ENERGIZING OHIO'S ECONOMY

Creating Jobs and Reducing Pollution With Wind Power

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Executive Summary

Developing Ohio's wind energy resources will advance Ohio's economy. Clean, renewable and home-grown wind energy will help to make Ohio more energy independent, create jobs, increase incomes, and help to prepare our economy for a potential national cap on global warming pollution.

In this report, we use an economic model to evaluate the impact of increasing wind energy production to 20 percent of Ohio retail electricity sales by 2020, in comparison with continuing business as usual.

We find that wind energy can provide significant benefits for Ohio's economy and environment. Accordingly, wind power and other renewable energy resources should play a central part in Ohio's energy policy.

Wind energy creates jobs.

- Diversifying Ohio's electricity supply with 20 percent wind energy by 2020 would create an estimated net of 40,000 person-years of employment through 2020, or the equivalent of 3,100 permanent, full-time jobs. It would also increase wages paid to Ohio workers by a cumulative net total of $3.7 billion through 2020.
- Harnessing Ohio's well-developed industrial base to manufacture renewable energy technologies for export would provide additional economic advantages. For example, the Renewable Energy Policy Project and Policy Matters Ohio estimate that a national commitment to wind energy could create more than 13,000 wind turbine component manufacturing jobs in Ohio – more than in any state except California.

Wind energy creates economic growth.

- Diversifying Ohio's electricity supply with wind energy would increase gross state product (GSP) by an estimated net of $8.2 billion through 2020.

Ohio's rural areas can benefit from wind energy development.

- Landowners can lease land for wind farms, creating an additional income stream. Increasing Ohio's use of wind energy could supplement landowner income with cumulative total lease payments of $200 million through 2020.
- Developing Ohio's wind power resources would generate on the order of $1.5 billion in property taxes (total through 2020) to fund education and other local government services, mainly in rural areas of the state.
- Communities can maximize local benefits by organizing and financing their own wind projects, much like the Bowling Green wind farm.

Wind energy reduces pollution. In total through 2020, wind power would prevent the release of:

- 170 million metric tons of carbon dioxide, the leading global warming pollutant (equivalent to retiring more than 2 million cars from the road);
- 470,000 tons of soot-forming sulfur dioxide;
- 120,000 tons of smog-forming nitrogen oxides; and
- 4,000 pounds of mercury, a neurological toxicant.

Wind energy can help prepare Ohio for a future cap on global warming pollution, protecting the economy from the rising cost of fossil fuels.

- The growing urgency of global warming makes limits on carbon dioxide pollution likely for the future. As these limits are set, power from carbon-heavy fossil fuels will become more expensive – and investments in fossil-fueled power plants will become less valuable. Since power plants can last 30 years or longer, it makes sense to consider the impact of global warming pollution limits now.
- In contrast, wind power and other renewable energy resources emit no global

warming pollution, and will not be subject to price increases from future global warming policy. By diversifying its electricity resources with wind, Ohio can protect its economy from the rising cost of fossil fuels.

Wind energy could make up 20 percent of Ohio's electricity consumption by 2020.

- Ohio has substantial wind resources along the glacial ridges of central Ohio, across the farmlands of northwest Ohio, as well as along and off the shores of Lake Erie. The National Renewable Energy Laboratory (NREL) estimates that wind turbines on three-hundredths of 1 percent of the land area of Ohio could produce 20 percent of Ohio's electricity needs in 2020.
- In addition to wind, Ohio has other renewable energy resources like biomass and solar energy that could contribute to a reliable electricity supply for the state. Ohio ranks 7th in the country in the availability of biomass stocks available at less than $40 per dry ton, according to the Oak Ridge National Laboratory – enough biomass to generate about 7.5 percent of Ohio's forecast electricity needs in 2020. Solar photovoltaic panels on 1 million Ohio rooftops could produce almost 3 percent of Ohio's forecast electricity needs in 2020.

Now is the time to move Ohio toward a clean energy future. To make this future a reality, Ohio's leaders should:

- **Adopt a renewable electricity standard of 20 percent by 2020.** Ohio should require utility companies to obtain a growing share of their electricity from in-state renewable sources of energy, beginning in 2009 and reaching 20 percent of sales by 2020. The standard should focus on renewable resources like wind, solar and clean biomass – while excluding toxic sources of energy like trash incineration, and excluding fossil fuels.
- **Reduce Ohio's global warming pollution.** Ohio should pursue the cheapest carbon-free sources of electricity first, including energy efficiency and renewable energy, before considering proposals that would increase the state's contribution to global warming. Moreover, Ohio should not allow any new coal facility to be built unless it includes carbon capture and sequestration, with verifiable and permanent carbon storage.

Introduction

Ohio's economy needs an infusion of new energy. According to Moody's Investors Service, Ohio is in the midst of an economic downturn longer than any since the Great Depression.[1] Since 2000, Ohio has lost nearly a quarter of its manufacturing jobs.[2]

However, Ohio has the resources right here at home to leverage its strengths and lay the foundation for a prosperous future.

The key is energy.

Almost 90 percent of Ohio's electricity is generated from coal.[3] This lack of diversification presents two serious challenges.

First, Ohio is deeply dependent on other states and countries for fuel. In 2005, Ohio imported more than 60 percent of its power plant fuel supplies, sending more than $1.5 billion dollars out of state.[4]

Second, Ohio's overdependence on fossil fuels exposes our economy to the risk that fuel supplies will become more expensive because of impending action to cap global warming pollution. Already, states across the country (home to at least 25 percent of the U.S. population) are beginning to restrict carbon dioxide emissions from power plants, industry and transportation.[5] The 2007 U.S. Congress is actively considering legislation that would require global warming pollution reductions as deep as 80 percent below 1990 levels by mid-century.[6] With international pressure to act continuing to increase, it is likely only a matter of time before a U.S. carbon cap becomes reality.

If Ohio chooses to extend its dependence on fossil fuels, meeting the requirements of a carbon cap will become more difficult and expensive, imposing serious costs on Ohio citizens and businesses. Since power plants can last 30 years or longer, we need to carefully consider the consequences of our energy decisions now.

Fortunately, Ohio has solutions to its energy problems. The state is blessed with significant potential to generate electricity from clean, renewable, and home-grown resources like wind power – plus enormous potential to use energy more efficiently. Pursuing such a "New Energy Future" would begin to free Ohio from our over-reliance on fossil fuels, make Ohio more energy independent, reduce the cost of compliance with a cap on global warming pollution, and safeguard future economic security.

Moreover, tapping into Ohio's wind energy and energy efficiency potential would help Ohio build and diversify its economy into the 21st century. Increasing local demand for products used in wind farms and in efficient products would promote the expansion of a new manufacturing industry to supply the state with clean energy technologies. It would also help position the state to capitalize on increasing regional and global demand for products that Ohio industry can supply.

In this report, we evaluate the impacts of diversifying Ohio's electricity supply with wind energy. The results are clear: wind energy is a smart diversification strategy that provides real advantages for both Ohio's economy and environment. Wind power should play a central part in Ohio's energy policy.

Wind Energy Benefits Ohio's Economy

Wind energy can provide a clean and sustainable supply of electricity for Ohio. At the same time, wind energy is an economic development engine that Ohio can use to move its economy forward.

In this report, we examine the impact of expanding Ohio's use of wind power to reach 20 percent of sales by 2020 (beginning in 2009). We present the results in comparison to a business-as-usual course in which Ohio expands its dependence on fossil fuels.

We use an input-output model of the Ohio state economy to compare how alternate policies affect the overall economy and the environment by describing how each policy affects spending and pollution levels. (See the Methodology section on page 27 for more details.)

The results confirm the findings of numerous earlier studies: developing clean energy resources will create thousands of good-paying jobs, millions of dollars of economic growth, and significant reductions in pollution.[7] (See *Clean Energy Policies Benefit the Economy* on page 8.)

Developing wind energy resources would greatly benefit Ohio's economy while reducing air pollution from power plants. Table 1 presents the results of our analysis, showing the economic advantages of a stronger commitment to wind power.

It is important to note that the economic benefits of wind energy calculated in this report do not include consideration of a cap on emissions of carbon dioxide, the leading pollutant responsible for global warming. Because wind energy is a carbon-free source of energy, it will not be subject to increased costs once limits are placed on carbon dioxide pollution – reducing the impact of a carbon cap on Ohio's economy. Taking these benefits into account would significantly increase the relative benefits of using wind power to diversify Ohio's electricity supply..

Employment Gains

Investing in wind energy would bring jobs to Ohio. Compared to building only coal-fired power plants, expanding wind energy use would

Table 1: Cumulative Net Impact of Wind Energy Scenario vs. Business as Usual (2007-2020)

Measure	Cumulative Net Impact
Jobs Created (Person-Years of Employment)	40,000
Wages Paid	$3.7 billion
Increase in Gross State Product	$8.2 billion
Avoided Global Warming Pollution (CO_2)	170 million metric tons
Avoided Smog-Forming NO_x Emissions	120,000 tons
Avoided Soot-Forming SO_2 Emissions	470,000 tons
Avoided Mercury Pollution	4,000 pounds

Note: A person-year of employment equals work for 1 person for 1 year. All dollar figures are expressed in 2006 values and are not discounted. For a detailed explanation of the methodology behind the results, see page 27.

