The Cape Wind Project

We the students of the University of Vermont are quite concerned with the effects of environmental degradation. In our attempt to raise the quality of our lives and those of future Americans we decided as a group to investigate the impact of the Cape Wind power project off the coast of Cape Cod in Horseshoe Bay. We understand that a private, profit-maximizing corporation will be in charge of the construction of this facility. We wanted to discuss the effects that this project may have on the community. We therefore offer this study in which we consider the impact the project will have on the cost energy per kWh, how the ocean front visibility will change for the residents in the area, the effect on fish and wildlife that live on the Cape, and the costs and benefits of wind power when compared to other types of energy production.[1]

1. Introduction

Scientists have predicted that within the 21st Century we will exhaust the world's easily obtainable reserves of oil, with prices beginning to rise substantially in the next decade (Campbell and Laherrère, 1998). In addition, the use of fossil fuels is associated with an extensive list of externalities that play significant roles in our daily lives. For these reasons, there has been increased pressure in both the public and the private sector for an expansion of renewable energy sources.

Wind energy projects have been proposed as an alternative to more traditional oil and coal burning power plants worldwide. Wind energy is a clean and renewable source of electric power and is the world's fastest growing energy source (American Wind Energy Association 2002). Wind power will help achieve independence from foreign oil sources as well as protect environmentally sensitive areas such as Alaska's Arctic National Wildlife Refuge. Wind energy projects have been proposed as an alternative to more traditional oil and coal burning power plants worldwide.

Currently, Cape Wind Associates (a partnership between Energy Management Incorporated and Wind Management LLC) is proposing to build an offshore wind park in Cape Cod, Massachusetts, the first in the U.S. The wind park, scheduled for completion in 2005, would be located five miles off the Cape Cod shore in Horseshoe Shoal and would consist of 170 wind turbines, each approximately 426 feet tall, over an area of 28 square miles (Cape Wind Associates, 2002, Zinner, 2002). Although they are more than 40 stories high, the turbines will only be visible from the shore on the clearest days. At optimum, the project's peak output would

[1]

produce enough electricity to offset up to 113 million gallons of imported oil per year (Cape Wind Associates, 2002).

What makes this project of considerable interest to us is that the main objection raised thus far is that the Cape Wind facility will damage a pristine and ecologically sensitive, and indeed one of the most beautiful areas of the United States. This is not, then, a typical dispute between developers and environmentalists that must be settled in the political arena. We offer our collective expertise because both the proponents and the opposition use, as their *principal line of argument,* environmental preservation. Our conclusion is that from this perspective the developers of the project deserve support and probably a subsidy from the public sector. This conclusion is tentative, however; due to the limitation of data on offshore wind generators in the U.S., the team studied projects similar to the proposed development in other parts of the world such as Denmark, Germany, England and India. Lack of existing data is perhaps the most significant limiting factor of this analysis.

The paper is organized as follows: the following section examines the impact on consumer costs. Section 3 discusses the effects on tourism and aesthetics; section 4 addresses the issue of property values while section 5 deals with the impact wildlife. Section 6 examines the effect of the project on commercial and recreational fishing, and section 7 looks at pollution and global warming. Section 8 presents the results of a cost-benefit analysis, and section 9 addresses the political environment and the proper role of the public sector.

2. Cost Effective Energy in Massachusetts

Wind power dates back to about 900 AD as a way to quickly grind grain and pump water in Persia. Today, wind turbines are becoming a feasible alternative source of energy as technological progress in the last ten years has led to economies of scale. While ground based wind farms already exist in the U.S., Massachusetts will the first state in the nation to benefit from an offshore facility.

Coal: $0.019/kWh
Oil: $0.027/kWh
Natural Gas: $0.029/kWh
Wind: $0.037/kWh

The primary sources of energy in Massachusetts are currently petroleum, natural gas, and coal as shown in Figure 1. A price comparison by energy source from the 1999 State Electricity Profiles shows wind as an uncompetitive source of energy, as noted in the box to the right (Energy Information Administration, 2001). But if the negative externalities associated with producing energy from non-renewable sources are factored in, we believe the social cost of coal, oil, and natural gas would be considerably higher. Secondly, oil and natural gas prices are subject to unpredictable market fluctuations, whereas the price of

wind power is set by the levelized annual construction cost. When the predicted scarcity of world oil supplies begins to be reflected in the price of fossil fuels, wind power may not be so inefficient in the future. Still, high initial capital costs today mean that it takes longest for wind power to recoup the energy costs of production than nuclear or coal power.

