which the IPP is selling power and that lacks significant marketing power. Unlike traditional utilities, IPPs do not possess transmission facilities that are essential to their customers and do not sell power in any retail service territory where have a franchise.

Interconnection: A connection between two electric systems permitting the transfer of electric energy in either direction.

Internal Combustion Engine: An engine in which fuel is burned inside the engine. A car's gasoline engine or rotary engine is an example of a internal combustion engine. It differs from engines having an external furnace, such as a steam engine.

Investor Owned Utility (IOU): A company, owned by stockholders for profit, that provides utility services. A designation used to differentiate a utility owned and operated for the benefit of shareholders from municipally owned and operated utilities and rural electric cooperatives.

Kilovolt (kV): One-thousand volts (1,000). Distribution lines in residential areas usually are kV (12,000 volts).

Kilowatt (kW): One thousand watts of electricity (See Watt).

Kilowatt-hour (kWh): One thousand watt-hours (see Watt-hour).

Landfill Gas: Gas generated by the natural degrading and decomposition of municipal solid waste by anaerobic microorganisms in sanitary landfills. The gases produced, carbon dioxide and methane, can be collected by a series of low-level pressure wells and can be processed into a medium Btu gas that can be burned to generate steam or electricity.

Levelized Cost: The present value of the total of building and operating a generating plant over its economic life, converted to equal annual payments. Costs are levelized in real dollars (i.e. adjusted to remove the impact of inflation).

Load Factor: A percent indicating the difference between the electrical energy a consumer used during a given time span and the amount that would have been used if the usage had stayed the peak demand level the whole time. The term also is used to mean the percentage of capacity an energy facility (such as power plant or gas pipeline) that is utilized in a given period of time.

Marginal Cost: The change in cost associated a unit change in quantity supplied or produced.

Marketer: An agent for generation projects who markets power on behalf of the generator. The marketer may also arrange transmission, firming or other ancillary services as needed. Though marketer may perform many of the same functions as a broker, the difference is that a marketer represents the generator while a broker acts as a middleman.

Market Clearing Price: The price at which supply equals demand.

Megawatt (MW): One million watts of electricity (See Watt).

Megawatt-hour (MWh): One million watt-hours of electricity (See Watt-hour).

Megawatts at Peak (MWp): The rating of a photovoltaic system at noon, or peak output.

Merchant Facilities: High-risk, high-profit facilities that operate, at least partially, at the whims of the market, as opposed to those facilities that are constructed with close cooperation of municipalities and have significant amounts of waste supply guaranteed.

Microturbine: A miniature combustion turbine, similar in concept to the larger gas turbines used in conventional utility power plants. Whereas large gas turbines rang from 20,000 to over 200,000 kW, microturbines range from 25 to 400 kW.

Municipal Solid Waste: Locally collected garbage, which can be processed and burned to produce energy.

Municipal Utility: A provider of utility services owned and operated by a municipal government.

Net Metering: Measuring the difference, over the net metering period, between electricity supplied to an eligible customer-generator from the electric grid and the electricity generated and fed back to the electric grid by the eligible customer-generator. Net-metered energy is measured by a meter capable of gauging power flow in both directions. Virginia's net-metering law applies to eligible renewable energy generating equipment of not more than 10 kilowatts (kW) in capacity for residential customers and of not more than 500 kW in capacity for non-residential customers. Eligible technologies include solar, wind and hydropower systems intended primarily to offset part or all of a customer's requirements for electricity. The legal definition of net metering is covered by Code of Virginia (2004), Title 56, Public Service Companies, Chapter 23 Virginia Electric Utility Restructuring Act, as amended in 2005.

Net Plant Capacity: The instantaneous peak dependable output of an electricity generating plant minus any internal electricity consumption (e.g., electricity used to power pumps, fans, etc. needed to run the facility). Typically measured in kilowatts or megawatts.

Net Plant Heat Rate: See Heat Rate. A measure of the fuel efficiency of a power generation station based on the Net Plant Capacity.

Nitrogen Oxides (NOx): Gases formed in great part from atmospheric nitrogen and oxygen when combustion takes place under conditions of high temperature and high pressure; considered a major air pollutant.

Non-Firm Energy: Electricity that is not required to be delivered or to be taken under the terms of an electric purchase contract.

Nonutility Generation: Electric generation by nonutility power producers to supply electric power for industrial, commercial, and military operations, or sales to electric utilities. See Nonutility Power Producer.

Nonutility Power Producer: A corporation, person, agency, authority, or other legal entity or instrument that owns electric generating capacity and is not an electric utility. Nonutility power producers include qualifying cogenerators, qualifying small power producers, and other nonutility generators (including independent power producers) without a designated, franchised service area that do not file forms listed in the Code of Federal Regulations, Title 18, Part 141.

Operation and Maintenance (O&M) Cost: Operating expenses are associated with operating a facility (i.e., supervising and engineering expenses). Maintenance expenses are that portion of expenses consisting of labor, materials, and other direct and indirect expenses incurred for preserving the operating efficiency or physical condition of utility plants that are used for power production, transmission, and distribution of energy.

Overnight Cost: The overnight construction cost is defined as the total of all costs incurred for building the plant accounted for as if they were spent instantaneously

Parabolic Dish: A high-temperature (above 180 degrees Fahrenheit) solar thermal concentrator, generally bowl-shaped, with two-axis tracking.

Parabolic Trough: A high-temperature (above 180 degrees Fahrenheit) solar thermal concentrator with the capacity for tracking the sun using one axis of rotation.

Passive Solar: A system in which solar energy alone is used for the transfer of thermal energy. Pumps, blowers, or other heat transfer devices that use energy other than solar are not used.

Peak Demand: The greatest demand which occurred during a specified period of time.

Peaking Unit: A power generating facility that is intended to run during high electricity demand periods. Typically these are the highest cost generators, such as simple cycle combustion turbines and inefficient fossil plants.

Photovoltaic Cell: An electronic device consisting of layers of semiconductor materials fabricated to form a junction (adjacent layers of materials with different electronic characteristics) and electrical contacts and being capable of converting incident light directly into electricity (direct current).

Photovoltaic Module: An integrated assembly of interconnected photovoltaic cells designed to deliver a selected level of working voltage and current at its output terminals, packaged for protection against environment degradation, and suited for incorporation in photovoltaic power systems.

Power Pool: Two or more interconnected utilities that plan and operate to supply electricity in the most reliable, economical way to meet their combined load.

Public Utility Holding Company Act of 1935 (PUHCA): This act prohibits acquisition of any wholesale or retail electric business through a holding company unless that business forms part of an integrated public utility system when combined with the utility's other electric business. The legislation also restricts ownership of an electric business by non-utility corporations.

Public Utility Regulatory Policies Act of 1978 (PURPA): One part of the National Energy Act, PURPA contains measures designed to encourage the conservation of energy, more efficient use of resources, and equitable rates. Principal among these were suggested retail rate reforms and new incentives for production of electricity by cogenerators and users of renewable resources.

Pulverized Coal: A finely ground form of coal used in many boiler applications. There are various pulverizer technologies that can be used.

Qualifying Facility (QF): A cogeneration or small power production facility that meets certain ownership, operating, and efficiency criteria established by the Federal Energy Regulatory Commission (FERC) pursuant to the Public Utility Regulatory Policies Act of 1978 (PURPA). (See the Code of Federal Regulations, Title 18, Part 292.)

Rankine Cycle: The steam-Rankine cycle employing steam turbines has been the mainstay of utility thermal electric power generation for many years. The cycle, as developed over the years uses superheat, reheat and regeneration. Modern steam Rankine systems operate at a cycle top temperature of about 1,073 degrees Celsius with efficiencies of about 40 percent.

Refuse-Derived Fuel (RDF): Fuel processed from municipal solid waste that can be in shredded, fluff, or densified pellet forms.

Reliability: The guarantee of system performance at all times and under all reasonable conditions to assure constancy, quality, adequacy and economy of electricity. It is also the assurance of a continuous supply of electricity for customers at the proper voltage and frequency.

Renewable Energy Source: An energy source that is regenerative or virtually inexhaustible. Typical examples are wind, geothermal, and water power.

Renewable Energy, Virginia State Corporation Commission Definition: Energy derived from sunlight, wind, falling water, sustainable biomass, energy from waste, wave motion, tides, and geothermal power, excluding energy derived from coal, oil, natural gas or nuclear power.

Reserve Margin: The differences between the dependable capacity of a utility's system and the anticipated peak load for a specified period.

Self-Generation: A generation facility dedicated to serving a particular retail customer, usually located on the customer's premises. The facility may either be owned directly by the retail customer or owned by a third party with a contractual arrangement to provide electricity to meet some or all of the customer's load.

Simple Cycle: An electric generating technology in which electricity is produced from one or more gas (combustion) turbines with no waste heat recovery.

Silicon: A semiconductor material made from silica, purified for photovoltaic applications.

Solar Energy: The radiant energy of the sun, which can be converted into other forms of energy, such as heat or electricity.

Stirling Engine: An external combustion engine that converts heat into useable mechanical energy (shaft work) by the heating (expanding) and cooling (contracting) of a captive gas such as helium or hydrogen.

Subbituminous: A dull black coal ranking between lignite and bituminous, it is mined chiefly in Montana and Wyoming.

Subcritical: A steam cycle that is designed with a main steam pressure lower than critical pressure.

Substation: An assemblage of equipment for the purposes of switching and/or changing or regulating the voltage of electricity.

Sulfur Oxides (SOx): Pungent, colorless gases formed primarily by the combustion of fossil fuels; considered major air pollutants; sulfur oxides may damage the human respiratory tract as well as vegetation.

Sunk Cost: In economics, a sunk cost is a cost that has already been incurred, and therefore cannot be avoided by any strategy going forward.

Supercritical: A steam cycle that is designed with a main steam pressure higher than critical pressure.

Tariff: A document, approved by the responsible regulatory agency, listing the terms and conditions, including a schedule of prices, under which utility services will be provided.

Time-Of-Use Rates: Electricity prices that vary depending on the time periods in which the energy is consumed. In a time-of- use rate structure, higher prices are charged during utility peak-load times. Such rates can provide an incentive for consumers to curb power use during peak times.

Tipping Fee: Price charged to deliver municipal solid waste to a landfill, waste-to-energy facility, or recycling facility.

Transmission losses: The general term applied to energy (kilowatt-hours) and power (kilowatts) lost in the operation of an electric system. Losses occur principally as energy transformations from kilowatt hours to waste heat in electrical conductors and apparatus.

Transmission System (Electric): An interconnected group of electric transmission lines and associated equipment for moving or transferring electric energy in bulk between points of supply and points at which it is transformed for delivery over the distribution system lines to consumers, or is delivered to other electric systems.

Turbine: A machine for generating rotary mechanical power from the energy of a stream of fluid (such as water, steam, or hot gas). Turbines convert the kinetic energy of fluids to mechanical energy through the principles of impulse and reaction, or a mixture of the two.

Unbundling: Disaggregating electric utility service into its basic components and offering each component separately for sale with separate rates for each component. For example, generation, transmission and distribution could be unbundled and offered as discrete services.

Variable O&M: Those operating and maintenance costs that vary according to the of plant output, such as lubricating oils, limestone and water.

Volt: The unit of electromotive force or electric pressure analogous to water pressure in pounds per square inch. It is the electromotive force that, if steadily applied to a circuit having a resistance of one ohm, will produce a current of one ampere.

Watt (W): The electrical unit of real power or rate of doing work. The rate of energy transfer equivalent to one ampere flowing due to an electrical pressure of one volt at unity power factor. One watt is equivalent to approximately 1/746 horsepower, or one joule per second.

Watt-hour: The total amount of energy used in one hour by a device that requires one watt of power for continuous operation. Electric energy is commonly sold by the kilowatt-hour

Wheeling: The use of the transmission facilities of one system to transmit power and energy by agreement of and for, another system with a corresponding wheeling charge (e.g., the transmission of electricity for compensation over a system that is received from one system and delivered to another system).

STUDY OBJECTIVES

STUDY AS APPROVED BY THE VIRGINIA COMMISSION ON ELECTRIC UTILITY RESTRUCTURING

Following is the text of the proposal presented to and approved by the Commission at its meeting on February 10, 2005:

> ***Proposed Study of Increased Use of Renewable Energy Resources in Virginia***
>
> **Study objective:** To provide legislators and policymakers with a factual basis to determine whether further efforts to stimulate increased use of renewable energy and environmentally beneficial resources to generate electricity in Virginia would be warranted.
>
> **Extract:** There is general need for greater understanding of the feasibility, costs, benefits and risks associated with the use of renewable energy and environmentally beneficial resources to generate electricity. Despite claims that these resources have a variety of benefits, such energy sources make a relatively small contribution to power generation in Virginia and the nation. An objective study should examine the existing barriers to deployment of such resources. This study should determine the cost of generating electricity from such sources and then compare it with the cost of power generated from traditional sources, for both the case of existing capacity and new capacity additions. This information can be used to estimate the scale of incentives or subsidies needed to encourage investment in renewable resources. In addition the study should review incentives that have been employed elsewhere for expanded deployment of such energy and analyze the effectiveness of each. The study could then recommend public policy initiatives to realize them, within the framework of Virginia's currently ongoing restructuring of the electricity industry.
>
> **Study components:**
> *The use of the term "renewable energy" in the following is understood to include the broad range of environmentally beneficial electric generating technologies.*
>
> 1. Identify existing renewable energy resources in Virginia.
> 2. Determine the cost of electricity produced by existing renewable energy resources in Virginia, by type.
> 3. Identify existing barriers to expansion of renewable energy resources in Virginia.
> 4. Identify existing federal, state and local incentives to use and/or expand use of renewable energy resources in Virginia.
> 5. Examine the effectiveness of existing incentives.
> 6. Determine the cost of new electric generating capacity additions using renewable energy resources in Virginia.

7. Compare the cost of new electric generating capacity additions using renewable energy resources in Virginia with the cost of new “traditional” electric generating capacity additions in Virginia.
8. Determine future renewable energy resource potential in Virginia.
9. Evaluate the costs of present and future air emissions compliance in Virginia and potential reductions in emissions and compliance costs due to increased use of renewables, including the effect of increased use of renewables on Virginia’s efforts to improve air quality in ozone nonattainment areas and regions, and elsewhere in Virginia.
10. Determine potential employment impacts in Virginia due to increased use of renewables, especially in economically distressed Southwest and Southside Virginia.
11. Examine the potential effects on suppliers of renewable fuel, equipment and services in Virginia.
12. Examine the potential effects on Virginia’s agriculture industry of using switch grass, sorghums, or other crops as boiler fuels, replacing cultivation of tobacco.
13. Estimate potential local tax base impacts due to increased use of renewables.
14. Examine and consider other benefits and risks of increased use of renewables.

The study is to [sic] **conducted by the Virginia Center for Coal & Energy Research and the following state agencies should cooperate with the study:**
Department of Environmental Quality
Department of Health
Virginia Employment Commission
State Corporation Commission
Coal and Energy Commission
Secretariat of Commerce and Trade
Department of Agriculture
Department of Mines, Minerals and Energy

In response to the above request from the Virginia Commission on Electric Utility Restructuring (CEUR), the Virginia Center for Coal and Energy Research (VCCER) recommended that the deliverables of the study be organized within the following five major tasks:

1. Resources, Existing and Future
2. Costs and Economic Measures
3. Incentives and Barriers
4. Cost versus Benefit Analyses
5. Economic Development Considerations

In completing these tasks, the VCCER solicited assistance from other organizations and groups with specific expertise and access to data. This insured that the complex parameters of individual tasks within the study were fully addressed within the fiscal and time limitations of the project. The VCCER managed and coordinated the project, and developed this final report.

EXECUTIVE SUMMARY

INTRODUCTION

The objective of this study, as requested by the Virginia Commission on Electric Utility Restructuring, was to review the current status and prospects for renewable energy in Virginia. The study reviews the current generation from renewables, the prospects for future resource development, renewable energy costs compared to fossil-fueled alternatives, incentives and impediments to the development of renewable energy, the economic impacts of renewable energy in Virginia, and environmental compliance considerations. This section summarizes the principal findings in each of these areas, and concludes with recommendations for further investigation and potential action. The complete analyses for each section are included as appendices to this report.

Investigations of the topics were carried out by various experts under the general direction of Virginia Tech's Virginia Center for Coal and Energy Research (VCCER). VCCER also contracted with Black & Veatch, a highly experienced energy consulting, engineering, and construction firm, to perform an independent review of the findings and assist with summarizing the key findings and recommendations for Virginia.

RENEWABLE ENERGY GENERATION AND RESOURCES

Renewable energy is defined (see Basic Energy Definitions, above) as the energy derived from sunlight, wind, falling water, sustainable biomass, waste, wave motion, tides, and geothermal power. Renewable energy sources are practically inexhaustible. Technologies to harness them are diverse; however, they are also of varying technological, economic and practical maturity. Renewable resources are available to some degree in Virginia, although some are only suitable for limited applications, such as geothermal heat pumps for home heating and cooling.

Steady advances in equipment and operating experience spurred by government incentives have led to a number of mature renewable technologies. The technical feasibility and cost competitiveness of energy from nearly every form of renewable energy have improved since the early 1980s. However, because the capital cost of renewables has generally been higher than the cost of equivalent capacity from conventional fossil fuel technologies (that is, coal, oil and natural gas) and nuclear generation, renewables have only made up a small fraction of electricity generation in most states. Nevertheless, the field is rapidly expanding from niche markets to meaningful contributions to the nation's electricity supply. This process has been accelerated by recent increases in the price of fossil fuels and incentives policies in some states.

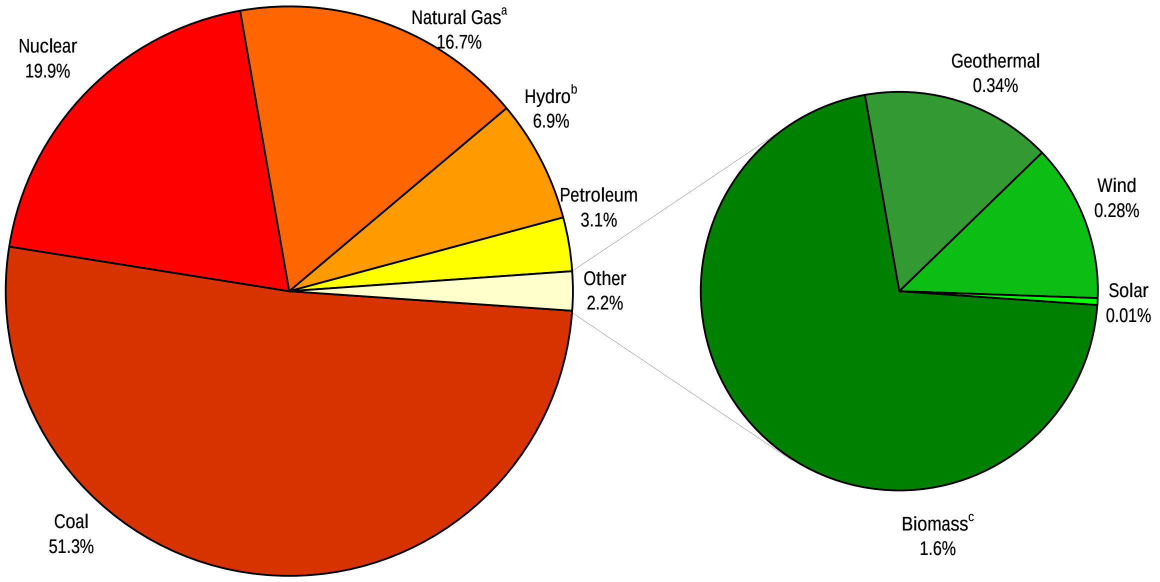
Excluding hydro, which is arguably the most mature of all electricity generation technologies, renewable energy only comprises about 2 percent of the U.S. electricity generation mix. Figure 1 is a summary of electricity generation for the United States in 2003, including a breakdown of the renewable energy portion of generation. For comparison, Figure 2 shows a breakdown of electricity generation in Virginia. Both figures reveal that renewable sources represent only a small percentage of total electricity generation. Further, for both the U.S. and Virginia, the largest sources of renewable generation are hydro followed by biomass (primarily wood waste). Other renewable energy sources, including wind and solar, make up much smaller portions of the total renewables, although these sources are growing.

A report analyzing the existing and potential renewable energy resources in Virginia was prepared for this study by the U.S. Department of Energy's (DOE) National Renewable Energy Laboratory (NREL). The report discusses the current renewable energy capacity in Virginia, analyzes the technical potential of wind, biomass, and photovoltaic energy in the state, and calculates the levelized cost of energy (LCOE) for several renewable technologies. The document can be found in Appendix A.

According to data collected from the U.S. DOE Energy Information Administration (EIA) and other sources, NREL estimates that there is currently about 1,340 MW of renewable energy capacity installed in Virginia (excluding pumped-storage hydro). By comparison, there is about 20,200 MW of total installed power generation capacity in the state. Conventional hydro makes up the largest fraction of the renewable energy total, about 750 MW. The remainder is largely from wood or waste wood fired plants (415 MW), with a lesser amount from municipal solid waste burners (about 140 MW) and landfill gas facilities (about 30 MW). There is currently very little grid-connected wind or solar installed in the state (both less than 1 MW).

The following section examines the potential for expanded deployment in Virginia of six major forms of renewable energy. In each case, the first estimate given is the NREL assessment, unless otherwise stated. The NREL analysis uses broad criteria to estimate a range of renewable energy generation that Virginia could potentially support in addition to current capacity. Estimates are also stated from Black & Veatch, and in some cases Navigant Consulting, reflecting the feasibility of expansion of these technologies in the near-term, based on their experience and available data.

- **Onshore wind energy:** 910-1,960 MW of onshore wind capacity by developing Class 3 and greater (>14 miles per hour) wind sites. The lower estimate is based on applying land use restrictions and assuming that 20 percent of the existing transmission capacity could be used for wind; the higher estimate has no restrictions on transmission capacity or distance from transmission. In reality, an even lower amount of transmission capacity might be available. About 60 percent of the identified wind resource is relatively low quality Class 3 winds. Because of their poor economics, these resources are generally not developed for utility scale applications at the current time, although future improvements in turbine technology may increase the viability of this resource. Based on these considerations, Black & Veatch feels that the near-term (5-10 years) development potential for wind in Virginia is limited to about 400 MW. Additional development could occur if low-speed wind turbine technology improves, the transmission grid is upgraded in key wind resource areas, or a greater amount of land is available for development than assumed by NREL.



[a] Includes a small amount of other gases (propane, refinery gas, etc.)
[b] Includes pumped storage hydro
[c] Includes wood, waste-to-energy, landfill gas, agricultural byproducts, etc.

Figure 1: U.S. Electricity Generation by Source, 2003 (Source: EIA).[1]

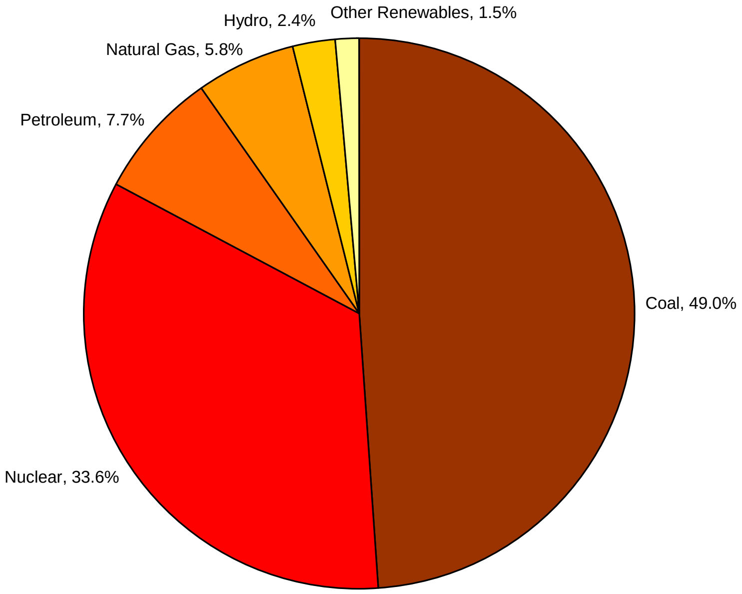


Figure 2: Virginia Electricity Generation by Source, 2003 (Source: EIA).[2]

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[1] U.S. Department of Energy (DOE) Energy Information Administration (EIA), "Renewable Energy Trends 2003" August 2004, avail. at: http://tonto.eia.doe.gov/FTPROOT/renewables/062803.pdf.
[2] U.S. Department of Energy (DOE) Energy Information Administration (EIA), “Electric Power Annual 2003” December 2004, avail. At: http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html

- **Offshore wind energy:** 1,300-32,000 MW of offshore wind capacity using class 5 and 6 winds (17 miles per hour or more). The lower estimate includes only resources within 20 miles of transmission. The higher estimate has no restrictions on distance from transmission or on transmission capacity. Black & Veatch's opinion is that potential for offshore development in Virginia is very limited in the near-term. Although there are active developments near Cape Cod and Long Island in the Northeast, there are currently no offshore wind farms operating in the United States. Offshore wind is considerably more expensive than onshore wind and other renewable energy options in Virginia. Therefore, offshore wind projects do not appear to be likely in the near future.

- **Landfill gas:** 15 candidate landfills with a potential for about 24 MW of generation, according to EPA estimates. Another 19 smaller landfills are available that could provide an additional 6 MW, for a total of 30 MW new generation capacity. Although relatively limited, landfill gas generation is typically inexpensive and reliable.

- **Biomass:** About 760 MW of electrical generation, with over 500 MW from forest residues. Other biomass sources include urban wood residues (180 MW), unutilized mill residues (14.5 MW), crop residues (32.8 MW), and animal manure (12.3 MW). Crops grown specifically for energy production, such as switchgrass, were not evaluated. Data for biomass resources is limited, and NREL recommends further study for better accuracy. It is important to note that NREL's estimate of available resources does not account for resources already being used, with the exception of mill residues. This is most likely to impact urban wood residues, which are probably already in use to a certain extent. These estimates are based on technical potential without considering economics. Black & Veatch estimates that about half of this potential, or 300 MW, could be developable in the near-term. NREL has assumed a thermal conversion efficiency of 30 percent. This is high compared to the small-scale biomass combustion technologies commonly in use today, which typically have efficiencies of 20-25 percent. However, this efficiency level could be obtained at relatively low cost if biomass is co-fired with coal in large, existing coal fueled power plants. Based on Black & Veatch estimates, co-firing an average of 5 percent biomass in the existing 4,600 MW of coal plants in Virginia would result in about 230 MW of capacity.

- **Solar Photovoltaics (PV):** About 16-19 percent of Virginia's annual electrical demand, with peak generating capacity of about 11,700 to 13,000 MW. This is an optimistic estimate of potential if systems were installed on all available commercial and residential roof space. Realistic estimates of near-term potential would be much lower. Virginia has modest solar resources compared to the rest of the United States, and solar can be up to ten times the cost of other renewable resources. The most active PV markets today are in states where large capital cost subsidies are provided by the local utilities or states (e.g., California, New Jersey). Navigant Consulting previously prepared estimates of potential demand in Virginia in 2010 at various cost levels. At costs 50 to 25 percent lower ($4.26/W to $6.30/W) than typical installed costs today ($8.50/W), estimated demand in Virginia would be 9 MW. Even this estimate could be high unless Virginia provides strong financial incentives targeting solar. At the lowest costs investigated ($1.00/W to $1.26/W) estimated demand would be 167 MW. Absent these cost declines, it is likely that less than 1 or 2 MW would be developed in the next few years.

- **Hydro:** 200 MW near-term potential (Black & Veatch estimate). NREL did not address the potential for upgrading existing hydro sites or developing new sites. The potential is significant, and can be estimated based on recent resource surveys performed by the Idaho National Engineering and Environmental Laboratory (INEEL).[3] The INEEL survey identifies 16 new site developments totaling 444 MW, and 17 projects totaling 280 MW that would involve upgrading existing sites or adding generation to sites with existing dams. The latter projects generally have lower environmental impacts and lower development costs.

The renewable resource potential estimates from NREL and Black & Veatch are summarized in Table 1.

Table 1: Summary of Virginia Renewable Resource Potential

Technology	NREL 2002 Installed Capacity, MW	NREL Additional Technical Potential, MW	B&V Near-Term Potential, MW	Capacity Factor[f]
Onshore Wind	0.01	910-1,960[a]	400	30-44%
Offshore Wind	--	1,300-32,000[b]	0	30-44%
Landfill gas	32	30[c]	30	90%
Biomass (direct)	415	760[d]	300	83%
Solar PV	0.22	11,700-13,000[e]	<1-2	14-20%
Municipal Solid Waste	136	N/A	N/A	70%
Hydro	750	N/A	200	50%
Totals	1,340	14,700-47,750	930	--

[a] Lowest estimate, based on 20% availability of existing lines, from Appendix A, Table 6, page A-6.
Highest estimate, based on no distance or transmission limits, from Appendix A, Table 4, page A-4.
[b] Lowest estimate based on using class 5 and 6 winds within 20 miles of transmission. Highest estimate based on no distance or transmission limits. Both from Appendix A, Table 5, page A-4.
[c] Estimate from Appendix A, Table 7, page A-6.
[d] Estimate from Appendix A, Table 8, page A-7.
[e] Estimates from Appendix A, Table 10, page A-8.
[f] Capacity Factor: The ratio of the electrical energy produced by a generating unit for the period of time considered to the electrical energy that could have been produced at continuous full-power operation during the same period.

Based on NREL's projections of renewable generation potential, from about 15,000 to 48,000 MW of new capacity could be possible in Virginia. By comparison, there is about 20,200 MW of total installed power generation capacity in the state. Black & Veatch estimates that of this renewable potential, approximately 930 MW could be economically developed in the near-term (5-15 years). Ignoring the needs for electricity storage and other practical constraints, it seems that there could be significant renewable potential in the state.

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[3] INEEL, "Estimation of Economic Parameters of U.S. Hydropower Resources," INEEL/EXT-03-00662, June 2003.

RENEWABLE ENERGY AND CONVENTIONAL ENERGY COSTS

NREL and Black & Veatch provided an analysis of the cost of producing electricity with existing and new renewable, conventional, and advanced technologies (Appendices A and B). The cost of energy from existing resources was assessed with a high-level analysis of the PJM wholesale electric market. The cost of new resources was analyzed by computing the levelized cost of energy (LCOE) for each resource.