Clean Energy Policies Benefit the Economy

The results of this study confirm and compare favorably with other recent research. In fact, this study's results are conservative by comparison:

- In 2001, researchers at the University of Illinois's Regional Economics Application Laboratory determined that a regional plan to boost renewable energy, along with energy efficiency and combined heat and power, would create 25,000 jobs in Ohio and increase the gross state product by $3.5 billion by 2020.[8]
- The Renewable Energy Policy Project and Policy Matters Ohio estimate that a national commitment to wind energy could create more than 13,000 turbine component manufacturing jobs in Ohio – the second largest manufacturing job potential of any state in the country.[9]
- In 2005, Environment Ohio Research & Policy Center estimated that enacting a national renewable electricity standard of 20 percent by 2020 and redirecting fossil fuel subsidies proposed in the 2005 energy bill to energy efficiency and renewable energy programs would create 3,700 jobs per year in Ohio and save Ohio consumers more than $1.3 billion on energy costs in the year 2020.[10]
- The Apollo Alliance estimates that implementing a comprehensive 10-year plan to achieve energy independence for America, with a strong investment in renewable energy and energy efficiency, would create more than 130,000 jobs in Ohio and increase state economic activity by more than $8 billion.[11]

increase employment through the year 2020 by an estimated 40,000 person-years, or the equivalent of 3,100 permanent, full-time jobs. Additionally, wages paid to Ohio workers would increase by a total of $3.7 billion through 2020. (See Table 2.)

Wind energy creates jobs in part by replacing expenditures for fuel with expenditures for labor and materials produced at home. Ohio is deeply dependent on fuel imports for power generation – relying on other states or countries for 90 percent of its natural gas, 59 percent of its coal and 97 percent of its petroleum.[12] For example, in 2005, $1.3 billion of the money Ohio spent on coal for electricity generation ended up leaving the state.[13] In contrast, wind energy has no fuel costs, keeping more dollars in the local economy and thus increasing employment in the state.

Renewable energy policies also produce more jobs than building fossil-fueled power plants because they stimulate industries that are more efficient at creating jobs than other parts of Ohio's economy. For example, every $1 million spent on construction in Ohio creates 16.3 jobs. Alternatively, investing $1 million dollars in coal mining creates only 6.5 jobs, while putting $1 million into natural gas distribution creates only 5.3 jobs.[14]

Figure 1 shows the trajectory of net cumulative job creation due to investment in wind energy, above and beyond the business-as-usual case. Similarly, Figure 2 shows the cumulative impact on net wages paid to workers in Ohio.

Table 2: Employment and Wage Impact of Wind Energy Scenario vs. Business as Usual (2007-2020)

Measure	Cumulative Net Impact
Employment Created (Person-Years, 2007-2020)	40,000
Wages Paid (2007-2020)	$3.7 billion

Figure 1: Cumulative Net Employment Increase of Wind Energy Scenario (vs. Business as Usual)

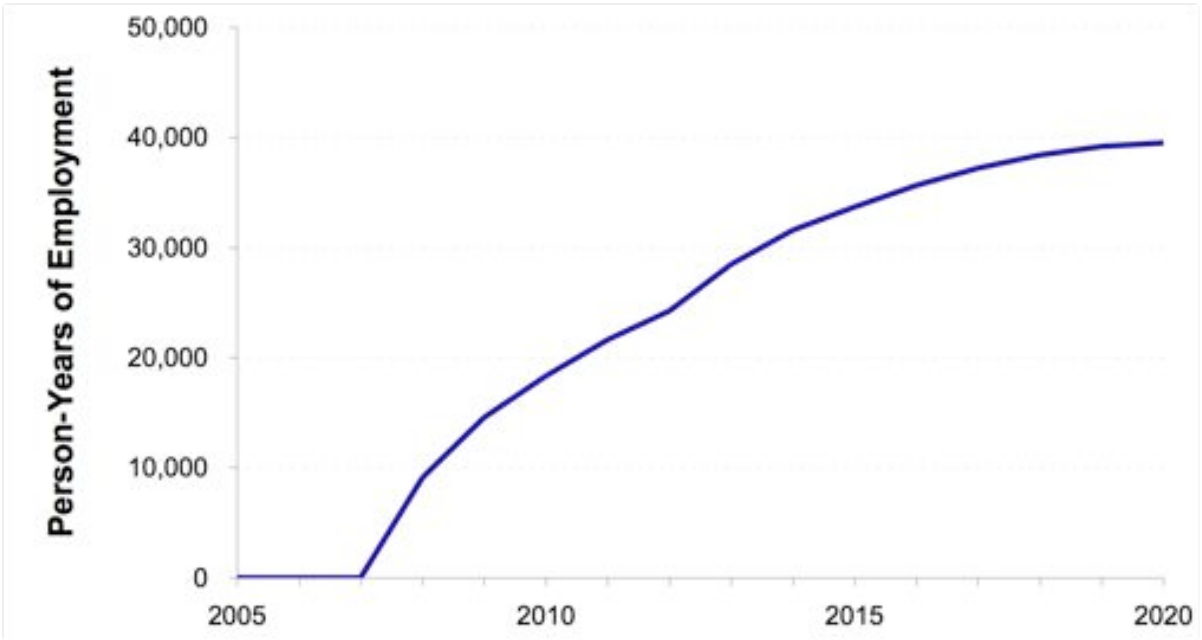
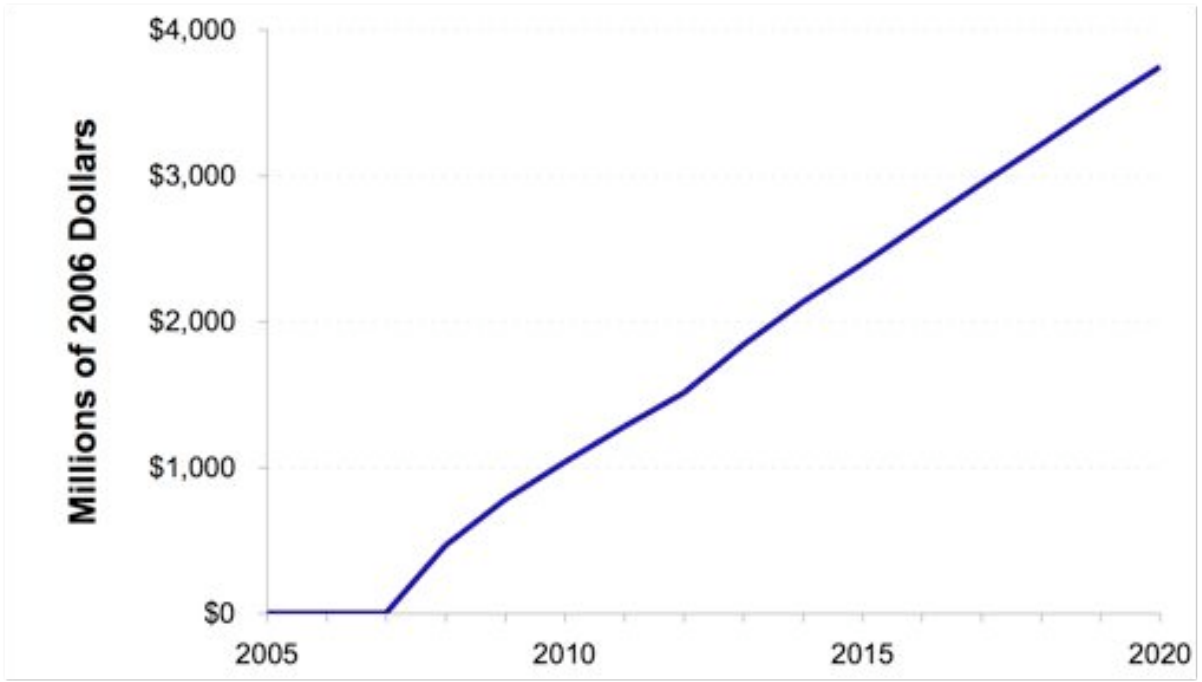


Figure 2: Cumulative Net Wage Increase of Wind Energy Scenario (vs. Business as Usual)



Wind Energy Creates Skilled, High-Paying Jobs

Investment in wind energy directly creates quality jobs in manufacturing, construction and building trades, operation and maintenance, and finance.

Manufacturing

Wind energy requires highly skilled manufacturing workers who design, build and assemble wind turbines.

Much of the work involved in wind energy goes into manufacturing, including rotor blades, structural towers, hubs, transmissions, generators and assorted electronic controls. According to a survey of wind energy companies by the Renewable Energy Policy Project (REPP) in 2001, manufacturing 10 MW of wind turbines requires a year of labor from 32 full-time workers.[15]

Ohio's well-developed manufacturing infrastructure makes it ideally suited for increased manufacturing of components for wind energy systems (and other forms of renewable energy).

