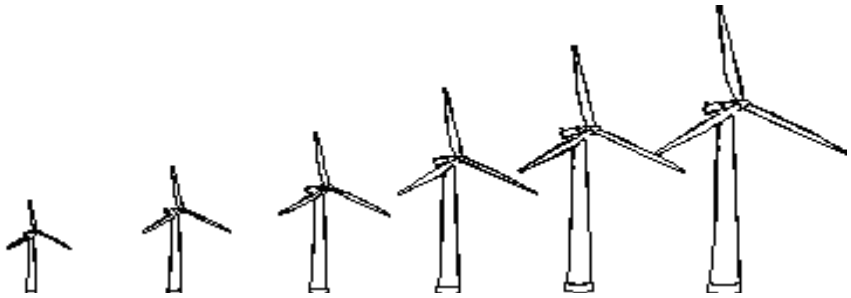
US energy production and consumption increases annually even as the consequences of such trends have become more starkly obvious. US dependence on foreign oil and the global ramifications of a fossil fuel-dependent society have dominated international headlines. Rising gas prices, alarming environmental indicators, and instability in many major oil production areas have inspired governments to pursue alternative energy sources. While rising gas prices most directly impact and worry the transportation sector, the environmental ramifications of our crude oil society transcend all uses and sectors, and indeed all political borders. In the US, the consumption of fossil fuels (primarily coal and natural gas) for electricity generation is responsible for upwards of 37% of all US carbon emissions (EIA 2000). Most of that pollution, to the tune of over 80% comes from the burning of coal, a sobering thought for Pennsylvania, the fourth largest coal producer in the states. As the global scientific community approaches consensus on the role of CO2 emissions in global warming, there is clearly an unprecedented need to tap into green energy sources. Over the last couple decades, wind power in particular has become an economically and socially feasible alternative energy source and wind power production is growing quickly.

Wind is the fastest growing mode of electricity generation in the world, with Europe leading the charge. In the US, wind power increased by 28% between 1999 and 2003 (Black and Veatch 2004). Currently, the US generates just over 6,700 MW of wind power annually, but new projects in planning and construction will nearly double that within five years. Nevertheless, currently wind power represents less than 1% of total US electricity production (AWEA 2005). With fossil fuel based electricity production responsible for the majority of US air pollution, and given that the world will without doubt run out of economically viable fossil fuels, wind power could play an increasingly significant role in the sustainability of the US and Pennsylvania. After a discussion of technological and environmental aspects of wind power, this paper will explore the political climate in Pennsylvania that encourages further wind power development.

Wind is ubiquitous, powerful, and easily accessible. Even before the Industrial Revolution, humanity put the wind to work moving sailboats and turning mills. Obviously, we are ever-improving our ability to convert the constant winds to forms of more useful energy. Today, wind power is harnessed by large turbines that convert the horizontal wind to torque, driving electrical generators. The efficiency of these turbines has improved greatly over the last several years. Table 1 presents developments in turbine technology through 2000 (www.awea.org). Development continues, and 5.0MW



	1981	1985	1990	1996	1999	2000
Rotor (meters)	10	17	27	40	50	71
Rating (KW)	25	100	225	550	750	1,650
Annual MWh	45	220	550	1,480	2,200	5,600

Table 1: Source www.awea.org

turbines are being tested now. The larger the turbines get, the more cost efficiently they can produce electricity. Figure 1 shows GE's 3.6 MW prototype turbine.

The fact that wind is free, inexhaustible, and completely clean makes it a very attractive alternative to fossil fuel derived electricity. With such promising features, why has wind power not been tapped into more zealously across the country? Not surprisingly, it's the money. The relatively higher costs of wind power (to be expected in a new technology) and the *dropping* price of traditional electrical generation simply priced wind power out of the market. That is, until recently. Over the last 20 years, the cost to produce electricity from wind power has dropped by 90% (AWEA 2005). Even without subsidies, technological improvements to industrial-scaled wind turbines have slashed the costs of wind power generation to the point that it is economically competitive with traditional fossil fuel production. Figure 2

Figure 1: GE 3.6 MW turbine.