For existing electric generators, the most appropriate measure of the cost to produce electricity is the marginal production cost because the capital investment has already been “sunk” into these generators. The annual average PJM market clearing price for 2004 was about 4.8¢ per kWh, which represents the average marginal cost of generation for all electric generators participating in the PJM market. The market price (marginal production cost) varies by hour depending upon the last generator dispatched to meet demand. For example, during off-peak hours of low power demand, the market price is set by low cost hydro, nuclear and coal-fueled generators. Whereas during times of peak demand, the price is set by more expensive natural gas-fueled combined cycle and simple cycle combustion turbine plants. The existing hydro generators in Virginia are the lowest cost resources on a marginal production cost basis. Existing biomass generators have production costs similar to coal-fueled and combined cycle plants. Landfill gas-fueled plants can produce electricity at a cost equivalent to simple cycle combustion turbines. Therefore, these existing renewable generators in Virginia are cost-competitive with various conventional generators.

The LCOE is a lifecycle estimate of the cost to generate power with a particular generation source including capital and operations costs, fuel costs, financing, taxes and incentives. Capital cost estimates for all renewable and conventional power generation technologies were based on estimates from the DOE EIA Annual Energy Outlook (AEO) 2005. Table 2 shows the capital cost, operating costs, mid-range capacity factors and levelized cost of energy (LCOE) estimates from NREL. NREL also provided capital and operating cost and LCOE estimates for conventional and advanced fossil-fueled and nuclear power generation sources, which are shown in Table 3. Nominal and real (inflation-adjusted) forms of LCOE are included with federal tax credits consistent with those defined in the Energy Policy Act of 2005. In addition, NREL provided estimates assuming low, mid and high capacity factors. For clarity, the tables below include only the mid-capacity factor estimate. Advanced resources are those that are not commercially available yet, but may be so in the next 20 years.

Table 2: Development Cost and Levelized Cost of Renewable Energy in Virginia

Technology	Capital Cost, $/kW	Fixed O&M, $/kW-yr	Variable O&M, $/MWh	Capacity Factor	Nominal LCOE (¢/kWh)	Real LCOE (¢/kWh)
Biomass	1,842	49.40	3.10	83%	6.3	5.0
Landfill Gas	1,571	105.82	0.01	90%	3.8	3.0
Wind	1,187	28.07	--	35%	5.1	4.0
Solar PV	4,678	10.83	--	17%	35.8	27.7

Source: NREL / EIA
Note: Includes production and investment tax incentives signed into law with the Energy Policy Act of 2005.

Table 3: Development Cost and Levelized Cost for Fossil and Nuclear Technologies

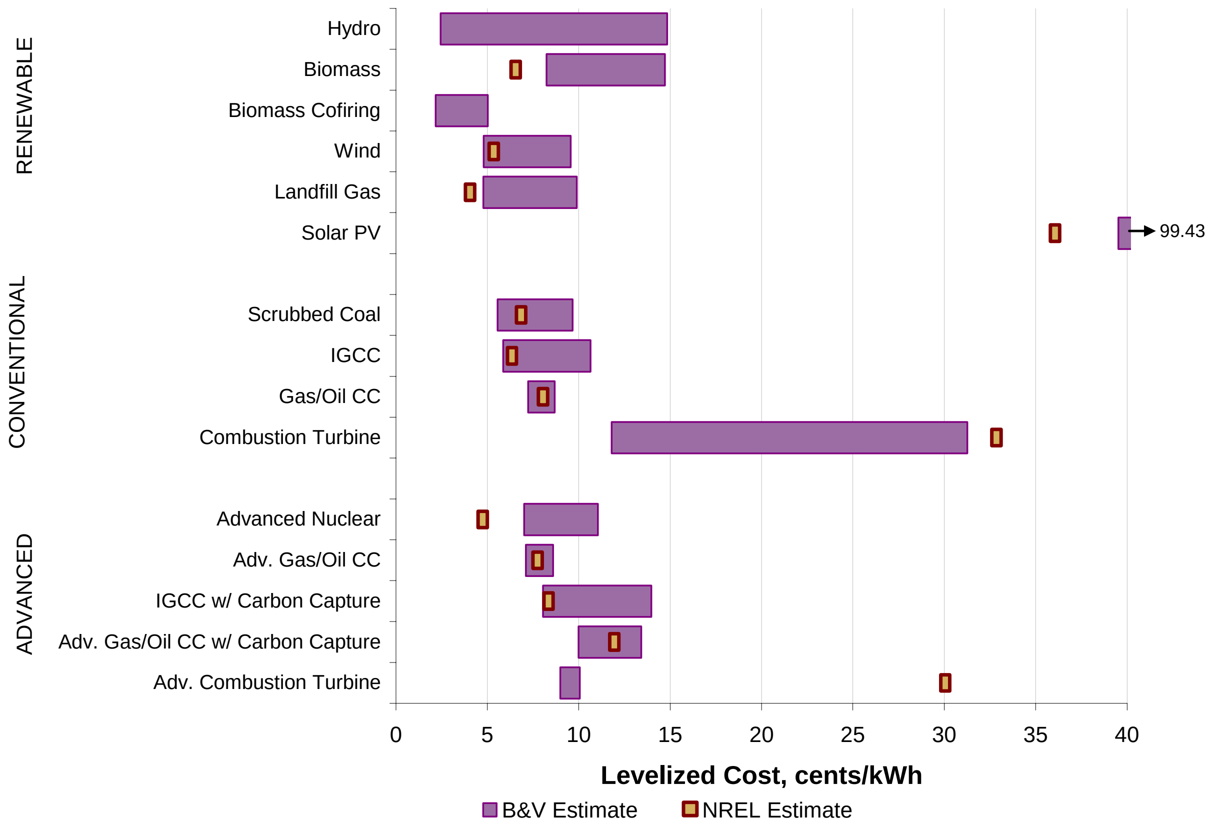
Technology	Capital Cost, $/kW	Fixed O&M, $/kW-yr	Variable O&M, $/MWh	Capacity Factor	Nominal LCOE (¢/kWh)	Real LCOE (¢/kWh)
Conventional Proven Resources						
Scrubbed Coal	1270	25.51	4.25	70%	6.6	5.1
IGCC	1468	35.82	2.70	80%	6.1	4.7
Gas/Oil Combined Cycle (CC)	594	11.56	1.92	45%	7.8	6.2
Combustion Turbine	414	11.22	3.31	4%	32.6	25.4
Advanced Resources						
Adv. Nuclear	2049	62.88	0.46	92%	4.5	3.5
Adv. Gas/Oil CC	584	10.84	1.85	45%	7.5	5.9
IGCC with Carbon Capture	2100	42.15	4.11	80%	8.1	6.4
Adv. Gas/Oil CC with Carbon Capture	1166	18.43	2.72	45%	11.7	9.2
Adv. Combustion Turbine	392	9.75	2.93	4%	29.8	23.3

Source: NREL / EIA
* IGCC - Integrated Gasification Combined Cycle

The capital cost estimates provided by NREL, based on DOE's methodology, are exclusive of major project development costs such as interest during construction, owner's costs (engineering, project management, transmission interconnection, etc.), and other indirect costs. Black & Veatch has increased the capital cost estimate ranges to include these costs and has provided a range of possible operations and fuel costs to calculate a range for the LCOE for each renewable, conventional, and advanced technology.

Figure 3 shows that hydro, biomass co-firing, wind, and landfill gas are generally competitive with conventional and advanced technologies on a nominal LCOE basis. Renewables have become increasingly competitive over the past few years as fossil fuel prices have risen. Of particular note are the (1) low end range for hydro, which represents relatively inexpensive upgrades of existing hydro plants to increase generation, and (2) biomass co-firing with coal, which can be inexpensive since the biomass takes advantage of the existing coal plant systems. It should be noted, however, that not all coal-fired power stations can easily handle biomass (or waste material) co-firing.

The LCOE approach is a simple measure of technology economics and does not provide a full picture of the value of a particular technology. For example, even if they have the same LCOE, a wind farm has a lower value to the grid than a gas-fired peaking plant. The reason is that wind is intermittent, whereas the gas-fired peaking is dependable and can be quickly dispatched. A more detailed analysis of the Virginia electricity market and the potential resources, taking dispatchability into consideration, will be necessary before it can be accurately determined just how renewables compare with fossil fuel alternatives.



*IGCC – Integrated Gasification Combined Cycle, CC- Combined Cycle
**Includes production and investment tax incentives in the Energy Policy Act of 2005.

Figure 3: Black & Veatch Nominal LCOE Estimates for Each Generation Technology

INCENTIVES AND IMPEDIMENTS

An analysis of the incentives and impediments to renewable energy systems in Virginia was prepared by Benjamin K. Sovacool and Richard F. Hirsh and submitted to the Virginia Center for Coal and Energy Research. The study identifies and discusses at length the various incentives for renewable energy development and the corresponding impediments to development. The report can be found in Appendix C.

Sovacool and Hirsh identified a number of state and federal incentives for developing renewable energy in Virginia. Federal incentives include:

- Investment and production tax credits for qualifying technologies
- Accelerated depreciation schedules for renewable technologies
- Tax credits for alcohol fuels
- Grants and discount loans.

The most significant of these incentives is the production tax credit for renewable energy, worth up to 1.9 cents/kWh. It has been a major driver in the growth of the wind industry, and has recently been expanded to include nearly all other types of renewable generation. Qualifying technologies and the size of the credit available to each technology are outlined in Table 4.

Table 4: Major Production Tax Credit Provisions

Resource	Credit Size*	Special Considerations
Wind	Full	None
Biomass		
Closed-Loop	Full	Crops grown specifically for energy
Closed-Loop Co-Firing	Full	Only specific coal power plants; based on % of biomass heat input
Open-Loop	Half	Does not include co-firing
Livestock Waste	Half	>150 kW; Does not include co-firing
Poultry Waste	Full	Incorporated with “livestock waste” with the American Jobs Creation Act of 2004
Geothermal	Full	Can’t also take investment tax credit
Solar	Full	Can’t also take investment tax credit; eligibility expires Dec. 31, 2005
Small Irrigation Hydro	Half	No dams or impoundments; 150 kW-5 MW
Incremental Hydro	Half	Increased generation from existing sites
Landfill Gas	Half	Can’t also take Sec. 29 tax credit
Municipal Solid Waste	Half	Includes new units added at existing plants.

Source: Black & Veatch
Notes: All Production Tax Credits are inflation-adjusted and equaled 1.9 cents/kWh (“Full”) or 0.9 cents/kWh (“Half”) in 2005.

Specific incentives offered in Virginia include:

- A local option property tax exemption for solar energy systems
- A solar manufacturing grant program which pays up to 75 cents per watt for the manufacture of solar panels in Virginia. Two firms built plants to take advantage of this program, although only one is currently operating, at a marginal level.
- A small wind incentives program which offers grants for up to $10,000 for landowners who install small wind turbine systems in 2004-2005 (limited to ten total projects)
- A net metering rule (see Basic Energy Definitions) for crediting eligible renewable energy generators (solar, wind or hydro)

- A streamlined certification process for small projects (under 50 MW) by the State Corporation Commission

A popular method of supporting renewable energy development has been the establishment of Renewable Portfolio Standards (RPS) which target a certain percentage of power to be procured from renewable energy sources. There are currently 22 states plus Washington DC that have mandates or voluntary targets. Notable state RPS programs include California (20 percent renewables by 2017), Hawaii (20 percent by 2020), New York (24 percent by 2013), Massachusetts (4 percent by 2009), Minnesota (19 percent by 2015), and Pennsylvania (18 percent by 2020). A map showing states with renewable portfolio standards is shown in Figure 4.

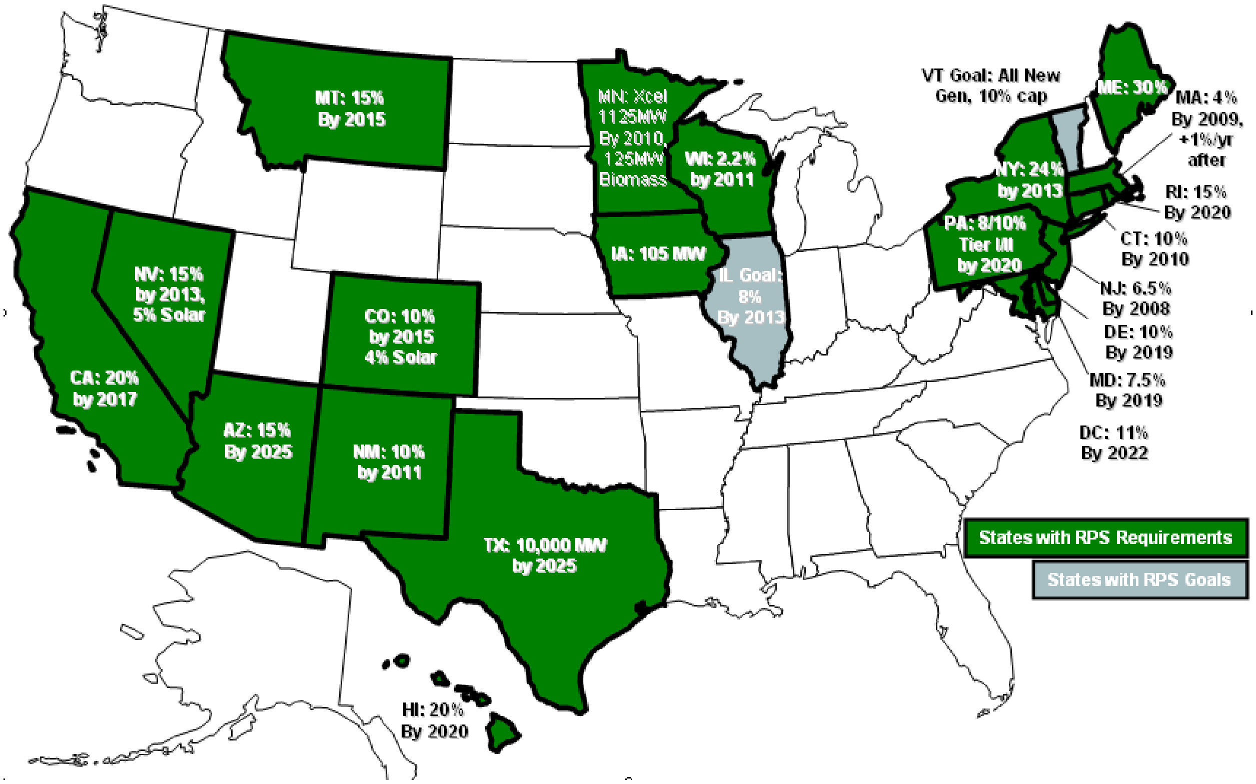


Figure 4: States with Renewable Portfolio Standards

It is worth noting that the participation of Virginia's utilities in the regional transmission organization known as PJM expands access to renewable generated power for both renewable generators and customers seeking "green energy." A number of the PJM states have RPS legislation in place. A recent development is the availability of the Generation Attributes Tracking System (GATS) launched by PJM. According to PJM, these certificates enable states to monitor compliance with green power requirements, track environmental and emissions attributes for electric generation in the PJM Interconnection region, and help renewable generators obtain additional value for their renewable resources. The certificates can be sold to energy suppliers who must comply with state renewable portfolio standards, thus capturing the additional value of renewable generation. GATS provides the states with a single regional, integrated system to document and track generation attributes.[4]

Other incentives or benefits briefly discussed by Sovacool and Hirsh include:

- **CO_2 neutral.** Renewable energy sources generally either do not produce carbon dioxide or, as in the case of biomass combustion, release only as much carbon dioxide as the biomass absorbed during growth.
- **Less polluting.** Renewable energy use can reduce pollution from electricity generation. Sources such as wind and solar energy do not produce emissions in power generation.
- **Sustainability.** Renewable energy sources have long-term sustainability, as opposed to fossil energy sources which will eventually be exhausted.
- **Immune to fuel price volatility.** Renewable energy is a local resource not imported from other states or countries. It is generally immune to rising fuel prices and fuel price volatility (particularly solar and wind). However, biomass is subject to fuel price fluctuations.

Countering the various incentives for renewable energy development, the report includes a long list of possible impediments. General impediments to renewable technologies include:

- **Variability of policy.** Federal policy regarding renewable energy has shifted frequently, creating uncertainty for investors and often resulting in boom and bust patterns of renewable energy development.
- **Perceived inability to provide base-load and peaking power.** Because renewable technologies such as solar and wind power rely on variable and uncontrollable sources for energy affected by the weather, they are generally viewed as inappropriate for base-load or peaking generation.
- **Public knowledge and opinion on power.** People generally oppose the construction of new power plants or transmission lines, not understanding that they are needed. Additionally, power generation has been traditionally carried out at large centralized power plants, and the impression is that this is the best way to generate electricity.
- **Decentralized generation.** Most renewable technologies cannot support such large, centralized generation facilities, and their development and deployment tends to bring generation closer to people’s homes, giving the impression that the renewable energy systems are more intrusive and damaging to property values than traditional systems. The controversy surrounding the Highland Wind Farm proposal in Virginia is a good example.

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[4] PJM Interconnection, “PJM EIS Creates First Environmental Certificates For Electric Generation,**”** October 17, 2005, news release available at: http://www.pjm.com/contributions/news-releases/2005/20051017-pjm-eis-creates-first-enviromental-certificate.pdf.

- **Site-specific design.** Renewable plants must be designed to meet specific site resources and conditions. Therefore, renewable systems are perceived as being more difficult and expensive to develop than traditional generation systems.

Technology-specific impediments include:

- **Onshore wind.** Intermittency of electrical generation, higher upfront costs, and environmental concerns such as avian and bat fatalities.
- **Offshore wind.** Cost and effects on marine life, ocean flows, increased vessel collisions and interference with military operations are the main concerns. The technology is still in early commercialization, with no utility offshore wind installations in the U.S. yet.
- **Solar PV.** High cost is the most significant impediment to the deployment of photovoltaic systems. Concerns about intermittency and land intensity also exist.
- **Biomass.** Biomass plants must burn more fuel than comparably-sized fossil plants due to the lower energy content per unit than fossil fuels. The low energy density of biomass increases transportation, storage, and processing costs. Biomass plants also release some pollutants. The fuel supply must be low-cost and sustainable on a long-term basis for a biomass plant to be viable.
- **Large hydro.** Concerns with large hydroelectric generation are possible disruption of supply due to drought and the environmental issues associated with large hydroelectric dams and reservoirs.
- **Small hydro.** Exhaustive licensing requirements, water supply issues, and possible effects on stream flow and fish populations are the dominant impediments to small hydro development.
- **Ocean.** Tidal and ocean current technologies have not reached commercial status.

ECONOMIC IMPACTS OF RENEWABLE ENERGY DEVELOPMENT IN VIRGINIA

A report on the economic impacts of renewable energy in Virginia was prepared by Stephen Aultman and Jeffrey Alwang of Virginia Tech, and can be found in Appendix D. The report discusses the renewable energy resources in Virginia and the potential direct, indirect, induced, and tax-related economic impacts of renewable energy projects in the state. It also discusses the impacts and feasibility of growing switchgrass as an energy crop to replace tobacco production in rural Virginia.

The economic impacts of a power generation project can be divided into the construction and operation periods. During both phases, there are direct as well as indirect economic impacts. Direct economic impacts are the funds directly spent by a project in the region on materials, equipment, and wages. Indirect economic impacts include employment created by purchases from vendors and multiplier impacts in the regional economy. The following economic metrics can be used to measure the direct and indirect economic impact of investment in renewable energy generators:

- **Gross State Output:** The total value of goods and services produced in the state
- **Earnings:** The value of wages and benefits earned by workers in the region
- **Employment:** Full and part-time jobs
- **Fiscal:** Impact on tax receipts by the state and local governments

The Aultman and Alwang study focused on the economic feasibility and economic impacts of investments in solar PV, wind, and biomass fuel supply infrastructure. The study concluded that utility investment in solar PV generation is not economically feasible given current wholesale electric prices. Additionally, the study concluded that even with net metering and retail electric rates, solar PV is not an economically viable alternative. However, investment in solar PV, as with any other industry, would cause commensurate increases to gross state output, earnings, and employment. The magnitude of these effects was not quantified.

Wind generation is considered to be economically feasible given the current status of the technology and available federal incentives. The Aultman and Alwang study identified at least 150 MW of wind energy potential from projects developed in the state within the next three years. The study estimated that the capital cost for these projects would be about $1,300/kW, of which about $800/kW is equipment. Several economic benefits of investment in a typical 150 MW wind energy project were identified and include:

- Direct economic impact of equipment purchases from in-state manufacturers; some wind energy components are produced at a GE manufacturing plant near Roanoke.
- 125 short-term direct construction jobs and 80 to 100 short-term indirect jobs could be created during construction.
- 25 direct long-term jobs and 12 to 25 indirect long-term jobs could be created to operate and maintain the plants.
- $2.2 million in annual direct earnings and between $1.1 million and $2.2 million in indirect earnings from the long-term operation of the plant.
- Net present value of $6.8 million in local property tax revenues

The Aultman and Alwang study also analyzed the potential effects on Virginia's agriculture industry of using switchgrass as a boiler fuel. This group concluded that while the precise impacts to employment and earnings are difficult to predict, the cultivation of switchgrass could lead to increased incomes in the farm and transportation sectors. However, there are several barriers to the large-scale adoption of switchgrass including:

- **Transportation.** As harvested, switchgrass is relatively wet and bulky, which makes transportation of any significant distance prohibitively expensive. An alternative is to collect switchgrass from several farms and process the switchgrass in a cubing plant before long-distance shipment. This added processing, however, adds significant cost to the biomass fuel.

- **Energy Density**. The current price for Central Appalachian coal is about $60 per ton compared to an estimated cost to produce switchgrass of $60 per ton. However, on an energy equivalent basis, Central Appalachian coal would have to cost about $165 per ton for switchgrass to be price competitive (including handling and transportation).
- **Limited Experience.** While switchgrass has been considered as a boiler fuel by many universities and research institutions, utilities have yet to utilize switchgrass on a long-term basis.

Despite these barriers, there are advantages to co-firing switchgrass at existing coal-fueled power stations including improved environmental performance, fuel diversity, renewable energy generation and support for the local community. As the cost of coal increases, or these other attributes gain value (eg, emissions allowances), co-firing switchgrass with coal will become more attractive. Not all coal-fired power stations, however, can easily handle biomass (or waste material) co-firing. Large scale pulverized coal (PC) units are not designed for such fuels and even where they can be used, environmental permits would have to be revisited. This is another area that will require more study, including consideration of the actual types of equipment in use in Virginia to determine compatibility with co-firing, operating efficiency and energy output.

Because of limitations in scope and available information, the study by Aultman and Alwang detailed only a few specific examples of economic impacts. It is, therefore, difficult to draw generalized conclusions based on this limited information. Most importantly, the economic impacts must be compared against fossil fuel development to determine if renewables provide greater or fewer relative benefits. To provide a complete analysis of the economic impacts of renewable energy would require:

- A detailed projection of the amount and timing of each type of renewable energy that would be developed
- A corresponding forecast for the amount of conventional fuels that would be developed in the absence of renewables
- An assessment of what percentage of the goods and services required for these projects would be sourced in Virginia (as opposed to buying imported solar panels or natural gas, for example)
- An assessment of the industry-specific multiplier impacts for each portion of a total project’s cost, and
- A projection of impacts on electricity rates based on the cost of generating an equivalent amount of energy from renewable or conventional resources.

Such a detailed investigation was clearly beyond the scope of this project, but some insights can be gained from a similar study Black & Veatch recently performed in Pennsylvania.

Black & Veatch conducted an analysis of the economic impacts of investments in renewable energy in Pennsylvania arising from the proposed Advanced Energy Portfolio Standard (AEPS).[5] This law has since been enacted in the state. Figure 5 shows the employment impact per MW of installed capacity for the advanced generation technologies (including renewables) and conventional fossil fuel alternatives. The figure shows that renewable technologies could generate significantly greater employment per installed MW than natural gas fueled combined cycle or simple cycle plants. However, on a per MW basis, the coal-fueled generation technologies (waste coal and pulverized coal) generate greater impacts per installed MW. This is because of coal mining within the state and the multiplier impact of purchases from that industry. However, an important note is that renewable energy technologies generally produce less energy output per installed MW, therefore more MW of renewable energy will need to be installed to produce the same amount of energy as fossil fueled technologies. For this reason, the cumulative impacts of renewable energy installations can be greater than for the fossil-fueled plants.

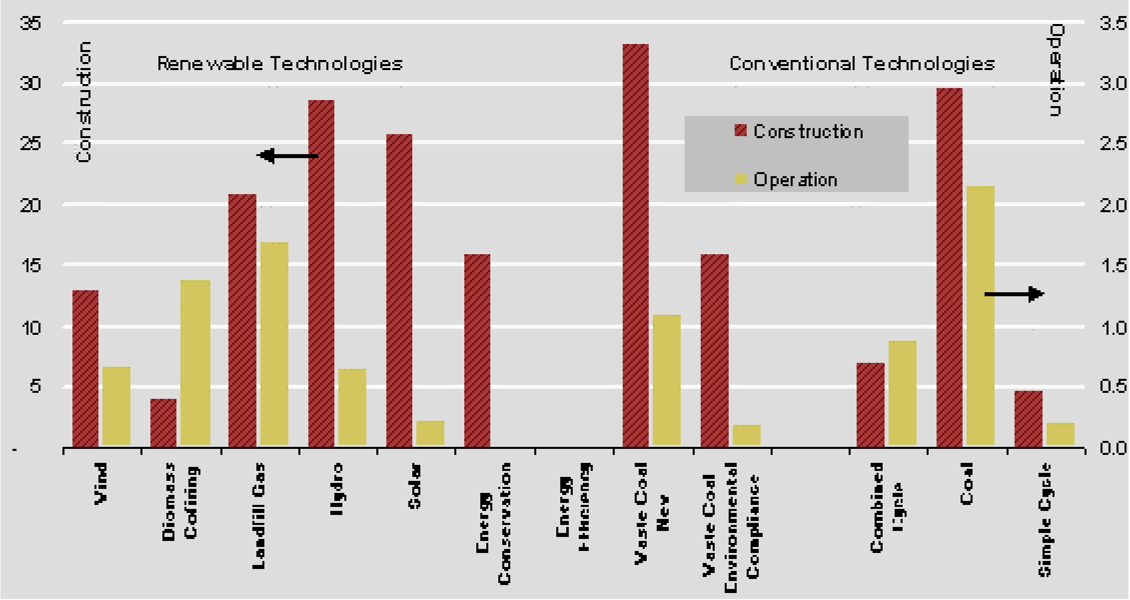

Figure 5: Employment Impacts (job-years) per Installed MW of Generation Capacity in PA

These results and comments are not directly applicable to Virginia because they are based upon Pennsylvania's specific renewable resources and the interrelationships of industries in the Pennsylvania economy, both of which will be different for Virginia. Rather, this analysis provides insight into the relative differences between technologies and the magnitude of possible economic impacts. A detailed resource assessment and complete regional multiplier analysis would be required for Virginia to determine the expected economic impacts for the state.

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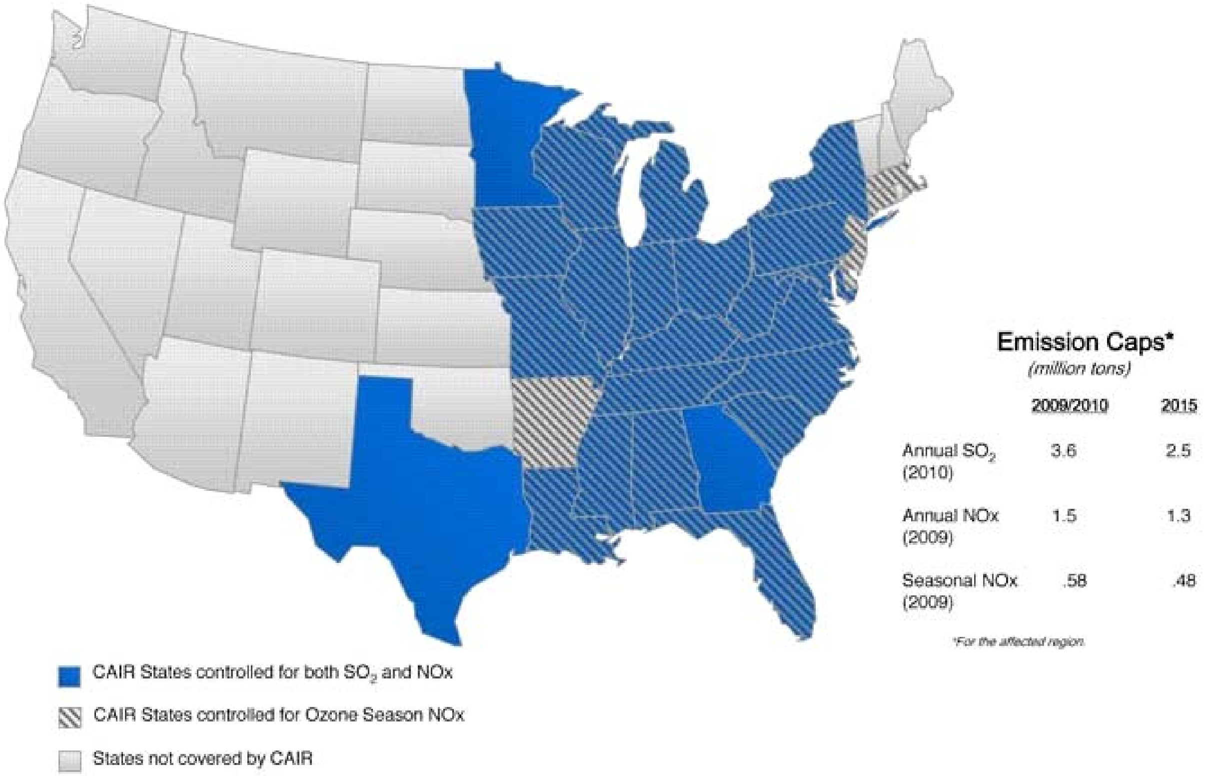
[5] Black & Veatch, "Economic Impact of Renewable Energy in Pennsylvania", 2004, available at: http://www.bv.com/energy/eec/renewPennStudy.htm.

ENVIRONMENTAL COMPLIANCE COSTS

It has been asserted that deployment of renewables can significantly reduce the cost of compliance with the applicable provisions of the Clean Air Act. Virginia is currently participating in the EPA NO_X SIP Call and Acid Rain Programs to control the amount of NO_X and SO_2 emitted by electric generators and large utility boilers. These programs currently cap the amount of seasonal NO_X and annual SO_2 emissions at 3.2 million tons per year and 9 million tons per year, respectively. To comply with the emissions cap, utilities are required to hold allowances (or credits) for each ton of each pollutant emitted per year. Power plants throughout the states affected by the SIP Call were allocated pollutant allowances based on state emissions caps and historic plant performance. When a plant emits more than their annual allocation of allowances, either pollution control equipment can be installed to reduce emissions or allowances must be purchased from other plants that have an excess of allowances.