Ohio is already home to more than 60 companies active in the wind turbine supply chain.[16] For example:

- Magna Machine, a metal casting and machining company based in Forest Park, won a $2.7 million contract to supply 100 turbine hubs to a turbine manufacturer in 2005. The contract helped Magna increase its annual revenues to $15 million and the number of its employees from 75 to 100.[17]
- Cast-Fab Technologies in Oakley estimated in early 2006 that manufacturing cast-iron parts for wind turbines would make up 20 to 25 percent of its business that year. Cast-Fab has annual revenues of more than $50 million and more than 300 employees.
- Rotek Incorporated, based in Aurora, manufactures bearings used in wind turbines.[18]
- Dyson Corporation of Painesville manufactures wind system components, including the nuts and bolts attaching towers to their foundations at the Maple Ridge Wind Farm near Watertown, New York.[19]
- Owens Corning employs workers at a facility in Toledo, lending its materials expertise to strengthening the blades used on wind turbines.[20]
- Michael Byrne Manufacturing Co. in Mansfield makes gears used to transfer energy from the rotating blades of a wind turbine to the generator inside a wind turbine.[21]
- Timken Company, with facilities in Canton and around the world, manufactures components for wind turbines (among many other products).[22] The company is one of Ohio's top ten manufacturing employers, with more than 6,000 Ohio employees.[23]

Other companies have the potential to build wind energy systems in Ohio, but are manufacturing components in locations closer to centers of demand. For example, Parker Hannifin Corporation manufactures dozens of components used in wind turbines, including braking systems that protect the turbine from high wind speeds and yaw controls that help the turbine capture wind energy more efficiently – but at their facilities in Europe and not in Cleveland.[24] Similarly, General Electric, the second-largest manufacturing employer in Ohio, is a major participant in the national and international wind energy market, but located its manufacturing facilities in Europe, California, and near shipping infrastructure on the Gulf Coast.[25]

Blade Manufacturing – NEG Micon

Ohio's steel industry could also produce structural steel for use in wind turbine towers to supply an increase in local demand. Towers account for about a quarter of the cost of a typical turbine. Producing towers locally helps to minimize the costs associated with transporting the large tower segments to the site of a wind installation. More than 22,000 Ohioans currently work directly in steel production and processing at 242 facilities located across the state, earning more than $1.3 billion in wages.[26] Increased demand for wind energy could increase employment in the steel industry.

In addition to providing local companies a chance to expand their operations, increased local demand for wind energy systems could create and enhance the opportunity for new companies to locate facilities in Ohio. The state has a well-developed industrial base and access to ports on the Great Lakes – assets that could attract manufacturers interested in tapping into the regional and global clean energy market. For example:

- The Spanish wind turbine manufacturing company Gamesa located its U.S. headquarters in Pennsylvania in part because of the state's commitment to renewable energy, as well as its strategic location.[27]
- Indian turbine manufacturer Suzlon located a new blade and nose cone manufacturing facility in Minnesota, which recently boosted its renewable electricity standard to 30 percent by 2020 for Xcel Energy, and 25 percent by 2025 for other providers.[28]
- Similarly, Colorado (which just increased its renewable electricity standard to 20 percent by 2020) will be home to the first North American manufacturing facility for Vestas, the world's largest turbine manufacturing company.[29] The Vestas facility will employ more than 400 people and produce 1,200 turbine blades every year.[30]

Building Trades, Construction and Installation

Installation of renewable energy facilities typically involves local construction firms and general contractors, boosting local economies. Large wind farms can need up to 300 workers on site during

Wind Turbine Assembly – BONUS Energy A/S

construction. These workers assemble turbines, erect towers, pour concrete, build roads, and lay cable – not to mention purchase housing and food from local businesses.[31] Additionally, wind farm construction can benefit local businesses that provide concrete and steel for tower foundations, gravel for roadways, supplies for wiring, and excavation or transport services.

For example, the construction of the Colorado Green wind farm in Lamar, Colorado required 400 construction workers to install 108 large wind turbines and towers.[32]

Ohio is home to many companies that already participate in the installation of commercial-scale wind farms. For example:

- JW Great Lakes Wind, a wholly-owned subsidiary of German wind developer juwi GmbH, has opened an office in Cleveland. As of May 2007, the company has more than 140 MW of wind capacity in development around Ohio.[33]
- Renaissance Group outside of Cleveland offers services in technology consulting, project management, energy systems, design, installation, education and outreach for wind energy.[34]

- ALL Erection & Crane Rental Corp. in Cleveland rents large structural cranes which can be used to erect towers and mount hubs.[35]
- Power Systems Development in Canton and Barrett Construction Services Inc. in North Benton offer construction services.
- EGC Enterprises in Chardon and Tuf-Tug Products/Deuer Developments in Moraine offer tools and tensioning equipment useful in tower installation and blade attachment.

Operation and Maintenance

The operation and maintenance needs of a wind farm create permanent, high-quality local jobs ranging from servicing turbines to accounting.

Wind farms need staff to operate and regularly service the turbines throughout their roughly 30-year lifetimes. A recent survey of large wind farms in Texas found that every 100 MW of capacity requires six full-time employees to operate, monitor, and service the turbines.[36] Other wind farms need more employees – for example, the Colorado Green wind farm in Lamar, a 162 MW facility, created 14 full time, well-paying operation and maintenance jobs in Prowers County.[37]

Ohio companies capable of offering operation and maintenance services include:

- North Coast Wind & Power, based in Port Clinton, which develops and manages utility-grade wind energy facilities.[38]
- Alignment Supplies in Maumee, which provides laser alignment technology, and Insight Services in Cleveland, which provides monitoring and analysis of oil condition. These services are useful in ensuring the proper operation of wind turbines.[39]

SPILLOVER EFFECTS

Each dollar spent on renewable energy creates impacts that ripple outward through the local economy, extending far beyond the direct creation of jobs at energy facilities.

For example, workers at a manufacturing plant need raw materials and equipment. Their work in assembling turbines supports jobs in equipment manufacturing and component supply. Contractors at a construction site need concrete and heavy equipment, and their work supports additional jobs supplying these needs. In addition to these indirect jobs, workers spend much of their wages in the local economy, purchasing goods and services like groceries and housing and supporting additional workers.

Maintenance Inspection BONUS Energy A/S

Wind Energy Has a Large Direct Economic Impact

The National Renewable Energy Laboratory found that a wind farm in Arizona, Colorado or Michigan has more than twice the direct economic impact of an equivalent coal or gas-fired power plant. (See Figure 3.) Much of the benefit stems from the fact that for power generation fueled by gas or coal, out-of-state fuel purchases divert a greater percentage of investment dollars out of the local economy. However, NREL examined a scenario in Colorado where 100 percent of the coal for a coal-fired plant came from in-state mines, and found that wind power still had a larger direct economic impact to the state. Additional benefits arise from the fact that wind facilities require more land than traditional power plants, and thus pay a proportionally larger share in property taxes. Wind facilities also provide more economic impact during construction than either coal- or gas-fired plants.

The Ohio Department of Development is currently working on a similar study focused on Ohio.

Similarly, a variety of studies confirm that renewable energy generates more total jobs per unit of energy produced than fossil-fuel technologies.[40] (See Figure 4.) The data in Figure 4 include consideration of jobs all across the U.S. (including manufacturing, construction, operation, maintenance, and fuel extraction and processing).

Figure 3: Direct Economic Impact of Equivalent Electric Generation from Wind, Gas and Coal Power Plants in Michigan[41]

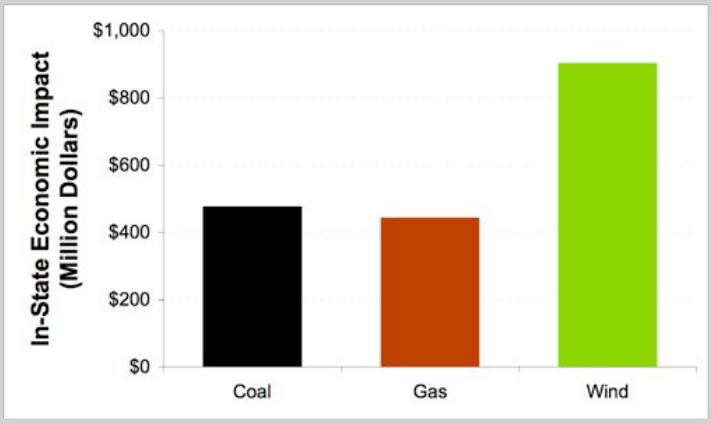
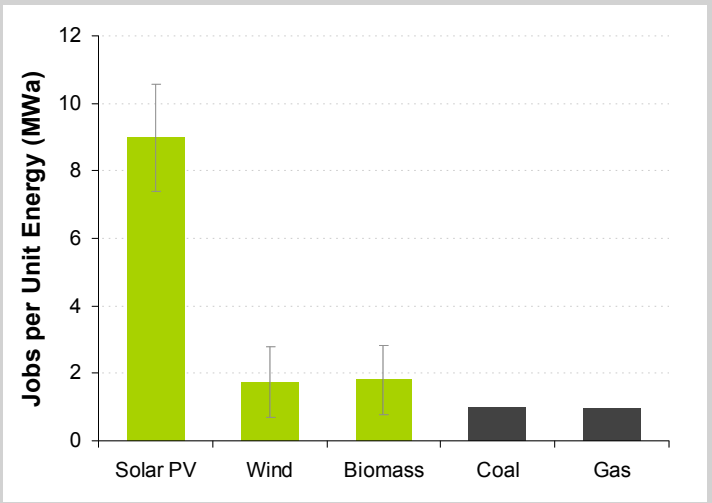


Figure 4: Jobs per Unit of Energy from Renewable and Fossil Technologies, U.S.[42]



Economic Output

Investments in renewable energy, dollar for dollar, produce a greater net benefit for Ohio's economy than traditional technologies.