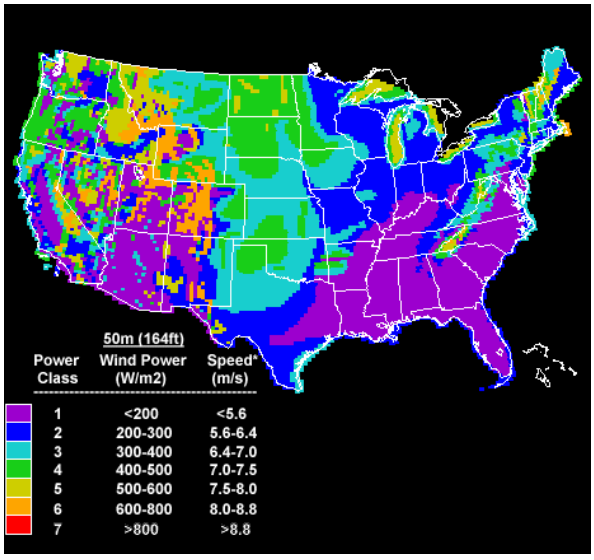
presents the levelized costs (i.e. the costs of capital, fuel, and maintenance costs divided by the estimated output of the system over its lifetime) for the major electricity sources in the US. An important factor to consider is that, since the levelized cost is dependent upon estimated output, the levelized cost is also tied directly to the amount of wind available. The better the wind resources, the cheaper the power. Clearly, the economic hurdle to the spread of wind power has been lowered, but the real argument for wind power is its environmental friendliness.

Figure 2: Data from www.awea.org

Energy Source	Levelized Costs
Coal	4.8 - 5.5
Gas	3.9 - 4.4
Hydro	5.1 - 11.3
Biomass	5.8 - 11.6
Nuclear	11.1 - 14.5
Wind	4.0 - 6.0

In terms of pollution, there is no contest between wind and fossil fuels. Pennsylvania, the fourth largest coal producer in the US, burned coal to produce 56% of its electricity in 2002; another 38% was obtained from nuclear power (EIA 2002). While the nuclear power represents a challenging waste disposal problem, the coal plants spew harmful pollutants in Pennsylvania's air and water. Pennsylvania ranks second in SO_2 emissions amongst the other states, sixth in NO_X emissions, and fifth in CO_2 emissions. Coal is responsible for the lion's share of these emissions: 99% of SO_2, 94% of NO_X, and 95% of CO_2 emissions (EIA 2002). Fossil fuel electricity plants are also the largest source of mercury pollution in the US, emitting 48 tons annually. Nuclear power, though it does not produce air pollution, yields radioactive waste, far from a benign byproduct. As demand for electricity increases, Pennsylvania must either pollute its air and water or develop a large, radioactive rubbish heap (or ship our waste to Arizona, of course), neither of