Additional NO_X and SO_2 emissions reductions will be required under the recently enacted Clean Air Interstate Rule (CAIR) issued by EPA in March 2005. CAIR was officially promulgated to address interstate transport of precursor emissions that significantly contribute to downwind non-attainment areas for the new 8-hour and $PM_{2.5}$ national ambient air quality standards. EPA structured the rule to compel regulation of emissions from electric generating units (EGUs) and encourage participation in an interstate cap-and-trade market. To accomplish this, CAIR establishes permanent reduction caps to be implemented in two phases in certain states as shown in Figure 6 and Table 5 below.



Emission Caps*

(million tons)

	2009/2010	2015
Annual SO_2 (2010)	3.6	2.5
Annual NOx (2009)	1.5	1.3
Seasonal NOx (2009)	.58	.48

*For the affected region.

Figure 6: CAIR Affected Region and Emission Caps

Table 5: CAIR Emission Caps and Reductions

	2009	2010	2015
SO_2 Annual		3.6 million tons (45% reduction)	2.5 million tons (73% reduction)
NO_X Annual	1.5 million tons (53% reduction)		1.3 million tons (61% reduction)
NO_X Seasonal	0.58 million tons		0.48 million tons

Notes: Reductions from 2003 levels in affected states

CAIR establishes annual SO_2 and annual and seasonal NO_X emission “budgets” for each affected state, which then can choose the sources to regulate, as well as whether to mandate controls or allow participation in EPA’s model cap-and-trade program. Under CAIR, the EPA is encouraging states to uniformly adopt their model cap-and-trade program to regulate EGUs. States that chose to participate in the proposed interstate cap-and-trade program will also decide how to allocate allowances from their respective budgets. A significant decision to be made by states will be the amount of allowances that may be set-aside for new generators or as incentive programs. For example, the Ad Hoc Committee created to advise on implementation of CAIR in Virginia has proposed to allocate a portion of the set-aside to renewable generators as an incentive. Ultimately, states must set forth measures for achieving compliance with the emission budgets in State Implementation Plans (SIPs) to be submitted to the EPA for approval.

The deployment of renewable energy generation in Virginia could decrease the cost of complying with CAIR to the extent that coal-fueled generation is reduced or retired as a result of the new equivalent renewable energy capacity, assuming that the new renewable energy capacity generates electricity at similar cost to the retired generators. Under the CAIR program, each state is allocated a budget based on the installation of cost-effective emissions-control technology at coal-fueled generators. If some of the coal-fueled generation fleet is retired due to the installation of renewables, those emissions allowances would still be allocated to the utilities who own the retired coal-fueled plants under the EPA’s model cap-and-trade program. The allowances could then be sold on the open market or used at other operating facilities to offset the cost of emissions control upgrade projects. Alternatively, if new renewable generation capacity offsets lower-emitting natural gas-fueled generation or if the renewable generators provide power at significantly higher cost than the retired coal-fueled generators, there could be a net increase in compliance cost. A comprehensive market study examining specific compliance options for utilities in Virginia and local government strategies for complying with National Ambient Air Quality Standards would be necessary to determine the net impacts

CONCLUSIONS AND RECOMMENDATIONS

The objective of this report was to provide an initial assessment of the current status and potential for renewable energy development in Virginia, evaluate development costs, and explore incentives and impediments to development. NREL estimates that there is significant potential for renewable energy development in excess of 15,000 MW, based on resources available in Virginia. This estimate does not take into consideration the economic viability of developing these resources. Black & Veatch estimates that, of this renewable potential, approximately 930 MW could be economically developed in the near-term (5-15 years). The analysis of development and energy production costs revealed that hydro, biomass co-firing, wind and landfill gas are currently cost-competitive with fossil-fueled alternatives, under the incentives presently available. The participation of Virginia's utilities in PJM allows access to multi-state sources and markets for renewable energy. The recently established GATS certificates enable implementation of renewable portfolio standards and allow state agencies to track generation attributes. There are many incentives and impediments to the large-scale deployment of renewable generators. The most significant incentive is the federal production tax credit and the most significant impediments are the intermittent nature of renewable generation and the uncertainty due to variability of renewable energy policies.

While this report provides an initial broad perspective of the potential for the renewable energy industry in Virginia, significant work is still needed to more accurately characterize the development potential and most prudent incentive strategy for the state. A detailed resource assessment, development costs estimate, and economic impacts analysis would provide valuable information to lawmakers, utilities and community stakeholders.

APPENDIX A

VIRGINIA RENEWABLE ENERGY RESOURCES AND COSTS

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INTRODUCTION

At the request of the VA Department of Mines, Minerals and Energy, Division of Energy and the Virginia Center for Coal and Energy Research at Virginia Tech, NREL has prepared a brief assessment of renewable resources in Virginia 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.

EXISTING RENEWABLE ENERGY CAPACITY AND GENERATION

Table 1 presents 2002 renewable energy capacity and generation data for Virginia from NREL and the Department of Energy's Energy Information Administration (EIA).[1] EIA reports 583 MW of non-hydro renewable energy capacity, including 168 MW of landfill gas and municipal solid waste generation and 415 MW of wood or waste wood-fired plants. EIA reports 757 MW of conventional hydro and a total of 3,086 MW of hydro, when pumped storage is included. 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 536 MW of non-hydro renewable energy capacity as of 2002, including 300 MW of wood or wood waste-fired facilities, 235 MW of landfill gas generation or other municipal solid waste facilities, 0.2 MW of photovoltaics, and 0.01 MW of wind generation capacity. REPIS reports 3087 MW of hydro including pumped hydro units. Of this, 247 MW are projects that are less than 30 MW in size, which is a common definition for small hydro.

Table 1: Virginia Renewable Energy Capacity and Generation[1,2]

	Capacity				Generation	
	REPIS 2002 MW	**REPIS % of Total Capacity**	**EIA 2002 MW**	**EIA % of Total Capacity**	**EIA 2002 MWh**	**EIA % of Total Generation**
MSW/Landfill Gas	235.1	1.2%	168	0.8%	1,106,144	1.5%
Conventional Hydro	NA	NA	757	3.8%	868,216	1.2%
Total Hydro (incl. Pumped Storage)	3,087	15.3%	3,086	15.3%	NA	NA
Photovoltaic	0.22	<1%	NA	NA	NA	NA
Wind	0.01	<1%	NA	NA	NA	NA
Wood/Wood Waste	300.8	1.5	415	2.1%	1,412,051	1.9%
Total	**3,623**	**17.9%**	**3669**	**18.2%**	**3,386,411**	**4.5%**
Non-hydro Total	**536.1**	**2.7%**	**583**	**2.9%**	**2,518,195**	**3.4%**

[1] EIA reports total Virginia capacity of 20,205 MW and total generation of 75,005,651 MWh.
[2] REPIS reports nameplate capacity, whereas EIA reports net summer capacity. REPIS does not report generation.

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[1] 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.

In addition, the U.S. Environmental Protection Agency's (EPA) Landfill Methane Outreach Program reports that Virginia currently has nine operational landfill gas electric generating facilities with a combined capacity of 31.8 MW. EPA also reports that there are seven direct-use facilities that do not provide electricity to the grid.[2]

According to the Virginia State Corporation Commission, there are 103 kW of solar photovoltaics installed under net metering tariffs in Virginia, as of July 2005.[3]

RENEWABLE ENERGY RESOURCES IN VIRGINIA

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 in 2002 with available surface data by NREL and wind meteorological consultants. The wind resource data has 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.[4] The Virginia wind resource map with transmission lines overlaid is presented in Attachment 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 Virginia.

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[2] Rachel Goldstein, EPA Landfill Methane Outreach Program, July 21, 2005, email correspondence. Two of the 14 landfills that have landfill gas to energy facilities in place have both direct use and electricity generation projects in place.

[3] K. Gravely, Virginia State Corporation Commission, July 25, 2005, email correspondence. Information was not available for all utilities.

[4] 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 protected 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 summarizes the results of our assessment of onshore wind resource availability (in square kilometers) with consideration of distance to transmission. Table 4 presents the technical potential wind energy generation capacity, assuming 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 7 wind resources in Virginia located within 20 miles of transmission could support about 625 MW of wind energy capacity. If Class 3 resources are included, about 1,375 MW of wind capacity could be supported within 20 miles of transmission.

Table 3: Wind Resource Land Area by Distance to Transmission (Onshore Only)

Distance to Transmission	Class 3 Area (km^2)	Class 4 Area (km^2)	Class 5 Area (km^2)	Class 6 Area (km^2)	Class 7 Area (km^2)
0 - 5 miles	60.5	28.9	15.9	14.7	3.4
5 - 10 miles	49.3	18.8	7.9	5.7	1.6
10 - 20 miles	39.9	12.1	4.7	7.0	4.3
> 20 miles	96.1	20.6	0.3	0.2	0.0
Total	245.8	80.4	28.7	27.7	9.3

Table 4: 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)	Class 7 Area (MW)	Total
0 - 5 miles	302.6	144.5	79.4	73.3	17.0	616.8
5 - 10 miles	246.6	93.9	39.4	28.6	8.2	416.7
10 - 20 miles	199.4	60.6	23.4	35.2	21.4	340.0
> 20 miles	480.4	103.0	1.3	1.2	0.1	586.0
Total	1,229.0	402.0	143.5	138.3	46.7	1959.5

Virginia has considerable potential offshore wind resources, using the same methodologies described above. Table 5 presents the wind resource area and potential generating capacity for offshore resources within 5, 10 and 20 miles of transmission. Virginia's Class 5 and Class 6 offshore wind resources have the technical potential to collectively support a total of about 32,000 MW of wind energy generating capacity and about 1,300 MW of capacity within 20 miles of transmission. Note that costs are higher for the development of offshore wind resources than onshore resources.

Table 5: Wind Energy Resource and Generation Potential by Distance to Transmission for Offshore Resources

Distance to Transmission	Class 4 Area (km^2)	Class 5 Area (km^2)	Class 6 Area (km^2)	Class 4 Area (MW)	Class 5 Area (MW)	Class 6 Area (MW)
0 - 5 miles	0.0	0.0	0.0	0.0	0.0	0.0
5 - 10 miles	49.0	25.7	0.0	245.0	128.4	0.0
10 - 20 miles	211.0	164.1	93.7	1,055.2	820.7	468.7
> 20 miles	74.2	928.3	5,212.5	371.2	4,641.3	26,062.4
Total	334.3	1,118.1	5,306.2	1,671.3	5,590.4	26,531.1

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 drops from about 1960 MW to 910 MW. The potential offshore wind capacity drops even further. The analysis shows that there are adequate Class 6 or Class 7 offshore wind resources to support nearly 2,900 MW of wind energy capacity (Table 6).

Table 6: Potential Wind Energy Capacity Assuming 20% Availability of Existing Transmission Lines (MW)

	Class 3	Class 4	Class 5	Class 6	Class 7	Total
On-shore	180.2	402.0	143.5	138.3	46.7	910.7
Off-shore	0	0	0	2861.9	0.4	2862.3
Total	180.2	402.0	143.9	3000.2	46.7	3773.0

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 2,000 MW of onshore wind generation in an approximately 20,000 MW system should be manageable and result in ancillary costs similar to those experienced in other regions. However, the addition of large amounts of offshore wind energy capacity could result in integration challenges or high ancillary costs.

Biomass Resources

According to the U.S. EPA Landfill Gas Methane Outreach Program, there are 15 landfills in Virginia that are candidates for electric generation (Table7).[5] 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. Collectively the 15 candidate landfills in Virginia represent about 24 MW of potential generating capacity. In addition, EPA reports another 19 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, Virginia's landfills could support a total of about 30 MW of electric generating capacity.

Table 7: Virginia Landfills with Potential for Electricity Generation

	Number of Landfills	Estimated Capacity
Candidate Landfills	15	24 MW
Potential Landfills	19	5.7 MW
Total Landfills w/o LFGE Projects	34	29.7 MW

Source: Goldstein, R. EPA Landfill Methane Outreach Program.

Additional information on biomass resources in Virginia is available from the National Renewable Energy Laboratory's biomass resource assessment, which is based on county-level data from the U.S. Department of Agriculture and other sources (Table 8). A detailed description of the data sources is provided in Attachment B. Table 8 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, forest residues

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[5] U.S. EPA Landfill Methane Operating Program, Energy Projects and Candidate Landfills http://www.epa.gov/lmop/proj/index.htm#1.

present the largest opportunity for electricity production, with a potential to support more than 500 MW of electric generating capacity. In addition, urban wood, mill, and crop residues could support up about 225 MW. Again this represents the technical potential and does not take into consideration the economic viability of using these resources for electricity generation. Virginia-specific research on biomass resource availability and usage would be useful for refining these estimates.

Table 8: Biomass Residues in Virginia

Resource	Available Resource (dry metric tons)	MWh/year	MW*
Urban Wood Residues	812,853	1,259,021	179.7
Unutilized Mill Residues	65,546	101,524	14.5
Forest Residues	2,403,375	3,722,567	531.2
Crop Residues	167,370	229,969	32.8
Animal Manure (methane)	23,284	97,137	12.3
Total		5,313,080	758.1

Source: NREL. *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%. Crop residues have been reduced to one-third of those reported in the NREL database to account for the potential for water erosion.

Solar Resources

Virginia has moderate solar resources relative to other parts of the United States (Figure 1). We estimate the technical potential for rooftop PV in Virginia based on a recent study by Navigant Consulting for The Energy Foundation, which builds on several earlier PV market studies that have been performed by Arthur D. Little for NREL and DOE.[6]

The studies estimate available roof space for PV by adjusting floor space data from the U.S. EIA's 2001 Residential Energy Consumption Survey and the 1999 Commercial Buildings Energy Consumption Survey for number of floors and other considerations such as structural compatibility for PV, shading, and orientation. Navigant assumes that 22% of residential roof area and 65% of commercial roof space will be available for PV. Table 9 provides estimates of total rooftop availability on residential and commercial buildings in Virginia, which has been adjusted to estimate the current totals in year 2005.

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[6] Building-Integrated Photovoltaics (BI-PV)—Analysis and US Market Potential, Prepared by Arthur D. Little, Inc. for the U.S. Department of Energy Office of Building Technologies, NREL/TP-472-7850, DE95004055, February 1995.
Electric Power Annual 2003. U.S. Energy Information Administration, DOE/EIA-0348(2003), December 2004.
PV Grid Connected Market Potential in 2010 under a Cost Breakthrough Scenario Prepared by Navigant Consulting for The Energy Foundation, March 2005.

Table 9: Estimated Rooftop Area Available for PV in 2005 (million square feet)

State	Residential Total	Commercial Total	State Total
Virginia	876	619	1,495

Rooftop area is 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 ~.81.[7]

Table 10 provides an estimate for the total capacity of PV systems installed on available rooftops in Virginia. The capacity of commercial buildings is provided based both on flat orientation and tilted orientation. Tilted orientation increases PV performance by optimizing energy production, but reduces the area available due to shading effects. It is assumed that tilted orientation decreases available install area by 25%.

Table 10: Estimated Available PV Capacity (Peak MW_{AC})
With Commercial PV Either Flat or Tilted (Year 2005 Estimates)

State	PV Capacity (Peak MW_{AC})				
	Residential Total	Commercial Total (flat orientation)	Commercial Total (tilted)	State Total (Commercial blds w/Flat Orientation)	State Total (Commercial blds w/Tilted Orientation)
Virginia	7,617	5,387	4,040	13,006	11,659

By applying typical solar PV capacity factors, the total technical energy potential of PV on rooftops can be estimated. The capacity factors were derived by using NREL's PVWatts PV simulation program[8] and based on an average of the largest population centers. Table 11 provides total potential annual PV energy production and compares this value with the total annual energy consumption.

Table 11: Estimated Technical Potential for Rooftop PV Energy Production in 2005

State	Representative Cities	Typical PV Capacity Factor (Based on AC Rating)	Annual Potential from PV on Rooftops (TWh)	Estimated Electricity Demand in 2005 (TWh)	Potential Fraction of Total Electricity from PV in 2005 (%)
Virginia	Sterling, Richmond, Norfolk, Roanoke	15-19%	16.8-19.4	101.5	16-19

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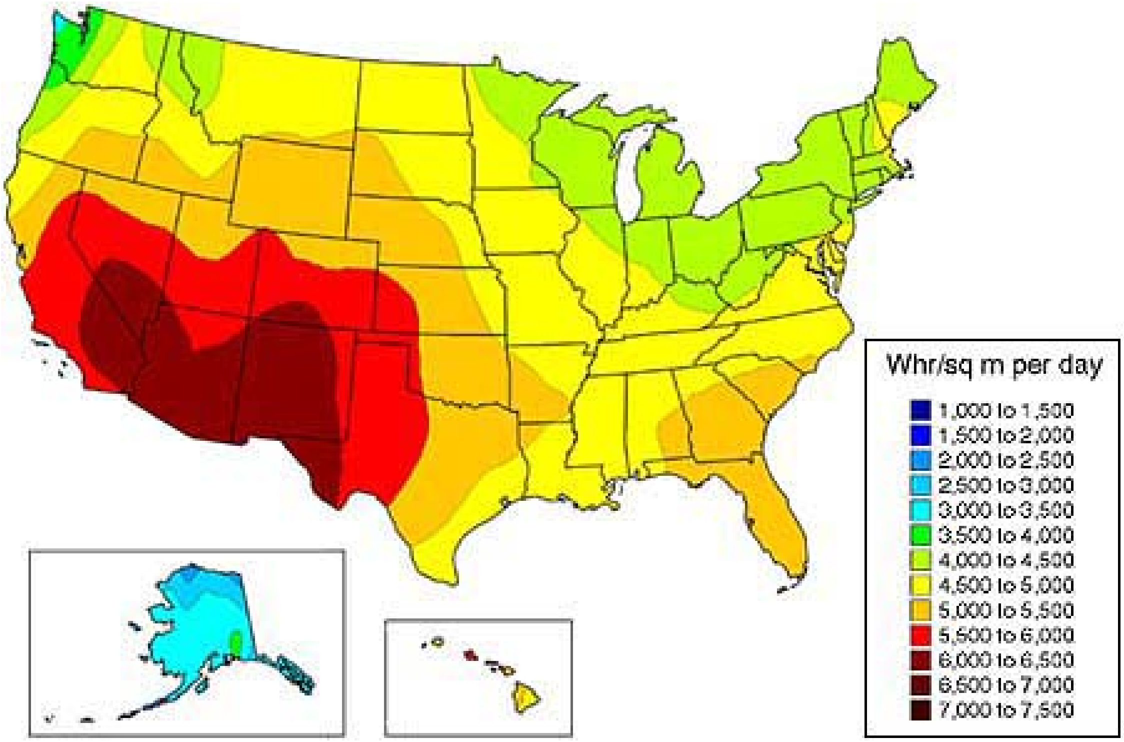
[7] This assumption is used in the Navigant study and is consistent with default assumptions used in NREL's PV Watts model http://rredc.nrel.gov/solar/calculators/PVWATTS/system.html.

[8] http://rredc.nrel.gov/solar/codes_algs/PVWATTS/version1

These estimates indicate that existing rooftop space could provide about 16-19% of the electricity demand of Virginia. 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. This estimate does not include the potential application of PV to industrial buildings, parking lot awnings, or other non-occupied structures.

The Navigant study estimated the technical potential for PV in Virginia by 2010 to be 16,542 MWp, including 9,666 MWp of residential system capacity and 6,875 MWp of commercial systems[9]. The study also estimated potential demand by residential and commercial customers in Virginia under various scenarios of system costs by 2010. It found that total demand in Virginia for grid connected systems (both residential and commercial) would be 9 MW at installed system costs of $4.26-$6.30, 14 MW at system costs of $3.00-$3.76, 22 MW at system costs of $2.00-$2.60, and 167 MW at system costs of $1.00-$1.26.



Solar resource for a flat-plate collector

Source: NREL

Figure 1: Map of Solar Resources for Flat Plate Collectors in the United States

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[9] Chaudhari, M., L. Frantzis, and T. Hoff. “PV Grid Connected Market Potential in 2010 Under a Cost Breakthrough Scenario.” Report prepared for the Energy Foundation, September 2004.

Thus, Virginia has ample solar technical potential; however, economics or policies will determine actual PV adoption rates. PV system costs are a function of module, inverter, and other balance of system costs. In addition, the ability to develop infrastructure within the state to support installation, maintenance, and the distribution of systems, will impact system costs.

LEVELIZED COST OF RENEWABLE TECHNOLOGIES FOR ELECTRICITY GENERATION

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[10].

Technology-specific cost and performance assumptions used to calculate levelized costs are sourced primarily from the Energy Information Administration (EIA) 2005 Annual Energy Outlook (AEO). Table 12 displays the AEO cost assumptions. The capacity factors used for biomass and landfill gas represent AEO expected national averages for 2005. 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 $1.58 to $1.71 (constant 2005 $/MBTU).

Table 12: AEO 2005 Cost Assumptions

	Renewable Technology					
	Biomass	MSW - Landfill Gas	Geo-thermal	Wind	Solar, Thermal	Solar, PV
Plant Capital Cost (including contingency) (2005 $/kW)	1842	1571	3254	1187	3099	4678
Fixed O&M Cost (2005 $/kW-yr)	49.40	105.82	109.92	28.07	52.59	10.83
Variable O&M Cost (2005 $/kWh)	0.00310	0.00001	0.00000	0.00000	0.00000	0.00000

Federal level credits are applied as follows (assuming incentives included 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: $.019/kWh for wind (10 years duration), $.009/kWh for biomass and municipal solid waste (both 10 years duration).[11]

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[10] 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.

[11] The production tax credit cannot be applied to investments for which the investment tax credit is taken.

No other technology-specific credits or incentives are assumed, including those available through the state.

The following additional assumptions are made for all technologies:

- 25-year system life
- 5-year accelerated depreciation with half-year convention (MACRS)
- Discounting via a nominal weighted cost of capital of 9.7% (based on 55%/45% split of debt/equity financing with 6.5%/16.7% nominal returns). The corresponding real weighted cost of capital is 7.2%
- Current costs and capacity factors (no cost and performance improvements over time)
- Inflation rate of 2.5%/yr
- Federal corporate tax rate of 35%
- Virginia state corporate tax rate of 6%
- 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 are not included
- Fixed and variables costs associated with electricity distribution and transmission are not included.

Table 13 identifies the LCOE, in 2005 $/kWh associated with several renewable technologies used for electricity generation for a range of capacity factors.[12] Nominal and real (inflation-adjusted) forms of levelized costs are included both with and without the federal production tax credit (PTC). Federal credits applied are appropriate after the enactment of the Energy Policy Act of 2005.

Table 13: Levelized Cost of Energy by Capacity Factor (2005 $/kWh)
(Credits After Energy Policy Act of 2005)

		Renewable Technology									
		Biomass		**MSW - Landfill Gas**		**Wind**		**Solar, PV (ITC 10%)**		**Solar, PV (ITC 30%)**	
		No PTC	PTC	No PTC	PTC	No PTC	PTC	No PTC	PTC	No PTC 1	PTC
Low	Capacity Factor - Low	83.0%		90.0%		30.0%		14.0%		14.0%	
	Nominal LCOE ($/kWh)	0.074	0.063	0.049	0.038	0.087	0.064	0.569	NA	0.434	NA
	Real LCOE ($/kWh)	0.059	0.050	0.039	0.030	0.069	0.050	0.443	NA	0.336	NA
Mid	Capacity Factor - Mid	83.0%		90.0%		35.0%		17.0%		17.0%	
	Nominal LCOE ($/kWh)	0.074	0.063	0.049	0.038	0.075	0.051	0.468	NA	0.358	NA
	Real LCOE ($/kWh)	0.059	0.050	0.039	0.030	0.059	0.040	0.365	NA	0.277	NA
High	Capacity Factor - High	83.0%		90.0%		44.0%		20.0%		20.0%	
	Nominal LCOE ($/kWh)	0.074	0.063	0.049	0.038	0.060	0.036	0.398	NA	0.304	NA
	Real LCOE ($/kWh)	0.059	0.050	0.039	0.030	0.047	0.028	0.310	NA	0.235	NA

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[12] 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 14 summarizes major Virginia state incentive programs currently in place for renewable technologies for electricity generation.[13]

Table 14: Virginia State Incentive Programs for Renewable Technologies

Solar Manufacturing Incentive Grant Program (SMIG)	Photovoltaics	Industry Recruitment	Commercial and industrial producers of photovoltaic panels	$4.5 million per year program-wide, at a rate of up to $0.75 per watt of panel sales, with a maximum of 6 MW	Perhaps the most widely publicized industrial recruitment program in the renewable energy industry. New manufacturers are eligible to receive annual incentive grants for six years. Expires at end of 2007.
Virginia Small Wind Incentives Program (VSWIP)	Small Wind	Grant	Commercial, Industrial, Residential, Nonprofit, Schools, Agricultural, Institutional	$10,000 or 33% of installed costs	Goal is to bridge the economic gap between energy derived from small wind turbines and that generated by conventional resources by providing support for up to 10 projects in two review periods (2004, 2005).
Local Option Property Tax Exemption for Solar	Solar (broadly defined)	Property Tax Exemption	Commercial, Industrial, Residential	Varies (local option)	Any Virginia county, city or town can exempt or partially exempt solar energy equipment, broadly defined as any "application which would otherwise require a conventional source of energy," from local property taxes. Twenty-one entities offered an exemption as of December 2004.
TVA - Green Power Switch Generation Partners Program	Small Wind, Photovoltaics (500W - 50 kW)	Production Incentive	Commercial, Residential	$500 (residential only) plus $0.15/kWh (residential/small-commercial) or $0.20/kWh (commercial) for 10 years	TVA purchases the entire output of a qualifying system through a participating power distributor; consumer receives a credit for the power generated.

Source: Database of State Incentives for Renewable Energy (DSIRE)

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[13] The information in Table 14 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). Available at http://www.dsireusa.org/

SUMMARY

Virginia has significant untapped renewable energy resources. To date, there is about 580 MW of operational non-hydro renewable energy capacity in Virginia. Virginia has the technical potential to develop from 13,000 MW to 45,000 MW of renewable energy generating capacity (Table 15). 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, Virginia has the technical potential to develop about 900 to 2,000 MW of onshore wind resources. In addition, Virginia has significant offshore wind resources. Specifically, Class 5 and Class 6 offshore wind resources, which are typically required for offshore utility scale projects, total about 31,000 MW, with about 1,400 MW of within 20 miles of transmission. Further, our analysis shows that about 2,900 MW of offshore wind energy capacity could be developed assuming 20% availability of transmission lines. Forest residues could potentially support about 500 MW of electric generation, while urban wood residues, mill residues, crop residues, and landfill gas could support about another 250 MW. Finally, Virginia could support perhaps 11,000 MW to 13,000 MW of solar electric generation on existing rooftops.

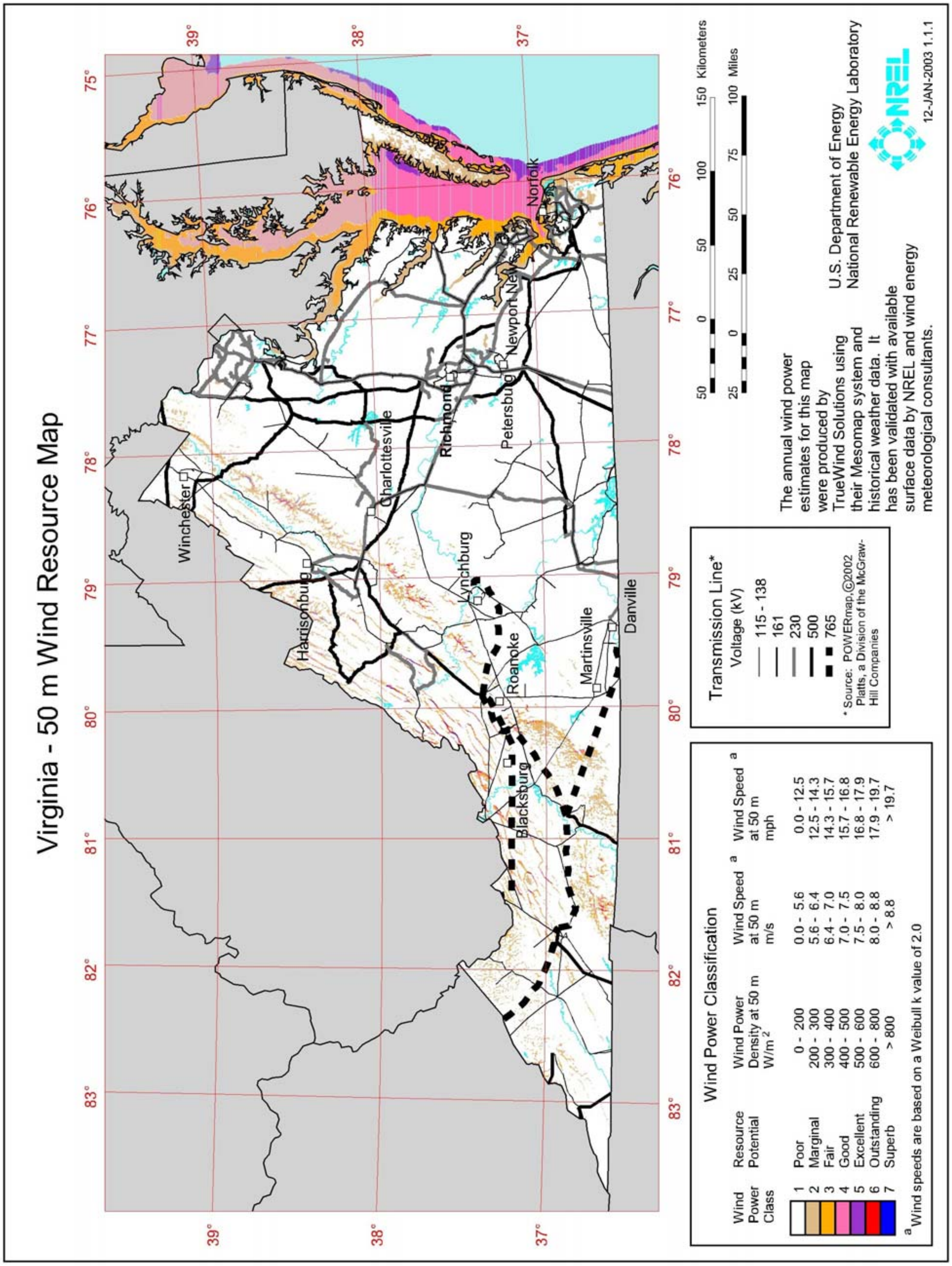
Table 15 also summarizes data on the capital and levelized costs of renewable energy generation facilities. Wind and landfill gas generating facilities are among the most economic, followed by biomass. In light of resource availability and cost, Virginia has the greatest potential to develop wind and biomass resources. While landfill gas generators are among the lowest cost renewables, there are limited resources to develop in Virginia. Finally, there is ample solar resource to support significant levels of PV, but at a higher cost than the other renewables.