To estimate the costs for Massachusetts residents, we take the initial investment for the construction of the Cape Wind Project at $700 million (Cape Wind Associates, 2002). The levelized annual cost of the project is $47.05 million/year.

$0.05 per kWh.[4] This drop in energy costs might also take place in Cape Cod, as plant managers learn to operate it more efficiently.

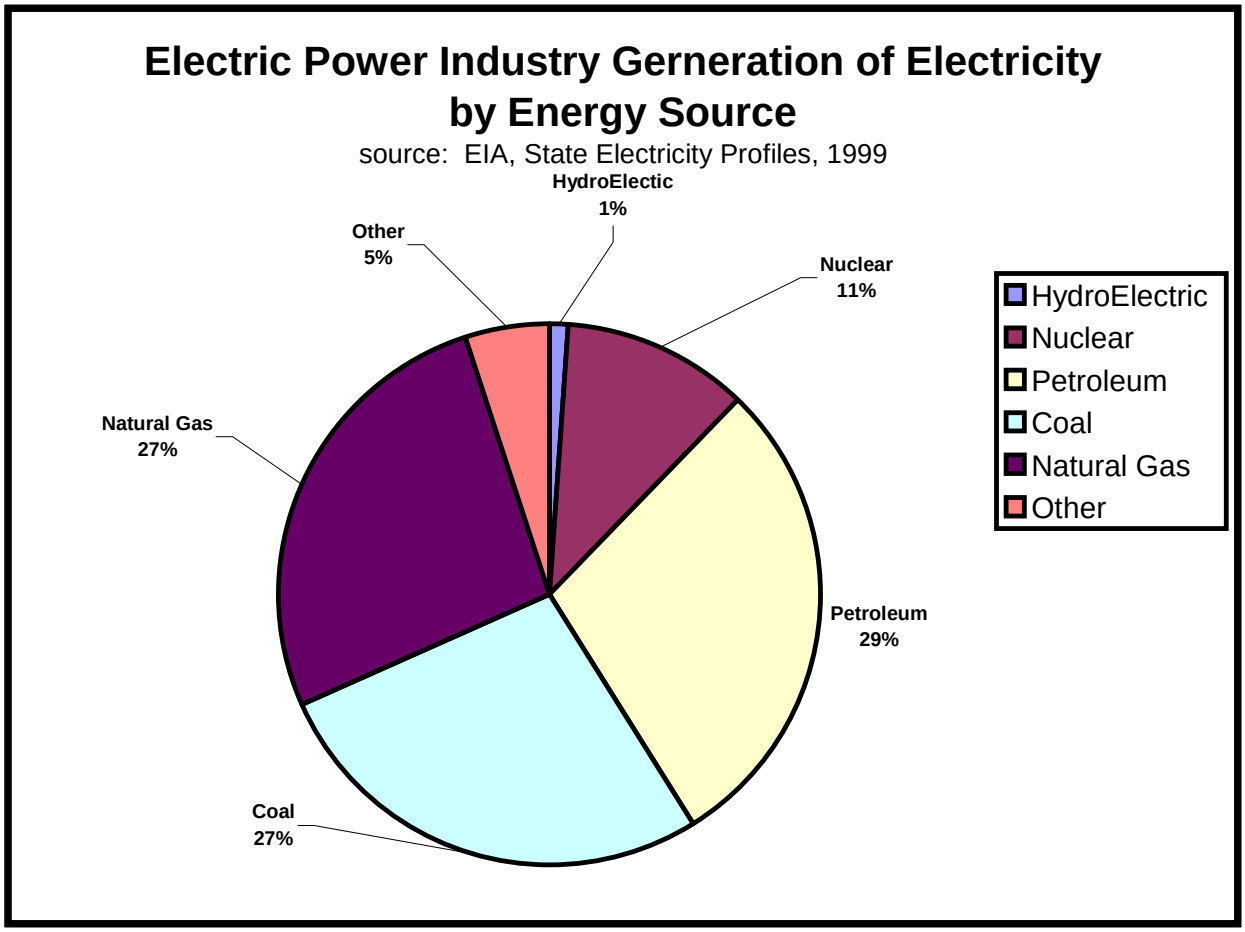

Figure 1

3. Environmental Impact of the Project

While the project will contribute cleaner energy to the Northeast, it is not without its own environmental impact. The main area of concern is the effect of an unsightly wind farm on Cape tourism. Cape Cod is, of course, well known for its pristine natural beauty and rich history. Tourism is a vital part of this region's economy and contributes significantly to the state's economy. In the year 2000, Massachusetts was ranked fourteenth in domestic travel expenditures and seventh in

[4] http://zebu.uoregon.edu/ph162/114.html

international travel expenditures among all fifty states and the District of Columbia. The direct traveler spending in the state, both domestic and international, totaled 13.3 billion in 2000, an increase of 8.7 percent from 1999 (Massachusetts Office of Travel and Tourism, 2002).

The Cape hosts 19 percent of Massachusetts' domestic travelers (ranked second behind the Boston metropolitan area), an estimated 4.7 million trips per year (Massachusetts Office of Travel and Tourism 2002). Domestic spending in the top five counties generated more than $2.6 billion in payroll income, some 84.1% of the total and one hundred thousand jobs or 82% of the total. Barnstable County on the Cape will be most affected by the Cape Wind project. It is now ranked third among counties in domestic expenditures with $713.1 million in domestic travel expenditures. These expenditures generated $202 million in payroll and created 9.4 thousand jobs (Massachusetts Office of Travel and Tourism,

by the anti-wind coalitions, which holds that property values will fall by 30-40%, as overall tourism decreases.