In addition to creating jobs and increasing wages paid in Ohio, expanded wind energy development would increase the state's overall economic output. Expanding Ohio's wind energy use to 20 percent of retail sales by 2020 would increase gross state product (GSP) by an estimated net cumulative total of $8.2 billion through 2020. Figure 5 shows the cumulative impact on GSP over time, in constant 2006 dollars.

GSP is the traditional measure of basic state economic activity. It is a measure of the goods and services produced within the state in a given year, minus imports. Renewable energy policies improve GSP because they increase the amount of money kept within the local economy. For example, every dollar invested in Ohio's electric utility sector and construction sector creates $0.775 and $0.658 worth of economic output, respectively. Alternatively, every dollar invested in coal mining and oil and gas extraction creates $0.637 and $0.549 worth of output, respectively.[43]

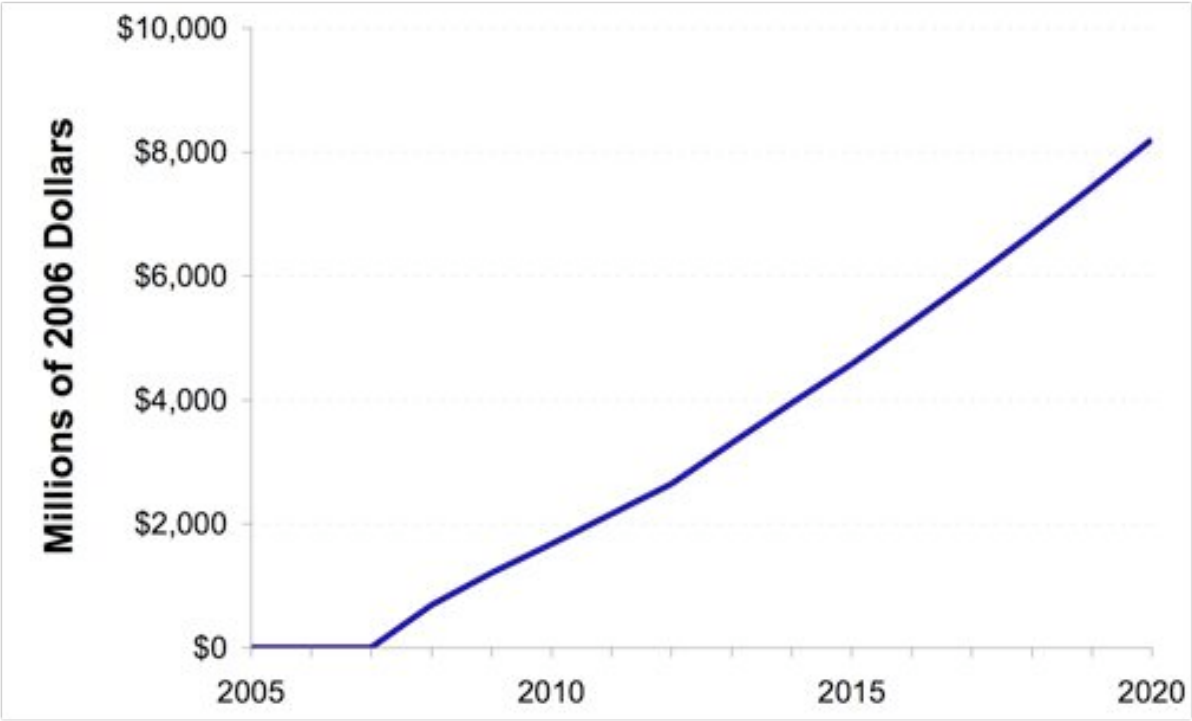
Benefits for Rural Ohio

Renewable energy can stimulate economies in rural Ohio. Benefits of wind energy development include jobs, royalties paid to landowners who lease land for wind farms, and property tax revenue for local governments.

Local Jobs

Wind farm installation can create jobs in rural parts of the state where local economies often depend on farming or resource extraction. Local jobs include construction and facility installation, operation and maintenance of the facility after it is constructed, and jobs induced by the additional money the workers spend in the local economy. For example, in 2006 Governor Blagojevich of Illinois announced the construction of a 400 MW

Figure 5: Cumulative Net Increase in Ohio Gross State Product due to Wind Energy Scenario (vs. Business-as-Usual)



wind farm near Bloomington, which is expected to create 250 year-long construction jobs and 40 permanent positions.[44]

Landowner Royalties

Rural landowners who lease their property for a wind facility can create an additional source of income. Unlike the income from a typical harvest, payments from wind energy are steady and year-round. The Union of Concerned Scientists estimates a typical farmer or rancher with good wind resources could increase the economic yield of their land by 30-100 percent.[45] For example, the wind farm under construction in Illinois' McLean County will generate an estimated $1.2 million in lease payments to area farmers per year.[46]

Lease terms vary, but they typically represent 2.5 percent of gross revenue from electricity sales.[47] Assuming a contract price for electricity generated from wind power of 3.5 ¢/kWh, a single 1.5 MW turbine would bring the landowner $3,285 each year.[48] In the case of land owned by a local government, leasing income could be funneled into local schools and services.

Under the wind energy deployment scenario evaluated in this report, energy produced by wind farms in Ohio through 2020 could supplement landowner income by about $200 million, benefiting farmers, other private landowners, and local and state government.[49]

Local Tax Income

Wind turbines raise the property tax base of a county, creating a new revenue source for education and other local government services. For example, the 400 MW wind farm under construction in McLean County, Illinois will pay an estimated $1.2 million per year in property taxes to the county government.[50] The Foote Creek Rim wind farm in Carbon County, Wyoming provides 30 percent of the county budget.[51]

If Ohio increased its use of wind energy to 20 percent by 2020, it would generate up to $1.5 billion in property taxes for local government coffers through 2020 (estimated).[52] Renewable energy can provide more local tax income,

The Bowling Green Wind Farm - NREL

distributed across more Ohio communities, than traditional fossil-fuel technologies. Coal-fired power plants pay a proportionally smaller share in property taxes than renewable energy, because they require less land.[53] In Michigan, Arizona and Colorado, the National Renewable Energy Lab estimates that wind would provide more than double the tax income as coal-fired plants on an energy equivalent basis.[54]

Opportunities for Local Ownership

Farmers, towns, local governments, schools, and energy cooperatives can also invest in and own a stake in utility-scale wind turbines to optimize local benefits. For example, the Bowling Green wind farm was the product of a collaboration between American Municipal Power-Ohio and Green Mountain Energy, and is now owned and operated by a 10-member collective, including the city of Bowling Green.[55] Similar locally-owned projects have been undertaken by the Illinois Rural Electric Cooperative, Spirit Lake Schools in Iowa, the Rosebud Sioux Tribe in South Dakota, and Lamar Light & Power in Colorado.[56] A variety of models are available for local communities to organize and finance wind projects. For example, see www.windustry.org.

Reduced Pollution

In addition to creating jobs and economic growth, investing in renewable energy would help create a cleaner, healthier future for Ohio. Increasing Ohio's wind energy generation would significantly reduce emissions of carbon dioxide, the leading cause of global warming, as well as speed progress in reducing soot, smog and mercury pollution, which damage public health. Table 4 summarizes the estimated pollution prevention impacts of a 20 percent by 2020 wind power scenario for Ohio. (We calculate the amount of pollution prevention based on the amount of displaced conventional generation and a per kWh baseline emission forecast, described in the Methodology section on page 27.)

Reduced Global Warming Pollution

Global warming poses a serious challenge to Ohio's future. Scientists have concluded that pollution caused by human activity is driving a warming trend now apparent across the globe.

Average temperatures worldwide have risen by about 1.4° F in the past century and now are increasing at a rate of about 0.36° F per decade.[57] The 10 warmest years of the global record have all occurred since 1990, and 2006 was the warmest year to date in the lower 48 states.[58]

According to the consensus view of the scientific community, this warming is primarily due to human activity, especially the burning of fossil fuels such as coal and petroleum. When burned, these fuels release carbon dioxide gas into the atmosphere, where it wraps around the earth like a blanket, trapping heat from the earth's surface that normally would escape back to space. Carbon dioxide levels in the atmosphere are now increasing faster than at any time in more than 10,000 years, and are higher now than at any point in more than 650,000 years.[59]

Scientists predict that summer temperatures in Ohio could be 6° to 14° F warmer than today by the year 2100.[60] A temperature rise on this scale would roughly double the amount of warming that has occurred since the last ice age.

Warming on such a scale would have serious consequences for Ohio. For example, a recent update to a Lake Erie management plan predicts global warming will lead to a steep drop in water levels over the next 64 years, a change that could cause the lake's surface area to shrink by up to 15 percent.[61] Reduced water levels in the lake would impose large costs on any part of Ohio's economy connected to shipping on the lake. Lower water levels, at minimum, will require more dredging – and possibly the physical relocation of Cleveland's port infrastructure.