Table 15: Summary of Virginia Renewable Resource Potential and Costs

Technology	2002 Installed Virginia	Virginia Technical Potential MW	Capacity Factor	Capital Cost $/kW	Real LCOE $/MWh	Virginia Potential
Wind	0.01	2,000-32,000	30-44%	1187	28-69	Good
Solar PV	0.22	11,000-13,000	14-20%	4678	235-336	Moderate
Biomass (direct)	415	750	83%	1842	50-59	Good
MSW/Landfill gas	168*	30	90%	1571	30-39	Limited

* May include municipal solid waste combustion. All other data presented here is for landfill gas generation facilities.

ATTACHMENT A: MAP OF VIRGINIA WIND RESOURCES AND TRANSMISSION LINES



ATTACHMENT B: NREL BIOMASS RESOURCE ASSESSMENT DATA SOURCES

Urban Wood Residues – This analysis includes wood residues from MSW (wood chips and pallets), utility tree trimming and/or private tree companies, and construction and demolition sites. Source: U.S. Census Bureau, 2000 Population data; Biocycle magazine: State of Garbage in America, January 2004; County Business Patterns 2002.

Unutilized Mill Residues – Primary mill residues include wood materials (coarse and fine) and bark generated at manufacturing plants (primary wood-using mills) when round wood products are processed into primary wood products, like slabs, edgings, trimmings, sawdust, veneer clippings and cores, and pulp screenings. This category identifies mill residues not being used for any byproduct, and includes mill residues burned as waste or landfilled. Source: USDA, Forest Service’s Timber Product Output database, 2002.

Forest Residues–Forest residues are logging residues and other removable material left after carrying out silviculture operations and site conversions. Logging residue comprises unused portions of trees, cut or killed by logging and left in the woods. Other removable materials are the unutilized volume of trees cut or killed during logging operations. Source: USDA, Forest Service’s Timber Product Output database, 2002

Crop Residues –The following crops were included in this analysis: corn, wheat, soybeans, cotton, sorghum, barley, oats, rice, rye, canola, dry edible beans, dry edible peas, peanuts, potatoes, safflower, sunflower, sugarcane, and flaxseed. The quantities of crop residues that can be available in each county are estimated using total grain production, crop to residue ratio, moisture content, and taking into consideration the amount of residue left on the field for soil protection, grazing, and other agricultural activities. Source: USDA, National Agricultural Statistics Service, 2002 data.

Manure – Methane emissions from animal manure in metric tons. The following animal types were included in this analysis: diary cows, beef cows, hogs and pigs, sheep, chickens and layers, broilers, and turkey. The methane emissions were calculated by animal type and manure management system. Source: USDA, National Agricultural Statistics Service, 2002 data.

APPENDIX B

ELECTRICITY GENERATION COSTS AND MEASURES

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Virginia Polytechnic Institute and State University

October 28, 2005

INTRODUCTION

The objective of this report is to characterize the cost of generating electricity with renewable energy resources relative to conventional fossil fueled alternatives. This report will present an estimate of the cost of generating electricity with existing resources through a brief analysis of the PJM wholesale electric market. Estimates of the cost of generating electricity with new renewable and conventional generation resources are also provided based on publicly available information sources, NREL experience and Black & Veatch experience.

COST OF ELECTRICITY WITH EXISTING RESOURCES

Existing electric generators in Virginia are able to sell power on the PJM wholesale electric market, which serves electric service territories throughout Pennsylvania, New Jersey, Delaware, Maryland, West Virginia, Virginia, Ohio, and Illinois. Each electric generator connected to PJM “bids” into the electric market on an hourly basis an electric price and is dispatched in ascending order according to bid price. All generators dispatched are then paid the price of the highest cost generator dispatched for that hour. Assuming that generators typically bid their cost to generate, the market price is equal to the production cost of the last plant dispatched. Generally, during off-peak hours (after 10:00 pm and before 6:00 am), coal generation is on the margin. Whereas natural gas fueled generation with higher marginal production costs are typically on the margin during peak hours during the middle of the day and evening. Figure 1 shows the annual average PJM market price by hour for 2004. The annual average price for 2004 was about $48 per MWh.

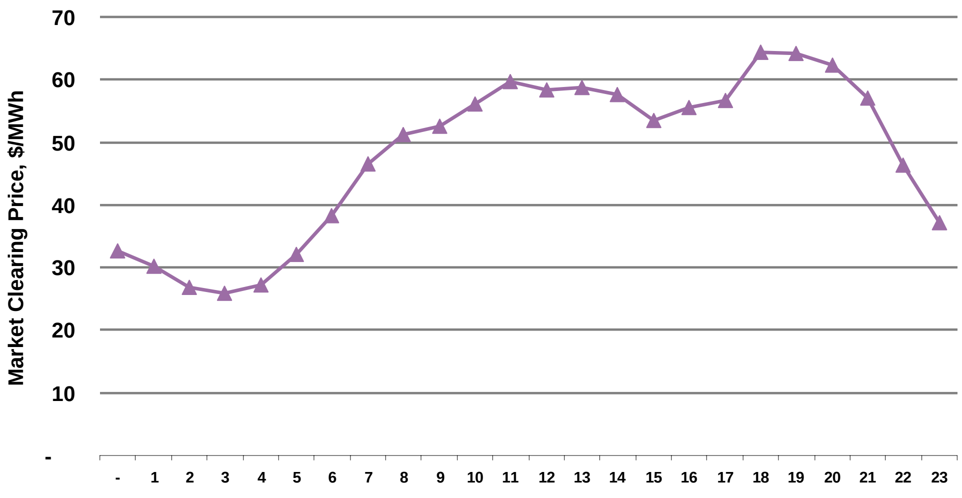

Figure 1: Hourly PJM Electric Market Prices

The analysis of the PJM wholesale electric market shows that the cost of generating electricity with existing resources is primarily driven by the marginal production cost (variable operations and fuel expenses). Figure 2 shows the marginal cost (excluding capital costs) of generating power with each of the installed generators in Virginia by technology and fuel. The figure shows that hydro is currently the least-cost generation resource in the state on a marginal cost basis. Coal and Nuclear plants that also generally provide base load electric service generate at a slightly higher cost. Some biomass plants also generate electricity at similar cost to coal-fueled generators. Natural gas fueled combined cycle and simple cycle combustion turbine plants that provide electricity only during peak demand hours have the highest marginal production cost. Landfill gas fueled power stations generate power at a similar cost to these plants. There is currently no installed wind energy capacity in Virginia.

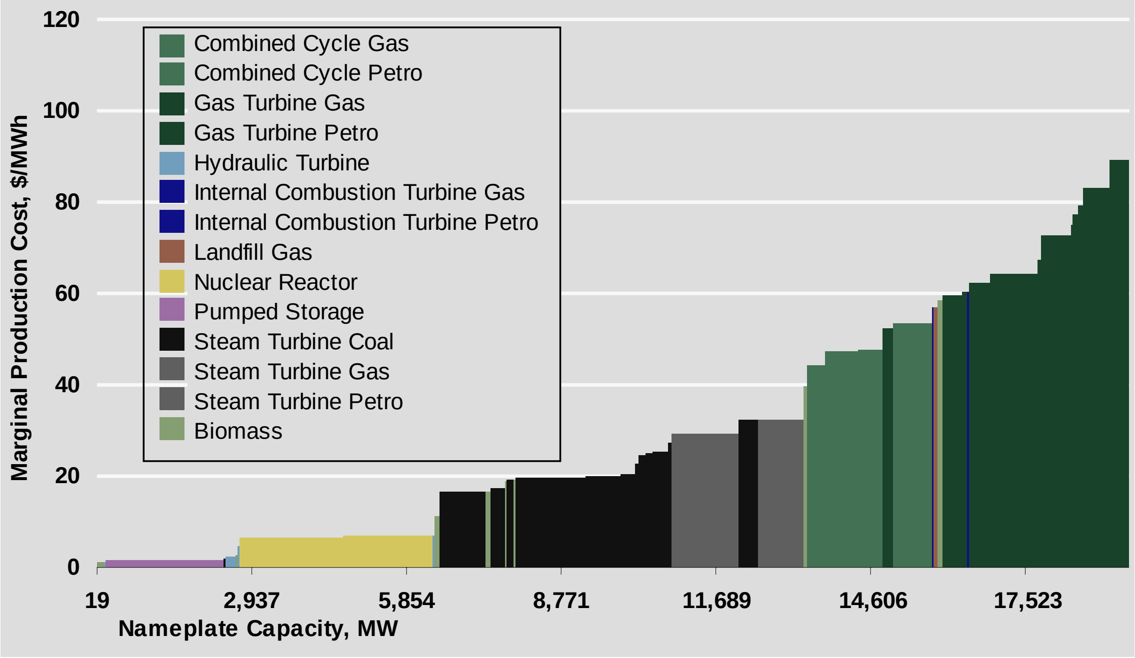

Figure 2: Virginia Generation Supply Curve

COST OF ELECTRICITY WITH NEW RESOURCES

While the cost of generating electricity with existing resources is driven primarily by the marginal production cost, an assessment of the cost of electricity from new generation resources must consider the capital investment in those resources. Therefore, the levelized cost of energy (LCOE) is the most appropriate measure of the cost of generating electricity with new resources. The LCOE is a present value measure of the lifecycle cost of generating power from a given technology considering the capital cost, operating costs (including fuel), performance, financing cost, and incentives. The LCOE is a useful calculation because it allows comparison of different generation technologies with different operating profiles on an equal basis.

The National Renewable Energy Laboratory (NREL) provided LCOE estimates based on performance and cost assumptions from the Department of Energy (DOE) Energy Information Administration (EIA) Annual Energy Outlook (AEO) 2005. 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 U.S. value. A consistent set of financial and economic assumptions were used by NREL to calculate the LCOE with each renewable and fossil fueled generation technology and are provided in Table 1. The following additional assumptions were also made for all technologies:

- 25-year system life
- Accelerated depreciation with half-year convention (Modified Accelerated Cost Recovery System [MACRS])
- Discounting via a nominal weighted cost of capital of 9.7% (based on 55%/45% split of debt/equity financing with 6.5%/16.7% nominal returns). The corresponding real weighted cost of capital is 7.0%
- Inflation rate of 2.5%/yr
- Federal corporate tax rate of 35% and Virginia state corporate tax rate of 6%
- 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 cost of electric interconnection is not included

Table 1: Financial Assumptions

Technology	Tax Life - MACRS (yr) [1]	Investment Tax Credit (%) [2]	Production Tax Credit ($/MWh,yr) [3]
Renewable Resources			
Biomass	5	NA	9, 10
Landfill Gas	5	NA	9, 10
Wind	5	NA	19, 10
Solar PV	5	30%	19, 10
Conventional Proven Resources			
Scrubbed Coal	20	NA	NA
Integrated Gasification Combined Cycle (IGCC)	20	10%	NA
Conventional Gas/Oil Combined Cycle (Conv Gas/Oil CC)	15	NA	NA
Conventional Combustion Turbine (Conv. Combust. Turbine)	15	NA	NA
Advanced Resources			
IGCC with Carbon Sequestration (IGCC with CS)	20	10%	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
Advanced Combustion Turbine (Adv. Combust. Turbine)	15	NA	NA
Advanced Nuclear (Adv. Nuclear)	15	NA	18, 8

Notes [1] Based on interpretation of IRS guidelines

[2] 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).
- The 30% ITC is available for Solar PV through 12/31/2007. The permanent ITC is 10%.

[3] Consistent with amounts specified under Energy Policy Act of 2005.

The LCOE estimates developed by NREL for renewable and fossil fueled generation resources are summarized in Table 2. Nominal and real (inflation-adjusted) forms of LCOE are included with the federal tax credits. Federal credits applied are consistent with those defined in the Energy Policy Act of 2005. NREL developed LCOE for different capacity factors (low, mid and high), however only the mid-range is shown in Table 2. The data indicates that with currently-available incentives, wind, landfill gas and biomass are competitive with conventional and advanced-fossil fueled technologies on an LCOE basis.

Table 2: Development Cost and Levelized Cost for Renewable, Fossil and Nuclear Technologies

Technology	Capital Cost, $/kW	Fixed O&M, $/kW-yr	Variable O&M, $/MWh	Capacity Factor	Nominal LCOE (¢/kWh)	Real LCOE (¢/kWh)
Renewable Technologies						
Biomass	1,842	49.40	3.10	83%	6.3	5.0
Landfill Gas	1,571	105.82	0.01	90%	3.8	3.0
Wind	1,187	28.07	--	35%	5.1	4.0
Solar PV	4,678	10.83	--	17%	35.8	27.7
Conventional Proven Technologies						
Scrubbed Coal	1270	25.51	4.25	70%	6.6	5.1
IGCC	1468	35.82	2.70	80%	6.1	4.7
Gas/Oil Combined Cycle (CC)	594	11.56	1.92	45%	7.8	6.2
Combustion Turbine	414	11.22	3.31	4%	32.6	25.4
Advanced Technologies						
Adv. Nuclear	2049	62.88	0.46	92%	4.5	3.5
Adv. Gas/Oil CC	584	10.84	1.85	45%	7.5	5.9
IGCC with Carbon Capture	2100	42.15	4.11	80%	8.1	6.4
Adv. Gas/Oil CC with Carbon Capture	1166	18.43	2.72	45%	11.7	9.2
Adv. Combustion Turbine	392	9.75	2.93	4%	29.8	23.3

Source: NREL / EIA
* IGCC - Integrated Gasification Combined Cycle

The AEO 2005 capital cost estimates are exclusive of major project indirect costs including interest during construction and owner's costs (engineering, project management, etc.). Therefore, Black & Veatch has provided a range of nominal LCOE estimates for each technology to reflect these indirect costs and the inherent variability in project capital cost,Figure 3. The nominal LCOE estimates provided by NREL are also included on this figure.

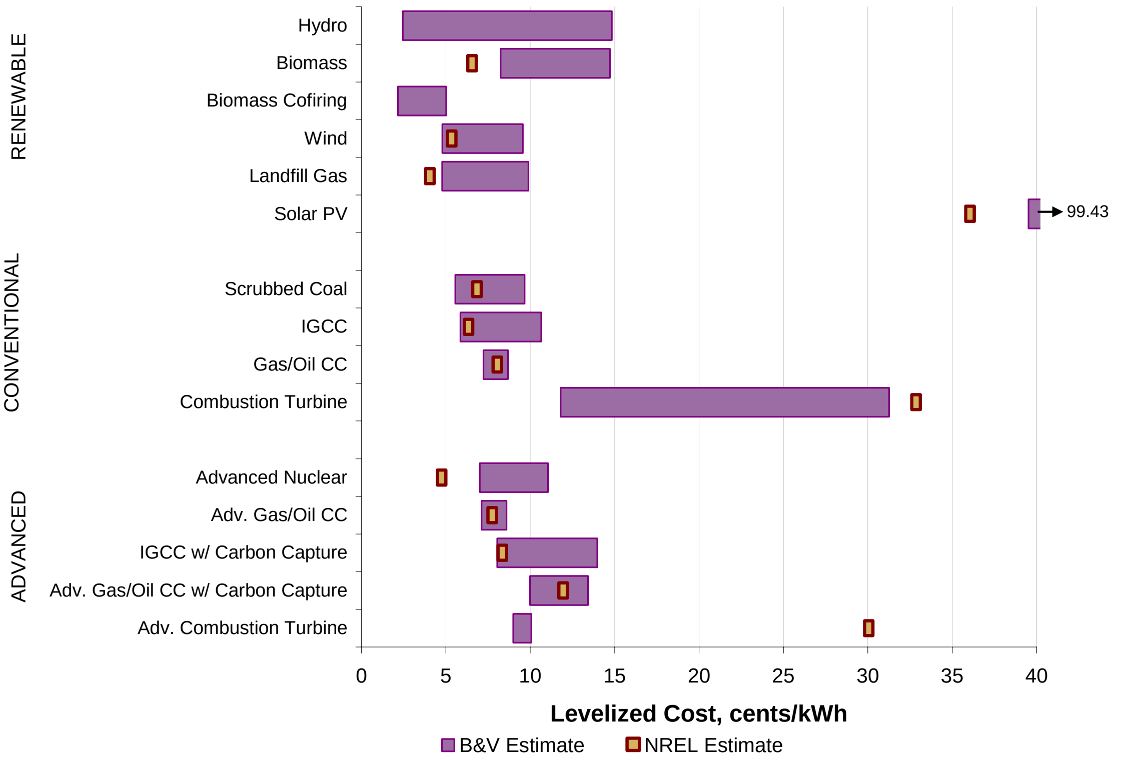

Figure 3: Renewable and Conventional Generation Nominal LCOE Estimates

This analysis of the cost of generating renewable energy demonstrated that renewable energy can be generated at a cost competitive with conventional fossil fueled generators on marginal production cost and LCOE bases. Although the cost of generating power from renewable resources can vary significantly by location, hydro, biomass, wind, and landfill gas are generally the least-cost options for generating renewable energy. Further, more detailed study of the available renewable energy resources and the cost of developing projects in Virginia would be required to more accurately assess the cost of generating renewable energy in Virginia.

APPENDIX C

INCENTIVES AND IMPEDIMENTS TO RENEWABLE ENERGY SYSTEMS IN VIRGINIA

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October 12, 2005
Revised January 16, 2006

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INTRODUCTION

This report investigates incentives and impediments to renewable energy technologies in Virginia. Though federal and state governments offer a variety of incentives, a large number of impediments have made renewable energy technologies unattractive to entrepreneurs and individuals in the Commonwealth. Nevertheless, the identification of these impediments can be useful as the first step in their elimination, since renewable energy technologies offer several benefits that often rise above traditional economic analyses.

Sources of Information

In identifying incentives and impediments to renewable energy, the authors collected a vast amount of information—including data on 35 different incentives and 117 impediments. They examined government reports, policy briefs, law journals and academic journals in addition to performing interviews and correspondence with more than thirty experts working for the Department of Energy, Oak Ridge National Laboratory, National Renewable Energy Laboratory, Energy Information Administration, Virginia Department of Environmental Quality and Virginia Tech's Consortium on Energy Restructuring.

Limitations of Study

Although the authors examined an abundance of data and analyses, this report should not be considered definitive or comprehensive. For one thing, experts do not agree on the impacts of existing and prospective incentives for and impediments to implementation of renewable energy technologies. Given the short amount of time and limited resources allotted for this study, the authors clearly could not do as much as they would have liked. Moreover, the report only briefly examines the incentives offered for renewable energy technologies in the recently signed Energy Policy Act of 2005. Due to its length, the new law will require significant time for us (and others) to analyze thoroughly. Despite these caveats, we believe the report highlights major incentives and impediments—all of which should be the source of further discussion and policy analysis.

Excluded Topics

While the report briefly describes some incentives that have been effective in other states, such as the renewable portfolio standard and public benefit funds, it omits discussion of others. For example, pollution prevention tax credits or a state carbon tax—both relatively novel policy suggestions—are not addressed in this report.

This document also excludes an evaluation of the incentives and impediments facing large-scale geothermal plants and ocean thermal energy conversion (OTEC) because the state of Virginia has virtually no geothermal or OTEC resources. Geothermal electric potential is highly dependent on rock porosity, permeability, subterranean reservoir temperature and geomorphic pressure. An electrical-grade hydrothermal system is one that can generate electricity by means of driving a turbine with geothermal fluids. At present, only high- and moderate-temperature systems have been used to generate power and they are located primarily near plate-boundary zones, none of which exist in Virginia.[2]

OTEC systems harness the temperature of the ocean to generate power (rather than using the movement of the tides as the energy source). These systems work by pumping ocean water at different depths—and thus at different temperatures—at a rapid rate, using the change in temperature to power a turbine. The physical factors of thermal resource and seafloor bathymetry (where the temperature difference between the warmer "top" part of the ocean and colder "bottom" part is greater than 20 degrees Celsius) greatly restrict the number of desirable sites among global shorelines. As a result, operational OTEC plants would be confined to equatorial and tropical waters.[3] This fact makes the possibility of an OTEC plant providing electricity near Virginia impractical.

In analyzing other renewable technologies, the study did not distinguish between utility-owned and nonutility-owned generation, nor between grid connected or stand alone power (even though the impediments for these different types of renewable energy may differ slightly).

The report also does not explicitly address the advantages of renewable energy systems, of which there are many. They generally have fewer negative environmental and human health consequences than their coal-, natural gas-fired and nuclear counterparts because they emit few or no pollutants and typically need no fuel to run. (Exceptions include biomass and landfill-methane systems, which use renewable fuel and which create some emissions.) Renewable energy technologies can therefore minimize dependence on foreign sources of fuel and help diversify the portfolio of energy resources used to make electricity.[4] Moreover, many renewable systems constitute modular technologies and can be sized at almost any capacity (or stacked to achieve large capacities).[5] Many renewable technologies can also be used in conjunction with other energy systems—such as fuel cells or micro-turbines—to create hybrid applications that maximize efficiency and extend the life-cycle of operation.[6]

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[2] Duffield and Sass 2003, p. 11-12.

[3] Vega, L. A. (2003). "Ocean Thermal Energy Conversion Primer." *Marine Technology Society Journal* 6(4): Winter, pp. 23-35.

[4] For concise summaries of these environmental benefits, see Union of Concerned Scientists. (2004). "Clean Energy: The Renewable Electricity Standard," May 20, 2005, retrieved from http://www.ucsusa.org/clean_energy/renewable_energy/page.cfm?pageID=46; Sawin, Janet. (2004). Mainstreaming Renewable Energy in the 21st Century. Washington, DC: Worldwatch Institute.

[5] For an excellent summary of the modular advantages of these technologies, see Lovins, Amory et al. (2002). Small is Profitable: The Hidden Benefits of Making Electrical Resources the Right Size. Snowmass, CO: Rocky Mountain Institute.

[6] For a brief summation of these advantages, see Marilyn Brown et al, "Solutions Towards a Climate Friendly Built Environment," Oak Ridge National Laboratory Report, June, 2005; Garman, David. (2001). "National Energy Policy: Conservation and Energy Efficiency." Hearing Before the Subcommittee on Energy and Air Quality of the House Committee on Energy and Commerce, June 22. Washington, DC: Government Printing Office; United States Department of Energy. (2002). "Homeland Security: Safeguarding America's Future With Energy Efficiency and Renewable Energy Technologies." Tenth Annual Report of the State Energy Advisory Board. August. Washington, DC: Department of Energy (Available: http://steab.org/docs/STEAB_Report_2002.pdf); Interlaboratory Working Group on Energy-Efficient and Clean Energy Technologies, Scenarios for a Clean Energy Future, (Oak Ridge National Laboratory and Lawrence Berkeley National Laboratory, 2000); and National Commission on Energy Policy, Ending the Energy Stalemate: A Bipartisan Strategy to Meet America's Energy Challenges, December, 2004.

Additionally, because renewable energy technologies usually produce power in small increments, they offer some advantages of other modular technologies known collectively as "distributed generation" (DG). Providing increased reliability to the transmission grid when set up appropriately, these DG technologies reduce peak-time demand and congestion on the network, viewed as a cause of the 2003 blackout in the Northeast and Midwest. Moreover, by constructing many localized power generation plants rather than a few large-scale generators distantly located from load centers, DG can help defer costly transmission upgrades and expansions. Perhaps most significant in the post-September 11, 2001 era, DG technologies can be used to improve the grid's security. Because of their dispersed nature, DG technologies are not as attractive to terrorists as nuclear plants, natural gas refineries and large transmission facilities, since decentralized power plants may help insulate parts of the grid from failure if a large component is brought down. Advocates of DG clearly realize that small-scale, distributed generation technologies will not replace the existing transmission-grid and centralized power plant system currently in place. However, they argue that the DG approach can offer several benefits to customers who have critical needs (such as certain types of businesses, government agencies, hospitals, educational institutions, etc.). Again, while these potential advantages are considerable, they remain outside the scope of this study.

Moreover, this work excludes a discussion of solar hot-water systems, biomass used for heat and motor fuels, underground energy sources for heat pumps and below-surface water employed for cooling. Rather, the study focuses on renewable energy technologies that yield electricity as a primary product.

External Costs and Benefits

Finally, this report does not explicitly address the nature of external costs and benefits. Defined as costs and benefits resulting from an activity that do not accrue to the parties involved in the activity,[7] externalities have won attention in recent decades as a way to make equitable choices of generation equipment. Put differently, externalities consist of costs and benefits not borne by the parties of an economic transaction. By omitting discussion of these costs and benefits, policy makers may create an uneven playing field for cost comparisons. In fact, some analysts believe the lack of consideration of such costs and benefits may be the greatest impediment to employing renewable energy systems in Virginia (and elsewhere) and constitute an implicit and significant subsidy to fossil and nuclear energy systems.

When dealing with electricity pricing, externalities often include the costs to individuals whose health is impaired by pollution (in excess of regulated costs); the value of impaired (or improved) viewscapes; and the impact on employment patterns and tax payments. They also subsume the impacts of smog, nutrient deposition, acid rain and global climate change on agriculture, forestry, fisheries, recreation, water resources and wildlife; as well as the cost to government to deploy military forces to secure energy resources. On a different note, some analysts consider the positive effects of economic development resulting from the deployment of

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[7] Paraphrase of definition in John Carlin, "Environmental Externalities in Electric Power Markets: Acid Rain, Urban Ozone, and Climate Change," U.S. Energy Information Administration, at http://www.eia.doe.gov/cneaf/pubs_html/rea/feature1.html, taken from NARUC, Environmental Externalities and Electric Utility Regulation (Washington, DC: NARUC, 1993), p. 3.

renewable (and nonrenewable energy) technologies to be an externality (though, in this case, a benefit). Because some of these external factors remain difficult to quantify, many economists and policy makers simply exclude discussion of them. By doing so, however, they make it impossible to perform valid comparisons between the costs of producing power from various generation technologies. Instead, policy makers often retain distorted notions of the costs of electricity and usually favor the use of traditional fossil-fuel generation technologies. This situation occurs despite efforts of the Department of Energy,[8] the National Association of Regulatory Utility Commissioners and others to educate policymakers.

Traditional electricity generation technologies typically appear to have cost advantages over those that use the wind, sun, or water as fuels. Fossil-fuel generation technologies have benefited from incremental improvements over a century and have taken advantage of economies of scale, mass production and huge government subsidies. For example, the Federal Government has developed large programs for a variety of fossil fuel subsidies in the form of direct financial transfer (grants), preferential tax treatment (tax credits, exemptions and rebates), trade restrictions (quotas) and direct investment in energy infrastructure, research and development.[9] Collectively, the United States has promoted these types of subsidies for fossil fuel and nuclear industries by spending more than $500 billion from 1955-2005.[10] From 2004-2008, the United States Tax Code will contain $10.2 billion in tax breaks alone for fossil fuels.[11]

Renewable energy technologies, which have been pursued most aggressively since the 1970s, have also benefited from policy incentives (as noted in this report), but they have been largely disadvantaged by the general neglect of consideration of externalities. In one recent study, traditional coal boiler generation technology appeared to produce relatively cheap power—under 5 cents per kWh over the life of the equipment, which included capital, operating and maintenance and fuel costs—while wind-turbine generators and biomass plants produced power that cost 7.4 cents per kWh and 8.9 cents per kWh respectively. But when analysts factored in a host of externality costs, coal boiler technology costs rose to almost 17 cents per kWh, while wind turbines and biomass plants yielded power costing around 10 cents per kWh.[12] Reflecting the view of many economists and policy makers, the authors of that study noted that overlooked externality costs impede "efforts to develop optimal electricity resources."[13]

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[8] For example, a DOE report noted: "DOE has increasingly recognized that the lack of accurate and consistent (across fuel types) information on external costs distorts Federal energy research decisions and PUC decisions about emission control technologies." John Carlin, "Environmental Externalities in Electric Power Markets: Acid Rain, Urban Ozone, and Climate Change," DOE EIA, 2002, at http://www.eia.doe.gov/cneaf/pubs_html/rea/feature1.html, obtained 13 May 2005.

[9] United Nations Environment Programme, Energy Subsidies: Lessons Learned in Assessing their Impact and Designing Policy Reforms (Geneva: United Nations Foundation, 2004) p. 22.

[10] See Navin Nayak, Redirecting America's Energy: The Economic and Consumer Benefits of Clean Energy Policies (Washington, DC: Public Interest Research Group, February, 2005) p. 1; Gregory Nemet, "The Effectiveness of Energy Research and Development in the U.S." Presentation at the American Association for the Advancement of Science, April 24, p. 6.

[11] Robert Costanza,."Does Wind Energy Make Economic Sense," The Times Argus Online, April 3, 2004, www.timesargus.com/opinion/story/81553.html.

[12] Ian F. Roth and Lawrence L. Ambs, "Incorporating Externalities into a Full Cost Approach to Electric Power Generation Life-cycle Costing," Energy 29 (2004): 2125-44.

[13] Ibid., p. 2142. Also see Anthony D. Owen, "Environmental Externalities, Market Distortions and the Economics of Renewable Energy Technologies," Energy Journal 25 (1 June 2004): 127-56.

Because this report excludes an analysis of externalities in Virginia, policy makers should be cautious when making conclusions based on cost data in other parts of this study. The listed costs reflect the relatively easy-to-calculate costs of constructing, maintaining and operating equipment and they include the costs to comply with existing regulations. They also include the price reductions that arise from tax incentives (such as the production tax credits for wind turbine power) that reflect at least some recognition by policy makers of the societal value of renewable resources. However, the costs listed in this study may omit a large number of costs borne by the Commonwealth's citizens (and citizens of other states and countries) that result from the production of electricity using various technologies.[14] Consequently, these data should be used only as a rough guide, with readers aware that they do not fully represent the total price, cost, or value of renewable or fossil energy technologies.

INCENTIVES FOR RENEWABLE ENERGY

Incentives for renewable energy have been implemented in a piecemeal manner by federal and state governments. (Virginia has provided relatively few incentives of its own, as noted below, trailing those of other states.) Like overall energy policy in the United States, legislation dealing with renewable energy has never taken a comprehensive nor integrated perspective. Therefore, the incentives that exist are often the result of special interests of certain parties and policymakers or as unintended consequence of neglected pieces of legislation. The spotty record of incentives can be seen in federal legislation, which has created several incentives that were later rescinded or allowed to expire. Some federal incentives remain, though their on-again/off-again nature has contributed to boom and bust cycles of construction of renewable facilities (especially wind turbines). Furthermore, uncertain or inconsistent incentives, such as ones that may depend on annual reauthorization or appropriation, serve as disincentives to businesses because electrical generation projects—renewable or nonrenewable—generally require several years to plan and implement and depend on predictable long-term cash flow estimates.

