UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
Exelon Generation Company, LLC	)	Docket No. 52-007-ESP
(Early Site Permit for Clinton ESP Site)	)	ASLBP No. 04-821-01-ESP

AFFIDAVIT OF BRUCE BIEWALD

I. Qualifications

I, Bruce Biewald, being duly sworn, state as follows:

I am currently president and owner of Synapse Energy Economics, Inc., a consulting company specializing in economic and policy analysis of the electricity industry, particularly issues of restructuring, market power, electricity market prices, consumer protection, stranded costs, efficiency, renewable energy, environmental quality, and nuclear power. I founded Synapse Energy Economics in 1996. Since that time Synapse has grown to be a company with $2 million annual revenue and a long list of successfully completed projects. We work for federal agencies, state regulatory commissions, attorneys general, consumer advocates, environmental groups, municipalities, foundations, and others. I graduated from the Massachusetts Institute of Technology in 1981, where I studied energy use in buildings. I was employed for 15 years at the Tellus Institute, where I was Manager of the Electricity Program, responsible for studies on a broad range of electric system regulatory and policy issues.

I have testified on energy issues in more than eighty regulatory proceedings in twenty-five states and two Canadian provinces and in state and Federal courts. I have co-authored more than one hundred reports, including studies for the Electric Power Research Institute, the U.S. Department of Energy, the U.S. Environmental Protection Agency, the Office of Technology Assessment, the New England Governors' Conference, the New England Conference of Public Utility Commissioners, and the National Association of Regulatory Utility Commissioners. My papers have been published in the *Electricity Journal*, *Energy Journal*, *Energy Policy*, *Public Utilities Fortnightly* and numerous conference proceedings, and I have made presentations on the economic and environmental dimensions of energy throughout the U.S. and internationally. I also have consulted for federal agencies, including the U.S. Department of Energy, the U.S. Department of Justice, the U.S. Environmental Protection Agency, the Federal Trade

Commission and National Renewable Energy Laboratory. Details of my experience are provided in Exhibit 1.

II. Introduction

Exelon[1] and the Nuclear Regulatory Commission (NRC) Staff, in their Draft Environmental Impact Statement (DEIS)) both conclude that alternatives to a new nuclear power plant at the Clinton site are "not environmentally preferable."[2] The information in both, however, does not adequately account for the environmental impacts of nuclear energy.

I believe that wind power is, quite clearly, environmentally preferable and wind power in combination with gas-fired generation will have more environmental impacts than exclusive use of wind power, but that such a combination is still environmentally preferable to nuclear power.

Exelon also claims that wind power alone and wind power in a combination with fossil-fuel fired generation will not be economically preferable to the ESP facility.[3] This incorrect conclusion is based upon an inappropriate comparison and a misrepresentation of the findings of a report from which Exelon draws its estimate for the range of levelized costs of nuclear power.

III. Environmental Impacts of Nuclear Power and its Alternatives

A. Summary

Exelon and the DEIS incorrectly inflate the environmental impacts associated with wind power and gas-fired generation. When these errors are corrected, it is clear that nuclear power has far more harmful environmental impact than wind power generation or an alternative combination of wind and other resources. As support for its erroneous conclusions about the relative environmental impacts and economic costs of various generation sources, Exelon filed an affidavit written by company consultants, Curtis Bagnall and William Maher. In this affidavit, Maher alleges that wind power kills birds, creates noise, has aesthetic impacts and uses more land than nuclear power. According to the DEIS, the land use requirements of wind power are the most significant issue associated with the development of wind, but does not state whether wind power is environmentally preferable or not. Instead it rules out wind capacity as baseload generation because of its "intermittence" (I address this issue later in this affidavit) and claims that "the ESP site is [environmentally] preferable to natural gas-fired generation

[1] The information provided by Exelon and discussed in this affidavit concerns Exelon's RAI Response dated September 23, 2004, Exelon's Environmental Report and the affidavit of Curtis Bagnall and William Maher associated with Exelon's Motion for Summary Disposition of Contention 3.1.
[2] See Maher & Bagnall Affidavit at § VIII and DEIS at page 8-22.
[3] Maher & Bagnall Affidavit at § VIII.

[alone and in combination with wind power] in the areas of air resources, ecological resources [habitat, ecology and wildlife impacts], water resources and aesthetics."[4] While wind and gas-fired generation do have some impacts, Exelon and the NRC Staff's statements on the subject are strongly biased in favor of nuclear power, exaggerate the environmental impacts of wind and gas-fired generation, and ignore analogous significant adverse environmental impacts of nuclear power.