On average, each megawatt-hour of electricity generated in Ohio produces about 1,830 pounds of carbon dioxide.[62] Under business-as-usual conditions, the U.S. Department of Energy forecasts that global warming emissions from Ohio's electricity sector will increase by about 8 percent from 2006 to 2020.[63]

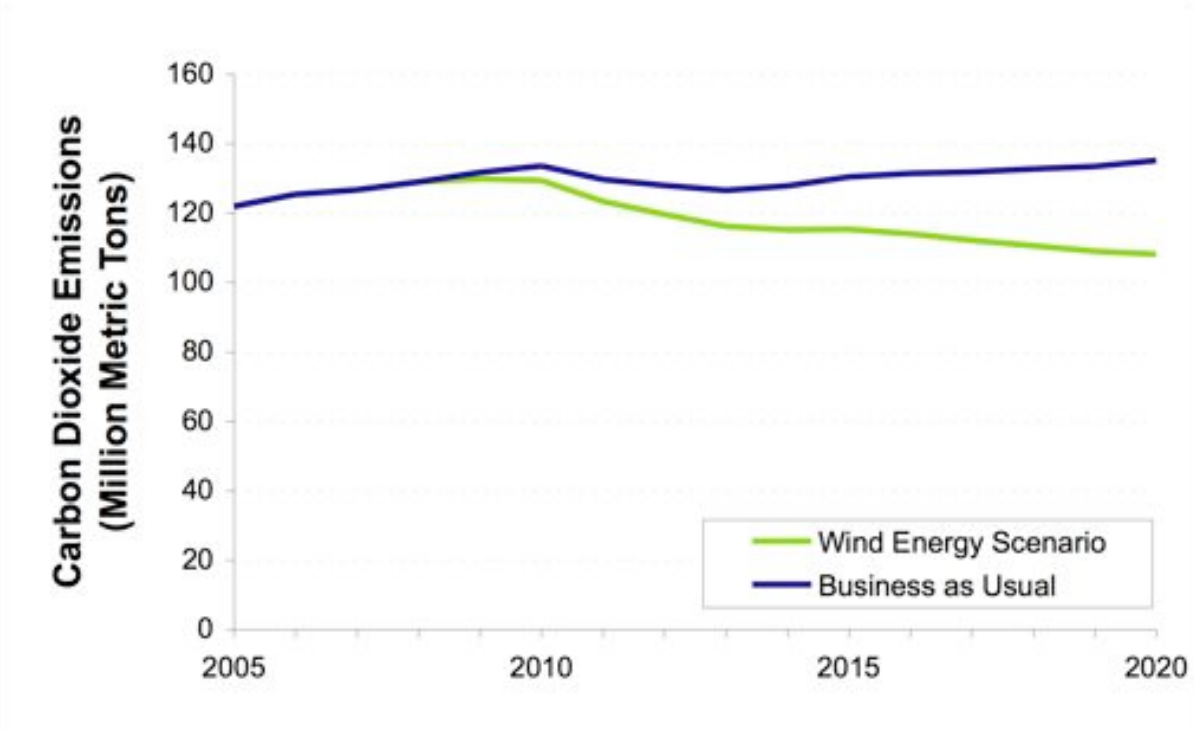
In contrast, diversifying Ohio's electricity supplies with wind power as modeled here would reduce carbon dioxide emissions from electricity generation in Ohio by about 20 percent below projected levels in 2020 – preventing about 27 million metric tons of carbon dioxide emissions in that year. (See Figure 6.) Cumulatively, this wind power scenario would prevent 170 million metric tons of carbon dioxide emissions through 2020, equivalent to retiring more than 2 million cars from the road.

Emission cuts on this scale would put Ohio well on the road to doing its fair share to mitigate the worst effects of global warming – which will require cuts in U.S. carbon dioxide emissions on the order of 80 percent by 2050.[64]

Table 4: Cumulative Pollution Prevention Impact of Wind Energy Scenario (vs. Business as Usual)

Measure	Wind Energy Scenario
Avoided Global Warming Pollution (CO_2)	170 million metric tons
Avoided Smog-Forming NO_x Emissions	120,000 tons
Avoided Soot-Forming SO_2 Emissions	470,000 tons
Avoided Mercury Pollution	4,000 pounds

Figure 6: Global Warming Pollution from Electricity Generation in Ohio



Reduced Soot and Smog

Coal and natural gas-fired power plants emit air pollution. For every megawatt-hour of electricity generated, the average Ohio power plant emits 15.6 pounds of soot-forming sulfur dioxide (ranking worst in the nation) and 3.8 pounds of smog-forming nitrogen oxides.[65] Partially because of this pollution, more than 30 counties across Ohio do not meet health-based air quality standards for smog, and more than 25 counties do not meet standards for soot.[66] Counties in non-attainment surround Columbus, Dayton, Cincinnati, Akron and Cleveland.

Sulfur dioxide emissions from coal-fired power plants form fine soot particles in the atmosphere. When inhaled, these particles become lodged deep in the lungs where they cause a variety of health problems, including asthma, bronchitis, lung cancer and heart attacks.[67] Soot pollution from power plants is responsible for significant harm to public health in Ohio. According to a study by Abt Associates, a frequent consultant to the U.S. EPA, airborne soot in Ohio cuts short the lives of nearly 2,000 people every year, and causes nearly 40,000 asthma attacks and more than 200,000 missed work days due to respiratory illness annually.[68]

Fossil-fueled power plants also emit nitrogen dioxide, one of the primary ingredients in smog. Smog makes lung tissues more sensitive to allergens and less able to ward off infections.[69] It scars airway tissues.[70] Children exposed to smog develop lungs with less flexibility and capacity than normal. During high smog days, otherwise healthy people who exercise cannot breathe normally.[71] Over time, smog exposure can lead to asthma, bronchitis, emphysema and other respiratory problems.[72]

Health problems imposed by soot and smog have serious economic consequences for Ohio. Beyond the loss of priceless years of healthy life, an unhealthy workforce is less productive.

Soot and smog pollution from power plants are projected to decrease in the coming years because of implementation of the Clean Air Act. Increasing Ohio's use of wind power could reduce soot and smog emissions even further:

- By 2020, the wind energy scenario would reduce smog-forming nitrogen dioxide emissions by nearly 17,000 tons per year versus projected levels, a decrease of 20 percent.
- It would also avoid more than 68,000 tons of soot-forming sulfur dioxide emissions, a reduction of 20 percent versus projected levels.
- Cumulatively, the wind energy scenario would prevent 120,000 pounds of nitrogen dioxide emissions and 470,000 pounds of sulfur dioxide emissions through 2020.

Reduced Mercury Deposition

Mercury emissions from coal-fired power plants and other industrial sources are making the fish in our lakes, rivers and streams unsafe to eat. Burning coal releases mercury into the air that eventually contaminates rivers and lakes, where bacteria convert it to a highly toxic form that bioaccumulates in fish.

In early 2007, two new studies of mercury deposition in the Northeast confirmed that U.S. coal-fired power plants are the chief cause of mercury contamination "hot spots."[73] The studies show that "mercury deposition is five times higher than previously estimated by EPA" in the area surrounding a coal plant in southern New Hampshire.[74] Dr. Thomas Holsen of Clarkson University and one of the study authors remarked that "... a significant fraction of the mercury emitted from coal-fired power plants in the U.S. is deposited in the area surrounding the plants." Dr. Charles Driscoll, another study author, noted that "biological mercury hotspots occur and ... mercury emissions from sources in the U.S., as opposed to China and other countries overseas, are the leading cause." This new research suggests that coal-fired power plants in Ohio (as opposed to those from out of state) may have a greater role in mercury deposition in the state's waterways than previously suspected.


Andy Olsen - iStockphoto

Mercury is a neurotoxin that is particularly damaging to the developing brain. In early 2004, EPA scientists estimated that one in six women of childbearing age in the U.S. has levels of mercury in her blood that are sufficiently high to put her potential children at risk of learning disabilities, developmental delays and problems with fine motor coordination, among other problems.[75]

In 2004, Ohio's coal-fired power plants emitted nearly 7,500 pounds of mercury.[76] This pollution has led to elevated levels of mercury in the fish in Ohio's waters.

The U.S. EPA tested fish across the country for mercury content in 1999. Every fish caught in Ohio contained mercury, with more than half exceeding the EPA "safe limit" for women of childbearing age.[77] Because of the danger of mercury exposure, the Ohio Environmental Protection Agency has issued a fish consumption advisory for all water bodies in Ohio. The agency warns that children under 15 and women of childbearing age should not eat more than one meal per week of any fish caught anywhere in the state. Hundreds of lakes and rivers have stronger advisories for specific species of fish – including bass, bullhead and catfish – that should be eaten no more than once or twice every two months, or not at all.[78]

Tapping Ohio's wind resources to reach 20 percent of sales by 2020 would prevent about 525 pounds of mercury emissions in 2020. The cumulative mercury pollution prevention through 2020 would be on the order of 4,000 pounds.

Preparing Ohio for a Future Cap on Global Warming Pollution

Although not directly quantified in this report, wind power has the added benefit of protecting Ohio's economy from the impact of action to limit America's contribution to global warming. Because wind power can generate electricity without carbon dioxide emissions (the leading cause of global warming), it is not vulnerable to price increases under a carbon-constrained economy.