General Federal Incentives

Largely as a result of the "energy crisis" of the 1970s, federal and state governments instituted a variety of policies for encouraging renewable energy technologies. Presidents Nixon and Ford hoped that concerted efforts would yield "energy independence," which generally meant the end of reliance on unstable foreign supplies of energy (largely oil). Going beyond rhetoric and some modest legislation, President Carter proposed an aggressive energy policy that included incentives for increased domestic production of energy (including the use of renewables) and energy efficiency. Seriously watered down by Congress, his policy nevertheless provided several valuable incentives for renewables. President Reagan allowed provisions of many of the energy laws to expire, along with them incentives for renewable energy and energy efficiency. Market forces, which he encouraged and the collapse of OPEC discipline, led to more than a decade of relatively low energy prices, which diminished interest in alternative energy technologies. In

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[14] It should be noted that renewable energy technologies also incur external costs. The process of manufacturing solar photovoltaic cells, for example, requires large energy inputs, while wind turbines incur external costs due to restricted land use, visual aesthetics, and objectionable noise. See Roth, "Incorporating externalities."

contrast, the recent rise in energy prices may serve as an incentive to entrepreneurs and homeowners to pursue renewable energy and energy efficiency.

Policies supportive of renewable energy consisted of legislative mandates—one in particular—that enabled novel technologies to be used within the formerly regulated electric utility industry. More commonly, legislation offers financial incentives (such as tax credits) to encourage development and installation of renewable technologies.

Legislative Mandate

The major legislative mandate spurring work on renewable energy technologies consisted of the Public Utility Regulatory Policies Act (PURPA) of 1978 (P.L. 95-617). Passed as one of five diluted measures of President Carter's national energy plan, the law primarily encouraged electric utility companies to reform rate structures so customers would reduce wasteful consumption of power. But one part of the law also had wide-ranging effects on companies and individuals that sought to use nontraditional sources of energy to produce electricity: it required power companies to purchase electricity produced by nonutilities if generated from highly efficient cogeneration plants and from renewable energy facilities.[15] Previously, utilities could decline to purchase such power created by these small-scale, decentralized producers, or they could offer low prices. PURPA, on the other hand, mandated that utilities purchase this power at rates that equaled their own cost of producing electricity.

In some states, regulators set these rates at high levels as a way to encourage production from renewable and cogenerating plants. By doing so, they motivated large research and development efforts on the technology, which contributed to huge declines in the cost of producing power. Largely because of the stimulation of PURPA, for example, entrepreneurs developed small wind turbines (between 0.05 to 0.5 MW) for use in clusters, with the amassed electricity sold to utilities. Costs dropped throughout the 1980s and into the 1990s such that wind turbines now produce larger amounts of power (up to 3 MW per turbine) at costs comparable to fossil fuel (including natural gas) in some parts of the country, and cheaper than other non-hydro renewable resource. Solar cell technologies also saw major improvements under the impetus of PURPA: costs per kWh dropped from about 90 cents in 1980 to about 20 cents in 1995.

The effect of PURPA has been limited by subsequent legislation. While the law remains in force (despite efforts to repeal it by those who believe it encourages expensive and unneeded power), the Energy Policy Act of 1992 has created a new class of independent generators (known as exempt wholesale generators) that sell power into an open wholesale (and sometimes retail) market.[16] Moreover, some states have seriously weakened the incentives offered to generators that took advantage of PURPA's provisions. The Energy Policy Act of 2005 further amended PURPA and limits the ability of some nonutility generators to sell power to the grid.[17]

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[15] The term "cogeneration" is now commonly referred to as combined heat and power (CHP), and refers to any electrical generator that also generates useable heat (or chilling) in addition to electricity.

[16] Much of these paragraphs on PURPA draw on Richard F. Hirsh, Power Loss: *The Origins of Deregulation and Restructuring in the American Electric Utility System* (Cambridge: MIT Press, 1999).

[17] P.L. 109-304, signed 8 August 2005. Section 1253 of the Energy Policy Act of 2005, "Cogeneration and Small Power Production Purchase and Sale Requirements."

Financial Incentives

Many pieces of legislation provided direct and indirect support of renewable resources over the years. For example:

- **Energy Tax Act of 1978** (P.L.95-618). The law offered income tax credits (30 percent of the first $2,000 and 20 percent of the next $8,000) to residential users of solar and wind-powered technologies. Businesses earned a 10 percent tax credit in addition to a 10 percent investment tax credit on solar, wind, geothermal and ocean thermal technologies. Many of the law's credits were allowed to expire between 1982 and 1985, during the Reagan administration.

- **Crude Oil Windfall Profits Tax Act of 1980** (P.L.96-223). Augmenting the terms of the Energy Tax Act of 1978, this legislation boosted the residential tax credit for solar, wind and geothermal energy technologies to 40 percent for the initial $10,000 in costs. Businesses also saw their tax credit for renewable energy technologies grow from 10 to 15 percent, while extending the credits until the end of 1985. Other terms allowed for tax-exempt interest to be paid on industrial development bonds for waste-to-energy, hydroelectric and renewable energy facilities.

- **Economic Recovery Tax Act of 1981** (P.L.97-34). An early piece of legislation during the Reagan administration, this law permitted accelerated depreciation of capital for renewable energy equipment. It also offered a 25 percent tax credit for spending on research and development.

- **Tax Equity and Fiscal Responsibility Act of 1982** (P.L.97-248). This law ended further acceleration in the depreciation formula created by the 1981 Economic Recovery Tax Act.

- **Tax Reform Act of 1986** (P.L.99-514). Though it repealed the 10 percent investment tax credit that benefited investors of renewable (and nonrenewable) energy technologies as well as the tax-free status of some industrial development bonds and other credits, it extended the business tax credits for some renewable technologies. For the first time, renewable energy technologies owned by public utilities could be depreciated on an accelerated basis. However, the business energy tax credit for wind powered systems was not extended; it expired at the end of 1985.

- **Energy Policy Act of 1992** (P.L.102-486). A major piece of legislation that sought to employ market forces to spur energy production and energy efficiency, the Energy Policy Act contained several provisions for renewable energy technologies. It gave a 10 percent business tax credit for purchases of solar and geothermal equipment. Perhaps most importantly, it offered a 10-year production tax credit of 1.5 cents per kWh for wind projects and biomass plants installed before mid-1999. The law also provided some tax credits for business investments in solar and geothermal facilities. The production tax credits were extended by Congress annually until the end of 2003. Congress did not reextend the credit until October 2004, with another expiration set for the end of 2005. (See Energy Policy Act of 2005, below, for more information on the production tax credits.)

- **Tax Relief Extension Act of 1999** (P.L. 106-170). As some of the terms of the Energy Policy Act of 1992 were about to expire, Congress passed this legislation, which extended and modified the production tax credit for wind turbine projects and some biomass facilities. Installations of these facilities needed to be completed before the end of 2001.[18]

- **Energy Policy Act of 2005 (P.L. 109-58).**[19] Passed by Congress after years of debate, the law provides several incentives for renewable energy, partly in return for extensive incentives for fossil and nuclear fuel technologies. Wind power entrepreneurs celebrate the fact that the law extends the production tax credit (at a rate of 1.9 cents per kWh) until the end of 2007.[20] Previously, Congress allowed the tax credit to expire before renewing it. By providing continuity, the boom and bust cycle of investment in wind turbine technology is likely to diminish. The law also requires purchase of power produced by ocean (current, tidal, or wave) technologies.[21] Moreover, the new act provides federal tax credits for solar energy homes. According to the Department of Energy, homeowners and businesses will receive a credit of up to thirty percent of the cost of installing a solar power, solar hot water, or solar thermal system. The solar energy tax credit is capped at $2,000 for each type of system and applies to systems installed during 2006 and 2007.[22] Finally, the energy bill reauthorizes the Energy Savings Performance Contract Program, which allows private contractors to help federal agencies improve the energy efficiency of their facilities by installing more efficient technologies such as renewable energy systems.[23]

Beyond the incentives discussed above that generally subsidized the cost of producing electricity with renewable energy facilities, the federal government established programs that sought to encourage technologies by eliminating market barriers and by offering incentives to create markets for them. These included:

- Residential Energy Conservation Subsidy Exclusion (for businesses)
- Renewable Energy Systems and Energy Efficiency Improvements Program
- Tribal Energy Program Grant

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[18] L Mark Gielecki, Fred Mayes, and Lawrence Prete, “Incentives, Mandates, and Government Programs for Promoting Renewable Energy,” Report to the Energy Information Administration, February, 2001, available at http://www.eia.doe.gov/cneaf/solar.renewables/rea_issues/incent.html)

[19] As of the date of this writing, the Energy Policy Act has not yet been assigned a Public Law number.

[20] American Wind Energy Association news release, “Energy Bill Extends Wind Power Incentive through 2007” 29 July 2005, at http://www.awea.org/news/energy_bill_extends_wind_power_072905.html.

[21] EV World news release, “Energy Bill Recognizes Potential of Ocean Renewable Energy**,”** 1 August 2005, at http://www.evworld.com/view.cfm?section=communique&newsid=9052&url=

[22] Department of Energy, “Net Metering, Tax Credits for Solar Energy Included in Energy Act,” August 9, 2005, available at http://www.eere.energy.gov/news/.

[23] See White House Press Release, “Energy Security for the 21st Century,” August 8, 2005, available at http://www.whitehouse.gov/infocus/energy/.

- Value-Added Producer Grant Program
- Energy Efficient Mortgage
- Energy Star Financing and Mortgages
- Residential Energy Conservation Subsidy Exclusion (Personal)
- Conservation Security Program Production Incentive
- U.S. Department of Energy's Alternative Fuels Data Center
- Federal Government's Green Power Purchasing Goal

Federal Energy Programs

In addition to providing incentives via legislative mandate and tax credits, the United States federal government also manages a number of related energy programs. A recent 2005 Government Accountability Office (GAO) report charged with "identifying major federal energy related energy efforts" and determining "the extent to which resources associated with federal energy-related efforts have changed" found more than 150 energy program activities and 11 tax preferences. The GAO grouped these incentives into eight major energy activity areas: energy supply, energy's impact on environment and health, low income energy consumer assistance, basic energy science research, energy delivery infrastructure, energy conservation, energy assurance and physical security and energy market competition and education. These programs are managed by 18 federal agencies, including the Department of Energy, Department of Agriculture and Department of Health and Human Services.[24] Incentives that directly affect renewable energy come from two of these areas: energy supply and basic energy science research.

According to the GAO, energy supply programs and related income tax preferences accounted for more than $6 billion of the federal resources devoted to energy programs. Energy supply measures are managed by six different federal agencies that conduct in excess of sixty-five program activities. The estimated budget authority for those programs addressing renewable energy tended to emphasize research and development, which consumed $349 million in fiscal year 2003. In addition, two income tax preferences—a new technology credit and exclusion of interest on facility bonds—support renewable energy at an estimated outlay of $510 million.[25]

The second program area—basic energy science—consists of general energy related research within the Department of Energy's Basic Office of Science. While the Office of Science's Basic Energy Science Program for fiscal year 2003 had more than $1 billion allocated to it, the majority of its research focused on advancing hydrogen production, high power batteries and nuclear fuel purification and reprocessing efforts, some of it—the GAO does not quantify exactly how much—was aimed at improving existing models for solar energy conversion and for "other energy sources."[26]

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[24] See Government Accountability Office, "National Energy Policy: Inventory of Major Federal Energy Programs and Status of Policy Recommendations," *United States GAO Report to Congress*, June, 2005 (GAO-05-379), p. 1-5.

[25] Ibid, p. 7-10.

[26] Ibid, p. 14-15.

Technology-Specific Incentives from the Federal Government

The incentives mentioned above (and a few highly specific measures) can be re-categorized (and supplemented) according to the technologies they support.

Wind Energy

- Public Utility Regulatory Policies Act of 1978
- Economic Recovery Tax Act of 1981. This law allows renewable energy systems to be depreciated within five years, which is a great benefit for wind energy developers. However, many restrictions exist that often diminish the value of the rapid depreciation.[27]
- Energy Policy Act of 1992
- Energy Policy Act of 2005
- Farm Security and Rural Investment Act of 2002 (P.L. 107-171). The law offers funding assistance to farmers, ranchers and small rural businesses that purchase renewable energy systems. Approximately $23 million was made available annually for fiscal years 2003 through 2005 as grants and loan guarantees.[28]
- Wind Powering America program. Managed by the Department of Energy, this initiative provides information for installing wind turbine facilities in rural areas and on Native American lands.[29]
- Environmental Protection Agency's Green Partnership Program. Established in 1992, the program provides free technical assistance and training for those homeowners and small businesses who wish to employ renewable resources in their community.

Photovoltaic Systems (Solar Panels)

- Renewable energy production tax credit, provision of Energy Policy Act of 1992, and renewed, most recently, to expire at the end of 2005.[30]
- Million Solar Roof Initiative. This Department of Energy program supports efforts between private companies and government bodies to install photovoltaic cells on one million roofs by 2010. The program offers workshops, information and other resources for helping to overcome market barriers and to increase the market for solar energy.[31]

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[27] Restrictions include individuals who must pay alternative minimum tax rates, for example. Also, non-tax-paying entities, such as municipalities, cannot exploit the accelerated depreciation benefit. See Edwin Ing, "Full Use of Federal Tax Incentives," *North American Windpower* 2 (No. 7, August 2005): 24-7.

[28] U.S. DOE, Energy Efficiency and Renewable Energy, "Wind Energy Provisions in 2002 Farm Bill," at http://www.eere.energy.gov/windandhydro/windpoweringamerica/ag_farm_bill.asp.

[29] U.S. DOE, "Wind Powering America," at http://www.eere.energy.gov/windandhydro/windpoweringamerica/.

[30] Union of Concerned Scientists, "Renewable Energy Tax Credit Saved Once Again, but Boom-Bust Cycle in Wind Industry Continues," revised 21 December 2004, at http://www.ucsusa.org/clean_energy/renewable_energy/page.cfm?pageID=121.

[31] U.S. Department of Energy, Energy Efficiency and Renewable Energy, "Million Solar Roofs," at http://www.millionsolarroofs.org/.

Biomass and Waste-to-Energy

- 1992 Energy Policy Act tax incentives.
- Executive Order 13134, 12 August 1999. Issued by President Clinton, the order seeks to promote biobased energy products through a comprehensive strategy of research, development and incentives.[32]
- Agricultural Risk Protection Act of 2000 (P.L.106-224). Included in this law are provisions for grants for research and development on biomass. Title III of the law is entitled the Biomass Research and Development Act of 2002.[33]
- Farm Security and Rural Investment Act of 2002 gives discount loans and grants for closed-loop biomass electricity.
- Alcohol fuels tax credit. The federal tax code contains several incentives benefiting alcohol fuels derived from biomass. Among them is a partial exemption of the excise tax paid on gasoline, a credit of $0.51 cents per gallon for converting biomass to ethanol and $0.60 per gallon for fuel other than ethanol.[34]
- 2005 "Billion Tons of Biomass" program from the United States Department of Agriculture. This program provides low interest loans, technical assistance and public workshops for those wishing to generate bioelectricity or combined bio-fuel and bioelectricity.

Virginia Incentives for Renewable Energy Technologies

The Commonwealth offers only a few incentives for renewable energy technologies.[35]

- **Local Option Property Tax Exemption for Solar Facilities**. Enacted in 1977, this provision permits counties, cities, or towns to give total or partial exemptions from local

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[32] The text of the order can be found at http://ceq.eh.doe.gov/nepa/regs/eos/eo13134.html. Also see U.S. Environmental Protection Agency, "Executive Orders," at http://www.energystar.gov/index.cfm?c=pt_reps_purch_procu.pt_reps_exec_orders.

[33] The text of title III can be found at http://www.bioproducts-bioenergy.gov/about/bio_act.asp.

[34] Salvatore Lazzari, Congressional Research Service, "Tax Incentives for Alcohol Fuels," CRES Report for Congress 95-261 E, 9 February 1995, at http://www.ncseonline.org/NLE/CRSreports/energy/eng-12.cfm?&CFID=13165225&CFTOKEN=61811498, and Internal Revenue Service, "Alcohol Fuel Mixture Credit," at http://www.irs.gov/publications/p378/ch04.html.

[35] Not included in this list is a program run by the Tennessee Valley Authority, a federal government power program that has a small presence in the state. TVA's Green Power Switch Generation Partners Program, designed for residential and small commercial customers, allows producers of power from solar photovoltaic and wind turbines to sell their output to the TVA at a rate of $0.15 per kWh. Customers must produce a minimum of 0.5 kW and a maximum of 50 kW. Residential producers can receive a TVA grant of $500 to defray construction costs. Other limits and conditions apply. The authors note it here only because the Database of State Incentives for Renewable Energy (at http://www.dsireusa.org/library/includes/map.cfm?State=VA&CurrentPageId=1) lists it as a program available to Virginians. However, one of the authors contacted the program administrators, who noted that only certain power distributors of TVA electricity participate in it. The sole Virginia cooperative that buys TVA power, the Powell Valley Electric Cooperative, which serves three counties, does not participate in the program. E-mail correspondence from Angela R. Hamlin , Product Manager, Green Power Switch, to Richard Hirsh, 5 August 2005. Also see "Green Power Switch Generation Partners," at http://www.gpsgenpartners.com.

property taxes for the use of solar energy or recycling equipment. Twenty-one of the state's 135 counties currently offer this exemption.[36]

- **Solar Manufacturing Incentive Grant Program**. Offered since 1996 (and scheduled for expiration at the end of 2007), this program authorized up to $4.5 million annually to encourage the manufacturing of solar photovoltaic panels. Managed by the Virginia Department of Mines, Minerals and Energy and the Virginia Economic Development Partnership, the fund pays up to $0.75 per watt (up to a maximum of 6 MW) for the first year, declining to $0.25 in the final two years (of a six year program). Since the program began in 1995, two firms built plants in Virginia; however, one has since closed and the other is operating only one shift.[37]
- **Virginia Small Wind Incentives Program.** Administered by James Madison University's Virginia Wind Energy Collaborative, this program offers grants of up to $10,000 for landowners who install small wind turbine systems (generally producing less than 20 kW each) in 2004 and 2005. Support is limited to ten projects.[38]

Additionally, the state legislature and Virginia State Corporation Commission have enacted some rules that seek to ease the burden of the small producer of power from renewable resources. These include:

- **Net metering rules**. Among the thorniest problems for the small producer of power is receiving payment for their output (PURPA notwithstanding). Virginia's net metering law, effective in 2000, enables residential producers of power (up to 10 kW) and commercial producers (up to 500 kW) to earn credits against their consumption on a net basis. For example, if customers buy 1,000 kWh of electricity from a utility and produce 250 kWh in a month, they only pay for 750 kWh. Several restrictions still apply and customers need to ensure that their equipment interconnects safely with the utility's equipment subject to standards established by several organizations.[39]
- **Interconnection standards**. The State Corporation Commission established simplified interconnection rules for small residential (up to 10kW) and commercial (up to 25kW) customers so they could exploit the net metering rules, noted above. Customers still need to meet many technical standards and must pay for inspections and insurance.[40]

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[36] Va. Code § 58.1-3661, Database of State Incentives for Renewable Energy, at http://www.dsireusa.org/library/includes/map.cfm?State=VA&CurrentPageId=1, and U.S. Census Bureau, State and County QuickFacts, at http://quickfacts.census.gov/qfd/maps/virginia_map.html. Few other tax incentives could be found during a search of the Virginia Department of Taxation web site, which contains a searchable tax policy library. For example, from 1983 through 1987, the commonwealth offered tax credits for individuals and businesses that employed renewable energy technologies. Tied to federal incentives, those credits were not renewed. 23 VAC 10-120-190 amd Va/ Code § 58.1-331. Office of Tax Policy website: http://www.policylibrary.tax.virginia.gov/OTP/policy.nsf.

[37] Va. Code § 45.1-392. Database of State Incentives for Renewable Energy, at http://www.dsireusa.org/library/includes/map.cfm?State=VA&CurrentPageId=1.

[38] Database of State Incentives for Renewable Energy, at http://www.dsireusa.org/library/includes/map.cfm?State=VA&CurrentPageId=1, and JMU Virginia Small Wind Incentives Program website, http://vwec.cisat.jmu.edu/vswip_program.htm.

[39] Va. Code § 56-594, and Database of State Incentives for Renewable Energy, at http://www.dsireusa.org/library/includes/map.cfm?State=VA&CurrentPageId=1.

[40] Regulation 20 VAC 5-315-40 , Va. Code § 56-578 , and Database of State Incentives for Renewable Energy, at http://www.dsireusa.org/library/includes/map.cfm?State=VA&CurrentPageId=1.

Incentives in Other States for Renewable Energy

Compared to some other states, Virginia offers few incentives for renewable energy technologies. Elsewhere, policy makers have created at least two major mechanisms to encourage development and use of renewable energy technologies. These mechanisms were often established (or promised to be established) during legislative negotiations that led to the partial deregulation of the states' electric utility networks. Advocates of environmentally preferable technologies sometimes played major roles in the restructuring legislation, enabling them to win concessions for support of renewable technologies after state regulation ended. They argued that, in the absence of state regulation, nothing would encourage power companies to stimulate use of energy-efficiency and renewable energy technologies.

The most common mechanisms for increasing renewable energy production consist of the public benefit fund (PBF) to support development of new technologies and the renewable portfolio standard (RPS).

Public Benefits Funds

Public benefit funds (also called system benefit funds) originated in the 1990s, at a time when state policy makers considered electric utility restructuring legislation. Afraid that gains made in pursuing research, development and implementation of environmentally preferable renewable energy technologies would end after regulators lost their sway, advocates of the novel technologies in some states won concessions for a new funding mechanism for high risk or long-term projects. The funds' income came from a small addition to the price of electricity paid by customers of companies that distributed power to them. It could not be avoided simply because customers bought power from a nonutility company in a deregulated system.[41] First implemented in Washington State in 1994, the charges were endorsed by the Federal Energy Regulatory Commission in 1995 as a way to fund services that had previously been included in customers' bills of regulated utility companies.[42] As part of the negotiations for California's restructuring law, environmental advocates won a provision for a public benefit fund that would expend at least $872 million on energy-efficiency work from 1998 to the end of 2001. For renewable energy programs, the fund would allocate $540 million.[43] To develop renewable energy technologies and other programs that would likely wither after deregulation, the

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[41] Eric Hirst, Ralph Cavanagh, and Peter Miller, "The Future of DSM in a Restructured US Electricity Industry," Energy Policy 24 (April 1996): 311. [Hirst, 1996 #26], p. 311.

[42] Ibid, p. 311. Washington Utilities and Transportation Commission, DSM Tarrifs UE-941375 and UE-941377, Olympia, WA, 1994, and FERC, "Promoting Wholesale Competition Through Open Access Non-Discriminatory Transmission Services by Public Utilities and Recovery of Stranded Costs by Public Utilities and Transmitting Utilities, Notice of Proposed Rulemaking and Supplemental Notice of Proposed Rulemaking, Docket Nos. RM95-8-000 and RM94-7-001, Washington, DC, 1995, cited in Hirst, "The Future of DSM."

[43] California bill, AB 1890, Article 7, Research, Environmental, and Low-Income Funds, Section 381(c)(1) to (c)(3). The law also mandated utility funding of low-income programs at 1996 levels or higher. Ibid., Section 382. See also R. Wiser, S. Pickle, and C. Goldman, "California Renewable Energy Policy and Implementation Issues--An Overview of Recent Regulatory and Legislative Action," Report LBNL-39247, UC-1321, September 1996. Recommendations on how to allocate funds for renewable technologies are included in California Energy Commission, Renewables Program Committee, "Policy Report on AB 1890, Renewables Funding," no date, but an accompanying letter was dated 7 March 1997.

California Energy Commission created its Public Interest Energy Research program, which initially drew about $62 million annually from the state's PBF.[44]

By mid-2003, twelve states had created PBFs. Seventeen organizations that administer the funds, which are scheduled to total $3.5 billion in a decade, collaborate through a nonprofit organization, the Clean Energy States Alliance. Seeking to expand the use of clean energy technologies (with special emphasis on solar, wind and fuel cells), the organization sponsors original research and collects information and analyses. It seeks to increase the efficiency of the research of state organizations by eliminating duplication of efforts and by providing forums for the states to share knowledge and insights.[45]

Virginia, it should be noted, is not one of these twelve states. It currently has no means for setting aside funds for research and development on new and renewable technologies. These technologies may benefit the public interest, but they may not immediately provide financial benefits to utility companies or independent generators.

Renewable Portfolio Standards

Along with public benefit funds in some cases, eighteen states and the District of Columbia have established "Renewable Portfolio Standards" (also known as renewable electricity standards) that seek to increase the amount of environmentally friendly generation capacity.[46] Simply put, the RPS is a legislative mandate that requires all producers of power in a state to employ renewable energy technologies to produce a certain percentage of capacity by a fixed date. Generating companies have the option of either building renewable facilities themselves or buying credits from other companies that own them. By giving companies this choice, the RPS creates a market for credits in a way similar to the federal trading of emissions credits under the Clean Air Act amendments of 1990. It therefore blends the benefits of "command and control" with the free market approach.

Advocates of the RPS approach argue that the mechanism creates a market for renewable energy technologies and therefore spurs research, development and implementation of the facilities. It also demonstrates to policy makers the practicality, cost-effectiveness and non-financial benefits (such as lower pollution) that these technologies provide. As the market for renewable energy technologies grows, manufacturers gain experience and further drive down the cost of clean electricity production.

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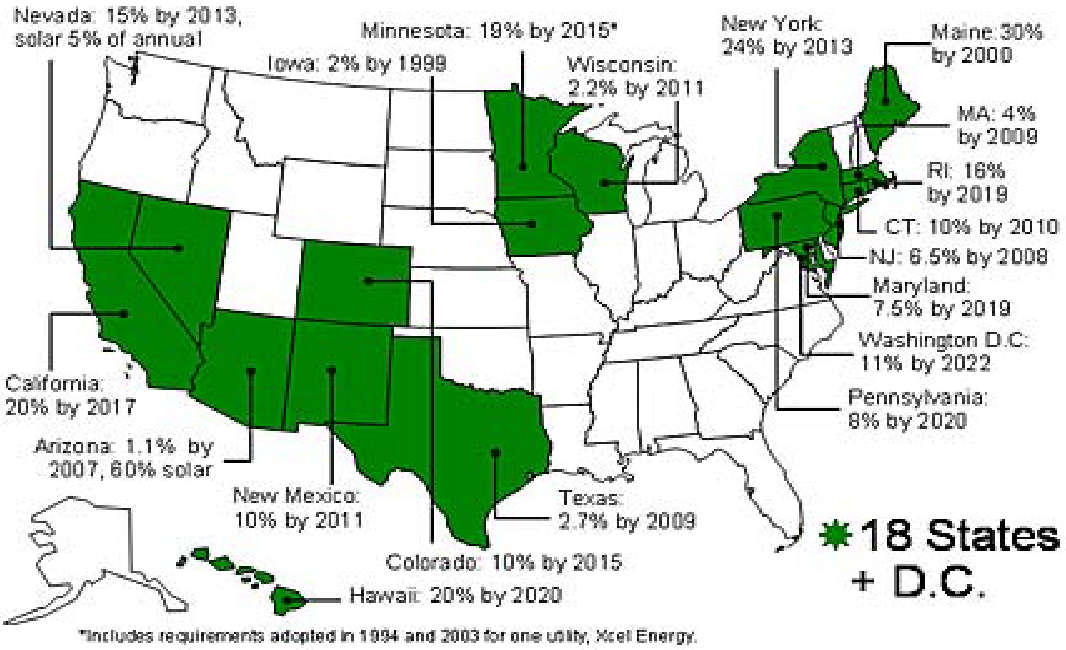
[44] An overview of the PIER program can be found at http://www.energy.ca.gov/research/innovations/.

[45] Clean Energy States Alliance, at http://www.cleanenergystates.org/index.html.

[46] This datum comes from the Union of Concerned Scientists, which has prepared a thorough overview and analysis of current RPS programs.



Source: Union of Concerned Scientists and the Oak Ridge National Laboratory

Figure 1: Renewable Electricity Standards

Each state that has developed an RPS defines renewable energy slightly differently.[47] Moreover, states have chosen different amounts of renewable capacity to be used by various dates. Iowa, for example, set a goal of 2% of capacity to be implemented by 2011. New York and California, by contrast, have set goals of 24% and 20% by 2013 and 2017 respectively. Since these states have large established bases of power, these percentages would yield huge amounts of renewable power. The Texas RPS has often been cited as a huge success. Governor George W. Bush signed legislation establishing the RPS in 1999, requiring 2,000 MW of renewable energy to be constructed by 2009.[48] But because of the good renewable resources in the state (largely wind) and improving technology, producers had already installed 1,293 MW by the end of 2004, most of it consisting of wind turbines.[49]

Virginia does not have a renewable portfolio standard. An RPS had been included in the Senate version of the long-debated federal energy bill. It would have required 10% of the nation's power

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[47] Union of Concerned Scientists, "Renewable Electricity Standards at Work in the States" at http://www.ucsusa.org/clean_energy/renewable_energy/page.cfm?pageID=47

[48] Ryan Wiser and Ole Langniss, "The Renewables Portfolio Standard in Texas: An Early Assessment," Lawrence Berkeley National Laboratories Report LBNL- 49107, 2001.

[49] David Garman, "Diversification of Power Generation." Hearing Before the House Committee on Energy and Commerce, Washington, DC: Government Printing Services, 8 March 2005. The American Wind Energy Association, a lobbying group for wind power technologies, noted that the cost of power from the new wind farms in Texas is lower than electricity produced from new natural gas plants. AWEA, "The Renewables Portfolio Standard: Recent Experience," at http://www.awea.org/pubs/factsheets/nyrps001.pdf.

to come from renewable technologies by 2020.[50] However, legislators deleted the provision of the RPS before final passage of the Energy Policy Act of 2005.[51]

International Incentives for Renewable Energy

As a final comparison, it is worth noting that renewable energy technologies have been successfully promoted with government policies in other countries. Wind turbines have been the most popular renewable technology, largely because of their cost effectiveness. At the end of 2004, Germany led the way with the highest total amount of installed wind power capacity (16,629 MW), providing about 6% of the country's total power consumption. Spain followed in second place (with 8,263 MW), followed by the United States (6,740 MW), Denmark (3,117 MW), India (3,000 MW), Italy (1,125 MW) and the Netherlands (1,078 MW).[52] Germany's success has resulted, in part, from legislation that guarantees a minimum price paid for electricity generated from wind turbines. A German federal law also sets the goal of increasing the wind power share of the market to at least 20% by 2020.[53] The long term of the incentive helps provide the security and predictability appreciated by entrepreneurs.

