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Potential Economic Impacts of Renewable Energy in Virginia

Prepared for Virginia Conservation Network

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Executive Summary

- The purpose of this research was to examine the capacity for renewable energy in Virginia and to quantify the potential economic benefits of renewable energy in Virginia. The research was based primarily on literature review of other renewable energy research and especially those involving economic impact studies and assessments. The tasks for this project included:
    - Literature review to develop estimates of electricity that can be produced from renewable sources in Virginia;
    - Literature review of renewable energy economic impact studies;
    - Development of scenarios of greater renewable energy production within Virginia for analysis of potential economic impacts; and,
    - Assessment of the potential economic impacts of the scenarios.

- The literature review provided information enabling the development of potential future use of renewable energy sources in Virginia. The 2010 Virginia Energy Plan and several other Virginia studies were reviewed and helped understanding of the characteristics and assumptions used in other research. The literature review of projects and research in other states was also useful to help fill out the body of information needed to develop meaningful scenarios for the economic analysis.

- Using this information, two scenarios were developed for long-term (to 2035) employment of four basic sources of renewable energy: biomass, solar photovoltaic, onshore wind and offshore wind. These are seen as the four key sources that could be implemented over the next twenty-five years that would have capacity to provide half of projected increase in electricity demand between 2010 and 2035.

- Based on growth factors in the Virginia Energy Plan (2010), there will be a need for an additional 19,448 MW of demand from 2010 to 2035. Virginia does not have the capacity to generate the additional electricity only from renewable sources, but capacity forecasts (See section 5.2) provide a basis for estimating that half of this demand (9,724 MW) could be met with renewable sources; the 50 percent threshold was set as a relatively feasible benchmark. The two scenarios assumed the following mix to provide the 9,724 MW:

	Scenario 1	Scenario 2
Biomass	50%	40%
On Shore Wind	18%	18%
Off Shore Wind	10%	33%
Solar	22%	9%

- The literature research provided information that enabled estimates of characteristics and costs of construction and operations and maintenance for each of the sources and amounts of power supplied in each of the scenarios.

- Econometric methods were then used to quantify the potential economic impacts of the renewable sources on Virginia for 2010 to 2035, both for construction and for annual operations. Greater economic impacts accrue for higher investments and costs, and the renewables require greater investment, they also have greater economic impacts. The economic impacts from the two scenarios of renewable sources plus those for coal and natural gas are shown in the following table:[1]

	Construction Costs	Annual Operating Costs	Gross State Product	Personal Earnings	Jobs Created
Scenario 1	$9.49 billion	$0.91 billion	$20.8 billion	$6.4 bilion	172,328
Scenario 2	$5.94 billion	$1.57 billion	$13 billion	$4 billion	107,890
Coal	$2.39 billion	$1.86 billion	$5.3 billion	$1.6 billion	43,442
Natural Gas	$1.13 billion	$0.24 billion	$2.5 billion	$0.75 billion	20,473

- The quantification of economic impacts shows that significant economic gains and new jobs would accrue from investment in renewable energy sources in both scenarios. The economic gains from the two renewable energy sources ranged from $13 billion to $20.8 billion – significantly higher than gains from coal and natural gas. The construction costs for renewables would be higher, operating costs would be comparable among all the different sources, but the higher investment required for renewables would create the most significant economic gains.

[1] Operating costs do not include fuel costs for any of the sources in the scenario analysis (coal, gas, biomass).

1. Findings of the Literature Review on Renewable Energy

This introductory section provides basic information on all renewable energy sources included in the study. It reviews relevant materials presenting an overview of legal and practical aspects of promoting renewable energy for electricity.

The introduction is followed by sections on individual renewable sources. Section two concentrates on solar, section three on onshore and offshore wind, and section four on biomass. All of them brief into what the renewable sources are, what the major environmental concerns are, and what are technological developments and perspectives, giving examples of projects and studies from other states. Section five provides the analysis of increased use of Virginia's renewable energy sources to produce in-state electricity, based on secondary data derived from available literature.

1.1 Literature Findings on All Renewable Energy Sources

Renewable Portfolio Standard (RPS)[2]

A Renewable Portfolio Standard (RPS) or Renewable Energy Standard (RES) requires a percent of energy sales (MWh) or installed capacity (MW) to come from renewable resources; most specify sales (MWh).

Percents usually increase incrementally from a base year to a later target; the table shows ultimate targets.

29 states and D.C. have RPS policies; 9 states and 3 power authorities have nonbinding goals without financial penalties.

[2] "Renewable Power & Energy Efficiency Market: Renewable Portfolio Standard." Federal Energy Regulatory Commission. May 2011. http://www.ferc.gov/market-oversight/othr-mkts/renew/othr-rnw-rps.pdf.

Table 1. Examples of Renewable Portfolio Standards in Selected States

State	Amount	Year	Notable Features
California*	33%	2020	• 20% by 2013 • Energy commission certifies eligible sources • Tradable credits limited to 25% until 2013, then 10% by 2017
New Jersey*	22.5%	2021	• Tiered system • Solar carve out: 2.12% by 2021 • Offshore wind carve out once projects operational
Pennsylvania	18%	2021	• Tiered system • Solar carve out: 0.5% by 2021 • Includes Demand Side Management Programs
North Carolina	12.5%	2021	• Electric cooperatives included • Various source carve outs including solar and energy efficiency • Purchase of out-of-state credits limited to 25% for large utilities • Customer costs capped
Virginia**	15%	2025	• Voluntary goal • Utilities receive 50 pt bonus for meeting each goal • Some renewable sources are eligible for double and triple credit

* Accelerated or strengthened RPS
** Voluntary standard
Sources: Derived from data used by: Lawrence Berkeley Labs, state Public Utility Commission (PUC) and state legislative tracking services, Pew Center. Details, including timelines, are in the *Database of State Incentives for Renewables and Efficiency: http://www.dsireusa.org*

1.2 Virginia Electricity Imports and Exports[3]

Virginia utilities do not own in-state generation capacity sufficient to meet the state's peak load plus the reserve capacity required by federal regulation.
It is sometimes less expensive to purchase electricity on the wholesale market than to generate the electricity at in-state, utility-owned facilities.
As demand has grown faster than additions to generation, imports have increased by an average of 1.4 percent per year over the last 10 years. In 2008,

[3] "The Virginia Energy Plan." Department of Mines, Minerals and Energy. July 2010.
"Virginia Electric Energy." *Virginia Center for Coal and Energy Research*. http://www.energy.vt.edu/vept/electric/index.asp.

Virginia imported 34% of electricity consumed in the state. However, much of the electricity imported from other states comes from generating facilities owned by Virginia's two investor owned utilities.

1.3 Major Incentives and Policies for Renewables in Virginia[4]

Solar Manufacturing Incentive Grant (SMIG) Program
The program offers up to $4.5 million per year to encourage the production of photovoltaic panels in Virginia. The incentive is paid at a rate of up to $0.75 per watt for panels sold in a calendar year, with a maximum of 6 MW. This program will expire in 2013.

Clean Energy Manufacturing Incentive Grant Program (CEMIG)
In April 2011, Virginia created the Clean Energy Manufacturing Incentive Grant Program. The program is meant to replace the *Solar Manufacturing Incentive Grant Program (SMIG) and the Biofuels Production Incentive Grant* Program, which will phase out in 2013 and 2017, respectively.

A clean energy manufacturer can receive a grant for up to six years if it:

- Begins or expands its operations in Virginia on or after July 1, 2011;
- Makes a capital investment of more than $50 million in Virginia on or after July 1, 2011;
- Creates 200 or more new full-time jobs on or after July 1, 2011;
- Enters a memorandum of understanding setting forth the requirements for capital investment and the creation of new full-time jobs.

Green Jobs Tax Credit
For every green job created with a yearly salary of $50,000 or more, the company will earn a $500 income tax credit for five years. The Office of Commerce and Trade will develop a full list of jobs eligible to qualify for the tax credit. Companies will be allowed tax credits for up to 350 green jobs created. If the taxpayer does not have enough tax liability to take the full credit, it may be carried forward for up to 5 years.