There is growing consensus, even within the United States, that concerted action must soon be taken to curb global warming emissions. For example:

- In 2005, seven northeastern U.S. states reached an agreement on the Regional Greenhouse Gas Initiative (RGGI), a program designed to reduce carbon dioxide pollution from power plants.[79] Subsequently, Maryland adopted a law that joins Maryland to the RGGI pact.[80] In 2007, Massachusetts and Rhode Island joined the program.[81]
- Governor Arnold Schwarzenegger of California (the state with the second-highest emissions of carbon dioxide) issued an executive order in 2005 setting a global warming pollution reduction target of 80 percent below current levels by 2050.[82] In September 2006, the state enacted a legally binding cap on emissions from the state's largest emitters.[83]
- In June 2005, the U.S. Conference of Mayors voted unanimously in favor of the Climate Protection Agreement, which matches the Kyoto Protocol's goal of reducing global warming pollution by 7 percent below 1990 levels by 2020.[84] The Conference represents 1,183 cities from all 50 states, including Columbus, Cleveland, Cincinnati, Toledo, Akron, Dayton, and more.
- Legislation is pending in the 2007 United States Congress that would significantly limit global warming pollution from power plants and other sources across the United States. The pending bills require pollution reductions as deep as 80 percent below 1990 levels by mid-century.[85]

With international pressure to act continuing to increase, it is only a matter of time before a U.S. carbon cap becomes reality.

A Carbon Cap will Make Power from Fossil Fuels More Expensive

A carbon cap will tend to make power generated from carbon-intensive fossil fuels (like coal) more expensive. Some electricity resource planners argue that future costs associated with global warming regulations are too uncertain, and thus leave estimates out of planning decisions altogether. However, this omission effectively assigns future carbon emissions a cost of zero – which is a risky assumption.

According to a 2006 analysis by Synapse Energy Economics, one ton of carbon dioxide pollution will likely cost between $10 and $40 in 2010; and between $20 and $50 in 2030.[86] At these prices, given Ohio's electricity-related carbon dioxide emissions of 145 million tons in 2005, the state's carbon exposure is greater than $1 billion dollars per year.[87] Moreover, Synapse bases its calculations on relatively modest policy proposals – not on the more stringent emission cuts that will be necessary to avoid the most dangerous consequences of global warming.

Carbon capture and storage technology is one way that Ohio could theoretically use fossil fuels while minimizing its impact on global warming. However, the technology is likely to be expensive. The Electric Power Research Institute (EPRI) estimates that energy from a conventional coal-fired power plant would cost 77 percent more with carbon capture and storage.[88] Even energy from an IGCC coal plant, the type of plant best suited for carbon capture, would cost over a third more with carbon storage.[89]

Moreover, carbon storage – on the scale at which it must be implemented to fight global warming – is an immature technology that will require many years of additional development before it becomes commercially viable.[90] As of 2006, there were only 21 demonstration projects in the world, and none

were large enough to store the lifetime emissions of even one power plant.[91]

Wind Power Offers Fixed Costs, Shielding Ohio

Wind power, because it produces energy without emitting carbon dioxide (the leading global warming pollutant), will not be subject to cost increases under a carbon cap. By diversifying its electricity fuel sources to include more wind, Ohio can shield itself from the cost impacts of a carbon cap.

The cost of wind power is almost entirely determined by the cost of manufacturing and installing the wind turbine technology. The wind that turns the turbine is owned by everyone and can be obtained for free. As a result, wind power can guarantee a fixed price for electricity over a period of 20 years or more.

The price certainty offered by wind power has value. For example, in comparison with natural gas (with highly volatile prices in the last 7 years), wind power has an extra value on the order of 0.5 cents per kWh, because utilities can know the future price of wind power with certainty.[92]

The same principle applies when considering the price impact of a future carbon cap. While power from fossil fuels will become more expensive, wind power is guaranteed to remain unaffected. One estimate of future energy costs of different technologies under different costs of carbon emissions places wind as the cheapest energy resource in 2010 with a cost of carbon larger than about $7 per ton, and as the cheapest of any resource under any cost of carbon by 2015.[93]

In other words, by choosing to develop wind energy resources to diversify its electricity supply, Ohio can make it easier and less expensive to meet the requirements of a carbon cap, protecting its citizens and its economy.

A Carbon Cap and Ohio Electricity Consumers

While a cap on emissions of carbon dioxide would likely increase the cost of electricity in Ohio (which is heavily dependent on coal for fuel) its design can include measures to protect Ohio electricity consumers. If allowances to emit pollution are sold at auction, the revenues could be used to reduce the cost of the program through investments in energy efficiency, or even to return some of the money directly to consumers. For further exploration of important considerations in the design of a carbon cap, see: U.S. PIRG Education Fund, *Cheaper, Cleaner, Smarter: The Case for Auctioning Allowances in a Global Warming Cap-and-Trade Program*, forthcoming.

Wind Power Can Supply up to One-Fifth of Ohio's Electricity

Wind energy could provide electricity for millions of Ohioans.

Western and northern Ohio have the strongest wind energy resources, especially areas northeast of Springfield, west of Mansfield and southwest of Sandusky. Central Ohio features two glacial ridges that would make ideal locations for wind turbines. One of the glacial ridges stretches north of I-70 from Champaign County north through Logan and Hardin counties. The other glacial ridge stretches north of Columbus through Richland and Morrow Counties.

In 2007, the National Renewable Energy Laboratory (NREL) published an updated estimate of Ohio's wind energy potential, along with a detailed map of Ohio's wind resource. (See Figure 7.) The estimate looks at wind resources at 100 meters (m) above the ground, a height commonly utilized by modern wind power technology.

At 100m height, Ohio has 13,000 square kilometers of land with wind speeds high enough to support commercial-scale wind farms.[94] Excluding urban areas, environmentally sensitive lands, water bodies, and Lake Erie, NREL estimates that this area could support a total of 66,000 MW of wind power capacity.[95]

If Ohio were to take advantage of only 20 percent of this area, wind energy could provide 20 percent of Ohio's electricity needs in 2020 (or about 37,000 GWh per year).[96] The wind turbines would cover only 0.03 percent of Ohio's total land area, allowing farmers to grow crops right up to the turbine base.[97]

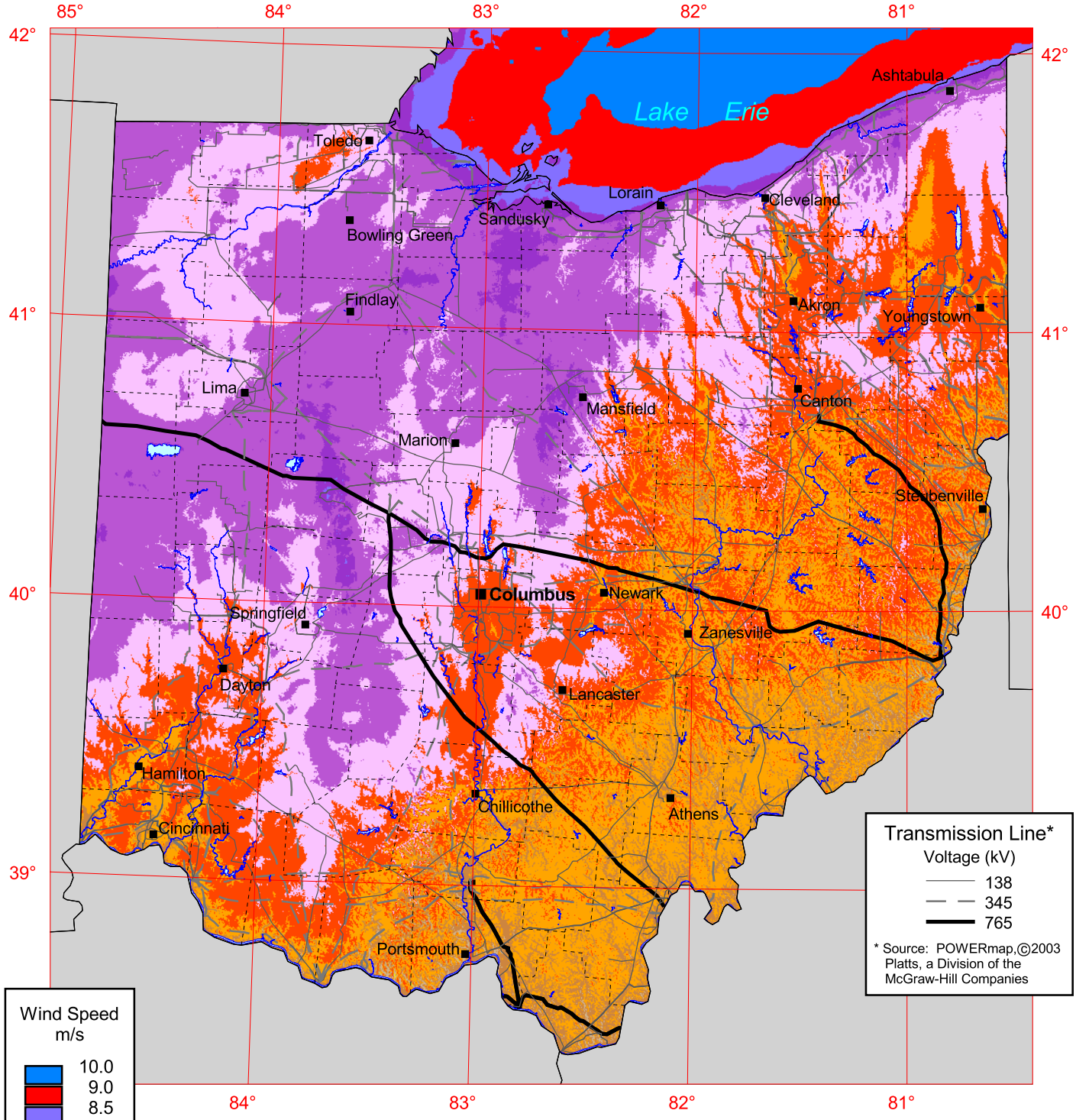
Moreover, Ohio's best wind resources are located offshore, in Lake Erie, where wind speeds are higher and more consistent. Developing a fraction of this resource would significantly increase Ohio's potential for producing wind energy. Initial studies show that up to 40 percent of Ohio's waters are "conditionally viable" for wind energy development.[98] One estimate places the average continuous wind energy potential of Lake Erie, including only sites less than 20 meters in depth, at 44 GW.[99]