GENERAL IMPEDIMENTS TO RENEWABLE ENERGY SYSTEMS

This section describes impediments to renewable energy technologies in general and then describes impediments to specific technologies. In this discussion, it is important to note that many of the impediments are not "real" in the sense that they have quantitatively measurable impacts. Rather, they are perceived impediments, reflecting general opinions among various stakeholders who make decisions about using renewable energy technologies. Perceived impediments may be sufficient to dissuade investment by potential developers and energy users.

The first category of broad-based impediments to renewable energy systems also generally applies to any small, decentralized generation unit (often called "distributed generation" or "distributed energy resources") used to produce electricity on-site. Besides renewable solar PV and wind, other distributed generation technologies include microturbines, fuel cells, natural gas turbines, Stirling engines and combined heat and power (CHP) generation units.

In assessing impediments, the authors did not focus solely on technical or economic factors. They also looked at the seamless web of political, social, environmental and cultural components

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[50] "Senate Adds RPS, but not Climate Change Provisions, to Energy Bill," Foster Electric Report (22 June 2005), report no. 412, p. 1, online version; and "Energy Policy: Senate Energy Debate Might Last Beyond Next Week," Environment and Energy Daily (17 June 2005), online version.

[51] Senator Patrick Leahy (I-Vermont) commented that the Senate bill would have done more to solve the nation's energy problems than the compromise bill that emerged from the House-Senate conference. "The Senate sent a good energy bill to conference," he said, "and we got back a frog." Discussion of Conference Report of Energy Policy Act of 2005, *Congressional Record—Senate* , 29 July 2005, 109th Congress, 1st Session, 151 Cong Rec S 9335, Vol. 151, No. 106, p. S. 9339.

[52] "Global Wind Power Continues Expansion," news release from Global Wind Energy Council, Brussels, 4 March 2005.

[53] "The German Wind Energy Industry," Renewables Made in Germany website, http://www.renewables-made-in-germany.com/index.cfm?cid=1461.

that matter just as much as technological and financial issues. As a result, the impediments facing renewable energy may appear complicated. Nevertheless, some of the most important impediments—social and technical—are listed in this section.

Variable and Inconsistent Incentives for Renewable Energy Technologies

Though the incentives noted in earlier sections of this report may appear significant, they have not always had a long-term impact because of the variability and inconsistency of policy. In other words, policies aimed at encouraging renewable energy technologies (and other distributed generation technologies) have changed frequently, discouraging the widespread adoption of the systems.

Since all policy is politically and ideologically motivated, such inconsistency should not seem totally unexpected. During the Carter administration, for example, new laws, regulations and tax credits stimulated the development of renewable energy and energy efficiency technologies. Yet, soon after assuming office, Ronald Reagan symbolically removed the solar collectors from the roof of the White House and took more substantive measures to end federal programs and tax credits that encouraged efficiency and alternative energy technologies.[54]

Reversing this trend somewhat, the Energy Policy Act of 1992, signed by Reagan's successor, George H.W. Bush, provided a production tax credit for certain renewable energy technologies. But those credits expired in 1999 and environmental advocates worked diligently to win Congressional approval for their reinstatement, often on an annual basis.[55] When Congress failed to renew the credits before the end of 2001, investment in wind turbine projects declined precipitously. Developers installed only 410 MW of new wind turbines in 2002, down from about 1,600 MW in 2001 and 2003.[56] Congress reinstated the credits in March 2002 for the remaining nine months of the year and for all of 2003. But the failure to extend the credit before the end of 2003 meant another bust cycle for the wind turbine industry.[57] Today, analysts expect another boom cycle with passage of the Energy Policy Act of 2005, but even that law extends the credits only for construction of projects completed before the end of 2007.[58]

The variability of policy relating to renewable energy technologies serves as a serious impediment. Entrepreneurs seeking investment from individuals and institutions often require consistent conditions upon which to make decisions. Forecasts of profitability usually require

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[54] Peter Behr, "Solar Industry Worried Reagan Might Pull the Plug;
Solar Electric Industry Worried Reagan Might Pull the Plug," *Washington Post* (29 September 1981), p. D7; Stephen Greene, "Solar Energy Industry Slips Into the Shadows; Fall in Oil Prices, Changes in Tax Rules Hurt Sales," *Washington Post* (9 November 1986), p. B1; and M.K. Heiman, "Expectations for Renewable Energy Under Market Restructuring: The U.S. Experience," corrected proof in *Energy*, online at doi:10.1016/j.energy.2005.02.014;

[55] CarolAnn Giovando, "Despite Banner Year, Wind Energy Faces Major Challenges," *Power* 143 (November/December 1999), p. 47.

[56] "Wind Group Says Loss of Tax Credits Stalls 1,000 MW," *Megawatt Daily* 9 (6 January 2004), p. 8.

[57] "Tax Credit Expiration Hurting Wind Industry: AWEA," *Megawatt Daily* 9 (13 May 2004), p. 9; and "Wind Project Installations Fall Sharply This Year," *Megawatt Daily* 9 (16 August 2004), online version.

[58] American Wind Energy Association news release, "Energy Bill Extends Wind Power Incentive through 2007," at http://www.awea.org/news/energy_bill_extends_wind_power_072905.html.

data concerning tax credits, depreciation schedules, cash flows and the like. When policymakers frequently change the factors that go into these financial calculations, they insert an extra level of uncertainty into the decision-making process. Consequently, policy variability mitigates the impact of some of the incentives.

Perceived Inability to Provide Base-Load, Uninterruptible and Peaking Power

The second most significant impediment to most renewable energy systems consists of their inability to provide consistent and dispatchable base-load, uninterruptible and peaking-power.

Base-load power is the power that is "always on," and must operate continuously to meet the minimal amount of demand that is always created by customers. Because it must always be available, this power is typically provided by large coal, natural gas and nuclear plants and is often called the "backbone" of the electric utility industry. Many renewable technologies, in contrast, depend on weather-related phenomena and thus provide electricity intermittently (or at different times of the day). As a result, most renewable energy systems (especially wind and solar) are viewed as inappropriate for base-load applications. They can serve as intermediate-load or peak-load providers of power, generating electricity when customers demand electricity during the hottest part of the day, for example. (Because peak-load power usually costs more to produce, renewable energy systems have great value, even if they do not produce base-load energy.)

Peak-load power equipment refers to those generators that are switched on during times of high demand to supplement base-load generators. Many peak-load facilities use natural gas turbines because they can be started and turned off quickly, unlike most coal-and nuclear-fueled base-load units, which require hours to start up. These peaking facilities have become more important as demand for electricity in the United States continues to grow. For example, 90% of new power plants on order (as of 2003) were gas-fueled,[59] and between 80% and 90% of new generation capacity between 1999 and 2004 has been fueled by natural gas.[60] Because many renewable technologies cannot be switched "on" or "off" as quickly, natural gas peaking facilities are likely to remain a better alternative for the provision of peak-load power.

One stipulation must be introduced when discussing this impediment, however. The tendency for renewable energy systems to provide only partial loads during different seasons and parts of the day does not mean that such technology can never be employed to provide base-load, uninterruptible, or peaking power. Some large hydroelectric plants, for instance, have reliable fuel sources and can provide more reliable base-load power than some fossil fueled plants. The fact that some renewable systems provide intermittent power does not mean such power cannot be predicted and used. A photovoltaic farm operating in the Mohave Desert, for example, may

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[59] Gray, Tom. (2003). "Trans-Praire and Interior West Wind 'Pipelines.'" *Wind Energy Weekly*, July 31, p. 12.

[60] Fertel, Marvin S. (2004). "The Future of Nuclear Power." *Hearing Before the Senate Subcommittee on Energy and Natural Resources*, March 4. Washington, DC: Government Printing Office, p. 3; Pirog, Robert. (2004). "Natural Gas Prices and Market Fundamentals." *CRS Report for Congress*. December 8. Washington, DC: Library of Congress, p. 7-8.

provide electricity only during the day, but this also happens to be when demand for electricity surges (meaning it could provide consistent peak-load power). In addition, all generators—regardless of their fuel—periodically need to be shut down for maintenance and repairs, in essence making them "intermittent." While renewable systems are not widely used to provide these types of important power—something that does significantly impede their diffusion—they are nonetheless excluded from generating this power in certain contexts.

Furthermore, no one advocates using only one renewable technology to supply all of the power needed by Americans. Just as the provision of fossil-fueled electricity includes a broad array of different technologies (including natural gas turbines, combined cycle coal-plants and diesel-engines), many analysts note that the same type of diversification would be best when considering renewable technologies. By using a statistically large, diverse portfolio of renewable options in different locations, these technologies can provide power that helps meet demand throughout the day and year (though certainly with limits) in flexible and environmentally friendly ways.

Historical Attitudes and Understanding of the Electric Power System as an Impediment

The relatively successful history of the American electric utility industry also serves as an impediment to the somewhat novel renewable energy technologies, partly because it "naturally" resists change from established practice. From the beginning of the twentieth century until the 1970s (and one could argue beyond then), the industry took advantage of incrementally improving, large-scale technology and managerial innovations to produce large amounts of power at declining costs.[61] Though the large-scale, central station paradigm has been challenged in the last two decades, as the trends toward more efficient and lower-cost power have ended, most people within and outside the industry still view the traditional approach to be the best.

Utility managers, in particular, resist change. Often viewing themselves as the heirs to stewards of technological and social progress, they look fondly to the colossal, centralized plants that have provided power for much of the industry's history. Driven by preferential fuel availability, economies of scale and lower staffing levels per facility, the predominately coal- and nuclear-fueled units produce immense amounts of electricity, often between 300 and 1,300 MW.[62] (Power *plants*, made up of several units, generate multiples of these amounts.) In addition, utility managers situated most large plants built after the 1950s outside cities. Urban expansion depleted the amount of property available for land intensive electricity generators and residents living in American cities became more aware of air pollution and environmental problems with energy production. (Planners located nuclear plants outside cities as a safety measure as well.) The advantages of this classical system—cheaper electricity prices and steady profits in the industry—were perceived as self-evident despite system efficiency losses (largely from transmission of power) and the cost of meeting regulatory obligations. Consequently, utility

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[61] Richard F. Hirsh, *Technology and Transformation in the American Electric Utility Industry* (New York: Cambridge University Press, 1989).

[62] Lovins, Amory et al. (2002). Small is Profitable: The Hidden Benefits of Making Electrical Resources the Right Size. Snowmass, CO: Rocky Mountain Institute, p. 284; Petchers, Neil. (2003). Combined Heating, Cooling & Power Handbook: Technologies & Applications. New York: The Fairmount Press; p. 5-6,

managers developed a deeply engrained way of thinking. Adopting a similar mindset, politicians often view large, centralized and distantly located plants as the best way to provide power. This tacit and widespread belief among business and policy leaders almost blinds these agents to new options for generation of power, such as renewable energy technologies.

Likewise, the public's attitude (or apathy) toward the utility industry serves as an impediment to the adoption of novel renewable energy technologies. As historian James C. Williams explains, people know that technology and technological systems are the tools with which they interact, but once technological landscapes are in place, people fold them so completely into their psyches that those very landscapes become almost invisible.[63] In other words, once electric power became part of people's lives, they rarely thought about how it is produced and how it got to them. (In an infamous 1978 study conducted by Southern California Edison, the most common answer to the question "where does electricity come from" was "from the socket in the wall."[64]) Consequently, consumers often oppose renewable energy technology not because they believe it is a poor alternative to fossil fuels, but because they do not realize that new plants of any type appear necessary to provide additional electricity. They would object as strongly to plans to build traditional power plants as well, simply because (unless they already live near a power plant) they generally do not think about where power originates and how it gets to their premises.

Ironically, perhaps, people have become accustomed to low-priced electricity and they often consume it indiscriminately, creating demand for construction of new power plants. American's preferences for sprawling growth, automobiles, individualistic heating and huge electricity consumption impose conditions on their future energy choices. Historian David Nye notes that, "Americans have built energy dependence into their zoning and their architecture … they think it natural to demand the largest per capita share of the world's energy supply."[65] While large amounts of consumption have accompanied the construction of the world's largest electrical transmission and distribution system that provides low-cost electricity, patterns of over-consumption have become engrained to a large extent. Thus, Americans simultaneously need more electricity, but they frequently oppose construction of new generation facilities (including renewable technologies) because they do not realize that they contribute to the necessity of new plants.

These two impediments—a preference for building large power plants and a poorly informed public—have at least three implications for renewable energy systems in Virginia. First, the tendency to build massive electrical generators—because such thinking has become institutionalized and self-sustaining within the electric utility and government communities—is likely to remain the "weapon of choice" for policymakers simply because they are well understood and familiar. The historical experience with a traditional technology leads many

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[63] See Hirsh, Richard F. (1995). "Teaching About Values and Engineering: The American Electric Utility Industry as a Case Study." Proceedings from the 1995 Frontiers in Education Conference, 52-71; Williams, James C. (2001). "Strictly Business: Notes on Deregulating Electricity." *Technology & Culture* 42 (July): 626-630.

[64] Larry Papay, former vice-president of Southern California Edison, "Energy Policy, Energy Efficiency, and Renewable Energy in the United States," interview with Benjamin Sovacool, September 21, 2005, p. 3.

[65] Nye, David E. (1999). *Consuming Power: A Social History of American Energies.* London: MIT Press, p. 257-258.

utility managers and legislators to avoid risk,[66] and they therefore resist novel and less-familiar renewable energy technologies. Second, the general public's ignorance of the sources of electric power translates into public opposition to almost any additional component of power system, whether it be a transmission line, a nuclear power plant, or a wind turbine. While people acknowledge the need for electricity, they do not want to see elements of the power infrastructure near their home. Finally, the paradigm of large and centralized plants have placed traditional electrical technology—such as coal-fired plants and geothermal facilities—far outside of cities. Thus, the deployment of renewable energy technologies that tend to be more modular, decentralized and distributed, is perceived as more intrusive and evident. They bring what previously seemed "invisible" to the foreground.

Difficulty in Setting Universal Standards

Another important impediment applies to all renewable technologies. Because renewable systems tend to be smaller and distributed, approaches aimed at installing them tend to be more difficult to standardize. This impediment can actually be viewed as a collection of at least two subordinate concerns.

First, renewable systems are more modular and site specific than traditional large-scale fossil-fueled plants due to the nature of renewable "fuels." For example, a wind turbine might work best atop a cloudy mountain, whereas a photovoltaic system reaches optimal performance in a hot and cloudless desert. As a result, the costs, capacity, need for storage and rate of payback will differ for almost every installation of a renewable facility.[67] The complexity of building a renewable energy plant in the right size and in the right place makes developing a "standard approach" like the one in use for constructing fossil-fueled plants extremely difficult. As a result, renewable energy technologies are perceived as more difficult to design and deploy.[68]

This technical complexity also makes renewable systems more difficult to site, permit and monitor. A 2003 Congressional Budget Office report noted that widespread use of distributed, small-scale renewable energy systems would greatly increase the cost of environmental monitoring.[69] Many other authors have warned that the deployment of a large number of small-scale renewable technologies could greatly complicate permitting requirements and measuring

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[66] The risk-averse nature of utility managers is explored in Richard F. Hirsh, *Technology and Transformation in the American Electric Utility Industry* (New York: Cambridge University Press, 1989).

[67] For discussions on how this variability prevents the deployment of renewables, see Lewis, Marlo. (2002). "Deviant Standard," September 23, Retrieved March 2005 from http://www.techcentralstation.com/092302C.html; International Energy Agency. (2002). Distributed Generation in Liberalized Electricity Markets. Paris: International Energy Agency, p. 34; Pepermans, G. et al. (2003). "Distributed Generation: Definition, Benefits, and Issues." Energy Policy (August): 21-29; Goett, Andrew and Richard Farmer. (2003). Prospects for Distributed Electricity Generation: A CBO Paper. Washington, DC: Congressional Budget Office, p. 20-21.

[68] See Taylor, Jerry. (2003). "Not Cheap, Not Green," CATO Institute Report, August 4, 2003, Retrieved from http://www.cato.org/testimony/ct4-16-5.html; Taylor, Jerry and Peter VanDoren. (2002). "Evaluating the Case for Renewable Energy: Is Government Support Warranted?" Cato Institute Policy Analysis No. 422. January 10, p. 1-15.

[69] Goett and Farmer 2003, p. 22.

the environmental impacts associated with their construction, generation, maintenance and decommissioning.[70]

Utility Monopoly Rules

Because the "classical" system of generating power from large plants through a transmission and distribution system has existed for more than a century, a number of traditional, "time-tested" regulatory and utility practices impede the wider use of renewable energy systems.

In many states that have begun restructuring their utility systems, formerly regulated "natural monopoly" power companies have been permitted to charge customers "stranded costs."[71] These costs are intended to cover a "fair return" on generation and transmission investments made by utilities during the era of regulation, when the investments were viewed as serving all users. Put simply, when a customer decides to install an electric generator independent from the utility, he or she arguably removes part of the grid's existing load requirement and "strands" part of the investment the utility made in the power system. Such fees greatly increase the cost of renewable energy systems because customers must pay them in addition to the cost of buying new technology.[72]

Utilities also require payment of a host of charges on those who use renewable energy systems that run intermittently. For example, they may ask for high rates for providing backup power for when the intermittent renewable-energy technologies do not produce power. They may also charge demand fees (a charge that penalizes customers for displacing demand from utilities) that discourage the use of intermittent power systems. A recent study undertaken by the National Renewable Energy Laboratory found more than seventeen different "extraneous" charges associated with the use of dispersed renewable technologies.[73] These types of charges, the senior editor of *Public Utilities Fortnightly* exclaimed, "are a major obstacle to the development of a competitive electricity market."[74]

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[70] See Arthur D. Little. (1999). "Distributed Generation: System Interfaces." An Arthur D. Little White Paper. Boston, MA: ADL Publishing, p. 18; vCasazza, John A. and George C. Loehr. (2000). The Evolution of Electric Power Transmission Under Deregulation: Selected Readings. New York: IEEE, p. 301; Zavadil, Robert and Mark McGranaghan. (2002). "Working Group Struggles with DG Interconnection Standard." EC&M, June 1, retrieved from http://www.powerquality.com/mag/power_working_group_strugges/.

[71] See Arthur D. Little. (1999). "Distributed Generation: Policy Framework for Regulators." An Arthur D. Little White Paper. Boston, MA: ADL Publishing, p. 40; Allen, Anthony. (2002). "The Legal Impediments to Distributed Generation." Energy Law Journal, 23: 505-523. For a great primer on stranded costs and their legitimacy, see Maloney, Michael T. and Wayne Brough. (1999). Promise for the Future, Penalties From the Past: The Nature and Causes of Stranded Costs in the Electric Industry. Washington, DC: Citizens for a Sound Energy Foundation.

[72] Bode, Denise A. (1999). "The Role of Federal Electric Utilities." Hearing Before the House Subcommittee on Energy and Power, May 19, 1999. Washington, DC: U.S. Government Printing Office, p. 137; Reicher, Daniel W. (1999). "Distributed Generation Technologies." Hearing Before the Senate Committee on Energy and Natural Resources, June 22. Washington, DC: Government Printing Services, p. 8.

[73] See Alderfer, R. Brent and Thomas J. Starrs. (2000). "Making Connections: Case Studies of Interconnection Barriers and Their Impact on Distributed Power Projects." National Renewable Energy Laboratory Report NREL/SR-200-28053. Golden, CO: NREL.

[74] Stavros, Richard. (1999). "Distributed Generation: Last Big Battle for State Regulators?" Public Utilities Fortnightly 137 (October 15): 34-43.

As one case in point, regulated utilities (and unregulated utilities, such as rural cooperatives) often make it difficult for individuals and companies to connect renewable technologies to "their" grids. In some cases, managers of these utilities have employed their formidable resources in attempts to thwart interconnections. For example, managers of a rural coop spent seven years trying to stop a family farmer in Iowa from connecting to the power company's distribution lines. The farmer sought to obtain net metering rates from the coop under the provisions of PURPA, appealing to Iowa's court system and FERC. Ultimately, FERC ruled in favor of the farmer and it scolded the coop's managers for deliberately disconnecting the family, for using delaying tactics and for arguing disingenuously to the courts and to FERC.[75]

Finally, Virginia's own net metering rule appears to have inadvertently impeded the wider use of renewable technologies such as solar and wind power. To begin with, Virginia law limits net metering eligibility to 0.1% of a utility's peak load. Furthermore, while in general, net metering rules tend to favor renewable energy systems, some analysts have noted that Virginia's rule in particular does not do so nearly enough. The definition of a properly functioning net metering system requires accurate pricing signals, so that customers can observe fluctuating levels of peak demand and consequential rising prices of electricity (and can thus choose when to conserve electricity or generate their own power). However, rather than allowing customers to sell back electricity at rates that change during the day depending on the value of power (also known as "time-of-use" rates), Virginia's net metering rule mandates only that utilities purchase power that reflects the average price of electricity. In essence, then, the owners of solar, wind and other renewable energy systems often receive less than what their generated electricity is worth, especially when they sell power at peak periods, such as in the late afternoon on hot, sunny days. As a result, the economics of renewable energy in Virginia—including payback periods and the overall costs of electricity—may be artificially high. The lack of adequate time-of-use rates may therefore act as a significant impediment to the more widespread use renewable energy systems.[76]

Interconnection Requirements

Another general impediment occurs when nonutility companies or other customers attempt to connect any type of distributed energy technology to the grid, usually to sell power to the utility

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[75] "Order Initiating Enforcement Proceeding and Requiring Midland Power Cooperative to Implement PURPA," FERC docket No. EL05-92-000, issued 6 June 2005, at http://www.ferc.gov/EventCalendar/Files/20050606170606-EL05-92-000.pdf. As a final note in the ruling, the FERC commissioners noted "Finally, we cannot help but note that Midland has used the legal process to thwart efforts to compel it to comply with PURPA for seven years, with a long history of using every means at its disposal to avoid its obligation to purchase from [the farmer's] small wind powered !QF." The commissioners also observed that the coop's legal fees must have exceeded its cost to have entered into a net metering arrangement with the customer. For a summary of this case, see "Connecting to the Grid: FERC Rules PURPA Supports Net Metering," Interstate Renewable Energy Council, at http://www.irecusa.org/articles/static/1/1114631056_1051597266.html.

[76] For more on these issues, see Peter Lowenthal, "Comments of Maryland, District of Columbia, Virginia Solar Energy Industries Association (MDV SEIA) In Case No. PUE-2004-00060," *Public Letter Regarding the Matter of Amending Regulations Governing Net Metering*, February 25, 2005, p. 3-15; and Commonwealth of Virginia State Corporation Commission, "In The Matter of Amending Regulations Governing Net Metering," *Order Adopting Final Regulations*, April 20, 2005, p. 4-28. Of course, one can argue that renewable energy producers gain a windfall when selling power at average prices at times (such as at 3:00 AM), when demand is low.

or other customers. Interconnection procedures that have been implemented—when they exist at all—vary greatly between utilities, municipalities, cities and states.[77]

This interconnection obstacle represents many distinct challenges, some of them technical. They include a utility's need to maintain voltage control, or keeping voltages within a certain range, as well as balancing the flow of alternating current to support proper grid synchronization. In addition, the adequate protection of people working on the grid must be guaranteed.[78] Most transmission networks have been designed as radial grids, meant only to send power in one direction. Renewable energy technologies complicate this design pattern because they enable the distribution of power in the opposite direction. Currently, those using distributed generation (DG) technologies, such as renewable-energy facilities, often depend on custom-designed electronics packages to solve these problems. The great expense in developing such packages obviously creates a disincentive for new users.[79]

For example, PJM Interconnection—the independent service operator responsible for roughly half of Virginia's power grid—mandates that customers wishing to interconnect distributed generators to the utility's transmission network conduct an extensive feasibility study. In addition, Section 36.1 of the PJM tariff requires a $10,000 surcharge—regardless of the size, ownership, or location of the connecting generator—for anyone who attempts to interconnect to PJM's transmission system.[80] This fee serves as an especially large disincentive for small-scale power generators.

Despite efforts by the National Association of Regulatory Utility Commissioners, the Federal Energy Regulatory Commission and the Institute of Electrical and Electronics Engineers, the federal government has not yet established standardized requirements for interconnecting renewable energy technologies and distributed generators with the grid. As the National Energy Policy Development Group concluded in 2001, "the lack of interconnection standards or guidelines for electricity supply and load impedes the use of distributed energy technologies."[81]

IMPEDIMENTS TO WIND ENERGY

The three most significant impediments to wind energy are intermittency of operation, their cost (including capital cost and cost of maintenance, which factor into the overall cost of electricity)

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[77] See Garman, David. (2001). "National Energy Policy." Hearing Before the Senate Finance Committee, July 19: Federal Document Clearing House Congressional Testimony, p. 23; Allen 2002, p. 507; Kolanowski, Bernard F. (2000). Small-Scale Cogeneration Handbook. Liburn, GA: The Fairmont Press, p. 42-43.

[78] See International Energy Agency 2002, p. 73-85; Steiner, Sheldon. (2004). "Pure Power: The ABC's of DG." Consulting-Specifying Engineer (March 1): 14-22; Borbely, Ann-Marie and Jan F. Kreider. (2001). Distributed Generation: The Power Paradigm for the New Millennium. New York: CRC Press, p. 312; Cummings, Francis H. and Philip M. Marston. (1999). "Paradigm Buster: Why Distributed Power will Rewrite the Open-Access Rules." Public Utilities Fortnightly 137 (October 15): 22-31.

[79] Starrs, Thomas J. (2001). "National Electricity Policy: Barriers to Competitive Generation." Hearing Before the Subcommittee on Energy and Air Quality House Committee on Energy and Commerce. July 27. Washington, DC: Government Printing Office, p. 104-109; Allen 2002; Alderfer and Starrs 2000, p. i-ii.

[80] See PJM Interconnection LLC, "OATT Attachment Feasibility Study Agreement Form," 2005, retrieved from http://www.pjm.com/planning/expansion-planning/form-oatt-feas-study.html.

[81] National Energy Policy Development Group. (2001). Reliable, Affordable, and Environmentally Sound Energy for America's Future. May. Washington, DC: Whitehouse Printing Services, p. 6-15.

and environmental and public concerns related to habitat destruction, avian and bat mortality, visual aesthetics and noise.

Intermittency

By far, the most substantial impediment to wind concerns intermittency of electricity generation. Wind turbines have unique technical characteristics that make their generation of electricity variable during the day and throughout the seasons. The intermittent nature of wind power threatens to create power surges and shortages when used on a large scale or for a large portion of a system's needs. Western Denmark's principal Transmission System Operator stated that the production of electricity from its wind turbines "can be akin to maneuvering a rapidly moving articulated lorry train without a steering wheel, accelerator, clutch, or brakes."[82] The intermittent nature of wind also results in penalties paid by utilities when generation supplies do not meet demand. A 2003 National Rural Electric Cooperative Association mentions that "because of wind's intermittent nature, wind units often cannot avoid deviations from even the most carefully made schedule …. [T]hey are likely to incur substantial penalties for scheduling deviations."[83]

In addition, wind power provides electricity only when the wind blows.[84] To smooth out fluctuations in generation capacity, wind-produced power works best when used in large numbers in geographically spaced locations (so the law of averages yields a relative constant supply). Alternatively, they need to be connected to backup or supplemental power plants that operate continuously (often in the form of coal-, gas-fired and nuclear plants).[85] The need for supplemental generation means that wind turbines typically cannot function in blackouts and they need expensive storage technology to operate during times of inadequate flows of air.[86]

Cost

While its operation produces no emissions and its fuel is completely renewable, some wind turbines (and larger wind farms) have much higher initial capital costs than fossil-fueled plants.

The main capital cost for wind power is the turbine, although the cost of installing the tower and the expense of delivery, interconnection and metering hardware must also be included when calculating the turbine's total "up-front" expenses. Wind systems designed for individual homes (in the range of 5 to 15 kW) cost between $2,500 and $3,000 per kW installed, yielding an average price of about $27,000.[87] The American Wind Energy Association noted in 2002 that the cost of utility-scale wind projects often exceeds $1,000 per kW. Thus, a 50 MW project

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[82] Mason. V.C. (2004). "Environmentally Unfriendly Wind Power—A Personal Opinion." Retrieved from www.dartdorset.org/ Unfriendly%20WF%2018%20Feb%202004.pdf, p. 3.

[83] National Rural Electric Cooperative Association. (2003). NRECA White Paper on Wind. April. Arlington, VA: NRECA, p. 57.

[84] See United States Government Accountability Office. (2004). "Renewable Energy: Wind Power's Contribution to Electric Power Generation and Impact on Farms and Rural Communities." GAO Report to the Ranking Democratic Member, Committee on Agriculture, Nutrition, and Forestry, U.S. Senate. Washington, DC: GAO, p. 14.

[85] Dworzak, David. (2005). "The Cost of a Windless Day." Electric Perspectives (May/June) 30(3): p. 79.

[86] Ibid.

[87] National Rural Electric Cooperative Association 2003, p. 61-62.

would run roughly $50 million in capital costs.[88] These large capital costs sometimes require longer comparative pay-back periods for wind projects. While they require less maintenance than a coal- or natural-gas plant of similar capacity, the expense of replacement parts for wind turbines can complicate or greatly diminish the rate of return for wind projects. A 2004 Department of Energy report cautioned that many turbines break during construction and that costly drivetrains tend to wear out more rapidly at low wind speeds.[89] The relative novelty of wind projects in the United States (though not so much in countries such as Germany and Spain that have greater experience with wind than the U.S.) also increases the financing and insurance costs for wind farms, adding a further financial disincentive to invest in wind.[90]

Environmental and Public Concerns

The most significant environmental concern with wind energy relates to the death of birds and bats resulting from collisions with wind turbine blades. A 1992 California Energy Commission study estimated that between 1,766 and 4,721 wild birds (including more than 40 species) die per year at the Altamount Pass Wind Resource Area, where more than 5,400 wind turbines operate continuously.[91] Some wind farms operating in Tennessee and California have been known to kill of up to forty-eight bats per turbine annually.[92] Closer to home, several studies conducted in the Appalachian Mountains (focused on the region from Tennessee to Vermont) have found that large numbers of nocturnal migrants (including bats) are uniquely at risk of colliding with wind turbines.[93] The number of avian deaths could be especially large if wind turbines were deployed over the Allegheny Front (which includes parts of Virginia) during the migration season, when more than 1.7 million birds per night fly over the state.[94]

To be fair, however, one needs to note that these mortality rates are hotly contested, and pale in comparison to other man-made objects. For example, tall, stationary communications towers have been estimated to kill more than 4 million birds each year.[95] In addition, some analysts have suggested that road traffic, power-lines and cats are a much greater risk to birds than wind-

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[88] American Wind Energy Association. (2002). "The Economics of Wind Energy." March, retrieved from http://www.awea.org/pubs/factsheets/EconomicsofWind-March2002.pdf, p. 4.