[4] "Database of State Incentives for Renewables & Efficiency." U.S. Department of Energy. http://www.dsireusa.org/incentives/index.cfm?state=VA&re=1&ee=1&spv=0&st=0&srp=1.
Commonwealth of Virginia State Corporation Commission. 2011. *Final Order on Dominion's biennial rate review.* Case No. PUE-2011-00027.

Local Option - Property Tax Exemption for Solar
Virginia allows any county, city or town to exempt or partially exempt solar energy equipment or recycling equipment from local property taxes. Residential, commercial or industrial property is eligible.

Virginia Resources Authority - Project and Equipment Financing
The Virginia Resources Authority (VRA) was created in 1984 and provides financial assistance to local governments in Virginia for a variety of projects, including energy and energy conservation projects. VRA offers several financing options.

Mandatory Utility Green Power Option
Electricity customers in Virginia have the option to purchase 100% renewable energy from their utility. If their utility does not offer a program that meets the 100% renewable energy requirement, its customers will be permitted to purchase green power from any licensed retail supplier.

- The Virginia State Corporation Commission approved in 2008 voluntary renewable energy options for customers of Dominion Virginia Power and the Appalachian Power Company, a subsidiary of American Electric Power. Customers of both utilities have an option to buy renewable energy certificates (RECs) to cover either a portion or the total amount of electricity that they consume. The two utilities can purchase renewable energy certificates (RECs) from a variety of renewable energy resources.
- The Commission also found that the two utilities failed to meet Virginia's statutory definition for a 100% renewable energy offering. Under Virginia law, the finding means that competitive electric suppliers can continue to offer renewable energy in the state.

Voluntary Renewable Energy Portfolio Goal
As part of legislation to re-regulate the state's electricity industry, Virginia enacted a voluntary renewable energy portfolio goal in 2007 encouraging investor-owned utilities to meet 12% of their energy needs from qualifying renewable energy sources by 2022. Legislation passed in 2009 expanded the goal to 15% by 2025 for total non-nuclear electricity consumption, essentially reducing the stated goal to 10% of total electricity usage. Participating utilities can recover costs for their RPS programs from ratepayers and are encouraged by the Virginia State Corporation Commission (SCC) to implement the cheapest programs possible, which means purchasing a great deal of out-of-state Renewable Energy Credits (REC), essentially undermining the original intent of the law, to incentivize renewable energy in Virginia. Investor-owned utilities that do voluntarily

participate in this program are also offered a performance incentive in the form of a bonus from ratepayers for each "RPS Goal" attained. In 2011, Dominion Virginia Power was awarded $76 million over two years from ratepayers for purchasing a majority of their renewable energy power from out-of-state RECs.

1.4 Additional options[5]

Offshore wind energy

- Dominion Virginia Power and the Richmond office of a French energy conglomerate (Alstom Power Inc.) have won $4.64 million in grants from the U.S. Energy Department to help stoke the industry for offshore wind energy. The grant will be spent on developing technology to maximize the energy output of offshore farms and to study how much it would cost to produce energy from a 600 MW offshore project. The DOE will issue such grants totaling $43 million to distribute among 41 projects.

Solar energy

- Virginia Tobacco Indemnification and Community Revitalization Commission have granted $5 million to Dominion Virginia Power and the Halifax County Industrial Development Authority to develop a solar and advanced storage facility in Halifax County, Va.

1.5 Representative Economic Advantages of Using Renewable Energy Sources[6]

This section presents a list of selected potential economic advantages of using renewable energy sources; the list is not exhaustive.

- The clean economy, which employs some 2.7 million workers, encompasses a significant number of jobs in establishments spread across a diverse group of industries.
- The clean economy offers more opportunities and better pay for low-skilled workers than the national economy as a whole.

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[5] "Database of State Incentives for Renewables & Efficiency." *U.S. Department of Energy.* http://www.dsireusa.org/incentives/index.cfm?state=VA&re=1&ee=1&spv=0&st=0&srp=1.
"Green Power Markets." *U.S. Department of Energy* http://apps3.eere.energy.gov/greenpower/markets/pricing.shtml?page=2&companyid=671.
[6] Muro, Mark and Rothwell, Jonathan. "Sizing the Green Economy: A National and Regional Green Jobs Assessment." The Brookings Institution. 2011.
Glickman, Lauren. 2011. "The Intermittency of Fossil Fuels." *RenewableEnergyWorld.com*. http://www.renewableenergyworld.com/rea/blog/post/2011/08/the-intermittency-of-fossil-fuels.
Bird, Lori A., and Karlynn S. Cory. 2008. *Renewable Energy Price-Stability Benefits in Utility Green Power Programs*. National Renewable Energy Laboratory.

- The clean economy grew slower in aggregate than the national economy between 2003 and 2010 but newer “cleantech” segments far outperformed the nation during the period, as did the clean economy overall during the recession. Today’s clean economy establishments added more than half a million jobs between 2003 and 2010, expanding at an annual rate of 3.4%. This performance somewhat lagged behind in the national economy, which grew by 4.3 percent annually over the period (if job losses from establishment closings are omitted to make the data comparable). And yet, during the middle of the recession – from 2008 to 2009 – the clean economy grew faster than the rest of the economy, expanding at a rate of 8.3% (partially due to large sums of public spending channeled by the Recovery and Reinvestment Act (ARRA) towards clean energy projects through much of 2009).
- Because the fuel is free, renewable energy stabilizes electricity prices thereby helping consumers save money over the long-term as fuel prices for traditional energy sources fluctuate.
- Renewable energy has stepped in as a substitute to conventional plants in events of their malfunction (after the earthquake and tsunami that shut down several of Japan’s nuclear reactors) or during unfavorable weather conditions such as the drought in Texas that shut down several coal plants.

1.6 Representative Economic Disadvantages of Using Renewable Energy Sources[7]

This section presents a list of selected potential economic disadvantages of using renewable energy sources; the list is not exhaustive.

- One of the difficulties inherent in the widening use of renewable electric generation technologies such as wind and solar energy is the unpredictable nature of the resource, and the geographical location of the sitting (to exploit the areas with best conditions the farms frequently have to be posited far from major population centers); hence there is a high cost of energy storage and construction of new, high-capacity transmission lines.
- Although a number of new energy storage technologies exist, the challenge is to make them robust, reliable, and economically competitive,

[7] “2011 Draft Energy Master Plan.” State of New Jersey Board of Public Utilities. 2011.
Bird, Lori A., and Karlynn S. Cory. 2008. *Renewable Energy Price-Stability Benefits in Utility Green Power Programs*. National Renewable Energy Laboratory.

while matching the most suitable technology to each energy source or location.

- Nationwide, increased electricity generation from renewable resources may result in an initial increase in electricity prices for consumers due to upfront capital-intensive costs.

2. Solar Energy Source

2.1 Overview[8]

In 2008, about 0.1% of the total energy supply in the United States came from solar sources. In theory, it could be much more. In practice, it will require considerable scientific and engineering progress in the ways of converting the energy of sunlight into usable forms. The technology is continually improving as demand for this resource increases due to strong policy at the state and federal levels.

Photovoltaic (PV)

In certain materials, the energy of incoming light kicks electrons into motion, creating a current. Sheets of these materials are routinely employed to power a host of devices—from orbiting satellites to pocket calculators—and many companies make roof-sized units for homes and office buildings.

- At the present time the best commercial PV systems produce electricity at five to six times the cost of other generation methods. If a system is installed at its point of use, which is often the case, its price may compete successfully at the retail level.
- Unless PV energy is consumed immediately, it must be stored in batteries or by some other method. Adequate and cost-effective storage solutions await development.
- PV systems produce maximum power close to the time of peak loads, which are driven by air-conditioning. Peak power is much more expensive than average power. With the advent of time-of-day pricing for power, PV power will grow more economical.