Since Cape Cod is renowned for its views, we cannot dismiss the loss in property value as the offshore wind farm disturbs residents. In the cost-benefit analysis below, we assume a 30% reduction in real estate in towns bordering the water overlooking the project. The initial deduction in real estate prices will be 10% for the first year, 8% for the following year and then tapering off until prices stabilize 6 years after the initial start of construction. Nantucket and Barnstable houses will be the bulk of the houses affected by the wind farm. We assume only 1% overlook the Horseshoe Shoal; thus only their houses will incur the 30% decrease in real-estate value. This figure multiplied by an average of $300,000 per home over the 5 years yields an undiscounted total of $88.7 million in property value losses.[5]

5. Cape Wildlife

Cape Wind Associates believe that the wind generator facilities located in designated areas would have minimal impact on wildlife (Cape Wind Associates, 2002). The spacing (1/3 mile to ½ mile apart) and the design of the turbine towers afford protection to boats and to the fish population (Cape Wind Associates, 2002). A study on wind energy in Denmark, Massachusetts and India (Nott, Broido & Johnson, 2001) indicates that the most significant damage turbines have is on the *bird* population. However, further studies based on wind generating parks in the U.S. provide no evidence of significant mortality. The chances for avian collision are slim in comparison to collisions on other man-made structures, i.e. electric wires (Cape Wind Associates, 2002). Nevertheless, the arguments advanced by the developers are largely based on experience with land-based wind power farms.

The local opposition on the Cape suggests that the project would indeed have considerable impact on wildlife. They argue that the turbines will leak oil, get struck by lightning, catch fire or the blades may shear off threatening the eco-system and wildlife (Alliance to Protect Nantucket Sound, 2002). The claim is that shorebird and waterfowl populations are particularly susceptible to collisions with the rotating blades due to their speed and maneuverability. In addition, migratory routes of birds may be disturbed (Alliance to Protect Nantucket Sound, 2002). Installation of turbine generators would damage the seabed, at least initially, threatening the undersea wildlife habitat as well. It is important to note, however, that the arguments presented by both sides are primarily based on data from land-wind farms. They also fail to take account of technological change. It is arguable that new and improved blades and turbines will have a smaller impact on the

[5] See the formal analysis in section 8.

surrounding environment and the wildlife (Blue Ridge Environmental Defense League, 2000).