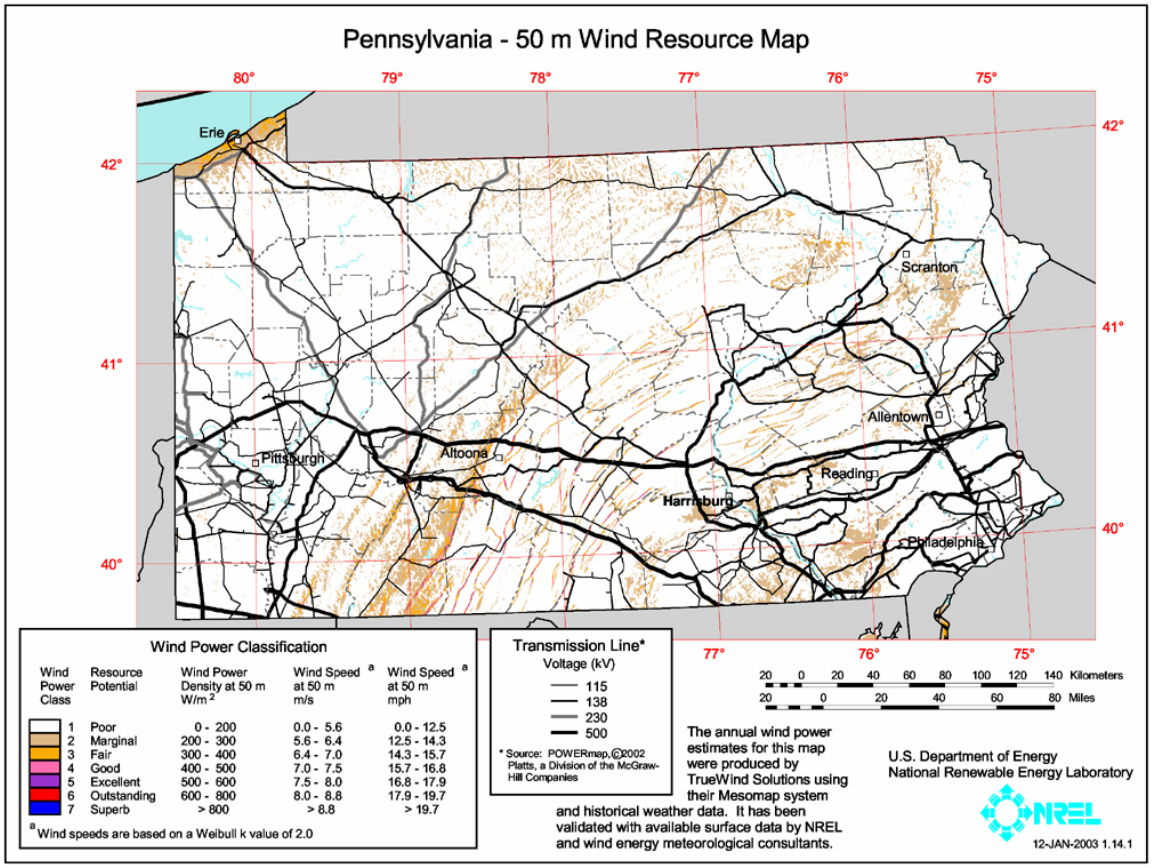
Figure 3: Wind map of the US.



which is environmentally sustainable. Wind power, however, is 100% clean. There are no harmful emissions, no toxic fuels, no potential for spills, and only the raw materials of the turbines to be recycled.

In addition to its economic viability and cleanliness, wind power is also relatively abundant. The Energy Efficiency and Renewable Energy (EERE) program of the Department of Energy has estimated the wind potential for the US and produced maps to provide potential estimates to interested states and individuals. Figure 3 presents wind potentials throughout the US, but this level of detail is insufficient for wind power planning purposes. For this, the EERE has constructed very detailed state wind maps. Pennsylvania's wind map (Figure 4) shows that the state's best wind sources are located on the ridges of the hills running through the central portion of the state. Potential is ranked in power classes from one to seven. Power class four and above is considered good wind potential; power class three is adequate in well-sited locations for modern technology; and power class two might be viable given future technological

Figure 4: Wind map of Pennsylvania (EERE)



developments. A recent study by Black and Veatch analyzed the potential for wind power in Pennsylvania with encouraging results. After eliminating off-limit land (such as national forests, most of state parks, etc.), and factoring land quality and technical capabilities, the report predicts that wind power could reach a capacity of 14,777MW and yield 43,651GWh per year. This represents over 21% of the 204,000GWh generated in Pennsylvania in 2002 (EIA 2002). Compared to electricity *consumption* in Pennsylvania, Black and Veatch report that this wind capacity could satisfy over 30% of current electricity demand in Pennsylvania.

So if wind power is clean, renewable, available, economically viable, and technologically feasible, what else is needed to drive the industry? The two most significant forces are supportive public policy and public demand for renewable energy, both of which require an informed and engaged public. Unlike some environmental issues, however, encouraging wind power development is not a personal choice. In other words, encouraging recycling, for example, requires a personal, direct appeal to citizens to change their own waste disposal behavior. No amount of PSAs, on the other hand, can encourage a citizen to build a wind turbine. Encouraging a burgeoning industry requires a community-level effort to encourage citizens to demand action from their political leaders. In Pennsylvania, several environmental groups have taken up the banner of wind power. The American Wind Energy Association, the Clean Air Council's Pennsylvania Wind Campaign, PennFutures.org, among others all have public education outlets to encourage consumers to demand green energy alternatives. Initially, the results of public education regarding wind power could be indirectly measured in the level of political support for wind power. As we will see, the success of these and other programs led to two major policy victories in Pennsylvania, electric utility deregulation and the passage of an alternative energy bill.