Solar PV technology is found in both large-scale and distributed systems and can be implemented where unobstructed access to sunlight is available.

Solar thermal generation

- Sunlight can also be focused and concentrated by mirrors and the resulting energy employed to heat liquids that drive turbines to create electricity—a technique called solar thermal generation.
- Existing systems produce electricity at about twice the cost of fossil-fuel sources.

[8] "What You Need to Know About Energy." *National Academy of Sciences*. https://download.nap.edu/catalog.php?record_id=12204.
"Make Solar Energy Economical." *National Academy of Engineering*. http://www.engineeringchallenges.org/cms/8996/9082.aspx.

2.2 Environmental Impacts[9]

Air Emissions
Emissions associated with generating electricity from solar technologies are negligible because no fuels are combusted.

Water Resource Use

- Photovoltaic systems do not require the use of any water to create electricity.

Water Discharges
Solar technologies do not discharge any water while creating electricity.

Solid Waste Generation

- Solar thermal technologies do not produce any substantial amount of solid waste while creating electricity.
- The production of photovoltaic wafers creates very small amounts of hazardous materials that must be handled properly to avert risk to the environment or to people.

Land Resource Use

- Photovoltaic systems require a negligible amount of land area because they are typically placed on existing structures.
- Solar thermal technologies may require a significant amount of land, depending upon the specific solar thermal technology used.
- Solar energy installations do not usually damage the land they occupy, but they prevent it from being used for other purposes.

[9] "Non-Hydroelectric Renewable Energy." *U.S. Environmental Protection Agency*. http://www.epa.gov/cleanenergy/energy-and-you/affect/non-hydro.html.

2.3 Predicted Improvements in Solar Thermal Technology Leading to Cost Reduction[10]

Troughs

- Effective but costly components could be replaced with troughs that are wider, and based on less expensive technologies.
- Direct steam generation (DSG) in the collector fields would allow high working temperatures and reduce investment costs.
- Other proposed innovations offering the potential for incremental cost reductions are more speculative, but merit further research.

Towers and dishes

- CSP towers can achieve even higher temperatures still, opening the door to better power cycle efficiencies.
- Storage costs can be reduced with higher temperatures, which allow more heat to be converted into electricity and less lost due to limited storage capacity.
- Improved efficiency also means a lower cooling load, thus reducing water consumption by wet cooling in plants in arid areas.
- The possibilities of these higher temperatures should be explored using different receiver technologies.

Improvements in storage technologies

- Increasing the overall working temperatures of plants is the best means of reducing storage costs.
- Several types of storage-specific research are promising, including the use of inexpensive recycled materials.

Emerging solar fuel technologies

Concentrating solar thermal technologies also allow the production of hydrogen (H2), which forms the basis of fuels, or carriers, that can help store solar energy and distribute it to industry, households and transportation.

[10]Philibert, Cédric. “Technology Roadmap: Concentrating Solar Power.” International Energy Agency. 2010.

2.4 Predicted Improvements in Solar PV Technology Leading to Cost Reduction[11]

Crystalline silicon

Today, the vast majority of PV modules are based on wafer based c-Si.

- The improvement is sought in the efficiency and effectiveness of resource consumption through materials reduction, improved cell concepts and automation of manufacturing.
- Continuous targeted R&D on sc-Si can result in a substantial cost reduction and an associated volume effect, both of which are needed to enhance the competiveness and accelerate the scaling-up of PV in the next decade.

Thin films

- Increased R&D is needed to bring thin film technologies to market and to create the necessary experience in industrial manufacturing and long term reliability.
- Thin film technologies are in the process of rapid growth and are expected to increase their market share significantly by 2020.

Emerging technologies and novel concepts

- PV cell is combined with a thermal radiation source. This concept could also become relevant for concentrating solar technologies in the future.
- Novel PV concepts aim at achieving ultra-high efficiency solar cells by developing active layers which best match the solar spectrum or which modify the incoming solar spectrum.
- These novel concepts are currently the subject of basic research. Their market relevance will depend on whether they can be combined with existing technologies or whether they lead to entirely new cell structures and processes.
- Large market deployment of such concepts – if proven successful – is expected in the medium to long term.

Concentrator technologies (CPV)

- As an alternative to the above so-called flat-plate technologies, direct solar radiation can be concentrated by optical means and used in concentrator solar cell technologies.

[11] Frankl, Paolo et al. "Technology Roadmap: Solar Photovoltaic Energy." International Energy Agency. 2010.

- Considerable research has been undertaken in this high-efficiency approach because of the attractive feature of the much smaller solar cell area required.
- The CPV technology is presently moving from pilot facilities to commercial-scale applications.

2.5 Examples of Development of Solar Energy Sources

Table 2. Data Derived from Other States' Projects and National Agencies

Solar PV	Data	Comment	Source
Plant lifetime	30 years	Value applicable to U.S. as a whole	"Cost and Performance Assumptions for Modeling Electricity Generation Technologies." NREL. 2010.
Nr of construction jobs / 1MW	25 / 1MW	The prediction states 100 construction jobs are needed to build a 4 MW facility	Dominion VA predictions 2011 for Halifax County
Nr of O&M / 1MW per year	0.2 / 1MW per year	The prediction states that 0.2 jobs per year per 1 MW will be needed	"Analysis for 2011 Draft New Jersey Energy Master Plan." Center for Energy, Economic & Environmental Policy (CEEEP). 2011
Wages – constr. median (2010$)	$53,585	Value includes the U.S. median wage of plant constructors	"Careers in Solar Power." U.S. Bureau of Labor Statistics. 2011
Wages – O&M average of median (2010$)	$52,539	Value include the average of U.S. median wages of plant operators and other O&M workers	"Careers in Solar Power." U.S. Bureau of Labor Statistics. 2011

2.6 Overview of the Solar Economic Impact Analysis in New Jersey[12]

New Jersey's solar requirements directly impact electricity prices and employment.

- The electricity price and direct employment changes have indirect and induced effects on New Jersey's economy and energy prices.
- The analysis included three scenarios.
- The analysis assumes that there is no solar manufacturing in New Jersey even though several firms do exist in the state.
- The analysis does not account for any environmental benefits.

[12] "2011 Draft Energy Master Plan." State of New Jersey Board of Public Utilities. 2011.

The economic and energy impacts of New Jersey's solar requirements were estimated using the R/ECONTM Model, an econometric model of New Jersey.

- R/ECON™ is comprised of over 300 equations, based on historical data for New Jersey and the United States, which are solved simultaneously.
- The heart of the model is a set of equations modeling employment, wages, and prices by industry.
- Generally, employment in an industry depends on demand for that industry's output and the state's wages and prices relative to the nation's.
- The U.S. data comes from IHS Global Insight, Inc., a national leader in economic forecasting.

Results

Overall, the New Jersey solar requirements have a slightly positive economic impact —the employment benefits from installing and maintaining solar equipment slightly outweigh the negative economic impacts of higher electric prices.

- The Solar Employment Effect has a slightly positive gross impact on New Jersey's economy but negligible impact on energy prices and consumption.
- The electricity price effect alone has a slightly negative impact on New Jersey's economy.
- The average job cost decreases over time.

3. Wind Energy Source

3.1 Overview[13]

Wind energy is a form of solar energy created by a combination of factors, including the uneven heating of Earth's atmosphere by solar radiation, variations in topography, and the rotation of the Earth. The wind-induced motion of huge multi-blade rotors—sweeping circles in the air over 100 yards in diameter—transforms the rotors' mechanical power into electricity.

Wind power is exploited not only onshore but also offshore, where wind speeds are higher and the wind is typically available more regularly and for longer periods of time. The depth of water and distance from centers of demand onshore are major factors influencing the siting of offshore developments.

Due to government incentives, wind electricity has been a booming resource in recent years. Between 2002 and 2006, the United States more than doubled its wind electricity generation, and in 2008, it overtook Germany as the top producer of wind electricity in the world. However, as of Q2 2011 there have been no offshore wind plants constructed in the U.S. Nor have there been any offshore wind projects that have completed project financing, with or without compensatory long-term power purchase agreements to shift the economic burden from developers to ratepayers. Hence, under the best of circumstances, new utility scale offshore wind projects are at least several years away.