Exelon and the NRC Staff's analyses also do not accurately represent the impacts of nuclear power from the start to the finish of the full fuel cycle. Accordingly, both understate the environmental impacts of the proposed ESP facility. Significant adverse environmental impacts and risks arise from mining, concentration, conversion, enrichment and transport of the uranium fuel necessary to power a nuclear reactor. There are also significant adverse impacts and risks involved in the construction and operation of the reactor as well as significant adverse environmental impacts and risks associated with the transportation, storage and disposal of waste produced by nuclear power plants, particularly the long-term storage of high-level radioactive wastes. Because Exelon's Environmental Report and in turn, the NRC's Draft Environmental Impact Statement, gloss over these crucial stages in the nuclear life-cycle, both improperly conclude that nuclear power is environmentally preferable.

B. Air Pollution Impacts

Wind generation produces no direct emissions of criteria air pollutants or greenhouse gases. Over its life-cycle wind power will produce a small amount of greenhouse gases, largely from the manufacture of plant equipment.

If Exelon were to develop a combination of resource alternatives to the ESP facility that included natural-gas fired capacity, that combination would result in emissions of air pollutants. The rate at which those pollutants are emitted depends on a variety of factors including capacity factor and capacity rating. The emission rates (in tons/per year) predicted by Exelon (see Table 9.2-2 of the ER) and found to be reasonable by the NRC Staff (see pages 8-11 – 8-13 of the DEIS) assume a total of 2,288 MW of natural gas capacity operating at a capacity factor of 85%. The emissions projected by Exelon from that capacity – 177 tons per year of SO_x,[5] 568 tons per year of NOx, 120 tons per year of CO and 99 tons per year of PM_{10} – are classified by Exelon as having a "moderate" impact[6] and by the NRC Staff as having a "small to moderate"[7] impact on air quality. If operated in combination with renewable generation Exelon states simply "these [emissions] would be reduced based on the level of renewable generation."[8] This qualitative rating of impacts has no real meaning for two reasons. First, neither Exelon nor the NRC Staff discusses how they concluded that this level of air emissions would

[4] See DEIS at 8-22.
[5] Unless natural gas directly from the wellhead is used, all sulfur has been removed and combustion of natural gas would therefore result in no SOx emissions.
[6] See ER at 9.2-16.
[7] See DEIS at 8-13.
[8] RAI Response, page 27.

have a “moderate” impact.[9] Second, as I will demonstrate in a later section of my affidavit, such a large amount of natural-gas fired capacity would not necessarily be required as part of a viable alternative in combination with renewable generation. If the capacity factor is held constant, then reducing the capacity would result in a proportional reduction in generation and in emissions - by half or more in this case. Such a reduction could materially impact the determination that natural gas capacity has a “moderate” impact on air quality; however, such a scenario is apparently not discussed by Exelon or the NRC Staff.

Demand side-management measures, in contrast, have no air emissions and *displace* some system air emissions.

The manufacturing of nuclear plant equipment and the construction of the plant will result in greenhouse gas emissions. The uranium fuel cycle also creates greenhouse gas emissions. In addition, the operation of nuclear power plants and the uranium fuel cycle produces air emissions of radionuclides, which will be discussed later on in this affidavit.

C. Impacts to Birds

Exelon claims that the impacts to birds from wind power are a significant wildlife concern. However, other human activities cause many more bird deaths per year as noted in Table 1. Even nature groups such as the Audubon Society – New York chapter, support the development of wind power where it properly sited to mitigate potential negative impacts to birds.[10] A review of the limited literature regarding avian mortality associated with wind power points to an average of around 2 birds killed per year per turbine.[11]

---

[9] This is important since Exelon’s ER claims that gas-fired generation is only inferior to the ESP facility in terms of air quality impacts (see ER at 9.T-6).

[10] “Audubon New York Position on Wind Power Development.” Adopted on June 22, 2004. Available at http://www.audubon.org/chapter/ny/ny/wind_power.htm.

[11] Erickson, Wallace P., et al. National Wind Coordinating Committee, “Avian Collisions with Wind Turbines: A Summary of Existing Studies and Comparisons to Other Sources of Avian Collision Mortality in the United States.” August 2001, page 2.

Table 1. Human – Caused Bird Mortality[12]

Human Activity	**Number of Birds Killed Per Year**
Collisions:	
Building window strikes	97 – 976 million
Communication towers	4 – 5 million
High Tension T&D lines	As much as 174 million
Cars	60 million
Wind Turbine rotors	***33,000***
Poisoning:	
Pesticides	72 million
Oil and Wastewater pits	2 million
Cats	Hundreds of millions

There appears to be no information available on bird impacts from the operation of natural gas-fired power plants. There may be impacts arising from the fuel-cycle because of bird habitat disturbances. These impacts would certainly vary depending on location and method of natural gas extraction and method of transportation of natural gas to the power plant.