Pennsylvania's recent adoption of the Advanced Energy Portfolio Standard (AEPS) legislation is a prime example of an informed public demanding an active legislature. Cousin to what other states often call a Renewable Portfolio Standard (RPS), the AEPS, which was signed in November of 2004, requires that the energy community of Pennsylvania diversify its energy sources to include certain percentages of advanced energy sources. The bill establishes two "tiers" of "advanced" fuels. Tier 1 includes solar

photovoltaic energy, wind power, low-impact hydropower, geothermal energy, biologically-derived methane gas, fuel cells, biomass energy, and coal mine methane. Electricity produced from these sources must comprise 8% of the state's energy mix by 2020. The Tier II fuels include waste coal, distributed generation systems, demand-side management, large-scale hydropower, municipal solid waste, by-products of the pulping process, and integrated combined coal gasification technology. The Tier II fuels must represent 10% of the energy mix by 2020. On one hand, this is a resounding success for the development of alternative energy, and puts Pennsylvania in a group of 18 states with similar legislation.

Wonderful though it may seem to have such alternative energies mandated, the bill falls short of what many pro-alternative energy groups would like to see. The inclusion of waste coal as an "advanced energy" is particularly galling. Waste coal, as the name implies, is the coal deemed too low in energy content to be incinerated by coal plants. Not only is it less efficient (in terms of energy released per unit mass processed) than standard coal, but it releases much more atmospheric mercury pollution per pound and still leaves a pile of coal ash that must be disposed of. Furthermore, coal-mine methane, though certainly an energy source that could be put to use, is not what most would consider an "advanced" energy source. Despite its weaknesses, at least the bill sets the stage for more aggressive pursuit of alternative energy policies in the future. In combination with Pennsylvania's progressive utilities regulations, or rather its *de*regulations, wind power has a fighting chance against our coal and nuclear heritage.

The other major legislation that supports wind power is The Electricity Customer Choice and Competition Act, signed in 1996 by former Governor Tom Ridge and enacted three years later, opened Pennsylvania's electricity markets to competition. Though the transmission and distribution of electricity remained in the hands of the public utilities, the legislation gave the power generators the ability to price their product competitively. Consumers could decide from whom to purchase their power. The American Wind Energy Association (AWEA) describes the Pennsylvania utilities-customer dynamic established by the bill as "the most advanced customer choice program in the nation" (2004). With legislation in place to encourage the industry, the wind power movement in Pennsylvania now shifts to encouraging the citizenry to purchase wind power from their

electricity providers. Once again, we can indirectly measure the success of the movement in With the freedom to choose and an interested public, wind power has become a fast-growing energy sector in the Keystone State.

Consumer demand and relatively high standard rates in 1999 created a favorable climate for clean, renewable energy in Pennsylvania. In fact, customer demand, primarily from the business sector, fueled the development of the 1999 commercial wind farm at Humbolt Industrial Park in Hazelton, PA (Bird et al, 2003). With standard electricity rates already high, the wind power produced at Humbolt was actually cheaper than some of the standard electricity rates available from competitors. Community Energy was able to sell the entire output of the plant to just 25 Pennsylvania businesses, interested in demonstrating to the public a commitment to greener industry. The Sheraton Rittenhouse Square Hotel purchased 20,000kWh making it, at the time, the state's largest buyer of wind power.

The sudden freedom to choose inspired Pennsylvania's residents to respond as well. The next year, Green Mountain Energy (an eco-conscious energy provider) teamed up with National Wind Power to develop the multi-megawatt Green Mountain Wind Farm in Garret, PA. With Green Mountain's large customer base already in place, developing a new wind power facility was a logical step for the company. This successful relationship spawned other projects, as larger utilities realized there was a significant market for green energy. According to the American Wind Energy Association, there are currently six wind farms online, generating a total of 129 MW of electricity. Several other proposed projects, including one already under construction may add over 200 MW more in production.

As we have seen, wind power is poised to become a major source of clean, renewable electricity in Pennsylvania. The technological, environmental, and political pieces are all in place, and the industry has responded with a flurry of wind projects throughout the state. Most Pennsylvania electricity consumers now have the option of purchasing wind power for a small premium, and in fact over 28,000 homes in PA are powered through wind energy. With such encouraging signs, it is easy to imagine Pennsylvania achieving a sustainable energy mix beyond the AEPS requirements in the future.

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