[89] See United States Department of Energy. (2004). Wind Power: Today & Tomorrow. Report from the U.S. Department of Energy Energy Efficiency and Renewable Energy Wind and Hydropower Technologies Program. Washington, DC: Department of Energy, p. 7-11.

[90] See American Wind Energy Association. (2002). "The Economics of Wind Energy." March, retrieved from http://www.awea.org/pubs/factsheets/EconomicsofWind-March2002.pdf, p. 4.

[91] For an excellent overview of the avian problems facing wind energy, see Asmus, Peter. (2005). "Wind and Wings: The Environmental Impact of Windpower." Electric Perspectives (May/June) 30(3):68-80.

[92] Ibid, p. 78.

[93] Boone, D. Daniel et al. (2005). Landscape Classification System: Addressing Environmental Issues Associated with Utility-Scale Wind Energy Development in Virginia. The Environmental Working Group of the Virginia Wind Energy Collaborative. Retrieved May, 2005, from http://www.VAwind.org/assets/docs/LCS-042105.pdf, p. 23-28.

[94] Rahall, Nick J. and Alan B. Mollohan. (2004). "Request to the General Accounting Office to Undertake Study on Wind Turbine Facilities." Public Correspondence to David M. Walker, Comptroller General of the United States GAO, June 22.

[95] See Chris Toffelson, "Reducing Bird Deaths From Tower Collisions," 2001, http://permanent.access.gpo.gov/lps1515/febmar2001/fatal.htm.

farms.[96] Moreover, death-rates of all flying animals have decreased in recent years as wind power entrepreneurs have installed larger turbine blades that turn more slowly and used advanced thermal monitoring and radar tracking to install turbines more carefully.[97]

As a further impediment, effective and large wind farms sometimes are highly land intensive. The Department of Energy notes that large-capacity utility wind turbines usually require one acre of land per turbine.[98] When these big machines are built in densely forested areas or ecosystems rich in flora and fauna, they can also fragment large tracts of habitat. At the Mountaineer Wind Energy Center in West Virginia, for instance, more than forty acres of forest were bulldozed and 150 acres of forest-interior were lost to erect eight turbines. Similarly, 350 acres of forest habitat were destroyed to construct twenty wind turbines at a Meyersdale, Pennsylvania, wind plant.[99]

However it should be noted that land employed for wind turbines can have several uses. Outside of the concrete pad on which the turbine rests (and possibly a pathway to the pad), the land can still be used for farming, ranching and foresting. Also, an assessment of the environmental impacts of wind turbines should be compared with those of alternative technologies—fossil, renewable and nuclear—used for making electricity. The use of traditional technologies also imposes serious impacts on air and water quality, land use and habitat and human health.

The environmental concerns raised from the use of wind turbines are accompanied by a host of other issues. Older wind turbines sometimes created interference with radio, TV and other electromagnetic transmissions. Moreover, while recent improvements in turbine technology can reduce these problems, blade noise has historically been heard up to one kilometer away.[100] Noise levels appear particularly problematic at night and are induced by low-frequency aerodynamic sounds generated by the interaction of turbine blades and the tower.[101] Finally, many people find wind turbines visually unattractive, especially in significant tourist or recreational destinations where the human-built turbines impose obtrusively on a pristine natural environment.[102] Consequently, many citizens campaign aggressively against their construction, as they have in Virginia's Highland County.[103]

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[96] See Bassam and Maegard 2004, p. 118; Vidal, John. (2004). "An Ill Wind?" *The Guardian (London)*, May 7, 2004, p. 2; Wind Energy Weekly. (1999). "Research Finds Risk to Birds Low at Minnesota Wind Site," Vol 18 # 847, May 11, retrieved from http://www.awea.org/wew/847-1.html.

[97] See Asmus 2005, p. 68-80.

[98] United States Department of Energy. (2004). Guide to Purchasing Green Power: Renewable Energy Certificates and On-Site Renewable Generation. Washington, DC: Department of Energy, p. 11.

[99] See Boone et al 2005, Appendix.

[100] Pimentel, David et. al. (1994). "Renewable Energy: Economic and Environmental Issues." BioScience, Vol 44 No 8, September, p. 29.

[101] Boone, D. Daniel et al. (2005). Landscape Classification System: Addressing Environmental Issues Associated with Utility-Scale Wind Energy Development in Virginia. The Environmental Working Group of the Virginia Wind Energy Collaborative. Retrieved May 2005 from http://www.VAwind.org/assets/docs/LCS-042105.pdf.

[102] Boone et al 2005, p. 30-31.

[103] For example, see Calvin R. Trice, "Windmill plan good for county?
Energy plan promises revenue for Highland, but at scenery's cost" *Richmond Times-Dispatch*, 10 July 2005, at http://www.timesdispatch.com/servlet/Satellite?pagename=RTD/MGArticle/RTD_BasicArticle&c=MGArticle&cid=1031783753002.

IMPEDIMENTS TO OFFSHORE WIND ENERGY

The impediments for offshore wind turbines include many of the same impediments as traditional, land-based wind turbines. Yet additionally, offshore wind turbines suffer from higher costs and a different set of environmental and public concerns.

Cost

While offshore wind turbines include many of the same parts (and costs) of land-based turbines, they are more expensive to install, operate and maintain (although they also have a higher possible capacity, and thus greater potential for making these costs back). A comprehensive study of distributed generators in Europe concluded that the foundations for off-shore turbines are understandably more expensive than their land-based counterparts because they must be moored and stabilized to the seabed floor. Additionally, the same study noted that the cost of sea transmission cables typically add more than 20% to the costs of an offshore wind project.[104]

In addition to being capital intensive, offshore wind projects face a more stringent permitting process. The organizers of the Cape Wind project near Nantucket Sound in Massachusetts had to assess not only the effects of their turbines on avian species, noise, climate and safety; they also needed to consider the effects on fish species, water quality, marine habitats, commercial and recreational navigation and telecommunications systems.[105] The strenuousness of permitting and the need for conducting expensive environmental impact assessments can result in longer delays for the approval of off-shore wind projects.

Environmental and Public Concerns

Offshore wind turbines usher in an additional collection of environmental concerns because of the possibility that they may endanger aquatic wildlife and ecosystem stability. Because only a small number of offshore wind projects exist in the United States, most studies on offshore wind have been undertaken by institutions in Europe. A study sponsored by the British government found that offshore wind turbines operating in the North Sea tended to disrupt sedimentation flows and reduce marine biodiversity.[106] A similar French and Norwegian study found that offshore turbines increase the risk of accidental collision between wind turbines and vessels. Such collisions could create chemical and oil spills that damage aquatic ecosystems.[107]

Furthermore, the areas in the United States with the most offshore wind potential include areas along the eastern seaboard—coastlines highly valued for their fisheries, aesthetics and

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[104] See Jorb, Wolfram et al. (2003). Decentralized Power Generation in the Liberalized EU Energy Markets: Results from the DECENT Research Project. New York: Springer, p. 27-29.

[105] Kaplan, Carolyn S. (2004). "Coastal Wind Energy Generation: Conflict and Capacity." Boston College Environmental Affairs Law Review 31, p. 170.

[106] Hiscock, K. et al, "High Level Environmental Screening Study for Offshore Wind Farm Developments—Marine Habitats and Species Project," *Report for the Department of Trade and Industry New and Renewable Energy Programme*, August, 2002, p. 3-6.

[107] OSPAR Commission, "Problems and Benefits Associated with the Development of Offshore Wind-Farms," 2004, Retrieved from www.ospar.org/documents/dbase/publications/p00212_Wind%20farms_Problems%20and%20benefits.pdf, p. 1.

recreational activities. A recent article in the *Boston College Environmental Affairs Law Review* noted that for many people, "fears of three hundred foot spinning turbines and blinking navigational lights blanketing the horizon have caused an uproar that threatens to drown out wind power's loudest advocates."[108]

IMPEDIMENTS TO PHOTOVOLTAIC SYSTEMS (SOLAR PANELS)

Photovoltaic (PV) electrical systems share a number of impediments with wind energy, but for different reasons. These impediments relate to the capital cost of PV systems, intermittency of electrical generation and land intensity required for large PV projects.

Cost

First, solar panels are expensive to manufacture, to site and to install. Photovoltaic cells are manufactured from costly multi-crystalline materials (the most popular being silicon, but also including gallium-arsenide, copper-indium-diselenide and cadmium-telluride) in both "thick" and "thin" models.[109] Like other renewable-energy technologies, they remain capital-intensive renewable technologies having low operating costs.[110] Solar installation sites must be carefully selected after consideration of several complex factors, including the amount of direct solar radiation, diffuse sky radiation, degree of cloudiness and air temperature.[111] While these factors do not apply to all solar systems,[112] the complexity associated with solar systems has convinced some policymakers that the calculation of the total cost to produce a kilowatt-hour of PV-generated electricity can be difficult and imprecise.

A typical "stand alone" system for home use requires a collector array, controller, inverter and battery bank, representing an investment of more than $20,000 for a few kilowatts of power.[113] The International Energy Agency estimated in 2002 that the installation cost of a basic photovoltaic system for individual use ranges from $5,000 to $7,000 per peak kW.[114] A similar study undertaken in the United States found that utility-scale PV farms often average around

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[108] Kaplan, Carolyn S. (2004). "Coastal Wind Energy Generation: Conflict and Capacity." Boston College Environmental Affairs Law Review 31, p. 198.

[109] For more on these manufacturing techniques, see Masters, Gilbert M. (2004). *Renewable and Efficient Electric Power Systems*. London: Wiley and Sons, p. 485-500; Sorenson 2000, p. 116; Berinstein, Paula. (2001). *Alternative Energy: Facts, Statistics, and Issues*. New York: Oryx Press, p. 64; and Willis, H. Lee and Walter G. Scott. (2000). *Distributed Power Generation: Planning and Evaluation*. New York: Marcel Dekker, p. 246-247.

[110] International Energy Agency 2002, p. 29-30.

[111] See Sorensen, Bent. (2000). Renewable Energy: Its Physics, Engineering, Use, Environmental Impacts, Economy and Planning Aspects. New York: Academic Press, p. 332; Bassam, Nasir E. and Preben Maegaard. (2004). *Integrated Renewable Energy for Rural Communities: Planning Guidelines, Technologies, and Applications.* New York: Elsevier Publishing, p. 30.

[112] For example, the use of solar shingles and amorphous silicon canopies do not require detailed design and site selection analysis.

[113] See Willis, H. Lee and Walter G. Scott. (2000). *Distributed Power Generation: Planning and Evaluation*. New York: Marcel Dekker, p. 256-257; Heinberg, Richard. (2003). *The Party's Over: Oil, War, and the Fate of Industrial Societies*. New York: New Society Publications, p. 142-143.

[114] International Energy Agency 2002, p. 29-30.

$7,000 per peak kW.[115] At even the best rates (where the cost of generating electricity is the most expensive), the capital expense of a PV system is three to seven times as expensive as coal and natural gas facilities (and up to four times as expensive as other renewable technologies like biomass gasification and wind turbines).[116]

Still, such high capital costs deter investment in PV systems, as their payback periods are substantially longer than some businesses are willing to permit. The average business often looks for a two- to three-year payback on capital investments on energy investments. Yet a recent *New York Times* article explained that "solar power cannot yet provide that; the average commercial installation is expected to pay for itself in five to nine years."[117] Low energy prices only enhance this impediment, as it means PV systems take even longer to pay for themselves. On the other hand, the recent trend toward higher-than-historically-average prices of energy may serve to encourage the use of PV and other renewable resources.

Having said this, PV systems have been demonstrated to be cost-effective in certain situations—for isolated users who remain distant from transmission lines and even for large utilities in niche applications. In the early 1990s, for example, Pacific Gas and Electric undertook a pioneering study (with real applications) showing that PV applications (and demand-side management techniques) near large demand centers (especially those at the end of distribution lines) provided benefits by deferring transmission and distribution upgrades, by extending equipment maintenance schedules and by improving distribution network reliability—all of which contributed to cost savings to the utility. The study demonstrated the value of more complex methods of analysis (and the abandonment of rule-of-thumb approaches that remain common in utility engineering circles) for reducing overall costs through the use of judiciously sited renewable energy and demand-side technologies.[118]

Intermittency

Much like wind turbines, large- and utility-scale PV systems can only produce electricity intermittently. They cannot function during the night and their users must rely on additional generating units (or the grid) to supplement lags in their production of electricity.[119] The costs of storing electricity generated from PV technology using batteries, pumped storage and flywheels also remain expensive. In addition, many regions of the world that consume the most energy (such as New York City, Washington, DC, and Richmond) do not have bright, year-round sunlight and they suffer from long fall and winter seasons that result in greatly fluctuating power

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[115] See Public Renewables Partnership, "PV Cost Factors," 2005, retrieved from http://www.repartners.org/solar/pvcost.htm.

[116] Taylor and Van Doren 2002, p. 4.

[117] Rendon, James. (2003). "In Search of Savings, Companies Turn to the Sun." *The New York Times*, October 12, p. B12.

[118] T. Hoff and D.S. Shugar, "The Value of Grid-Support Photovoltaics in Reducing Distribution System Losses," *IEEE Transactions on Energy Conversion* 10 (Sept. 1995): 569-76; and Charles D. Feinstein, Ren Orans, and Stephen W. Chapel, "The Distributed Utility: A New Electric Utility Planning and Pricing Paradigm, *Annual Review of Energy and the Environment* 22 (1997): 155-85.
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[119] Bradley 1997, p. 12.

supplies from PV.[120] Again, as with wind turbines, this intermittency makes PV systems a poor choice for wholesale electricity markets and the provision of base-load power.

Land Intensity

Finally, PV systems convert sunlight to electricity at relatively low efficiency rates of 7 to 17%.[121] Because of this low conversion rate, PV systems require prodigious amounts of land (or building roof space) to generate significant amounts of electricity.[122] While PV technology may offer benefits for stand alone power for some residences and for supplying electricity to remote applications, solar panels require too much space to generate large amounts of electricity. One study concluded that "satisfying current U.S. electrical consumption would require nearly 10 billion square meters of photovoltaic solar panels."[123] This technical fact may explain why, as of 2002, PV systems supplied only .02% of electricity in the United States, or 844 MWh;h.[124] However, there is very large potential for PV on roofs of buildings and other structures (e.g., canopies). Consequently, an increased footprint on landscape is not always necessary for solar to have significant impact on supply.

IMPEDIMENTS TO BIOMASS / WASTE-TO-ENERGY FACILITIES

As noted elsewhere in this report, the category "biomass" includes a wide variety of fuels and techniques. For the current section, we restrict the use of the term to include the combustion of agricultural residues, woodchips, forest wastes and energy crops to produce electricity. Biomass generation also includes advanced combustion techniques such as biomass gasification (in which the biomaterial is gasified prior to its combustion to increase efficiency) and co-firing (in which biomass burns with another fuel, such as coal or natural gas, to increase its density). Finally, the electrical generation from landfill gas and anaerobic digestion, burning of municipal wastes and trash and the incineration of industrial wastes is also covered under the term "biomass." The primary impediments to biomass—the low energy density of fuel, variability of fuel sources and environmental and public concerns—apply to all forms of biomass.

Low Energy Density of Fuel

While biomass sources are abundant (and can be found close to any community in Virginia), such fuels possess very low energy density. In other words, the energy content per volume of biomass remains much less than the same volume of most other fuels. A study conducted by the American Society for Mechanical Engineers found that the average heating value for biomass fuels in the United States range from 300 to 400 Btu/cubic foot, almost one sixth the energy

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[120] Friedman, S. Julio and Thomas Homer-Dixon. (2004). "Out of the Energy Box." *Foreign Affairs* 83(6) November/December, p. 76.

[121] Efficiency refers to the percentage of converting sunlight to electricity. See also Leslie, Leonard G. (2003). Design and Analysis of a Grid Connected Photovoltaic Generation System With Active Filtering Function (Master's Thesis). Blacksburg, VA: Virginia Tech, p. 7-8.

[122] Borbely, Ann-Marie and Jan F. Kreider. (2001). *Distributed Generation: The Power Paradigm for the New Millennium*. New York: CRC Press, p. 107.

[123] Friedman and Homer-Dixon 2004, p. 77.

[124] Cragg, Chris. (2002). "The Magic of Solar PV." *Platts Energy Economist* 254 (December), p. 9-15.

density of most forms of coal.[125] Such low energy density means that large amounts of fuel are needed to produce electricity. As a result, the transportation, storage and processing costs for biomass become greater. Large bioelectric plants also need expensive bulk feedstock systems to sort and dry biomass material.[126]

Variability of Fuel Sources

The variability in biomass fuel—not just its energy density, but its moisture content, molecular composition and purity—also plays a role in the combustion process and can be viewed as an impediment. An oak tree burns differently than a pine tree, let alone tobacco residue, switch-grass, or sweet sorghum. Most biomass fuels possess high water content and are often wet when burned. Consequently, large amounts of wasted energy go up the stack as water vapor, leading to relatively low thermal efficiencies for converting fuel to electricity—usually less than 20%. On one hand, this statistic reveals two important advantages of biomass combustion, namely the ability to combust a variety of fuels, making fuel shortages unlikely, and the production of steam ideal for CHP applications. On the other hand, it also means more fuel must be burned to produce electricity. The result tends to be slightly more expensive electricity, often around 9 cents per kWh, using conventional means of analysis (in which externalities are not included, for example).[127] In addition, many biomass fuels—especially municipal waste and construction timber—are contaminated with chemical pollutants, pesticides and paint. The separation of these non-biodegradable materials from combustible material increases the complexity and cost of bioelectric generation.[128]

Environmental and Public Concerns

Much like the combustion of coal, the burning of biomass emits a significant number of pollutants into the atmosphere. While biomass combustion has the advantage of not releasing any net carbon dioxide into the atmosphere (and thus contributes little to the global inventory of greenhouse gases,), it releases measurable levels of particulate matter, nitrous oxides and sulfur oxides.[129] As an influential report written by the Energy Justice Network concluded, "all biomass combustion technologies put pollution in the air in order to make 'green energy'."[130] Moreover, dioxin and polyvinylchloride contamination can occur when wood waste derived from

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[125] Boyce, Meherwan P. (2002). Handbook for Cogeneration and Combined Cycle Power Plants. New York: ASME Press, p. 21.

[126] Borbely and Kreider 2001, p. 375-376; Bauen, Ausilio, Jeremy Woods, and Rebecca Hailes. (2004). "Bioelectricity Vision: Achieving a 15% of Electricity from Biomass in OECD Countries by 2020." *Reported by the Centre for Energy Policy and Technology*, April, 2004. London: WWF International, p. 30.

[127] Masters, Gilbert M. (2004). *Renewable and Efficient Electric Power Systems*. London: Wiley and Sons, p. 192.

[128] Bauen, Woods, and Hailes 2004, p. 33.

[129] For well written reports on these environmental implications concerning biomass combustion, see Ewall, Mike. (2000). "The Burning Issues with Biomass," March, 2000, retrieved from http://www.energyjustice.net/biomass/; Monastersky, R. (1990). "Biomass Burning Ignites Concern," *Science News*, March 31, p. 32-35; Pimentel, David et. al. (1994). "Renewable Energy: Economic and Environmental Issues." *BioScience*, Vol 44 No 8, September; and Mishra, Vinod. (2003). "Effect of Indoor Air Pollution from Biomass Combustion on Prevalance of Asthma in the Elderly." *Environmental Health Perspectives* 111(1): January, Retrieved March 2005 from http://ehp.niehs.nih.gov/members/2003/5559/5559.html.

[130] Ewall, Mike. (2000). "The Burning Issues with Biomass," March, 2000, Retrieved from http://www.energyjustice.net/biomass/, p. 3.

construction and demolition projects, urban tree trimmings, and paper and lumber mills are burned.[131] A 1996 study undertaken by the Environmental Research Foundation concluded that biomass combustion, while much better for the environment than fossil-fueled generation, was still responsible for 2% of all dioxin contamination in the Great Lakes region.[132] To minimize the release of contaminants, biomass plants must employ pollution prevention technology in the form of scrubbers and filters.[133]

These environmental concerns parallel aesthetic concerns about land use, smell and traffic congestion. The use of agricultural wastes and forest residues—including energy crops, sugar, legumes and vineyard grain—to generate electricity sometimes strips local ecosystems of needed nutrients and minerals. Widespread use of these fuels can contribute to habitat destruction and deforestation.[134] Furthermore, the combustion of biomass has been reported to release foul odors near some plants and they can contribute to traffic congestion when large amounts of fuel must be delivered by trucks.[135]

LARGE-SCALE HYDROELECTRIC

Large-scale hydroelectric generators include dams that generate at least 60 to 100 MW of power. The most significant impediments to these sizeable hydroelectric plants are intermittency due to disruption of supply, a host of environmental concerns and the capital intensity of dam construction.

Disruption of Supply

The largest—and simplest—impediment to hydropower deals with weather and climate. Lack of adequate snowfall and rain leaves may hydroelectric facilities susceptible to disruptions and interruptions in supply. In the Pacific Northwest, where recent snowfall has been below average, weather problems have forced policymakers to choose between further depletion of water resources to produce electricity for energy-intensive industries (such as the aluminum industry) or to protect these resources for use by commercial and recreational pursuits.[136] In addition, many analysts have highlighted the role that poor hydroelectric generation played in the 2000-2001 California electricity crisis, where a shortage of rainfall depleted needed hydroelectric reserves that could have provided enough generation to prevent blackouts throughout the state

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[131] Ibid, p. 5.

[132] Montague, Peter. (1996). “How to Eliminate Dioxin.” *Rachel’s Environment & Health Weekly* 508 (August 22). Retrieved May 2005 from http://listerv.repp.org/pipermail/bioenergy/1996-August/003007.html, p. 4.

[133] Casa, Kathryn. (2005). “Shades of Green: Biomass Plant Would Have Cross-Border Effects.” *Vermont Guardian*, February 21, p. 13.

[134] See Ewall, Ibid; Kleinbach, Paul and Henry Hinrichs. (2002). *Energy: Its Use and the Environment*. New York: Harcourt College Publishers, p. 562.

[135] Myers, Ben. (2005). “Virginia Tech and Biomass.” Personal Communication (Email), May 6, 2005, p. 1-3.

[136] Dingell, John D. (2001). “National Energy Policy Report of the National Energy Policy Development Group.” *Hearing Before the Subcommittee on Energy and Air Quality of the House Committee on Energy and Commerce*. June 13. Washington, DC: Government Printing Office, p. 5.

metropolitan regions.[137] Finally, some scientists believe that climate change will increase the frequency and severity of droughts, further compromising the reliability of hydroelectric power.[138]

Environmental Concerns

The most extensively debated and complex problems facing hydropower relate to habitat and ecosystem destruction, emissions from reservoirs, water quality and sedimentation. All these concerns arise because of the dam's role as a physical barrier interrupting water flows for lakes, rivers and streams. Consequently, dams can drastically disrupt the movement of species and change upstream and downstream habitats. Such barriers also result in modified habitats with environments more conductive to invasive plant, fish, snail, insect and animal species, all of which may overwhelm local ecosystems.[139]

To maintain an adequate supply of energy resources in reserve, most dams impound water in extensive reservoirs. However, these reservoirs often emit large amounts of carbon dioxide from rotting vegetation and carbon inflows. The comprehensive *World Commission on Dams* report noted that "a first estimate suggests that gross emissions from reservoirs may account for between 10% and 28% of the global warming potential of greenhouse gas emissions."[140] The International Rivers Network warned that, "in some cases, reservoirs may have a greater impact on global warming than similar-sized gas-fired power stations."[141]

Capital Intensity

Like other renewable energy technologies, hydroelectric plants can produce electricity at little resource cost. However, they remain "hugely expensive to build and their costs are usually far higher than estimated."[142] The World Commission on Dams Report concluded that, on average, dams end up costing 56% more to build than predicted. Coupled with inflated costs comes underperformance and expensive maintenance needs, as well as costly resettlement programs for displaced people.[143] Also, larger dams take a long time to build, making it difficult to match capacity accurately with projected demand. Finally, the vagaries of river flow make hydroelectric dams unsuitable for some types of uninterruptible power.

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[137] For an excellent summary, see the Congressional Budget Office, "Causes of the 2001 California Blackout and Lessons for the Future," 2002, p. 2-9.

[138] International Rivers Network. (2004). *Dammed Rivers, Damned Lives: The Case Against Large Dams*. Berkeley, California. Retrieved from http://www.irn.org/largedams, p. 2.

[139] World Commission on Dams. (2000). *Dams and Development: A New Framework for Decisonmaking*. November. London: Earthscan Publications, p. 80.

[140] World Commission on Dams. (2000). *Dams and Development: A New Framework for Decisonmaking*. November. London: Earthscan Publications, p. 75-76.

[141] International Rivers Network. (2004). *Dammed Rivers, Damned Lives: The Case Against Large Dams*. Berkeley, California. Retrieved from http://www.irn.org/largedams, p. 4.

[142] International Rivers Network. (2004). *Dammed Rivers, Damned Lives: The Case Against Large Dams*. Berkeley, California. Retrieved from http://www.irn.org/largedams, p. 1.

[143] For more on these social and economic effects, see the World Commission on Dams 2000.

SMALL-SCALE HYDROELECTRIC

Small-scale hydroelectric systems—also referred to as "run-of-the-mill," "micro-hydro," and "run-of-the-river" hydropower—differ from large hydroelectric dams in two ways. First, the smaller systems have much lower capacities, often between 25 kW and 50 MW. Second, smaller systems have different basic components: they typically consist of a water conveyance channel or pressured pipeline to deliver water to a turbine or waterwheel that powers a generator, which in turn transforms the energy of flowing water into electricity.[144] Because they operate on a much smaller scale, run-of-the-mill hydro plants escape many of the challenges raised by their larger counterparts, since they use smaller turbines and require much smaller reservoirs. However, these smaller plants still face licensing and permitting challenges and a different set of environmental problems.

Licensing and Permitting

Small-hydroelectric facilities—even though they operate at much lower capacities and impose an inherently smaller environmental footprint—must complete the same type of extensive licensing and environmental impact assessment as bigger plants. Apart from being unnecessarily complex, the application process for a hydro license, regardless of the size of the plant and independent of its environmental impact assessment, can exceed twelve months. The costs for such licenses, consequently, prohibit investment in small hydrosystems. Furthermore, the application process for all dams requires extensive environmental permitting and environmental impact assessments that can take as long as seven years to complete (usually in the form of basin-wide assessments that evaluate the environmental impacts from a dam on the entire surrounding ecosystem).[145] As a result, the Director of Government Affairs for American Rivers, a nonprofit group that advocates the use of hydropower, recently concluded that "the licensing process has often been complex and resource intensive for all parties, including energy producers, property owners, recreationists, fisherman and conservationists."[146]

Environmental Concerns

Because most small hydropower systems operate in small rivers and streams, they produce a different set of environmental impacts. These often include significant chemical and geomorphological consequences of altering stream flow and disrupting the nutrient cycle, which hurts various types of plant life. Many small dams can also drastically reduce fish populations (notably species of salmon in the Pacific Northwest) by cutting off tributaries and increasing the

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[144] Bassam and Maegaard 2004, p. 142.

[145] For more on these concerns, see Powers, Kyna. (2004). "Hydropower Licenses and Relicensing Conditions: Current Issues and Legislative Activity." *CRS Issue Brief for Congress*. November 4. Library of Congress: Congressional Research Service; and Birnbaum, Elizabeth. (2001). "Electricity Generation and Transmission: Hydroelectric Re-licensing Procedures." Hearing Before the House Committee on Energy and Commerce. July 19. Washington, DC: Government Printing Services, p. 78-91.

[146] Bettenberg, William. (2001). "Electricity Generation and Transmission: Hydroelectric Re-licensing Procedures." Hearing Before the House Committee on Energy and Commerce. July 19. Washington, DC: Government Printing Services, p. 51-60.

number of contaminants in freshwater.[147] Finally, a recent study undertaken by the Department of Energy on dead salmon at hydropower projects in the Columbia Basin concluded that hydroelectric turbine and spillway turbulence has a tendency to disorient fish, making them more susceptible to predation by other fish and birds.[148]

TIDAL TURBINES, OCEAN AND WAVE POWER

The category of electricity known as "ocean power" is often categorized as shoreline, near-shore and offshore "wave extraction" technologies. Shoreline devices use oscillating water columns, mid-level tidal turbines, tapered channel systems and submerged hollow air chambers to produce power. Near-shore devices often attempt to harness energy from waters immediately beyond the breaker zone. Offshore devices typically include buoys, static platforms, seabed and deep-sea-turbines to generate power.[149] The most commonly used form of this technology employs an array of ocean turbines to utilize the movement of ocean water to generate power. These ocean turbines face two primary impediments: cost and environmental concerns.

Cost

Because tidal- and ocean-turbines are a much newer technology than other renewables, the amount of data on their impediments (such as comprehensive cost analyses and product reviews) remains limited. Such plants do not currently exist in the commercial sector and they remain in the planning and theoretical state. However, a preliminary assessment suggests that the construction for tidal plants would be time-consuming and capital intensive. For instance, the construction of a proposed tidal plant across the Severn River in the United Kingdom is estimated to cost $12 billion. Such plants are also expected to be expensive to maintain, as they must deal with the risk of severe weather, corrosion from salt water and erosion from the shifting tides. Marine growth can build up on turbine blades and arrays of experimental tidal turbines have been known to cause ingresses of debris. To deal with these problems, tidal turbines will require expensive corrosion resistance materials, bearings and sealants.[150] As a result, a 2001 Department of Energy report noted that such technologies are still in the developing stages and that "the cost per kilowatt hour of tidal power is not competitive with conventional fossil fuel power … [W]ave energy sources cannot compete economically with traditional power sources."[151]

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[147] See World Commission on Dams, 2000; Koch, F. (2002). "Hydropower, Society, and the Environment." *Energy Policy* 30(24): 1251-1263.