The effect on wildlife may merit further study. For the moment we ignore the existence value of any wildlife loss in the cost-benefit analysis below.

6. Cape Cod Fisheries

Fishing is more likely to be adversely affected. Cape fishing is a $16 million industry that could be affected if fishermen are landed during the construction period. During the 18-month construction period, fishermen might well suffer losses. Sea bass and bluefish use Horseshoe Shoal as one of their primary feeding grounds in Nantucket Sound. Nearly 80 boats troll the proposed wind farm site during the summer.

The fishing industry of Cape Cod consists of the commercial fishing industry and the recreational fishing industry. The relatively small area of Horseshoe Shoal is a popular fishing location for Cape Cod residents. At any time there may be 20 – 25 boats about, a number that jumps to 40 in the spring (Ross, 2001). These fishermen fear that the wind farm "will block off a productive fishery" and "devastate an important segment of the local economy" (Ross, 2001). Fish are believed to sense their environment primarily through sound and vibration; the presence of the turbines could disrupt their ability to find food, mates, or desired habitat (Benson, 2002)

In order to weigh the costs and benefits of the Cape Wind project on local fisheries, we interviewed people from both the commercial and recreational industries from Cape Cod. The community seems divided. Some replies conveyed uncertainty: "We can never really tell," argued one respondent, "what might happen with the ocean." Many fishermen continue to worry that their livelihoods will be put in jeopardy by the project. The only strong, mostly non-biased voice we heard on the issue is the state representative Matthew Patrick, who remarked: "Don't try to justify your negativity on protecting the fisheries. This project will enhance the fisheries in many ways".[6]

To find out how, we looked at the recent experience in Europe. In Denmark 50% of electrical power comes from wind and there is also a large wind farm in Middelgrunden. Despite the short time span these installations have been in service, the data suggest that wind farms actually increased the population of sea life, due to what is known as the

"reef effect". Writing in *Scientific American*, Williams notes "Initially fishermen worried about their catch volume decreasing, but several European studies suggest that the heavily anchored turbines act like shipwrecks and in fact improve fish numbers" (Williams, 2002). The artificial reefs are believed to provide fish with new habitat and feeding grounds and have been found to be an effective means at increasing the bio-productivity of coastal waters.

Construction is another matter; there will be a definite short-run, localized negative impact on fishing in the area during the period of construction. Dredging has proved to be the worst aspect of the construction process. Since the shoal is quite shallow, this phase of the project could be quite devastating.

Again we returned to the European experience for guidance. The problem with noise and vibrations has been addressed by several studies conducted in Denmark. An Environmental Impact Assessment (EIA) for the Horns Rev offshore wind farm (slated for construction in summer 2002) found that underwater noise and vibrations would likely have a negligible effect on fish populations and distribution (Elsamprojekt A/S, 2000). An environmental impact statement completed for the Middelgrunden wind farm indicated only temporary disruption of fish during dredging; however, studies also showed no impact on fish or the fishing industry after installation (Middelgrunden Wind Turbine Cooperative, 2001). Furthermore, because the Nantucket Sound is an area where powerboats have been producing noise and vibration for years, the additional noise pollution produced by the turbines is, in our judgment, unlikely to be significant.

In the longer run, wind power will reduce pollutants in the atmosphere and oceans, which suggests a net long-term *benefit* rather than cost of the wind farm project. We omitted the increase in productivity in the formal cost-benefit analysis below.

Since the only scientific evidence available indicating offshore wind farms affect fisheries is positive in the post-construction period, the degree to which the wind farm will impact fisherpersons depends on their discount rate of the future. Fisherpeople with a high discount rate would discourage the construction of wind parks, as they would fear a loss in revenue during the construction process. However, those with a low discount rate would willingly promote the construction of the project and sacrifice some profits today in hope of increased profits in the future due to the creation of new habitats and increased fish population.

To assess the impact of the construction period on social welfare, we look at the disruption of both commercial and recreational fishing.

improbable that the rest of the world will respond to the threat of global warming.