Continued expansion of wind power depends on a variety of factors, including fossil fuel prices, federal tax credits, state renewable energy programs, technology improvements, access to transmission grids, and public concern about environmental impacts.

[13] "What You Need to Know About Energy: Renewable Sources - Wind." *The National Academy of Sciences*. http://needtoknow.nas.edu/energy/energy-sources/renewable-sources/wind.php.
"2011 Draft Energy Master Plan." State of New Jersey Board of Public Utilities. 2011.

3.2 Environmental Impacts[14]

Air Emissions

Emissions associated with generating electricity from wind technology are negligible because no fuels are combusted.

Water Resource Use

Wind turbines do not require the use of water except possibly in regions with little to no rainfall, for cleaning purposes only.

Water Discharges

Wind turbines do not discharge any water while creating electricity.

Solid Waste Generation

Wind turbines do not produce any substantial amount of solid waste while creating electricity.

Land Resource Use

- When wind turbines are removed from land, there are no solid wastes or fuel residues left behind.
- Improperly installed or landscaped turbines may cause soil erosion.

Wildlife

- Bird and bat mortality have been an issue at some land-based wind farms. Improvements to wind turbine technologies and turbine siting have helped mitigate bird mortality. Research on impacts to bats is now underway.
- Recent study focused on two-year ecological impacts of the turbines, sponsored by NoordzeeWind, a joint venture of Nuon and Shell Wind Energy found that offshore wind farms can encourage biodiversity at the base of turbines, while surrounding rocks provide habitat for animals that dwell on the sea floor.
- Proper siting of wind projects plays a crucial role in minimizing potential wildlife impacts.
- During the construction phase of offshore projects, installation of the turbines into the seafloor can generate undersea noise that can potentially

[14] "Non-Hydroelectric Renewable Energy." *U.S. Environmental Protection Agency*. http://www.epa.gov/cleanenergy/energy-and-you/affect/non-hydro.html.
"20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply." Department of Energy and Department of the Interior. July 2008.
"Offshore Wind Farms May Enhance Biodiversity." Industrial Fuels and Power. August 2011. http://www.ifandp.com/article/0013043.html.

disorient or damage the eardrums of nearby whales and porpoises. There are several ways to mitigate this impact including the use of spotters to identify when affected species are in the area to new technologies such as a bubble wall where a pipeline surrounding the installation area sends bubbles up from the sea floor to soften the noises.

3.3 Predicted Improvements in Wind Technology Leading to Cost Reduction[15]

Opportunities

- Turbine blades used in offshore wind projects can be much larger than those used in onshore projects and with fewer siting issues
- Offshore facilities are much more efficient than onshore projects, due to higher wind speeds, hence higher capacity factors;
- The blades may be allowed to rotate faster offshore, as blade noise is less likely to disturb human habitations. Faster rotors operate at lower torque, which means lighter, less costly drivetrain components.
- Coastal and shallow water installations have the advantage of offshore wind characteristics at a lower cost.

Challenges:

- resistance to corrosive salt waters;
- coexistence with marine life and activities;
- with increased water depth the installation cost is much higher;
- exposure to more extreme open ocean conditions and storms;
- with long distance electrical transmission on high-voltage submarine cables the installation cost is higher;
- turbine maintenance at sea.

- Uncertainty drives up the costs of financing offshore wind projects to the point where financing charges account for roughly half of the cost of offshore wind energy.

Predictions

[15] Musial, Walter and Ram, Bonnie. "Large-Scale Offshore Wind Power in the United States: Assessment of Opportunities and Barriers." National Renewable Energy Laboratory. September 2010.
Beaudry-Losique Jacques et al. "A National Offshore Wind Strategy: Creating an Offshore Wind Energy Industry in the United States." U.S. Department of Energy, Energy Efficiency and Renewable Energy. February 2011.

- As was experienced with land-based wind systems over the past two decades, offshore wind costs are expected to drop with greater experience, increased deployment, and improved technology.
- To make offshore wind energy more cost effective, some manufacturers are designing larger wind turbines capable of generating more electricity per turbine. Several manufacturers are considering 10-MW turbine designs, and programs, such as UpWind in the European Union, are developing the tools to allow these larger machines to emerge.
- New technologies are being created, or adapted from the oil and gas industry.
- To enable construction of wind projects in deep water, three idealized concepts have arisen for floating platform designs, including the semi-submersible, the spar buoy, and the tension-leg platform, each of which use a different method for achieving static stability.
- The advanced technology under development focuses on:
    - Technology to reduce capital costs;
    - Applied research to decrease installation, operations, and maintenance costs;
    - Turbine innovation to increase energy capture;
    - Codes and standards development to reduce technical risks and financing costs and specifically on research on innovative turbines; marine systems engineering; computational tools and test data; resource planning; siting and permitting; complementary infrastructure; and advanced technology demonstration projects.

3.4 Examples of Development of Wind Energy Sources

Table 3. Data Derived from Other States' Projects and National Agencies

Onshore Wind	Data	Comment	Source
Plant lifetime	25 years	Value applicable to U.S. as a whole	"Cost and Performance Assumptions for Modeling Electricity Generation Technologies." NREL. 2010.
Nr of construction jobs / 1MW	2 / 1MW	The prediction states 590 construction jobs are needed to build a 300 MW facility	"Economic Impact Analysis – Wind Energy." North Carolina Department of Commerce. Policy, Research & Strategic Planning. 2010
Nr of O&M / 1MW per year	3 / 1MW per year	The prediction states that 300 jobs per year per 1,000 MW will be needed	"Economic Development Impacts of Colorado's First 2000 Megawatts of Wind Energy." NREL. 2008.
Wages – constr. median (2010$)	$42,701	Value is the average of wage predictions of construction workers NC study ($44,000), and the median wage of construction workers by BLS ($41,402)	"Careers in Wind Energy." U.S. Bureau of Labor Statistics. 2010 "Economic Impact Analysis – Wind Energy." North Carolina Department of Commerce. Policy, Research & Strategic Planning. 2010
Wages – O&M average of median (2010$)	$37,500	Value includes the U.S. median wages of wind turbine technicians	"Careers in Solar Power."U.S. Bureau of Labor Statistics. 2011

3.5 Overview of the Onshore Wind Economic Impact Analysis in North Carolina[16]

Results of the study are estimates, and in some cases based on forecasts. The proposed wind energy power generation facility is expected to generate 300 megawatts of power at full capacity from one-hundred and fifty wind turbines.

- The company is expected to invest $750 million: $712.5 million in tangible personal property (machinery and equipment) and $37.5 million in real property construction.
- At full employment the facility will employ 19 people with an average annual wage in excess of $100,000–more than double the median wage in North Carolina.

Analysis Assumptions and Methodology

- The North Carolina Department of Commerce uses IMPLAN software for economic impact modeling. IMPLAN allows development of local level input-output models to estimate the economic impact of new firms moving into an area, plant closures, and other activities. This model is widely used by local, state and federal government agencies as well as private industry and universities.
- While the vast majority of the firm's overall additional investment spending is wind turbines, these purchases will be from firms located outside the state. The company indicated 1% of overall initial investment will be purchased in North Carolina, and will come from engineering and site work services as well as non-specialty electrical needs such as wiring.
- Wind energy is a part of a larger IMPLAN industry sector titled "electric power generation, transmission, and distribution". In reviewing this industry's supply chain, carrying out research and through discussions with the company, it was determined the production function (commodity inputs) for this more general industry is different than the production function specific to wind energy generation. In order to better represent the wind energy production function, NCDOC staff and the company created a production function in IMPLAN3 specific to wind energy. Additional customization was done to match wage and employment data provided by the firm.
- Because a wind energy generation facility does not exist in North Carolina, it was determined the modeling results are not as exact as they would be if the industry already had a footprint. Therefore, sensitivity analysis was applied and multiple scenarios were considered. Results are presented as

[16] "Economic Impact Analysis – Wind Energy." North Carolina Department of Commerce. May 2010.

a range of potential values. Outliers on the low and the high end of the spectrum were removed.