While offshore wind energy technology is less mature than on-shore technology, it is growing in importance as a source of electricity worldwide. Several sites on the Atlantic and Gulf coasts and in the Great Lakes are vying to become the first operational offshore wind facility in North America. For example, a Canadian company based in Ontario has proposed a 710 MW wind energy project far offshore in Lake Huron.[100] If the project is approved, it could be operational during the year 2008. It would be one of the largest offshore wind energy projects in the world, and one of the largest wind farms in North America.

Capturing Ohio's wind power does not mean that consumers will have to pay more for electricity. In particularly windy areas of the country, wind power is already the cheapest new electricity resource available.[101] For example, a recently constructed wind farm in Lamar, Colorado is producing electricity for less than 3.3 cents per kWh (with the benefit of the federal production tax credit).[102] The contract price for electricity from Texas wind farms is even less – sometimes less than half the cost of power from a natural gas-fired plant.[103]

In May 2007, the Cleveland Foundation released a study of the impact of increasing renewable energy generation in Ohio on retail electricity rates. Increased use of renewables would have no impact on rates in the near term. By 2020, prices

Ohio - Annual Average Wind Speed Estimates at 100-m Height



Total wind energy potential from windy lands (7.2 m/s and greater) = 66,000 MW (land-based development only).

Sensitive environmental lands, urban areas, airports, and water bodies (such as Lake Erie) are excluded.

50 0 50 100 Kilometers

25 0 25 50 75 Miles

NREL

U.S. Department of Energy
National Renewable Energy Laboratory

18-APR-2007 4.1.2

would rise only 0.2 cents per kilowatt-hour (just over 2 percent more than current residential rates). The study also found that if Congress acts to limit global warming pollution, this relatively small increase would disappear.[104]

Even though wind speeds vary, wind power can make a valuable contribution to the overall electricity grid. Nations such as Denmark have shown that it is possible to obtain as much as 20 percent of their electricity supplies from wind (and even more at certain times and places). And a recent study undertaken in Minnesota found that utilities can obtain up to one-quarter of their electricity from wind without harming grid reliability, and with only minor costs for absorbing the intermittent power.[105]

Additional Sources of Renewable Energy in Ohio

Ohio could also generate renewable energy using biomass or solar energy technologies.

Biomass

Nationwide, energy crops could ultimately provide up to 14 percent of U.S. electricity (or 13 percent of motor fuel), while at the same time bolstering the health of rural economies.[106] Ohio ranks 7th in the country in the availability of biomass stocks available at less than $40 per dry ton, according to a survey of biomass resources across the country by the U.S. Department of Energy's Oak Ridge National Laboratory.[107] The study estimates that Ohio could divert close to three-quarters of a million dry tons of safely combustible biomass (including yard waste, pallets and other wood materials) from landfills every year, at a cost of $20 per dry ton or less. Ohio also has the capacity to supply more than 10 million dry tons of agricultural wastes and dedicated energy crops like switchgrass per year at a delivered cost of $40 per dry ton or less.[108]

If Ohio were to use all of this biomass for clean electricity production, it would generate 14,000 GWh/yr, about 9 percent of current electricity consumption in the state. [109] (Biomass that produces toxic emissions should not be considered renewable.)

Switchgrass is a potential biofuel that will grow in Ohio's climate.

Solar

The sun's energy can directly provide electricity for home or business use through the use of solar photovoltaic (PV) panels. Solar PV is a particularly valuable contributor to the overall electric grid since it provides power at times when demand is highest (when the sun is shining and air conditioning use is high) and when electricity is the most expensive to produce.

For most Americans, however, PV systems remain relatively expensive compared to buying electricity from the grid. While PV installations have increased at a steady clip in recent years, at the end of 2005, there was only 479 megawatts of PV capacity installed in the United States.[110]

The good news, however, is that the cost of PV systems has declined at an average rate of about 4 percent per year over the last 15 years.[111] And the cost is likely to keep going down as the industry gets larger and achieves economies of scale. Recognizing this, countries like Germany and states like California have recently made strong commitments to solar power, helping to subsidize the cost of PV systems now in anticipation that PV will become cost-competitive in the near future. California alone has targeted 3 gigawatts (GW) of solar PV capacity over the next decade as part of its "million solar roofs" program.[112]

Ohio has significant solar energy potential. A solar PV system in Ohio would produce approximately 80 percent of the energy of the same system located in Florida.[113] If solar panels (with an average area of 300 square feet per system) were installed on 1 million Ohio rooftops, they could produce 5,000 GWh per year, or almost 3 percent of Ohio's forecast electricity needs in 2020.[114]

In addition to providing electricity, solar energy can also provide heat and light – the most cost-effective way to tap into the sun. Solar technologies can be as simple as designing a building to achieve maximum exposure to sunlight during the winter or using a fiber-optic cable to pipe concentrated daylight into a building. In addition, roof-mounted solar collectors allow solar energy to be captured and used to heat household water (or for commercial and industrial use). Typically, solar hot water systems pre-heat tap water before adding it to a standard hot water heater. As a result, the systems can reduce electricity or fossil fuel use for water heating by about two-thirds.[115]

Solar Panels at Oberlin College NREL

Policy Recommendations

Investing in renewable energy would give a boost to Ohio's economy, create tens of thousands of jobs and increase wages, all while reducing pollution. Ohio's leaders should ensure that renewables play a prominent role in the state's energy future. Specifically, the state should:

Enact a Renewable Electricity Standard

Ohio should aim to generate a large and growing percentage of our electricity from wind energy and other clean and renewable energy resources. To achieve this goal, Ohio should:

- **Adopt a renewable electricity standard of 20 percent by 2020.** Renewable electricity standards (RES, also referred to as renewable portfolio standards) require that a certain percentage of the electricity supplied to consumers come from renewable resources. Renewable electricity standards help to increase the confidence of investors and renewable energy developers, promoting investment under stable market conditions that will support long-term demand for renewables. The 25 states (plus the District of Columbia) that currently have an RES generate the bulk of the wind energy in the U.S. – and have attracted a number of new wind turbine factories, each employing hundreds of workers. By adopting an RES, Ohio can encourage greater investment in home-grown resources.

  The first key to designing a RES is to set the right target. Increasing renewable power generation by at least 1 percent per year is a realistic goal that many states are already reaching. For example, in July 2007, the Illinois General Assembly adopted an RES that will increase renewable electricity generation to 25 percent of Illinois' electricity consumption by 2025 (while also creating a substantial and complementary energy efficiency program).[116] Experience in other states shows that the longer the time frame and the more visionary the goal, the greater the long-term investment and economic development. Given Ohio's considerable renewable energy resources, reaching a target of 20 percent renewable electricity by 2020 is an achievable goal.

  The second key to designing an RES is defining "renewable." Renewable sources of energy are essentially inexhaustible and have positive benefits for Ohio's environment. Eligible forms of energy should include wind, solar, geothermal, biomass, and hydropower projects certified by the Low Impact Hydropower Institute. Ohio should not allow fossil fuels, municipal solid waste, or other energy sources with toxic emissions or global warming emissions to receive credit as "renewable" sources of electricity. (See page 30 for a definition of clean biomass.)

  The third key to a successful RES is an enforcement provision that ensures compliance. For example, a utility failing to meet the standard in a given year should pay a fee that is significantly higher than the cost of replacement power for every MWh below the standard in a given year. Any penalty fees collected should be put into a renewable electricity fund to promote the development of renewable electricity resources in Ohio.

Reduce Ohio's Global Warming Pollution

- Ohio should prioritize the use of the cheapest carbon-free sources of electricity first, including energy efficiency and

renewable energy, before considering proposals that would increase the state's contribution to global warming. Ohio has vast reserves of energy efficiency and renewable energy potential that can meet the state's additional electricity needs (and more) for decades to come. Tapping into these resources will create demand for clean energy technologies that can fuel the development of a robust clean energy manufacturing industry in the state.

- Given the urgency of addressing global warming, Ohio should not allow any new coal facility to be built unless it includes carbon capture and storage, with conditions that storage be verifiable and permanent. Moreover, Ohio should not permit any new coal or nuclear plants unless proponents can prove that they are the least-cost electricity solution, given likely constraints on global warming emissions.