The threat from air pollution is more immediate. In the average year, pollution from power plants cost Massachusetts residents 78,000 lost workdays, 441 premature births, 104 hospital emergency room visits and 8,800 asthma attacks. (Abt Associates, 2000). Implementation of the Cape Wind Project would reduce emission of carbon and sulfur dioxides (40,642 tons), carbon monoxides (120 tons), nitrous oxide (1,566 tons) and particulates (448 tons).

The installation of the wind turbines would eliminate the carbon dioxide released into the atmosphere by an alternative form of energy generation. The Federal government estimates that the current estimated cost of carbon sequestration is in the range of $100 to $300 a ton.[10] Table 1 presents estimates of the savings generated as a result of eliminating carbon from each resource.

Table 1: Carbon Emissions

Resource	Tons of Carbon not emitted (millions/year)	Low Savings ($ mn/year)	High Savings ($ mn/year)
Coal	1.5	151.3	453.9
Oil	0.7	74.3	222.8
Gas	0.57	56.7	170.0

Source: Cape Wind Associates, 2002

Using the current cost to remove the carbon dioxide from the atmosphere is one way of determining how to value each ton of carbon that is emitted. Keep in mind that the data of the table considers the costs of removing carbon dioxide only and disregards the impact of sulfur dioxide, nitrogen oxides, particulates and methane generated by electricity production.

If the northeast grid absorbs the generated power, rather the Cape, the benefit to the Cape would be even greater. By distributing the generated clean power among the regions directly west of the Cape, the effect will be to decrease air pollutants that have been considered an important social cost in the eastern part of the United States for decades.

[10] http://www.fe.doe.gov/coal_power/sequestration/index.shtml

8. Costs Benefit Analysis

Table 2 summarizes the assumptions in the foregoing discussion. Construction costs are the published $700 mn estimate given by Cape Wind Associates. The principal benefit is the $800 mn energy savings also claimed by the developers. The table shows the levelized cost factor (LCF) that converts the construction costs into an annual charge. Maintenance is taken as one percent per year plus another $1.6mn in labor for operations and maintenance.[11] The other important annual cost is the property tax owed to the municipality, but that is also a social benefit.

The next entries in the table report the results of the property value losses as noted in section 4 above. These losses are timed as indicated. Foregone fishing revenues are broken down into commercial and recreational and are only applied in the first three construction years as noted in section 6 above.

In addition to the energy savings just mentioned, benefits also include sick days missed because of reduced pollution. Part of the labor costs of construction will be returned to the local economy as well as the increase in employment due to operations and maintenance. The assumption, as seen in the table, is that 80% will be re-spent.

Table 2: Cost-Benefit Analysis

Costs	
Assumptions	
Construction of Project	$700,000,000
Interest Rate	0.03
Horizon: Number of years	20
Levelized cost factor (LCF)	0.0672
Maintenance (Labor)	36 employees
Maintenance (Labor) @ $45,000/year x 36 employed	$1,620,000
Physical Maintenance	1% total project cost
Property Tax on Lines	$50,000/year
Number of Households In Barnstable and Nantucket Counties	98,514

Loss In Property Value for 4th Year	4%
Loss In Property Value for 5th Year	2%
Loss in Property Value for Additional Years	0%
Results -- Annual Costs	
Project Construction (LAC)	$47,050,995
Maintenance (Labor)	$1,620,000
Physical Maintenance	$7,000,000
Property Taxes	$50,000
Total private costs - used for cost per kWh	$55,720,995
Power produced (kWh)	1.50.E+09
Cost per kWh	$0.037
Loss In Property Value for 1st Year	$29,554,200
Loss In Property Value for 2nd Year	$23,643,360
Loss In Property Value for 3rd Year	$17,732,520
Loss In Property Value for 4th Year	$11,821,680
Loss In Property Value for 5th Year	$5,910,840
Foregone Fishing Revenues per year (first three years).	
Commercial	$6,400,000
Recreational	$12,925,000
Benefits	
Assumptions	
Energy Savings Over 20 years	$800,000,000
Sick Days from Energy (Coal) Production	78,000
Reduction of Sick Days Due to Project	20%
Average Daily Wage of Coal Worker @ 12/hour	$96
Number of Workers for Project Construction	2,000
Salary for Construction Workers $40,000/year	$80,000,000
Percentage of Salaries Contributed to Local Economy	80%
Results -- Annual Benefits	
Energy Savings (Discounted Annually)	$53,772,566
Gain in Labor from Reduction of Sick Days	$1,497,600
Gain in Contribution to Local Economy from Workers	$64,000,000
Carbon Reduction	0

Source: Author's calculations

Table 2 lists no benefits from reduced carbon emissions or other greenhouse gases. We will integrate the data of Table 1, the cost to remove carbon dioxide from the atmosphere, in an extended analysis later in this section. It is evident that including this benefit will have a profound impact on the ratio of benefits to costs.