Economic Impacts
This project consists of two analysis components: construction and investment to build the facility, and the operations associated with producing wind energy at the facility.

Construction and Personal Property Impacts

- Approximately 590 one-time jobs will result from facility construction, with more than 300 directly needed to construct the facility.
- Total labor income is expected to be $26 million (an average of $44,000 per employee).
- Construction of the facility will positively impact the state's gross domestic product by $34 million and increase state output by over $75 million.

Facility Operations Impacts

- The facility will directly employ 19 workers and is estimated to increase the state's gross domestic product by $30 million annually at full employment. An additional 29 to 120 indirect and induced jobs will be supported by the company's activities.
- At full employment, estimated total labor income for these multiplier jobs is between $1.2 and $4.5.
- These multiplier jobs are expected to increase the state's gross domestic product by $2 to $8 million, and increase state output by $4 to $14 million.
- The infancy of the industry in the state along with minimal year-to-year investment shows the majority of the project impacts will be direct effects rather than the multiplier effects.

Impacts beyond the Scope of This Project

- This project examines the economic impacts of a facility being constructed and operated in North Carolina, thus this project analysis is not comprehensive and does not consider all benefits or all costs associated with the project.
- This analysis looks at the benefits in a standard economic perspective of jobs created and increases to state output. It does not place an economic value on this facility producing no greenhouse gas or harmful containments that other energy generating facilities may produce.
- It does not value the initial development this facility would provide to the development of the "green economy", or any other intrinsic benefits. The IMPLAN model is a static model, thus the scenario of enhancing the

supply chain of green technology by locating an end product within the state is not considered in this model.
- Additions to the green energy supply chain are not likely to happen as a result of this project alone, but the development of this industry's value chain can only be enhanced by the addition of this facility in the state. Additionally, concerns regarding visual and noise pollution as a result of wind turbines, as well as other costs are not within the scope of this project.

3.6 Issues Related to the Potential Onshore and Offshore Wind Development in New Jersey[17]

- Although a wind resource map can be indicative of wind potential, actual wind measurements for a period of at least one year are needed to determine the feasibility of installing wind turbine equipment at a specific site.
- The development of onshore wind has been limited due to existing laws, regulations, and concerns regarding the impact on wildlife, including bird and bat migration, habitat protection, and the lack of high quality onshore wind resources.
- Since the capital cost of onshore wind is much lower than either offshore wind or solar PV, it may be useful for New Jersey to take full advantage of any onshore wind potential in order to meet the RPS objectives in a way that reasonably balances economic, environmental, and reliability objectives.
- New Jersey's wind resource map shows low average onshore wind speeds, unsuitable for wind generation, but attractive wind speeds on the coast and offshore.
- The New Jersey Regional Anemometer Grant Program (NJ-RAGP) was funded initially by the DOE's Wind Powering America Program and is now run by the the New Jersey Board of Public Utilities Office of Clean Energy. The NJ-RAGP has been available to New Jersey colleges and universities interested in administering and delivering the anemometer loan program. The data are available to potential investors and other interested parties to understand better the local wind resource and the corresponding energy production.
- Since turbine blades for offshore wind plants are increasing in size, it is reasonable to assume that a turbine manufacturing facility will have to be

[17] "2011 Draft Energy Master Plan." State of New Jersey. http://www.nj.gov/emp/docs/pdf/2011%20Draft%20Energy%20Master%20Plan.pdf.
"2011 New Jersey Energy Master Plan". State of New Jersey. http://nj.gov/emp/docs/pdf/2011_Final_Energy_Master_Plan.pdf.

located somewhere on the East Coast to provide blades for the growing list of proposed offshore wind facilities.

- The Christie Administration intends that the OWEDA (Offshore Wind Economic Development Act – OWEDA defines the terms and conditions under which "qualified" offshore New Jersey wind projects will be supported by New Jersey ratepayers) will incentivize the development of offshore wind manufacturing and construction companies in New Jersey.
- The 2008 Energy Master Plan called for 1,000 MW of offshore wind generation by the end of 2012. It soon became apparent that this goal was no longer feasible because delays in federal leasing on the outer continental shelf, the failure of any project to have begun construction, the decline in wholesale energy prices, and the controversy surrounding other offshore projects elsewhere in the mid-Atlantic and New England states have stymied the offshore wind industry.
- To jump start offshore wind development, in 2010, OWEDA called for at least 1,100 MW of offshore wind generation to be subsidized. Depending upon the scale, projects proposed could reach 3000 MW of offshore wind. The Board of Public Utilities is confident that the 1,100 MW offshore wind target objective is achievable and has adopted new rules which balance costs and benefits in the broader context of the overall impact on New Jersey's manufacturing and employment objectives, as well as recognition of the potential benefits offshore wind energy has on the environment and retail electricity prices.
- To be eligible for ratepayer financing projects must demonstrate net economic and environmental benefits to the State.

3.7 Economic Impact Analysis of the Cape Wind Off-Shore Renewable Energy Project[18]

Region of Impact

- Global Insight defined the region of impact (ROI) as Barnstable County, Massachusetts, which contains a total of 15 cities and towns. Barnstable County was selected as the ROI because the majority of the direct M/A and C/I and operation impacts will be concentrated there, including: the hiring of M/A and C/I workers, purchase of non-labor goods and services during M/A and C/I and operation phases, presence of an on-shore support base to support offshore construction and annual operation and maintenance activities (O&M), and the presence of on-shore.

[18] "Economic Impact Analysis of the Cape Wind Off-Shore Renewable Energy Project." Global Insight. 2003.

- Southeastern Massachusetts and possibly Rhode Island would also benefit from on-shore facilities that may be established there during M/A and C/I, including the fabrication of blades and other components, the assembly of the WTGs, and the stockpiling of M/A and C/I materials. Barnstable County is located within easy daily commuting distance of both the Boston and Providence PMSAs, so any skilled M/A and C/I workers not available from the ROI would be obtainable from these two PMSAs, suggesting that no in-migration of M/A and C/I workers would occur.
- The purchases of construction labor, and non-labor inputs such as concrete and aggregates, steel, and support services such as the crew boats and barges used to support the offshore construction activities, will be concentrated in Barnstable County.
- The purchase of much of the specialized equipment that will comprise the WTGs such as the rotors, generators, and nacellas etc. will occur outside the ROI, and likely outside Massachusetts.
- The fabrication and assembly of the WTG's components and other support or assembly facilities may be located in southeastern Massachusetts. Assembly and fabrication activities at these locations, along with spending by C/I workers, would generate significant temporary increases in employment and income in their host counties during the M/A and C/I phase.

3.8 Current Issues with the Cape Wind Offshore Facility off the Coast of Cape Cod

May 2010[19]

The project turns out to cost the ratepayers more than $2 billion to build – three times its original estimate. In 2013 the price of electricity from the facility would be double than from conventional power plants and land-based wind farms; under the 15-year National Grid contract, the price of Cape Wind's electricity would increase 3.5% each year.

May 2011[20]

The Cape Wind project is in doubt due to the federal support being put on hold until more resources for the program are available. However, there is no

[19] Fitzgerald, Jay. "Cape Wind rate Shock." Boston Herald BizSmart. May 2010. At http://www.bostonherald.com/business/general/view.bg?articleid=1253263.

[20] Cassidy, Patrick. "Gov't Financial Support for Cape Wind in Doubt." Cape Cod Times. May 2011. http://www.capecodonline.com/apps/pbcs.dll/article?AID=/20110513/NEWS11/110519876.

assurance that the DOE will ever be in position to continue the evaluation of the project. The loan backed by the federal government would have reduced the anticipated cost of the project to electricity customers. Currently the project is expected to cost more than $2 billion.

December 2011[21]
Massachusetts Supreme Judicial Court upholds Cape Wind/ National Grid 15-year PPA.