Methodology

Environment Ohio Research & Policy Center developed an Ohio-specific energy and economic model to project the economic and pollution reduction impacts of deploying wind energy technologies. The model employs input-output economic principles and is based on statistics that describe the production and exchange of goods and services within the various sectors of the Ohio economy, as provided by the Minnesota IMPLAN Group, Inc. (MIG), with all dollar results reported as the equivalent of 2006 values.[117] The results are generally consistent with a large number of state-level studies that have been carried out previously.[118] This approach allows a meaningful comparison of baseline projections of energy consumption and prices with changes driven by clean energy policies.[119]

Establishing the Default Path

We first established a baseline forecast for energy development in Ohio from 2007 to 2020. This default path served as the point of comparison with the alternate wind energy scenario.

We used projections for future energy demand developed by the Ohio Public Utilities Commission, which predict that electricity demand will increase by an average of 1 percent per year through 2020.[120]

Forecasts for future electricity prices come from the Ohio Public Utilities Commission.[121] Forecasts for natural gas consumption, coal consumption, power plant heat rates and power plant environmental performance were established using the most recent statistics from the U.S. Energy Information Administration (EIA) for Ohio's electricity sector, projected to 2020 using the trajectory set in the regional tables of EIA's *Annual Energy Outlook 2007*.[122] For example, EIA forecasts a 0.5 percent annual growth rate for coal consumption in the East Central Area Reliability region, which, when applied to Ohio, yields a forecast for the quantity of coal the state will consume in the future.

Describing the Trajectory of Wind Energy Deployment

The wind energy scenario consists of increased use of wind energy, driven by a renewable electricity standard. We assumed generation from wind power would grow evenly, beginning in 2009 and thereafter increasing its share of Ohio's total electricity consumption to reach 20 percent of Ohio's total retail electricity sales on an annual basis by 2020.

Modeling Environmental Impact

We calculate the amount of pollution reduction based on the amount of displaced conventional generation and the per kWh baseline emission forecast per EIA's *Annual Energy Outlook 2007*, described above. We translate avoided global warming pollution into cars removed equivalent assuming carbon dioxide emissions for an average passenger car of 11,470 pounds per year, per U.S EPA.

Modeling Economic Impact

Renewable energy deployment would require a change in technology investments, energy prices, energy expenditures, and government programs. We estimated these expenditures for wind energy deployment based on estimated capital, operations, maintenance and fuel costs for wind energy vs. a business-as-usual course of building new coal-fired power plants. We then mapped the change in expenditures and prices into the IMPLAN-derived state energy and economic model to estimate macroeconomic impacts as compared to the business-as-usual scenario. Throughout the report, all dollar figures are reported as undiscounted 2006 dollars. For a more complete description of how the model was created, see the short working paper, "Modeling

State Energy Policy Scenarios," available from Environment Ohio Research & Policy Center.[123]

KEY ASSUMPTIONS

Key assumptions used in the economic modeling are as follows:

Generation Costs:

Generation costs for renewable energy under the wind energy scenario and for coal-fired power plants under the default case are outlined in Table 7. We estimated the costs of wind energy based on 2006 data for wind projects.[124] We also assume that capital costs and operation, maintenance and fuel costs of each technology will decline as the technologies mature.[125] We assume that wind projects in Ohio installed between now and 2020 will achieve an average capacity factor of 34 percent, consistent with 100 meter hub heights and wind resources of class 4 or greater. These costs do not include the production tax credit for renewable energy.

Local Impacts:

To take into account the fact that all economic activity for wind power development is not necessarily tied to Ohio, we assume that 80 percent of all expenses for renewable technology, including manufacturing, construction, financing, and ongoing operation and maintenance, will be local. We also assume that 80 percent of relevant investment will happen in Ohio and 80 percent of energy bill savings or losses affect spending within the Ohio economy. These assumptions apply equally to the wind power scenario and to the business-as-usual case.

Price Dynamics

We assumed that renewable energy would have the effect of reducing upward pressure on the price of natural gas and coal, which are set by a regional and national market. Based on estimates of how much natural gas and electricity would be saved compared to the base case forecast, we predicted change in national demand. In turn, the change in national demand was translated into an estimate of the effect on electricity and natural gas prices in Ohio.

Natural gas prices were calculated using the following coefficients:[126]

	Intercept	Year	Quantity	Deflator
Natural Gas	0.0052	-0.1485	2.0817	1.0101

And the following equation:

[Intercept] * (Number of years since 2003)^[Year] * [National Demand]^[Quantity] / [Deflator]

To the extent that other states adopt energy efficiency programs and renewable energy standards and reduce their fuel demand, it will have positive impacts on Ohio's economy. The effect of policies established in other states or at the federal level are not modeled in this report.

Table 7: Generation Costs

Generation Costs (in 2001 dollars)	Wind Energy[127]	New Coal Plants[128]
Investment ($/kW)	$1,300	$1,350
O&M ($/kWh)	$0.008	$0.007
Fuel Cost ($/kWh)	$0.000	$0.017
Capacity Factor	0.34	0.8
Heat Rate (BTU/kWh)	n/a	9500
Learning Rate per year	0.98	0.99
Initial Cost ($/kWh)	$0.072	$0.052
Air Emissions Rate	0%	100%

Appendices

A Note on Electricity Units

Megawatts (MW) are the standard measure of a power plant's generating capacity, or the amount of power it could produce if operating at full speed. Utilities measure their ability to supply demand on the grid at any one time in terms of MW. One MW equals 1,000 kilowatts (kW). One thousand MW equal one gigawatt (GW).

Power plant output and electricity consumption over a fixed length of time are measured in terms of megawatt-hours (MWh). For example, a 50 MW power plant operating at full capacity for one hour produces 50 MWh of electricity. If that plant operates for a year at full capacity, it generates 438,000 MWh of electricity (50 MW capacity x 8,760 hours/year). To give a sense of scale, an average household uses about 10 MWh of electricity each year.

Most plants do not operate at full capacity all the time; they may be shut down for maintenance or they may be operated at only part of their maximum generating potential because their power is not needed or their power source (such as wind) is not available. The actual amount of power that a plant generates compared to its full potential is reported as its capacity factor. Thus a 50 MW plant with a 33 percent capacity factor would produce 144,540 MWh of electricity in a year (50 MW x 8,760 hours/year x 33% capacity factor).

Key Economic Multipliers for Ohio

Table A1: Type 1 Multipliers for the Ohio Economy[129]

SECTOR	Type I Multiplier Employment (Per $MM of Final Demand)	Type I Multiplier Compensation (Per Dollar of Final Demand)	Type I Multiplier Value-Added (Per Dollar of Final Demand)	Labor Productivity Growth (Percent/Year)
Agriculture	26.2	0.193	0.556	1.54%
Oil and Gas Extraction	9.0	0.222	0.549	2.66%
Coal mining	6.5	0.297	0.637	2.66%
Other Mining	8.8	0.387	0.726	2.66%
Electric Utilities	5.5	0.284	0.775	2.80%
Natural gas distribution	5.3	0.227	0.454	3.40%
Construction	16.3	0.484	0.658	2.00%
Manufacturing	8.3	0.334	0.547	2.30%
Wholesale trade	10.9	0.464	0.841	1.50%
Transportation and Public Utilities	14.7	0.538	0.769	2.80%
Retail Trade	25.1	0.545	0.838	1.50%
Services	16.3	0.435	0.824	0.40%
Finance	10.7	0.400	0.789	1.50%
Government	19.4	0.824	0.969	0.40%

Definition of Clean Biomass

Some technologies categorized as "biomass" are actually toxic and should be avoided, including waste and tire incineration. Environment Ohio Research & Policy Center defines clean biomass as:

1) Any plant-derived organic matter available on a renewable basis;
2) Non-hazardous plant matter waste material that is segregated from other waste materials and is derived from:
    a) an agricultural crop, crop by-product or residue resource;
    b) waste such as landscape or right-of-way tree trimmings or small diameter forest thinnings, but <u>not including:</u>
        i) municipal solid waste,
        ii) recyclable post-consumer waste paper,
        iii) painted, treated, or pressurized wood,
        iv) wood contaminated with plastic or metals, or
        v) tires;
3) Gasified animal waste;
4) Digester gas;
5) Biogases and biofuels derived, converted or processed from plant or animal waste or other organic materials; or
6) Landfill methane.

Any biomass combustion must meet the best available control technologies for emissions. Preference should be given for gasified biomass technologies.

Notes

[1] Mark Niquette, "State's Credit Outlook Slips; Economy Judged to Be Worst Since Depression," *Columbus Dispatch*, 21 February 2007.

[2] Ibid., Mark Niquette; Editorial, "Moody Blues; Bond Rating Service's Gloomy Outlook for Ohio's Economy Is No Bolt from the Blue, but it's a Sobering Portent," *Cleveland Plain Dealer*, 27 February 2007.

[3] Energy Information Administration, U.S. Department of Energy, *Ohio Electricity Profile 2005 Edition*, DOE/EIA-0348, March 2007.

[4] Data for 2005, obtained from Greg Payne, Ohio Department of Development, Office of Energy Efficiency, personal correspondence, 28 March 2007. See Also: Energy Information Administration, U.S. Department of Energy, *Form FERC-423 Database: Monthly Cost and Quality of Fuels for Electric Plants Data - 2005*, downloaded from www.eia.doe.gov, 20 March 2007.

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