The net benefit cost ratio based on Table 2 is 1.06, not a strongly positive result for the developers. Indeed if we look at the published private costs and benefits only, the result is much less favorable. The internal rate of return is slightly less than 1.6%.

Table 3 shows the impact of the benefits of carbon reduction on the results. With carbon emissions taken into account there is little doubt about the payoff of the Cape Wind Project.

Table 3: Cost-Benefit with Carbon Emissions Counted in Total Benefits

	Low Savings	High Savings
None	1.06	--
Coal	1.59	2.66
Oil	1.32	1.84
Gas	1.26	1.65

Source: Author's calculations

9. Assessing the Political Environment of Wind Turbines

Clearly, few will oppose the idea that wind power is an acceptable clean alternative for generating electricity. However the citizens of Cape Cod have expressed their objection to the Cape Wind project on the grounds of environmental degradation. In 1986, the Ocean Sanctuaries Act was passed, protecting the open waters from business ventures. The township of Barnstable will try to use this law to deny the application of the Cape Wind Association for the construction of the wind farm. We wondered how widespread the opposition to the project could be. We believe it is important to assess the popularity of alternative energy in the state of Massachusetts.

Recently, a state trust fund of $168.8 million was set up under the 1998 industry deregulation law. Imposing a $0.50 to $0.75 tax per month on residential electric bills financed the majority of the fund. Currently, the Massachusetts Technology Collaborative manages the fund. A survey performed by the Collaborative has determined that 57 percent of Massachusetts residents would be willing to pay a premium of up to $10 for electricity created by alternative energy sources.

Additionally, 70 percent of those surveyed claimed that a tax deduction would convince them to pay a premium. Cape Cod had a *higher* percentage rates supporting the $10 monthly premium. Mitchell Adams, executive director of the Collaborative, realizes that these findings are not entirely reliable as "there is a big difference between people telling pollsters they would pay more for green power and actually writing checks each month to do so."

Currently, Massachusetts utilities receive approximately 13 percent of their power from renewable energy sources, a substantial portion of which comes from hydroelectric power, which most environmentalists consider ecologically damaging. On February 6th of this year, a new state energy plan was unveiled. This plan supports a one percent increase next year in energy from renewable sources. If implemented, the state will obtain some 4 percent by 2009. The burden of the responsibility in enacting this plan would be borne by utility companies and energy marketers.

Surveys done in Europe suggest that 90% of respondents react positively to wind energy. This support is tenuous and is certainly limited as the distance to the nearest turbine decreases. Within the opposing 10% only a small minority of residents ever considers taking action; although it has been observed that it only takes one determined adversary to delay a project A BBC study noted, "...the overwhelming majority of respondents (79%) had not attended any meetings concerning the proposed wind plants. Of those who did attend, half went to gain more insight on project." (Gipe: 1995)

This evidence from Europe suggests that the strength of the anti-wind coalitions is limited. Politically it would seem to be wise to support this program due to the high level of support within the general public for wind energy. Cape property owners directly affected by the view of the turbines are the only constituency staunchly opposed.

One of the potential problems for wind energy is the cost, which may well have been underestimated by the developers. Kahn and Wiser of the Lawrence Berkeley Laboratory's Energy and Environment Division did an analysis of the cost structure for the development of a wind energy source. Their overall conclusion is that costs can be most substantially reduced if a wind energy project is owned by a public utility, or if private, by an investor owned utility (IOU). Costs could also be substantially reduced if the wind project could receive the same financing options that a gas plant developer receives. "Utility ownership of wind plants is cheaper," Wiser and Kahn note,

> ...due to lower cost debt (interest rate of 7.5% compared to 9.5% for a developer), longer debt payment periods (20 years compared to 12 for a developer), and the absence of a "debt service coverage ratio" (DSCR) requirement. The DSCR is a mechanism by which a lender reduces risk of

default on a loan by requiring that a wind project generate enough cash each year to exceed loan payments.[12]

Ultimately wind power may come into existence only under the protective wing of state subsidies. But as the previous section shows, the benefits of eliminating pollution and greenhouse gases far outweigh the costs.