Demand-side management measures would generally have no impacts on birds.

As for nuclear power, bird collisions with nuclear power plant cooling towers have occurred and could occur again with a new nuclear power plant. For example, at the Susquehanna plant in eastern Pennsylvania, 1500 dead birds were collected between 1978 and 1986.[13]

The NRC's Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants (which also serves as the basis for analysis of impact to birds in the ESP facility's Draft EIS) concludes, however, that "the significance of the mortality caused by cooling towers is determined by examining the actual numbers and species of birds killed and comparing this mortality with the total avian mortality resulting from other man-made objects and with the abundance of birds populations near the towers."[14] The Generic EIS's analysis on bird collisions is attached as Exhibit 2. Doing the same for wind generation leads one to conclude that other man-made structures would cause significantly more avian mortality. And the NRC Staff states "Bird collisions have not proven to be the problem that was predicted."[15]

---

[12] Based on information in "Migratory Bird Mortality." U.S. Fish and Wildlife Service, January 2002, available at http://www.fws.gov/birds/mortality-fact-sheet.pdf.

[13] See Exhibit 2.

[14] Nuclear Regulatory Commission. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. May 1996. Available at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/.

[15] See DEIS at 8-17.

Avian mortality data for wind, gas and nuclear generation is quite scarce and the impacts on birds will be location and equipment specific. Thus, it is difficult to generalize and to say with confidence what the impact on birds will be at a particular wind, gas-fired or nuclear facility in a particular time period.

When considering the relative avian impacts of wind, gas-fired and nuclear power, it would be appropriate to include the impact of the full fuel-cycle on avian habitat. Otherwise, the comparisons will be biased against wind. A genuine concern about human impacts upon bird populations would lead one to do a balanced and complete analysis, one that would include the full fuel cycle of the energy options being evaluated.

D. Noise Impacts

According to Exelon's Environmental Report, cooling tower operations are expected to cause a noise level of 55 dB at 1,000 feet (a distance slightly greater than 350 m).[16] By contrast, Maher states in his affidavit that "the noise level generated from a typical wind farm at 350 meters distance varies between 35 and 45 dB(A)."[17] This is approximately the level of noise in the reading room of a library.[18] Such a statement would seem contrary to the assertion that "wind turbines can generate a relatively large amount of noise."[19] Indeed, even on windy days when the amount of sound produced by wind turbines increases, that sound "will be partly masked by ambient noise, such as that from the wind rustling leaves or grasses. The sound also tends to be spread out across many frequencies, like white noise, further contributing to its unobtrusiveness."[20]

Noise caused by the operation of a natural gas power plant will vary depending on the acoustic design of the plant. The relative ability to mitigate noise from gas-fired capacity can be seen by the fact that this capacity is frequently located in densely populated areas. Demand-side management measures would have no discernible noise impact.

E. Aesthetic Impacts

Maher alleges "[W]ind facilities may have aesthetic impacts. Nationwide, many communities have opposed the placement of nearby wind projects." The aesthetic impacts of wind farms are entirely subjective, can be positive or negative and are subject to change as the public gains more knowledge of wind. Despite this variability in perception, surveys do indicate widespread public support for wind.[21] For example, a survey in North Carolina by the Appalachian State University Energy Center found that 2

---

[16] Environmental Report, at 5.3-11.

[17] Reeves, Ari and Frederic Beck. "Wind Energy for Electric Power." REPP, June 2003 (Updated November 2003), page 17. and Maher & Bagnall Affidavit at § V.A.3.

[18] Reeves, Ari and Frederic Beck. Wind Energy for Electric Power. REPP, June 2003 (Updated November 2003), page 17.

[19] Maher & Bagnall Affidavit at § V.A.3.

[20] Reeves, Ari and Frederic Beck. Wind Energy for Electric Power. REPP, June 2003 (Updated November 2003), page 17.

[21] Damborg, Steffen. "Public Attitudes Towards Wind Power" Available at http://www.windpower.org/media(485,1033)/public_attitudes_towards_wind_power.pdf.

of 3 respondents would support wind projects visible from their homes.[22] Once wind farms are operational, public support generally increases for wind farms as opposed to support seen prior to construction.[23] In fact a Danish study indicates that people who live close to wind farms tend to support them more than those who live farther away.[24] Limited studies available on wind farms' impacts on tourism show that even in areas highly valued by tourists for their scenery, the presence of wind farms does not negatively influence their decision to visit there.[25]

Public opposition has been expressed in response to proposals to build several wind projects. It is important to note, though, that such opposition is not limited to wind farms, but also applies to many other forms of development *including* nuclear power plants and their necessary offshoot, a spent fuel repository.