[148] Glenn Cada, "Solving the Mystery of the Dead Salmon," *Oak Ridge National Laboratory Science & Technology Highlights*, No 1, 2005, p. 5.

[149] For more on ocean power, see United States Department of Energy. (2001). "Energy Savers: Ocean Energy." *Energy Efficiency and Renewable Energy*, Washington, DC: October, Department of Energy; Von Jouanne, Annette. (2005). "The Promise of Wave Power." *EnergyBiz Magazine,* March/April: 73-74; and Bassam and Maegaard 2004, p. 156; Berinstein, Paula. (2001). *Alternative Energy: Facts, Statistics, and Issues*. New York: Oryx Press, p. 113-114.

[150] Bassam and Maegaard 2004, p. 156-157.

[151] Department of Energy 2001, p. 6.

Environmental Concerns

Although ocean-derived energy would theoretically require no fuel and produce no emissions, its operation would not come without environmental challenges. Collections of many turbines in a single location can alter ocean current and negatively influence water quality, especially the distribution of nutrients within marine ecosystems. In addition, like hydroelectric facilities, tidal power plants that dam estuaries can impede sea life migration and can shift sedimentation and silt movements within bays and river deltas.[152]

CONCLUSION

As this report demonstrates, the impediments facing renewable energy systems in Virginia include an amalgam of technical, social, economic, political and cultural factors. For a concise summary of these impediments, see the following tables.

Table 1: Impediments Facing All Renewable Energy Systems in Virginia

Variable Public Policy	Inability to Provide Select Forms of Power	Historical Attitudes and Understanding of the Electric Power System	Difficulty in Standardizing	Monopoly Rules	Interconnection Standards

Table 2: Technology-Specific Impediments

	Intermittency	Cost	Environmental and Public Concerns	Other Concerns
Wind turbines	☑	☑	☑	
Offshore Wind Energy		☑	☑	
Solar Energy	☑	☑		Land Intensity (Except Roof/Canopied Systems)
Biomass/Waste-to-Energy			☑	Low Energy Density (For Some Forms), Variability of Fuel
Geothermal	.		☑	Capital Intensity of Extraction, Limited availability
Large Hydroelectric			☑	Disruption of Supply, Capital Intensity, Limited Availability
Small Hydroelectric			☑	Licensing and Permitting
Ocean Power		☑	☑	
OTEC		☑	☑	Limited Availability

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[152] Department of Energy 2001, p. 3.

These tables suggest that many impediments face the deployment of renewable technologies in Virginia. Nevertheless, the technologies have merits that demand consideration by legislators, who have the authority to remove some of the impediments and create appropriate incentives. For example, they can address the problem of policy variability by creating laws and regulations that offer appealing long-term incentives for investors. Likewise, they can order regulatory agencies to institute rules that eliminate vestiges of monopoly power (held by incumbent utility companies) in an era of supposed deregulation and restructuring. To be sure, some of the impediments cannot be addressed on the statewide level. Interconnection standards must be developed and implemented on a national (and even cross-border) basis because of the integrated nature of the North American electrical grid.

Despite the existence of several impediments, renewable energy technologies offer several advantages (as already noted). Moreover, they remain an excellent option for the provision of modular, clean and efficient electricity generation. The modularity of renewable energy systems makes them ideal for industries and commercial enterprises wishing to generate a limited amount of electricity or to add incremental amounts of power generation to their portfolio. The emissions-free status of many renewable energy technologies makes them attractive for urban customers already suffering from pollution and those customers constrained by stringent environmental permitting. Moreover, renewable energy systems can increase the efficiency and reliability of the electric utility system by reducing demands on the transmission and distribution networks. In some cases, they are also simpler to operate and repair than their larger fossil-fueled brethren. Finally, as components of distributed generation systems, renewable energy technologies may enhance the reliability and security of the grid, especially during deliberate or unintentional malfunctions of critical transmission lines and large-scale power plants. In these distributed applications, renewable energy technologies offer benefits that transcend simple dollar and cents comparisons with traditional, large-scale generation technologies.

APPENDIX D

ECONOMIC DEVELOPMENT IMPACTS OF RENEWABLE ENERGY IN RURAL VIRGINIA

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INTRODUCTION

This section of the report examines the economic development impacts that would result from an increased use of renewable energy. While there are many potential renewable sources, the three that will be examined in-depth in this report are: electricity generation from photovoltaic solar, wind derived energy and biomass. Economic impacts depend critically on the location of the facility in question, the size and type of investment, and the structure of the local economy. The estimates presented here are rough guides; in the case of an actual investment, the impact would be site- and context-specific.

ECONOMIC DEVELOPMENT IMPACTS DEFINED

Economic impacts are usually accrued in four distinct ways: direct economic impacts, indirect and induced impacts and changes in tax revenue. Direct impacts are those impacts that arise immediately from the new or expanded operation of a producer. These include increased income, employment, value of production and sales resulting directly from a renewable energy production operation. Indirect impacts are those impacts that are caused because the producer purchases more locally supplied inputs. An example could be that because of an increase in biomass operations a local supplier of farm goods would experience an increase in sales and he would in turn purchase more inputs, both physical and labor. Induced impacts result from spending caused by increased income related to the direct and indirect impacts. The additional labor hired by the renewable energy producer and his suppliers will now have more money to spend and this spending will increase local economic activity. An increase in investment and output will often have tax revenue implications. The change in tax revenue depends on the size of capital investment and the level of economic activity generated by the increased output.

The increase in economic activity caused by a change in output (the direct effect) is often referred to as the multiplier effect. To determine the size of the multiplier it is necessary to understand the inputs that go into producing energy, the value of the energy produced and linkages between renewable energy producers and the rest of the state economy. The impacts depend on the strength of linkages within the state’s economy, how many of the purchased inputs are imported from other states (leakages), etc. These effects are normally measured using a regional economic model, but we present rough ranges of typical multipliers. When a producer expands production there can be significant increases in local tax revenue depending on the size of the capital investment, changes in incomes and resulting purchases (sales taxes) and other ripple effects through the economy.

It is important to note that the economic impacts from increased production of renewable energy are conceptually no different than impacts generated from any other industrial investment. The exact nature of the industry will determine what inputs are purchased locally and the linkages to the rest of the economy, but direct, indirect and induced impacts exist for all industries. The Virginia Economic Development Partnership has a framework for evaluating the impacts of industries that receive economic development incentives and it is important to compare the impacts of renewable energy incentives against other available alternatives.

PHOTOVOLTAIC SOLAR (PV)

The first step in this economic analysis was to estimate the potential for PV in Virginia given reasonable assumptions about available solar energy and the cost of alternatives. Information was gathered from the National Renewable Energy Laboratory regarding available solar energy in Virginia[1]. This information showed that Virginia has receives relatively little solar radiation compared to many Western states. The feasibility of both utility scale and residential scale projects was investigated. Due to the limited amount of potential solar energy in Virginia the rate of return on PV investments at the utility scale would be well below required returns on capital for an investor-owned utility. This is due to the limited amount of solar energy in Virginia and the low price of wholesale electricity.

The potential for residential and commercial use of PV technology was examined next. To calculate the cost of generating PV electricity in Virginia, estimates for equipment and generating potential were obtained[2]. Assumptions can be found in Attachment A. The calculations show that, given normal residential utility rates, an investment in PV would fall far short of paying for itself over a 30-year useful life. For an investment in PV equipment to break even, a residential electricity rate of more than 30 cents per kWh or equipment costs per kW of less than $2,000 would be required. Current rates for residential electricity are 7-9 cents per kWh and the cost per kW of PV capacity is in excess of $6,500. To determine the potential for PV technology it is necessary to compare it with other technologies that reduce energy costs. When compared to conservation options such as the installation of energy-efficient windows, PV cells are an inferior investment. Given its high cost and the availability of more cost-efficient alternatives there is little potential for the increased use of PV in Virginia at this time.

Because of the limited potential for PV, a comprehensive assessment of impacts was not considered necessary. The direct impacts would include the construction costs, the avoided utility costs and maintenance costs. Because PV requires no fuel inputs and little maintenance, the indirect impacts would be minimal. Tax impacts will depend on the value of the investments and changes in local incomes. Incentives to encourage more photovoltaic manufacturing in the Commonwealth should be evaluated using the VEDP framework. If PV becomes economically feasible, the existence of a PV manufacturing capacity in the state will increase the multiplier associated with installation of PV capacity.

WIND POWER

The first step in this analysis is to determine the potential for wind energy in Virginia. Wind power in Virginia faces physical and economic constraints in the near term. The most important physical factor is a limited number of high-wind areas close to transmission lines. From this perspective it is likely that more than 150MW of capacity could be added in the state over the next 3 years, though the actual number of new wind farms developed will depend significantly of

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[1] National Renewable Energy Laboratory, "Maps of Solar Market Potential at Federal Sites" Thursday, August 22, 2005, http://www.nrel.gov/gis/femp_maps.html#pv.

[2] Equipment Cost Estimates obtained from BP Solar Marketing Manager Oliver Koehler

economic factors[3]. Nationwide, the wind industry has doubled total installed capacity over the last five years, due in large part to a continuation of the federal production tax credit and the implementation of renewable portfolio standards (RPS)[4]. Currently, wind farms are a low-cost means for utilities to generate additional renewable energy and comply with renewable portfolio standards. Even though Virginia does not have a renewable portfolio standard, states such as Maine and others allow utilities to purchase renewable energy credits from utilities in other states and count them toward their RPS requirement[5]. With a number of states phasing in renewable portfolio standards and the recent extension of the federal production tax credit through 2007, the economic outlook for wind power in the near term is fairly strong[6].

Despite favorable economic conditions and available wind resources, Virginia currently has no utility scale wind operations[7]. A developer is trying to site a wind farm in Highland County, but faces significant local opposition[8]. In the short term, it appears that the major obstacles to increased wind development will be regulatory and legal in nature rather than economic.

Impacts

The economic impacts of wind development are best understood by examining the construction and operation phases of the project separately. The construction of wind farms often generates substantial, though temporary, employment and increases economic activity in the host county. To put this into perspective, a recent wind development in Wisconsin installed 20 turbines with towers more than 200ft tall. The foundation for *each* of these turbines required 167 tons of concrete[9].

Based on the experiences of Iowa and Minnesota, if 150 MWs of wind derived generating capacity were installed in Virginia, roughly 125 short-term construction jobs would be created[10]. Given typical multipliers associated with construction projects of such magnitude, an additional 80-100 short-term jobs are likely to be created. These jobs would disappear as soon as construction is complete. The cost to install wind power including construction, equipment, administrative, legal and miscellaneous expenses is approximately $1.3 million per MW[11]. Of

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[3] Bird, Lori, et al. "Virginia Renewable Energy Resources and Costs," Appendix A of this report, Table 6, page A-6.
[4] American Wind Energy Association, "US Installed Capacity (MW) 1981-2004" Thursday, August 11, 2005, http://www.awea.org/faq/instcap.html.
[5] DSIRE. "Renewable Portfolio Standard", Thursday, August 11, 2005, http://www.dsireusa.org/library/includes/tabsrch.cfm?state=ME&type=RPS&back=regtab&Sector=S&CurrentPageID=7.
[6] Foss, Brad. "Energy Bill is a Mixed Bag for Some." Washington Post Friday, July 29, 2005. Thursday, August 11, 2005, www.washingtonpost.com/wp-dyn/content/article/2005/07/29/AR2005072901079.html.
[7] American Wind Energy Association. "Wind Energy Projects Throughout The United States of America", Thursday, August 11, 2005, http://www.awea.org/projects/index.html.
[8] Cramer, John. " An electric debate about turbines in Highland County." Roanoke Times Saturday, May 21, 2005. Monday, May 23, 2005, http://www.roanoke.com/printer/printpage.aspx?arcID=24032.
[9] Renew Wisconsin. "Montfort Wind Farm", Thursday, August 11, 2005, http://www.renewwisconsin.org/windfarm/montfort.html.
[10] American Wind Energy Association. "Wind Energy and Economic Development: Building Sustainable Jobs and Communities", Thursday, August 11, 2005, http://www.awea.org/pubs/factsheets/EconDev.PDF.

[11] Siegel, Michael. "Economic and Fiscal Impacts of the Proposed New Highland Wind Project on Highland County, Virginia" Friday, August 12, 2005, http://johnrsweet.com/Personal/Wind/PDF/SiegelEconomicReport20040520.pdf, p 1.

that, roughly $800,000 is equipment costs[12]. To maximize the economic development potential of wind power, it may be beneficial to offer an incentive for developers to use equipment produced in Virginia. General Electric has a facility in the Roanoke area involved with wind power. It is difficult to predict how an increase in wind development in Virginia would affect their operations and this topic might warrant further research.

Once construction is complete, the towers and turbines need to be serviced regularly, generating long-term operations and maintenance jobs. It is likely that 25 long-term jobs would be necessary to service 150 MWs of capacity[13]. In addition to construction and O&M jobs, wind development provides additional income to land owners and developers. Often, wind developers will contract with farmers and other land owners in high wind areas for the right to construct wind turbines on their property. The typical lease payment to a land owner is $2,000 annually per turbine[14]. The additional annual net income to the wind developer is $20,000 per turbine while making loan payments, 10-12 years in duration, and $73,000 a year there after[15, 16]. The addition of 150MWs of capacity would generate an additional $2.2 million dollars of annual net income statewide to land owners and developers. It is important to note that these are general estimates and that the actual profitability of an individual project will depend significantly on the abundance of local wind, efficiency of the turbines and the cost of financing.

Using typical multipliers, the 25 long-term O&M jobs would create 12-25 additional jobs and the additional $2.2 million in income will generate an additional $1.1-2.2 million in indirect and induced incomes. With the multiplier effects, the installation of 150 MWs of wind power would create 37-50 long term jobs and increase economic activity by $3.3-4.4 million.

Tax Revenue and Rural Development Impacts

The main benefit of wind development to rural communities will be an increase in property tax revenue. Because wind-power is capital intensive, the development of a wind farm can significantly increase the local property tax base of rural communities. In the case of Highland County, if the planned wind farm is built, it will increase the real property tax base by more than 10%[17]. It is important to note that the exact level of tax benefit that localities will gain depends significantly on the State Corporation Commission (SCC) and the depreciation rules that they develop for wind assets. Because there are no utility-scale wind operations in Virginia, the SCC has not yet established a depreciation schedule for wind assets and thus there is no precedent for estimating tax revenues. To illustrate the importance of the depreciation rules, Table 1 shows the tax revenues that Highland County would receive under different depreciation schedules. With a

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[12] American Wind Energy Association. "The Economics of Wind Energy" Friday, August 12, 2005, http://www.awea.org/pubs/factsheets/EconomicsofWind-March2002.pdf.

[13] American Wind Energy Association. "Wind Energy and Economic Development: Building Sustainable Jobs and Communities", Thursday, August 11, 2005, http://www.awea.org/pubs/factsheets/EconDev.PDF.

[14] Raloff, J. 2001. "Power Harvests" *Science News* 160 (3): p45

[15] Raloff, J. 2001. "Power Harvests" *Science News* 160 (3): p45

[16] American Corn Growers Foundation. "Electricity from the Wind: Economic Development for Rural Communities" Friday, August 12, 2005, http://www.acgf.org/programs/news_releases/index_120103.htm.

[17] Siegel, Michael. "Economic and Fiscal Impacts of the Proposed New Highland Wind Project on Highland County, Virginia" Friday, August 12, 2005, http://johnrsweet.com/Personal/Wind/PDF/SiegelEconomicReport20040520.pdf, p 9.

difference of more than 25% between the high and low scenarios, depreciation rules will significantly impact the benefits of wind power development to local governments.

Table 1. NPV of Tax Revenue under Different Depreciation Schedules (per MW)

20-year Straight Line Depreciation	$40,170
20-year Straight Line Depreciation to 80%	$45,430
25-year Straight Line Depreciation to 80%	$51,510

An increase in wind development in rural counties may not do much to stimulate jobs in distressed labor markets. While wind power will generate some jobs at the state level, the number of these jobs that are filled by citizens in rural counties such as Highland is likely to be limited. In his economic impact analysis, Michael Siegel investigated how employment in very rural counties in four other states had changed after wind developments had been constructed. In similar situations in other states his research showed that, because of the highly specialized nature of the work, most of the construction jobs were filled by contractors from the turbine manufacturer and not local residents[18]. The construction jobs filled by local residents are likely to be limited to those involving earth moving and cement. The maintenance jobs may be filled by someone in the county, but other states this had not occurred. Because of this, the primary benefit to extremely rural localities from increased wind development will be tax-related. Wind development will increase employment in the state, but these jobs may not contribute significantly to the labor markets in distressed rural localities.

BIOMASS

Biomass is the last source of renewable energy to be examined in this chapter. Biomass is a broad term that refers to the potential energy in plant matter and includes everything from wood and crop residuals to crops grown for the sole purpose of energy production. Biomass is best examined in two distinct categories--biomass from waste streams and biomass from dedicated energy crops.

Forestry and agricultural wastes and residuals are almost always a cheaper source of biomass than dedicated energy crops. The woodchip burning power plant in Hurt, Virginia is an excellent example of a utility using a residual from the forestry industry. The use of residuals to generate power has several advantages. First, the forester no longer has to dump the woodchips in a landfill and avoids disposal costs. Given the increasing scarcity of landfill space, this is also advantageous for society at large. Second, the forester receives payment for the woodchips and has additional income (the payment minus shipping costs plus avoided disposal fees). Incomes are also created in the transportation industry as waste forest products are shipped as far as 100 miles. The major disadvantage to the use of residuals for power generation is that their supply can be intermittent and is largely determined by the parent industry. Given the need for reliable power generation, this irregularity can be problematic. The total potential for renewable energy

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[18] Siegel, Michael. "Economic and Fiscal Impacts of the Proposed New Highland Wind Project on Highland County, Virginia" Friday, August 12, 2005, http://johnrsweet.com/Personal/Wind/PDF/SiegelEconomicReport20040520.pdf, p 2.

from biomass residuals and waste streams is difficult to estimate and is extremely local in nature. The nature of economic development impacts will depend significantly on the local situation but will generally result in increased incomes and additional transportation jobs.

The remainder of this report will focus on the economic development potential of an increase in switchgrass production as a boiler crop. Although there are many different sources of biomass, this report will focus on switchgrass because of its potential to positively affect employment in distressed Southside Virginia and as a replacement crop for tobacco producers. Because switchgrass is an input used in power generation and not a final good, the input-output framework is not a good way of discussing economic development impacts. Instead, this section of the chapter will discuss the advantages of switchgrass production, factors affecting economic viability and the economic impacts of increased switchgrass production.

Switchgrass is a perennial warm-season grass native to Virginia. Switchgrass is very productive and has a higher yield (tons/acre) than other crops such as alfalfa and fescue. Switchgrass has been shown to limit the deterioration of highly erodible soils, improve local water quality and provide important habitat for wildlife including several species of game birds[19]. This is an important feature given the condition of much of the soil in Southside Virginia. Because switchgrass is essentially a hay crop, the equipment and skills necessary to produce it already exist. The degree to which it can replace tobacco production and help intensify land use in Virginia is largely a question of economics and will be examined below.

Switchgrass is not currently an economically viable alternative to coal. It has lower energy content per ton than coal, with approximately 1.8 tons of switchgrass having the same energy content as a ton of Central Appalachian coal[20]. It is estimated that switchgrass can be grown and harvested for $60 a ton[21]. The spot market price for Central Appalachian coal is similarly $60 a ton[22]. Neglecting transportation and processing costs, coal prices would need to increase to more than $107/ton before switchgrass would be a viable alternative to coal on an energy-equivalent basis. If transportation and processing costs are included, coal prices would need to reach $165/ton before switchgrass would become competitive.

While switchgrass is not currently economical, there are a number of technical and regulatory factors that may change this. Compared to the coal and wind industries, the biomass industry is in its infancy and there is still great potential for technological advances to lower the cost of processing and transporting switchgrass. Future environmental regulations may allow for biomass to be used to attain compliance with increasingly strict emissions standards. Advances in growing techniques and cultivar varieties may lower the cost of production.

A technical problem facing switchgrass is the cost of transport. Switchgrass is bulky and has a lower Btu content per ton than most fossil fuels. Because of this and its bulk when harvested

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[19] McLaughlin et al. "High Value Renewable Energy from Prairie Grasses" Environ. Sci. Technol. 2002, 36, 2122-2129

[20] Smeenk et al. "Evaluation Of An Integrated Biomass Gasification/Fuel Cell Power Plant" Tuesday, 16 August 2005, http://www.cvrcd.org/ResearchPapers/evaluation_paper.htm.

[21] Iowa State University Extension. "Cost of Producing Switchgrass for Biomass in Southern Iowa" Friday, August 19, 2005, http://www.hort.purdue.edu/newcrop/ncnu02/v5-267.html.

[22] DOE EIA, "Coal News and Markets: Week of August 14, 2005" Tuesday, 16 August 2005, http://www.eia.doe.gov/cneaf/coal/page/coalnews/coalmar.html.

using standard methods, switchgrass production and processing must be located much closer to utilities than coal. In 2001, the average coal shipment traveled more than 680 miles[23]. Studies investigating switchgrass transportation do not consider distances greater than 75 miles[24]. Finding innovative ways of shipping biomass and reducing transportation costs will significantly enhance the potential of switchgrass.

Another technological issue limiting switchgrass is that few of the technologies to utilize it have been commercialized to date. Test burns have been conducted in Iowa to evaluate the potential for co-firing switchgrass with coal in a commercial power plant, but as of yet the technology is not ready for use on a commercial scale[25]. A major hurdle is the need for a bulk handling system for switchgrass. The plant in Iowa is investigating systems to take bales of hay and grind them on site. An alternative to this approach is offsite processing of hay bales into a form with superior bulk handling properties. The technology for cubing hay and other agricultural materials already exists and such a processing facility would add to the economic development potential for switchgrass. The disadvantage to this approach is that it will increase shipping costs.

Conversion of switchgrass to ethanol is another approach that shows promise, but is not yet cost-effective. Research is continuing in cellulosic ethanol production and the technology may improve significantly over the next five years.

Regulatory changes can significantly impact the potential for switchgrass. Co-firing switchgrass has been shown to reduce sulfur emissions and the combustion of switchgrass creates almost zero net carbon emissions[26]. If pollution regulations become stricter in coming years it may become cost effective for coal power plants to co-fire biomass to minimize compliance costs. Even without new regulations current market-based pollution control mechanisms may spur action. The cost of acid rain permits under the Clean Air Act has more than doubled over the past year to $690 per ton[27]. If acid rain permit prices continue to escalate it may make economic sense for utilities without scrubbers to co-fire switchgrass with coal to lower their sulfur emissions. Similar opportunities may arise for mercury and greenhouse gas emissions in the coming years.

This section will examine the economic development impacts that would occur if switchgrass were to become economically viable. If a 600MW coal power plant were to co-fire switchgrass at the 5% level, 154,000 tons of switchgrass would be needed per year[28]. Assuming a 4.5 ton per acre yield, approximately 34,200 acres of land would be needed to meet this production goal[29]. To put this in perspective, in 2003 Halifax and Mecklenburg Counties harvested 23,000 and

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[23] Energy Information Agency. “Coal Transportation: Rates and Trends in the United States, 1979-2001: Table 2.02” Wednesday, 17 August 2005, http://www.eia.doe.gov/cneaf/coal/page/trans/ratesntrends.html.

[24] Walsh, M.E. “U.S. Bioenergy Crop Economic Analyses: Status and Needs” *Biomass and Bioenergy* Vol. 14, #4, pp. 341-350, 1998.

[25] Amos, W. “Summary of Chariton Valley Switchgrass Co-Fire Testing at the Ottumwa Generating Station in Chillicothe, Iowa” Wednesday, 17 August 2005, http://www.cvrcd.org/ResearchPapers/2002final-report/NREL%20draft%20report.pdf.

[26] McLaughlin et al. “High Value Renewable Energy from Prairie Grasses” Environ. Sci. Technol. 2002, 36, 2122-2129

[27] U.S. EPA. “2005 Acid Rain Allowance Auction Results” Thursday, 18 August 2005, http://www.epa.gov/airmarkets/auctions/2005/05summary.html.

[28] Assumes 80% capacity factor and 33% thermal efficiency.

[29] Iowa State University Extension. “Cost of Producing Switchgrass for Biomass in Southern Iowa” Friday, August 19, 2005, http://www.hort.purdue.edu/newcrop/ncnu02/v5-267.html.

29,000 acres of hay respectively at a yield of 2.0 tons an acres[30]. It is likely that acreage from tobacco and other crops would need to be replaced by switchgrass production in order to meet demand. The average farm size in Halifax County is 246 acres[31]. To have 34,200 acres of land in switchgrass production would provide work and help the financial viability of 140 farm families on average.

The next element in this analysis is transportation. Switchgrass once harvested will require transportation from the field to a processing facility and then to the utility. The cost of transporting switchgrass 25 miles via tractor trailer is estimated at $5 per dry ton and $11 per dry ton over a distance of 75 miles[32]. Transport of 154,000 tons of switchgrass will require 15,400 tractor trailer hauls annually. With an average hauling distance of 35 miles and a rate of .35 cents per mile, switchgrass transportation would create an additional $188,650 in income for truck drivers and create additional loading and unloading jobs.

To improve the bulk handling properties of switchgrass the construction of a processing facility is likely. Construction of a 12,000 ton/year cubing facility is estimated to cost $2.3 million dollars[33]. The construction of processing facilities for 154,000 tons of switchgrass per year would represent a $26.5 million dollar investment in Southside Virginia[34]. If such facilities were constructed in Halifax County, this would increase machinery tax revenues by $134,000 annually. The increase in net real estate tax revenue would not be substantial, because most of the investment is in the form of machinery. In addition to tax benefits, $540,000 of employment income would be created by the cubing operations. With multiplier effects, value-added incomes in Southside Virginia will increase by $1-1.45 million. There will also be increases in sales and other tax revenues resulting from the general increase in economic activity.

The final step in the economic impact analyses is to evaluate the economic activity displaced by burning switchgrass instead of coal. Simply shifting revenues from the coal industry to the agricultural industry would not be a net gain for the state. This, however, is not the case. In 2000, less than half of the coal burned in Virginia was mined in the state[35,36]. Therefore, there is potential for switchgrass to displace out-of-state coal and provide a net increase in economic activity. It is also important to note that the amount of coal displaced represents less than half of one percent of the state's annual coal consumption[37].

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[30] Virginia Agricultural Statistics Service, "Hay Acreage, Yield, and Production, 2003" Friday, August 19, 2005, http://www.nass.usda.gov/va/pg40-4304.pdf.

[31] National Agricultural Statistics Service, "2002 Census of Agriculture County Profile: Halifax County" Friday, August 26, 2005, http://www.nass.usda.gov/census/census02/profiles/va/cp51083.PDF.

[32] Walsh, M.E. "U.S. Bioenergy Crop Economic Analyses: Status and Needs" *Biomass and Bioenergy* Vol. 14, #4, pp. 341-350, 1998.

[33] Sokhansanj et al. "Biomass Densification – Cubing Operations and Costs for Corn Stover" *Applied Engineering in Agriculture* Vol. 20(4): 495-499

[34] Assumes that facilities larger than 12,000 tons/year will be built and 10% economy of scale is realized

[35] Virginia Energy Patterns and Trends. "Summary of Domestic and Export Shipments" Saturday, August 27, 2005, http://www.energy.vt.edu/vept/coal/distribution.asp.

[36] Virginia Energy Patterns and Trends. "Virginia Coal Consumption 1990-2003" Saturday, August 27, 2005, http://www.energy.vt.edu/vept/coal/coal_consumption.asp.

[37] Virginia Energy Patterns and Trends. "Virginia Coal Consumption 1990-2003" Saturday, August 27, 2005 http://www.energy.vt.edu/vept/coal/coal_consumption.asp.

Switchgrass has economic development potential if it can become a cost effective alternative to coal. Whether it becomes competitive will depend largely on the pace of technological innovation and environmental regulation. Switchgrass intensifies local land use and provides increased income to farmers and the transportation and processing required would contribute significantly to local labor markets. Whether the economic development benefits of co-firing switchgrass or agricultural residuals are significant enough to justify subsidizing the industry is an important question and may warrant further study.

CONCLUSIONS AND RECOMMENDATIONS

Increased use of renewable energy offers modest opportunities for economic development. With the exception of wind power, the technologies used to harness biomass and solar energy will need to improve before they are cost effective. Capital investments associated with wind and biomass energy can be at a magnitude where they lead to substantial increases in tax revenues, particularly in more isolated communities. A 150MW increase in wind generated electricity will create 37-50 long-term jobs but is not expected to contribute to distressed labor markets. The presence in the state of industries that supply inputs into generation of renewable energy (such as manufacturers of photovoltaic cells) will increase economic impacts, but these industries are inherently no more valuable than any other industry, and incentives for such industries should be evaluated using the same criteria as any other alternative.

It is important to monitor the State Corporation Commission as they set wind depreciation rules, because these rules will have a significant impact on the local tax revenues. When considering economic development incentives it is important to use the Virginia Economic Development framework to ensure that government money is spent in an efficient manner.

ATTACHMENT A

Assumptions for the Cost of Photovoltaic Solar in Virginia

- 125kW capacity system
- Cost per kW of capacity: $6,500
- Annual electricity generation per kW of capacity: 1,400 kWhs
- Useful life: 30 years
- Discount rate: 6%

These assumptions are meant to be reasonably optimistic and represent the cost of PV to a commercial user installing a fairly large system and thus capturing economies of scale. For residential customers installing smaller systems the cost per kW of capacity will be closer to $8,000 and raise the cost per kWh significantly.

ATTACHMENT B

Net Present Value of Tax Revenue Calculations

Assumptions for these calculations come from the “Economic and Fiscal Impacts of the Proposed New Highland Wind Project on Highland County, Virginia” report prepared by Mike Siegel and a conversation with Bobby Tucker at the State Corporation Commission.

- Full Market Value is 90% of capitalized value
- Used stated ratio for Highland County (77.9%)
- Used Highland County Tax Rate 62 cents per $100
- Discounted revenues at 6%

Appendix E: Revision History:

Date	Location	Revisions
1/16/06	p. C-1	Added revision date
	p. C-17, last full paragraph	Additions indicated in red, also minor corrections to punctuation. The first category of broad-based impediments to renewable energy systems also generally applies to any small, decentralized generation unit (often called "distributed generation" or "distributed energy resources") used to produce electricity on-site. Besides renewable solar PV and wind, other distributed generation technologies include microturbines, fuel cells, natural gas turbines, Stirling engines and combined heat and power (CHP) generation units.
	p. ii	Added Appendix E to Table of Contents
	p. E-1	Added Appendix E: Revision History