11. Conclusions

The proposed Cape Cod wind project is a highly charged issue, with strong opinions (if not always strong data) from the developers' side and from those that oppose the development. The analysis presented here is an attempt to evaluate the main sources of conflict using data already gathered for the Cape project, data from similar projects in other parts of the world, and energy and environmental costs of current, non-renewable energy sources. In terms of aesthetics and tourism, it was found that there is no consensus on the impacts of offshore wind farms. In addition, there have been no documented negative effects on wildlife or long-term impact on the fishing industry. Finally, wind power has been associated with the reduction of both energy costs and environmental degradation. These findings lead us to conclude that the Cape Cod wind project should go forward.

Massachusetts residents, especially those that reside in Cape Cod thus should be especially concerned with global climate change and environmental and health implications related with consumption of fossil fuels in the future. While we do not find the evidence absolutely conclusive, there is enough data to seriously consider the long-term benefits associated with wind energy.

The Cape Wind project is a glimpse into our future. In a world that is so dependent on exhaustible resources as sources of power, harvesting wind energy is likely to be a significant part of the solution to our growing need for power. After looking at the facts, we recommend that the Cape Winds Association be allowed to undertake this project as intended. In the short run there are negative effects of the project as we have seen; environmental economics, however, teaches us to think about the longer run. The Hoover dam didn't decrease tourism and neither did the Golden Gate Bridge. Chernobyl on the other hand did; the Cape Wind project would produce two thirds of what the Pilgrim nuclear plant in Plymouth produces and would do so without radioactivity.

[12] (http://www.awea.org/faq/cost.html)

11. References

Abt Associates, 2000, "The Particulate-Related Health Benefits of Reducing Power Plant Emissions" http://www.capewind

Alliance to Protect Nantucket Sound, 2002, Save Nantucket Sound. Available: www.saveoursound.org

Australian Wind Energy Association, 2002, "Wind farm impacts on local tourism." http://www.auswea.com.au/cgibin/WEAremdm.pl?Do=obj1&Page=PNum89

Benson, R, 2002, Editorial: "How Noise Could Hurt Fish Stocks" *The Cape Cod Times* http://www.saveoursound.org/pdfs/bensonedit.pdf

Blue Ridge Environmental Defense League, 2000, "Campaign for Energy Efficiency" http://www.bredl.org/energy/greenmtnwindfarm.htm

Campbell, Colin J., and Laherrère, Jean H., 1998, "The End of Cheap Oil," *Scientific American* (March).

Cape Wind Associates, 2002, Cape Wind environmental studies. http://www.capewind.org/protecting/enstu02.htm

Danish Wind Industry Association, 2002, "Operation and Maintenance Cost for Wind Turbines" http://www.windpower.org/tour/econ/oandm.htm

Elsamprojekt A/S, 2000, "Horns Rev Offshore Wind Farm: Environmental Impact Assessment." http://www.hornsrev.dk/Engelsk/Miljoeforhold/pdf/Resume_eng.pdf

Energy Information Administration, 2001, State Electricity Profiles-Massachusetts, Nov. 20, ftp.eia.doe.gov

Energy Information Administration, 2001a, Annual Energy Outlook 2002 with Projections to 2020. Report# DOE/EIA 0383(2002). Dec. 21, 2001. ftp.eia.doe.gov

Gipe, Paul B., 1995, *Wind Energy - Comes of Age New* York: .John Wiley & Sons, Inc

Massachusetts Office of Travel and Tourism, 2002. http://www.massvacation.com/jsp/static_in/research/welcome.jsp?cat=95

Mass. Office of Travel and Tourism, 2002, The Economic Impact of Travel on Mass. Counties 2000. Washington, DC.