F. Water Impacts

Wind generation has no impacts on water quality since large quantities of water are not used as a coolant or in other aspects of operation. Demand-side energy measures also require no significant water use.

Natural gas plants have varied water requirements, depending largely upon the cooling system used. Dry air cooling uses the least amount of water, while once-through cooling uses the most (~500 gpm/MWe).

By contrast, nuclear power plants can be expected to use large amounts of water during operation. By Exelon's estimate, the ESP facility will use approximately 49,000 gallons of water per minute (assuming the cooling system design referred to here is actually used).[26] That water is frequently discharged back to the source at a highly elevated temperature and contains biocides, anti-corrosion and anti-scaling chemicals.[27]

G. Land Use Impacts

Wind farms require more acreage than is sufficient simply to place the turbines and their towers. Land surrounding the turbines must be free of obstructions that could diminish the wind resource. This land can, however, be used for agriculture or grazing without concern for the safety of animals or crops. Maher contends that wind power uses more

---

[22] Grady, Dennis O. "Public Attitudes Toward Wind Energy in Western and Eastern North Carolina: A Systematic Survey." 4 March 2004 available at http://www.energy.appstate.edu/docs/wnc_enc_present.ppt.
[23] Damborg, Steffen. "Public Attitudes Towards Wind Power" Available at http://www.windpower.org/media(485,1033)/public_attitudes_towards_wind_power.pdf , page 5.
[24] Damborg, Steffen. "Public Attitudes Towards Wind Power" Available at http://www.windpower.org/media(485,1033)/public_attitudes_towards_wind_power.pdf
[25] "Tourist Attitudes Towards Wind Farms." British Wind Energy Association, available at http://www.bwea.com/pdf/mori_briefing.pdf. and Martin's Hill Wind Farm Tourist Survey available at http://www.cse.org.uk/cgi-bin/projects.cgi?policy&&1019.
[26] Based on the ER at 3.T-2.
[27] Environmental Report at 5.3-2 and 5.T-2.

land than nuclear power and therefore is "not an environmentally preferable alternative."[28] This conclusion is based upon the following calculation:

> If all of Illinois' 1,800 km^2 of Class 4 and Class 3+ sites were developed using 2 MW turbines, 9,000 MW of installed capacity would utilize 1,125 acres for the placement of wind turbines. Based upon a capacity factor of 17%, this project would have an average annual output of 1,530 MWe, which corresponds to 0.73 acres/MWe. Even if an optimistic capacity factor of 29% is used, this project would occupy 0.43 acres/MWe. In contrast, based upon a capacity factor of 90%, the EGC ESP facility would have an average annual output of 1,962 MWe and would only occupy approximately 461 acres (approximately 0.23 acres/MWe).[29]

I do not agree with Bagnall that 29% is an optimistic capacity factor assumption for wind. Using the wind power calculator provided by the Danish Wind Energy Association[30] to develop a rough estimate of capacity factor and assuming a 180 m elevation (which is the mean elevation of Illinois),[31] the average wind speeds for Class 4 as stated by Bagnall[32] and a 2 MW turbine, the range of capacity factors in a Class 4 resource area would be 35 – 39%. The assumption of a 29% capacity factor appears to be from "Repowering the Midwest" which assumed a 29% capacity factor for wind farms built in the year 2000 in Class 4 areas. Bagnall failed to mention that the study projected improvements in capacity factor over the study period. Since 2001, when the study was performed, there have been improvements in wind turbine technologies such that a 29% capacity factor would not be representative of wind power plants built in 2005 or later. Assuming a 35% capacity factor, on the other hand, decreases the land use required by wind to 0.35 acres/MWe, much closer to the land used in the *operation* of the ESP facility.

Exelon's land use data are also inconsistent with land use figures in the NRC's Generic Environmental Impact Statement for License Renewal of Nuclear Plants (NUREG-1437 Vol.1), which estimates that wind generation (excluding land that will be available for second uses) requires approximately half the amount of land on a MWe basis as nuclear power.[33]

---

[28] Exelon's Motion for Summary Disposition of Contention 3.1, page 23.
[29] Maher & Bagnall Affidavit at § V.A.3.
[30] The calculator can be found at http://www.windpower.org/en/tour/wres/pow/index.htm.
[31] Encarta Encyclopedia, http://encarta.msn.com/encyclopedia_761566615/Illinois.html
[32] Maher & Bagnall Affidavit at § V.A.1.
[33] Table 8.2 at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/v1/TBL8-2.html