[21] Kessler, Richard A. 2011. "Massachusetts Court Upholds Cape Wind, National Grid PPA." http://www.rechargenews.com/energy/wind/article295818.ece.

4. Biomass Energy Source

4.1 Overview[22]

Of all the renewable energy sources, biomass - biological matter that can be used as fuel or for industrial production - contributes the most to the U.S. energy supply.

- Biomass is more sustainable than fossil fuels because the CO_2 it releases is balanced by the CO_2 absorbed by plants growing for the next harvest.
- Experts predict the contribution from biomass will likely increase more than 55% by 2030.
- Much more research needs to be done on its use as an energy resource, but there is promise that it will reduce America's dependence on fossil fuels, decreasing long-term emissions of greenhouse gases and lessening our reliance on foreign sources for our energy supply.

Biomass products

- Wood and wood waste, including wood, sawdust, wood chips, and slash;
- Energy crops such as fast growing trees, corn, barley, warm season grasses, winter cover crops, and others;
- Agricultural waste such as crop residue (i.e. corn, wheat, soybeans, cotton, sorghum, barley, oats, rice, rye, canola, beans, peas, peanuts, potatoes, safflower, sunflower, sugarcane, and flaxseed), animal litter; and waste from food processing;
- Municipal solid waste and landfill gas generated from waste;
- Algae.

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[22] "What You Need to Know About Energy: Renewable Sources - Biomass." 2010. *National Academy of Sciences*. http://needtoknow.nas.edu/energy/energy-sources/renewable-sources/biomass.php.
Milbrandt, Anelia. 2005. *A Georgraphic Perspective on the Current Biomass Resource Availability in the United States*. National Renewable Energy Laboratory.
Glossary of Terms. 2006. *Virginia Department of Mines Minerals and Energy.* http://www.dmme.virginia.gov/de/glossaryterms.shtml.
"Renewable: Biomass." 2010. U.S. *Energy Information Administration*. http://www.ei.lehigh.edu/eli/energy/resources/readings/biomass.pdf.
"Biomass: Manure for Fuel." *State Energy Conservation Office*. http://www.seco.cpa.state.tx.us/re_biomass-manure.htm.
"Woody Biomass Utilization." 2010. *U.S. Forest Service*. http://www.fs.fed.us/woodybiomass/.
Parhizkar, Omid, and Robert L. Smith. 2008. "Application of GIS to Estimate the Availability of Virginia's Biomass Residues for Bioenergy Production." *Forest Products Journal* 58 (3).
Robertson, Guy, Peter Gaulke, Ruth McWilliams, Sarah LaPlante, and Richard Guldin. 2011. *National Report on Sustainable Forests - 2010*. United States Department of Agriculture.

Waste-to-Energy

Garbage, often called municipal solid waste (MSW) contains biomass (or biogenic) materials like paper, cardboard, food scraps, grass clippings, leaves, wood, and leather products, and other non-biomass combustible materials, mainly plastics and other synthetic materials made from petroleum.

- Today, each American throws away about 4.5 pounds of trash every day, which can be combusted in waste-to-energy plants. Its heat energy can be used to make steam to heat buildings or to generate electricity.
- It costs more to generate electricity at a waste-to-energy plant than it does at a coal, nuclear, or hydropower plant.

Woody Biomass

The most common form of biomass is wood and wood waste including limbs, tops, needles, leaves, bark, and other woody parts that are the by-products of forest management, sawdust, wood chips, wood scrap, and paper mill residues, trees cut or otherwise killed by commercial operations (e.g. thinning or weeding).

- It does not include volume removed from the inventory by reclassification of timberland to productive reserved forestland.
- About 80% of the wood and wood waste fuel used in the southeastern United States is consumed by industry, electric power producers, and commercial businesses.
- Many manufacturing plants in the wood and paper products industry use wood waste to produce their own steam and electricity. This saves these companies money because they do not have to dispose of their waste products and they do not have to buy as much electricity.

- Because a substantial amount of the available wood and wood waste is already being commercially utilized, it is important that the addition of biomass energy production not exceed the carrying capacity of regional forests. That risk is diminished by increased use of recycled material in paper production, afforestation of farmland to grow woody biomass, domestic use of biomass energy products (e.g. pellets) currently being exported, and sustainability certification (e.g. Forest Stewardship Council, Sustainable Forestry Initiative) for source forests.

Landfill Gas

- Landfill gas energy facilities capture the methane (the principal component of natural gas) from municipal solid waste and combust it for energy.
- Some landfills burn the methane gas in a controlled way to get rid of it. But the methane can also be used as an energy source. Landfills can collect

the methane gas, treat it, and then sell it as a commercial fuel. It can then be burned to generate steam and electricity.
- The disadvantage is that landfills occupy valuable land.

Animal Waste

Biogas can be produced in large tanks called "digesters" where manure and bedding material from barns is put. Also, farm manure ponds can be covered to capture biogas. The biogas can be used to generate electricity or heat for use on the farm, or to sell electricity to an electric utility. Small- and mid-scale operations have the potential to solve serious waste and water quality issues associated with this industry.

4.2 Alternative Usage of Biomass

Poultry Waste to Energy[23]

Poultry bedding can be used as biomass fuel. It provides a year round litter outlet for the poultry industry, and increases employment from plant operations and litter procurement.

- Conversion of litter into energy is carbon dioxide neutral.
- Use as fuel creates a new, continuous outlet for litter, improving poultry house utilization.
- Phosphorus and other soil nutrients are captured as benign, odor-free ash.
- The discharged ash has value as an exportable fertilizer.
- Litter is converted to energy via gasification which eliminates problematic fuel glassing
- The intermediate, synthetic gas can be cleansed prior to use as fuel.
- US Department of Energy promotes gasification due to its superior energy efficiency, and environmental performance.

[23] "Poultry Litter to Energy: A Solution for the Watershed." Nuffield International. http://www.nuffieldinternational.org/append_f/Poultry%20Litter%20to%20Energy_A%20Solution%20for%20the%20Watershed.pdf.

4.3 Environmental Impacts[24]

Air Emissions

- Any fossil energy that is used to grow, harvest, and process fuel from biomass releases some of that net CO_2, but overall, biomass may contribute significantly less to climate change than fossil fuels.
- However, the resulting release of biomass and soil carbon to the atmosphere in the form of CO_2 may greatly exceed the greenhouse-gas savings associated with biofuel production on such lands for many years. This phenomenon is referred to as a "carbon debt."

Water Resource Use

- Biomass power plants require the use of water, because the boilers burning the biomass need water for steam production and for cooling. If this water is used over and over again, the amount of water needed is reduced.
- Whenever any type of power plant removes water from a lake or river, fish and other aquatic life can be killed, which then affects those animals and people that depend on these aquatic resources.

Water Discharges

- As with conventional facilities, the water used for cooling is much warmer when it is returned to the lake or river than when it was removed. Pollutants in the water and the higher temperature of the water can harm fish and plants in the lake or river where the power plant water is discharged.
- This discharge usually requires a permit and is monitored.
- Less pesticide and fertilizer runoff will reach local streams and ponds than if food crops are grown. Crops grown for biomass fuel require fewer pesticides and fertilizers than crops grown for food.

Solid Waste Generation

The burning of biomass in boilers creates a solid waste called ash that must be disposed of properly. The ash from biomass normally contains extremely low levels of hazardous elements.

Land Resource Use

- Biomass power plants, much like fossil fuel power plants, require large areas of land for equipment and fuel storage. If these biomass plants burn

[24] "Non-Hydroelectric Renewable Energy." *U.S. Environmental Protection Agency*. http://www.epa.gov/cleanenergy/energy-and-you/affect/non-hydro.html.

a waste source such as construction wood waste or agricultural waste, they can provide a benefit by freeing areas of land that might otherwise have been used for landfills or waste piles.

- Biomass grown for fuel purposes requires large areas of land and, over time, can deplete the soil of nutrients. Fuel crops must be managed so that they stabilize the soil, reduce erosion, provide wildlife habitat, and serve recreational purposes.