Table 2. Land impacts of operating a 1000 MWe equivalent power plant

Alternative	**Land Use**	**Acres/MWe**
Wind	50,000 acres, (2-3% actually occupied by turbines), rest available for agriculture	1 – 1.5
Natural Gas	44 ha (110 acres) for plant site and 1500 ha (3,600 acres) for entire fuel cycle	3.7
Advanced LWR	80-200 ha (500-1,000 acres) for plant site, plus exclusion acres and 400 ha (1,500-2,000 acres) for entire fuel cycle (some of this would be permanently committed acreage)	2-3

Based on the NRC's Generic Environmental Impact Statement for License Renewal of Nuclear Plants (NUREG-1437 Vol.1), the DEIS at 8-17 and http://www.ppmenergy.com/pdf/lo_oview.pdf

According to the NRC, natural gas capacity uses 3.7 acres/MWe. The capacity factor used to determine this estimate is not given, but the California Energy Commission reports that modern natural gas-fired generation uses approximately 0.05 acre/MW installed.[34] This figure is exclusive of fuel cycle land use. Using these two numbers, one can deduce that the NRC assumed about a 45% capacity factor. Using a capacity factor more typical of a baseload unit, such as 85%, means that natural gas generation requires 1.95 acres/MWe.

Demand-side management measures, on the other hand, would generally have no significant land use requirements.

It is very important to recognize, however, that this metric of "land use impacts" is an incorrect simplification of the issue. It makes no distinction between the magnitudes of land use impacts. For example, impacts from land use by a storage facility for spent nuclear fuel simply are not comparable to land use impacts from the operation of a wind power facility. And because they are not comparable, they cannot be measured by a simple estimate of acres used. The land used for long-term storage of high-level radioactive waste will be removed from other uses for *thousands of years*. Such is not the case for wind power or natural gas-fired generation. In the case of wind, for example, much of the land will remain available for other uses that do not diminish the wind resource.

H. Impacts from Nuclear Waste, Accidents and Terrorist Attack

In contrast to nuclear power plants, the decommissioning of a wind farm is relatively straightforward. No radioactive or other wastes harmful to public and environmental health have been created and there are no fuel cycle impacts, let alone a fuel cycle to be concerned with. Natural-gas fired facilities are more complex to decommission than wind farms, but also do not have to contend with the issue of radioactive waste disposal. Nuclear power plants do, on the other hand, create radioactive waste. This waste has serious possible human and environmental health impacts.

[34] California Energy Commission, "Environmental Performance Report of California's Electric Generating Facilities," July 2001, page 35, available at http://www.energy.ca.gov/reports/2001-06-28_700-01-001.PDF

Waste associated with nuclear power plants is created even before operation of the plant commences. The mining, milling, enrichment and fabrication of uranium fuel have their own significant adverse environmental impacts. Uranium tailings created during this process release a variety of radionuclides to the atmosphere. Of principal concern is Rn-222, which is an inert gas with low solubility in water. Rn-222 diffuses out of the tailings pile and disperses quickly into the atmosphere. Although its half-life is less than 4 days, this release continues virtually forever because Th-230, one of its precursors, has a half-life of 80,000 years. Adverse health impacts arise from radon and its daughters as they are inhaled, deposited, and retained in the respiratory system.[35]

Nuclear wastes can release radionuclides into the environment. Low-level wastes will remain hazardous for hundreds of years. Occupational exposure to radionuclides can result from workers handling, packaging, and storing the wastes. Moreover, long-term exposure may result from radioactive effluent from waste buried in trenches and in-ground containers. Another potential source of exposure is associated with the possibility of accidents during handling, transport, and final disposal. In the U.S., between 1971 and 1991, accidents during transport and handling have produced contamination beyond the boundaries of low-level waste sites.[36]

High-level wastes consist primarily of spent fuel generated by the nuclear fission process, and can remain highly radioactive for thousands of years. High-level wastes are also subject to occupational and accident-related risks. High-level wastes are currently stored on the site of the generation facilities pending the development of a permanent storage facility.

Estimating the direct physical impacts of damages due to radionuclide emissions is a complex task replete with uncertainties, scientific disagreements, and unresolved issues. Impacts will depend upon a variety of factors, including the actual level of emissions into air, water and soil; the transport of radionuclides through those media, based on climatological and topographical conditions; the exposure of receptor areas or populations, and the dose-response relationship of those populations.[37] What *is* certain, however, is that assuming zero impacts is wrong.

A review of Exelon and the NRC Staff's analysis of the fuel cycle impacts of uranium leaves much to be desired. This analysis is presented in Section 5.7 of Exelon's Environmental Report and Section 6.1 of the DEIS. Under NRC rules "every environmental report prepared for the construction permit stage of a light-water-cooled nuclear power reactor…shall take Table S-3, *Table of Uranium Fuel Cycle Environmental Data,* as the basis for evaluating the contribution of the environmental effects of uranium mining and milling, the production of uranium hexafluoride, isotopic

---

[35] Schurgin and Hollocher, 1979, *Lung Cancer among Uranium Mine Workers,* in *The Nuclear Fuel Cycle*, Union of Concerned Scientists, Cambridge.
[36] Ohio State University Extension Research available at http://www.ag.ohio-state.edu/~rer/rerhtml/rer_49.html.
[37] For more information see "Non-Price Factors of Boston Edison's Demand-Side Management Programs: A Review of the Societal Benefits of Energy Efficiency." By the Tellus Institute, August 1, 1995.

enrichment, [and] fuel fabrication." The environmental impacts of the uranium fuel cycle, that is, the mining, milling and production of nuclear fuel, and the waste products generated by reactor operation of the possible reactor designs, are contained in Exelon's Environmental Report in Table 5.7-1 through Table 5.7-3 and are based on the information in Table S-3. Table S-3, which was developed in 1979, is designed to account for all uranium fuel cycle impacts for a 1000 MWe reactor; the impacts are scaled depending on the size of the reactor being evaluated.

Since the development of Table S-3, many changes have occurred in the uranium fuel cycle, but the Table has not been changed to account for these developments. In particular, reprocessing, the chemical separation of uranium and plutonium, is not being carried out in the United States. Exelon recognizes this change for the gas-cooled reactor (Table 5.7-1) by stating that no fuel is reprocessed, yet it maintains in the same table that fuel from an LWR is reprocessed. If reprocessing is to be included, the environmental impact of reprocessing should be taken into account in Table S-3; the table does not do so. For example, iodine-129, Cs-137 and Sr-90 are regularly released from a reprocessing plant, but do not appear in Table S-3. Not surprisingly, the true economic costs of reprocessing nuclear fuel have also not been taken into account. In other words, while utilities and the federal government paid about $21 million to have fuel reprocessed at the former West Valley, New York reprocessing plant, the cost to decommission the plant, including solidifying the high-level waste, is expected to cost over $4 billion.[38]

Another major aspect of waste disposal not correctly included in Table S-3 is the fact that no high-level waste repository exists, and may never exist. That is, irradiated fuel may remain in dry storage casks at the ESP facility site forever. The impact of permanent disposal at the ESP facility site has not been included in Table S-3. In fact, the DEIS goes so far as to state "the Commission notes that [high-level and transuranic wastes] are to be buried at a repository [that does not exist], such as the candidate repository at Yucca Mountain, and that no release to the environment is expected to be associated with such disposal."[39]

Finally, if fuel is reprocessed, the recycled uranium will contain contaminants, such as technetium-99,[40] that have not been included in Table S-3. The NRC is investigating this issue, but this investigation has been ongoing since 1979 and it is not clear when this analysis will be completed and/or included in Table S-3. Recognizing that Table S-3 is inadequate in this respect, the NRC Staff points to a separate analysis of exposure from technetium-99 and radon-222 that it performed for the 1996 *Generic Environmental Impact Statement for License Renewal of Nuclear Plants.* If Table S-3 can be supplemented with additional analyses where it does not reflect current reality, it makes no sense to arbitrarily exclude the possibility of additional modifications to the Table.

The NRC Staff also does not agree with other values listed in Table S-3. For example, in the Draft EIS, the Staff argues that nuclear power plant improvements have reduced the

---

[38] Federal News Service for March 1, 2000.
[39] See DEIS at 6-13.
[40] Hanford 1996 Environmental Report, http://www.hanford.gov/docs/annualrp96/1996/4_8_4.pdf .

annual fuel requirement from that listed in the table. The Draft EIS also states that because foreign uranium will be increasingly utilized in nuclear power plants, the impacts of the uranium fuel cycle should be reduced from their values in the table.[41]

While I don't agree that environmental impacts arising from uranium fuel mined and processed abroad do not deserve consideration in these proceedings, it seems clear that there is at least agreement that Table S-3 does not accurately represent reality.

The adverse environmental impacts of transportation of nuclear materials are supposedly presented in Table S-4 (Table 3.8-3 in the ER). As with Table S-3, many changes have occurred since Table S-4 was developed. Three examples are important. Nuclear fuel is no longer being transported one to four fuel assemblies at a time by truck. Since the development of dry storage casks, a standard rail or barge shipment contains 10 to 12 MTU of irradiated nuclear fuel. Casks are no longer 25 tons. The HI-STAR 100 cask[42] holding 24 PWR fuel assemblies on a rail car weighs over 211 tons. The internal heat generated can be up to 20 kw. Carrying heavier casks implies that accidents may be more frequent; not all bridges can carry a train load of cars, each weighing 211 tons. The environmental impact of accidents with large casks has not been assessed by the Nuclear Regulatory Commission.