4.4. Improvements in Biomass Technology Leading to Cost Reduction[25]

Biomass can now be converted to a material that can be fed to the boiler in place of the coal with no or minor modifications to the boiler. The two processes are torrefaction and pelletization.

Another technology, equally known and proven, and showing equal or greater promise, is gasification. The gas produced can replace fossil fuels whether it is coal, oil or natural gas. Both of these technologies will enable “green” credits to be obtained, which will enhance the economics of using them.

Torrefaction and Pelletization
The process of torrefcation reduces the total dry weight of the biomass by some 30 percent while retaining about 90 percent of the thermal capacity.
In effect, the process increases the energy density of the biomass by 20 to 30 percent depending on the feedstock and process conditions. The torrefied biomass, which results from the process, can now be ground and pelletized.

- The final product is easy to handle and transport. The bulk material receiving and handling systems as well as the feed equipment of most coal-fired boilers will handle it without modification, either mixed with coal or alone.
- The torrefied pellets are delivered to the power plant using the same equipment that is used to handle coal. The pellets can be stored with the coal because they will not absorb water in storage.
- The transport cost per unit of energy produced is much lower for torrefied and pelletized biomass than for bulk unprocessed biomass, due to the energy density and physical compaction.

[25] Wise, James and Jones, Gareth. “Boilers: Economic Change from Coal to Biomass.” Biomass Power & Thermal Magazine. May 2011. http://www.biomassmagazine.com/articles/5553/boilers-economic-change-from-coal-to-biomass.

- The pellets can be mixed with the coal before pulverizing for a pulverized coal boiler, or fired mixed, or separately in other boiler types. Emission controls will need to be checked, but current controls in place would normally be adequate for firing torrefied material.
- So far there is only one commercial torrefaction plant operating in the world, located in the Netherlands.
- Considerable work in developing the technology and equipment has been done in these countries as well as in Ukraine and Australia.

Torrefaction and pelletization of biomass provide a viable and economic alternative to the modification of coal-fired boilers. Considerable savings in the cost of conversion in the United States can be realized once commercial plants are installed and running.

Gasification
Another technology that shows obvious promise in the conversion of coal, oil or natural gas-fired boilers to alternate renewable fuels is gasification.

- The conversion from coal to synthesis gas requires number gasifiers installed outside. Each unit has a loading/metering system feeding the gasifier.
- The discharge from the gasifier is piped into the furnace. For burning in a boiler, gas cleaning is not required. Most of the ash is discharged at the exit of the gasifier and consists of inorganic material and ungasified biomass, which has proven to be a valuable byproduct as a soil conditioner/fertilizer.

The production unit for the syngas should quickly pay for itself by avoiding continuously purchasing coal, oil or natural gas, even when using relatively pure biomass as raw material.

4.5 Examples of Development of Biomass Energy Sources

Table 4. Data Derived from Other States' Projects and National Agencies

Biomass	Data	Comment	Source
Plant lifetime	35 years	Average of values for the U.S, as a whole (40 years) and Va predictions (30 years)	*Cost and Performance Assumptions for Modeling Electricity Generation Technologies*. NREL. 2010.
Nr of construction jobs / 1MW	275 for 65MW	Average of values from two studies = 150 workers for a 56MW facility (Georgia) and 400 workers for a 75MW facility (New Hampshire)	New Hampshire predictions 2011 (SeaCostline.com and Forbes.com) Georgia predictions 2011 (forestbusinessnetwork.com)
Nr of O&M / 1MW per year	47 / 65MW per year	Average of values from two studies = 55 workers for a 56MW facility (Georgia) and 40 workers for a 75MW facility (New Hampshire)	*Analysis for 2011 Draft New Jersey Energy Master Plan Update*. Center for Energy, Economic & Environmental Policy (CEEEP). 2011
Wages – constr. median	$43,000	U.S. average earnings of construction workers	Bureau of Labor Statistics
Wages – O&M average of median	$45,263	U.S. average earnings of O&M workers	Bureau of Labor Statistics

5. Development of Scenarios

Given the above information from the results of the studies from different states, national and state agencies, and Virginia planned projects, scenarios for the increased usage of renewable energy for electricity generation in Virginia were developed.

5.1 Overview of Assumptions for Scenarios

- According to the 2010 Virginia Energy Plan, to sustain the current level of electricity import and to reach the future demand, an additional 7,200 MW of electricity needs to be produced. The demand for electricity by 2020 remains as estimated in the 2010 Virginia Energy Plan.
- The analysis assumes that 50% of the 2035 electricity demand would be generated from expansion of four renewable energy sources – solar PV, onshore wind, offshore wind, and biomass. Solar thermal is not included in the analysis, as it focuses on production of electricity; solar thermal is used to generate heat. Biomass is not divided into individual forms, as data are only available for biomass as a whole.
- The 2035 electricity demand (19,448 MW), is calculated as estimated in 2010 VEP demand in 2020 (7,200 MW) increased by the expected 2.26% growth per year after 2020 to 2035.
- Because of the uncertainty regarding the exact number and timing of the possible closings of conventional electricity generation plants, their status is assumed to remain unchanged.
- The average lifetime of plants is 25 years so to simplify this exercise, 25 years of operation is used.
- Based on the literature, Virginia does not have sufficient renewable energy sources to meet the increased demand for electricity by 2035 from renewable sources only. Therefore it is assumed that 50% of 2035 electricity demand is met by renewables.
- Both scenarios assume a large percentage of electricity to be extracted from biomass, as it is relatively cheap to construct or convert from other plant types. It is also assumed that the full capacity of onshore wind will be used, because its estimated levelized cost is second cheapest. Because of solar PV forecasted potential data unavailability, it is assumed that Virginia does have the capacity to provide the needed percentage.
- Construction jobs are one-time and their number depends on plant size. In order to assess the economic impact, the number of years when the

construction jobs would be provided has to be assumed. The analysis assumes it to be two to three years.

- Given the size of plants cited in the literature for which data are available, we will assume a certain number of those size plants to make up the total MW estimated in the scenarios.
- Data used in the analysis were extracted from other analyses conducted by states and organizations and relies on their accuracy and rationale.
- There are gaps in data availability; not all previous analyses provide specific data on all indicators (i.e. employment, wages, costs, project sizes), hence this analysis is a compilation of data from different sources and different years expressed as $2008. Therefore this analysis is likely not to present the exact situation; rather it is an approximation/estimation based on best available data.
- Data are limited due to inconsistency in energy capacity expression; this analysis is targeted to stay consistent with values being expressed in MW, because the capacity of plants that could be constructed is expressed in MW.
- Data extracted from the most recent available studies were used in the analysis.
- The analysis considers the economic impacts on the whole state, without division into particular counties that would benefit the most from hosting the plants.
- The analysis does not account for any environmental benefits.

5.2 Potential Economic Impacts

Table 5. Potential Economic Impacts of Renewable Energy in Virginia
Scenario Description

Timeframe: 2010 – 2035
Electricity Demand to be Provided by Renewable Sources: 9,724 MW
50% of the 2035 demand (19,448 MW), calculated as current demand + 7,200 MW by 2020 + 2.26% growth per year after 2020
Imports: current 34% rate

Scenario 1 –Base
2035

Biomass is the prime source because the technology is available and relatively cheap. Only a small percentage of offshore wind will be used because it is many years off and may enter the market much later than other sources.

Electricity demand to be provided by renewables	9,724 MW

Renewable energy source	**Assumed percentage to be used**	**MW needed to achieve the assumed %**	**Forecasted capacity in VA**	**Source**
Biomass	50%	4,862MW	7,000 MW	"The Virginia Energy Savers Handbook." Virginia Department of Mines Minerals and Energy. 2008
Onshore Wind	18%	1,793 MW	1,793 MW	American Wind Energy Association. 2010.
Offshore Wind	10%	872 MW	3,200 MW	"Virginia Offshore Wind Studies July 2007 to March 2010. Final Report." Virginia Coastal Energy Research Consortium.
Solar	22%	2,139 MW	Missing data	Limitation of PV potential data in VA is probably due to current level of installed cost

Table 6. Potential Economic Impacts of Renewable Energy in Virginia
Scenario Description

Timeframe: 2010 – 2035
Electricity Demand to be Provided by Renewable Sources: 9,724 MW
50% of the 2035 demand (19,448 MW), calculated as current demand + 7,200 MW by 2020 + 2.26% growth per year after 2020
Imports: current 34% rate

Scenario 2 – Tech advances in Offshore Wind
2035

Maximum of predicted offshore wind potential in Virginia will be used, due to some technological breakthrough and market entrance earlier than expected.

Electricity demand to be provided by renewables 9,724 MW

Renewable Energy Source	Assumed percentage to be used	MW needed to achieve the assumed %	Forecasted capacity in VA	Source
Biomass	40%	3,889 MW	7,000 MW	"The Virginia Energy Savers Handbook." Virginia Department of Mines Minerals and Energy. 2008
Onshore Wind	18%	1,793 MW	1,793 MW	American Wind Energy Association. 2010. AND VCCER: A Study of Increased Renewable Energy Resources in Virginia. November 11, 2005, Updated Jan 16, 2006,
Offshore Wind	33%	3,200 MW	3,200 MW	"Virginia Offshore Wind Studies July 2007 to March 2010. Final Report." Virginia Coastal Energy Research Consortium.
Solar	9%	875 MW	Missing data	Limitation of PV potential data in VA is probably due to current level of installed cost

Economic Multipliers

The total economic impacts of alternative energy sources reflect the combination of direct outlays for construction of generating capacity and post-construction operations and their subsequent monetary effects as these funds are circulated through the economy; that is, the re-spending of these direct outlays will generate additional economic activity that otherwise would not have occurred. The total value of these combined direct and indirect values can be estimated by the application of appropriate multipliers that have been calculated for each state and sector (e.g., construction, utilities) by the Bureau of Economic Analysis of the U.S. Department of Commerce employing its Regional Input-Output Model (RIMS II).

The results of these calculations are estimates of (1) output value—total contribution to the state economy, (2) personal earnings—new earnings realized by the resident workforce of the state in which spending occurs and (3) the local and non-local jobs supported by these outlays—full-time year-round jobs. The key variables governing the magnitude and significance of these economic impacts are their dollar value, the category of outlay (e.g., building construction, utilities operations), the direct employment and payroll associated with the direct spending, and the geographic area of analysis and the complexity of the state economy.

The size and complexity of the economy determine the extent to which the state economy can provide the inputs (goods and services purchased in support of construction activities associated with alternative sources of generating capacity and purchased by electrical generation plant or facilities employees as they spend their wages) and retain the outputs of these economic activities; i.e., how self-sufficient the state is. In this analysis, the Commonwealth of Virginia has a sufficiently large and complex economy that retains a substantial portion of the payroll spending associated with generation facilities operations but must import construction materials related to the specialized equipment that is involved in these generation plant scenarios. In those cases, this direct spending leaks out of the state with little residual economic impact. These self-sufficiencies and leakages are reflected in the state economic multipliers.

Impacts of Building and Operating Renewable Energy Production Capacity on the Commonwealth of Virginia Economy

Direct Outlays to Build and Operate Renewable Energy Production Facilities to Generate 9724 MW by 2035 Compared with Coal-fired and Gas Generation
(in millions of 2010 dollars)

Phase	Scenario 1	Scenario 2	Coal	Gas
Construction	$9,483.5	$5,937.4	$2,390.7	$1,126.7
Annual Operations	$913.7	$1,572.6	$1,857.6	$235.2

Economic Impacts on the Commonwealth of Virginia of Direct Outlays
To Construct and Operate Renewable Energy Alternatives
Compared to Coal and Gas Generation
(in billions of 2010 dollars)

Scenarios	Total Output (1)	Personal Earnings (2)	Jobs (3)
Construction			
Scenario 1	$20.83	$6.36	172,328
Scenario 2	$13.04	$3.97	107,890
Coal	$5.25	$1.60	43,442
Gas	$2.47	$0.75	20,473
Annual Operations			
Scenario 1	$1.52	$0.34	6,206
Scenario 2	$2.61	$0.59	10,682
Coal	$3.08	$0.70	12,618
Gas	$0.38	$0.09	1,597

Source: GMU Center for Regional Analysis

(1) Contribution to Gross State product;

(2) Personal earnings generated and accruing to workers residing in the State; jobs supported by the payroll spending of workers directly and indirectly in the energy production across all sectors of the state and national economies.

The quantification of economic impacts shows that significant economic gains and new jobs would accrue form investment in renewable energy sources (both scenarios). The economic gains from the two renewable energy sources ranged from $13 billion to $20.8 billion – significantly higher than gains from coal and natural gas. The construction costs for renewables would be higher, operating costs would be comparable among all the different sources, but the higher investment required for renewables would create the most significant economic gains.

Appendix

Table 7. Major Manufacturing Facilities of Solar Technology in U.S.

State **city**	**Company**	**Products manufactured**	**No. of employees**
Unknown state (as of April 2011), most likely Colorado	GE Energy	Thin-film photovoltaic panels	400; and 600 related jobs
Ohio Perrysburg	First Solar	Thin film PV modules	600
Arizona* Mesa	First Solar	Thin film PV modules *Construction expected to be finished in the second quarter of 2012	400-500 construction jobs 600 after opening
California Milpitas	SunPower Corporation and Flextronics	Solar panels	100
Colorado Longmont	Abound Solar	Thin–film photovoltaic panels	300
Indiana* Tipton *Development expected to begin in 2012	Abound Solar	Thin–film photovoltaic panels	1,000
Nevada North Las Vegas	Amonix	Concentrated photovoltaic (CPV) solar power systems	300
Oregon Hillsboro **California** Camarillo **Washington** Vancouver	Solarworld Industries USA subsidiary of Shell Renewables, Ltd.	Wafers, cells, laminates, or solar panels	600 Combined
Tennessee Memphis	Sharp Manufacturing Company of America	Solar panels	450
New Mexico Albuquerque	SCHOTT Solar	Solar photovoltaic panels, solar thermal parabolic troughs	300
California San Diego	KoyceraSolar Energy	PV Solar panels	75

Note: Number of employees is an estimation

Table 8. Major Manufacturing Facilities of Wind Technology in U.S.

State city	Company	Products manufactured	No. of employees
Iowa Cedar Rapids	Clipper Windpower	Powertrains, permanent magnet generators, variable speed system, high speed control system, low-voltage ride-through, lightning protection, two-person service lifts	360
New Hampshire Durham	Aeronautica Windpower and Goss International	Nacelles for mid-scale electric wind turbine generators	115
Iowa Newton	TPI Composites	Wind turbine blades	500
Idaho* Pocatello	Nordic Windpower	Nacelles, which sit on top of the turbines' towers and include the gear box, generator, controller, brake and low- and high-speed shafts *Planned to be moved to Kansas City	160
Michigan Saginaw	Northern Power Systems	Utility-scale wind turbines	137
Arkansas Fort Smith	Mitsubishi Power Systems Americas, Inc. (MPSA)	Wind turbine nacelle	330
Minnesota Pipestone	Suzlon Rotor Corporation	Rotor blades	350
Colorado Windsor	Vestas	Rotor blades	650
Colorado Brighton	Vestas	Nacelles	280
Colorado Pueblo	Vestas	Wind tower	283
Illinois Elgin	Winergy Drive Systems Corp. and Siemens Drive Technologies	Mechanical drives for wind turbines	355
Kansas* Newton	New Millennium Wind Energy	Vertical-axis wind turbines *the plant is expected to be operational in 2012	70 (first year); up to 350 (in 3 to 4 years)

Note: Number of employees is an estimation

Sources: Major Manufacturing Facilities of Solar and Wind Technology in U.S.

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