Nor is the prospect of large radiological releases associated with terrorist attacks examined by Exelon or the NRC Staff. A recent report by the National Academy of Sciences concluded that "To the committee's knowledge, there are currently no requirements in place to defend against the kinds of larger-scale, premeditated, skillful attacks that were carried out on September 11, 2001, whether or not a commercial aircraft is involved."[43] The panel envisioned attacks ranging from draining part of the water from spent fuel pools to an attack involving aircraft or explosives.[44]

G. Conclusion

Wind power uses no significant amounts of water, has limited impact on wildlife, generates small amounts of air emissions over its life-cycle, uses less land than nuclear power, uses it more benignly and does not permanently commit any of it, creates no radioactive waste and no public or environmental health concerns are raised by the prospect of accidents at a wind farm. Clearly, wind power is environmentally preferable to nuclear power.

The Draft EIS claims that "the ESP site is [environmentally] preferable to natural gas-fired generation and the combination of alternatives in the areas of air resources, ecological resources [habitat, ecology and wildlife impacts], water resources and

[41] See DEIS at 6-8.
[42] "NRC Amends Regulations to add HI-STAR Fuel Storage Cask Design to Approved List." Available at http://www.nrc.gov/reading-rm/doc-collections/news/1999/99-189.html.
[43] Committee on the Safety and Security of Commercial Spent Nuclear Fuel Storage, National Research Council. *Safety and Security of Commercial Spent Nuclear Fuel Storage: Public Report.* 2005, page 47.
[44] Ibid, page 49.

aesthetics."[45] But neither the ER nor the DEIS explain why the projected air emissions from natural gas-fired facilities are of importance. Neither the ER nor the DEIS weigh the possible impacts on ecological resources from the fuel cycle of uranium or natural gas. Given the wide range of possible plant designs for nuclear or gas-fired generation (particularly the possible cooling systems), it is impossible to determine that natural gas capacity would have greater impacts on water resources. Likewise, it is impossible to conclude natural gas-fired generation would have greater aesthetic impacts than nuclear power plants. If aesthetics are measured by public reaction, as I assume is meant here, nuclear power plants have received and will likely continue to experience strong opposition. Even if an individual nuclear power plant were to receive public support, we must consider the full range of impacts from the plant and there remains the issue of support for a repository for the waste. The idea that radioactive waste has "environmental effects [that] are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource" is absurd. We currently have no way to guarantee that public health will never be compromised whether from the transport and storage of spent fuel in a storage facility (that does not exist) or from accidents or terrorist attacks at nuclear power plants. Nuclear power is not environmentally preferable to natural gas-fired generation in combination with wind power.

IV. Economic Costs of Nuclear Power and its Alternatives

A. Summary

Exelon's motion states that "it is undisputed that nuclear power is currently economically preferable to wind power."[46] This statement is simply not true. The construction of new nuclear generating units would be expensive and financially risky. Comparisons of the direct costs per kWh indicate that wind is preferable to new nuclear generation (see discussion following) and when the financial considerations - an essential element of economic comparisons for capital-intensive projects - are figured into the analysis, it is clear that wind is economically superior. The Annual Energy Outlook (AEO) 2005 puts it very clearly and concisely: "new [nuclear] plants are not expected to be economical."[47] One can observe the result of this in the market, in that new wind projects are actually being built throughout the Midwest while new nuclear capacity is, quite appropriately, given its economics, stalled. Exelon also incorrectly dismisses wind power and other alternatives as viable options for baseload generation. I will address these inaccuracies in the sections that follow.

[45] See DEIS at 8-22.
[46] Exelon's Motion for Summary Disposition of Contention 3.1, page 21.
[47] Energy Information Administration, "Annual Energy Outlook 2005." Available at http://www.eia.doe.gov/oiaf/aeo/electricity.html#elepri

B. Estimating Costs of Nuclear Power and its Alternatives

Exelon's Environmental Report concludes that "the projected costs associated with all other forms of generation other than the EGC ESP Facility are greater than the EGC ESP Facility. Therefore, the cost associated with the operation of the combination alternative would not be competitive with the EGC ESP facility."[48] This statement is based on the estimated cost of nuclear power coming, in part, from "The Economic Future of Nuclear Power," a report prepared by the University of Chicago. The RAI Response states "The projected cost associated with the operation a [sic] new nuclear facility similar to the EGC ESP facility is in the range of 3.1 to 4.6 cents per kWh."[49]

In addition, the lower bound of Exelon's estimate for the ESP facility's levelized cost range ($0.031/kWh) assumes a 10% learning rate from plant to plant, a 5 year construction period, no risk premium, the lowest capital cost ($1200 per kW)[50], and that the proposed EGC ESP would be the *seventh* such facility constructed in the country. It is, therefore, likely too low for several reasons:

1. Currently, only three new nuclear plants are proposed in the country. Should the ESP application be approved it seems likely that the facility will be among the first constructed, certainly not the seventh.
2. According to the University of Chicago study, a 10% learning rate is "aggressive." The study states that such a learning rate "would necessitate a continuous stream of orders that keep engineering teams and construction crews intact, a highly competitive construction industry, and streamlined regulation largely eliminating construction delays."[51] This is clearly not true of the nuclear industry today and difficult to imagine being the case in the future, given that only three permit applications for new nuclear plants are pending. "Streamlined regulation" for an undertaking as complex and controversial as nuclear plant construction can hardly be assured, despite the best efforts and good faith of regulators.
3. For the first three plants, the University of Chicago study assumes a risk premium of 3%, which according to "informal conversations with a number of Wall Street analysts corroborate[s] [a] 3 percent premium as a *lower* [emphasis added] bound estimate."[52] If delays in construction occur, as happened in the 1970s and 1980s,

[48] RAI Response, page 17-18.
[49] RAI Response, page 17.
[50] "Economic Future of Nuclear Power," The University of Chicago for the U.S. DOE, August 2004, page 9-15.
[51] "Economic Future of Nuclear Power," The University of Chicago for the U.S. DOE, August 2004, page 4-1.
[52] "Economic Future of Nuclear Power," The University of Chicago for the U.S. DOE, August 2004, page 5-21.

investors are likely to require an even greater risk premium, and certainly not *no* risk premium.

4. The capital cost, $1200/kW, is among the most optimistic and Maher provides no justification for this figure as the most accurate capital cost estimate for the EGC ESP facility. Even the Scully Capital Report, which Maher claims "provide[s] a better estimate of the LCOE of a new AP1000,"[53] assumes a capital cost above $1200/kW.

Any claim that the capital cost of the EGC ESP facility will be $1,200/kW must be prefaced by noting the great deal of uncertainty surrounding this figure. The authors of the University of Chicago study attempt to provide a range of costs that are based on averaging differences in estimates of components of nuclear plant costs, specifically the costs of structures and improvements, reactor plant equipment, turbine plant equipment and construction services.[54] The overnight cost ranges[55] they produced are shown in Table 3.

Table 3. Uncertainties in Overnight Capital Costs, $ per kW, 2003 Prices

Characterization of Reactor	**Lower Range**	**Midpoint**	**Upper Range**
Average of Mature Designs	1,080	1,200	1,320
New Designs, FOAKE Costs Not Paid	1,350	1,500	1,650
Advanced New Design, FOAKE Costs Not Paid	1,620	1,800	1,980

The study authors add "as another source of uncertainty, of the four designs considered likely candidates for construction by 2015, only the ABWR has had its proof of concept established. The construction costs of plants whose prototypes have never been built [such as the AP1000 design selected by Exelon as representative of the costs of the ESP facility] have to be considered less certain."[56] To account for this uncertainty, the authors outline a statistical approach by which a probability weighted range of overnight costs can be reached. However, they state, "lacking knowledge of the actual probability distributions and recognizing the tendency for probabilities of midrange values to be higher than outlying values, it is hoped that the $1,200, $1,500, and $1,800 per kW estimate used in this study represents a confidence interval for overnight capital costs associated with a higher degree of reliability."[57]

---

[53] Affidavit of Maher and Bagnall, § IV.

[54] "Economic Future of Nuclear Power," The University of Chicago for the U.S. DOE, August 2004, page 3-19.

[55] The overnight cost of a power plant is the cost to build the plant without consideration of the financing costs.

[56] "Economic Future of Nuclear Power," The University of Chicago for the U.S. DOE, August 2004, page 3-19.

[57] "Economic Future of Nuclear Power," The University of Chicago for the U.S. DOE, August 2004, page 3-20.

There has been limited construction of new nuclear power plants in the past ten years (only in select countries abroad). The data available from these plants shows overnight costs around $2000/kW or higher, suggesting that even the high end of the University of Chicago estimate is overly optimistic, although country-specific factors such as cost of materials may differ from those in the United States. Table 4 reports the overnight costs of these recent plants.

Table 4. Estimated Construction Costs for Recently Built Nuclear Power Plants, $ per kW, 2003 Prices[58]

Country	**Name of Plant**	**Start of Commercial Operation**	**Overnight Cost**
Japan	Onagawa 3	January 2002	2,417
Japan	Genkai 3	March 1994	2,827
Japan	Genkai 4	July 1997	2,296
Japan	Kariwa 6	NA	2,027
Japan	Kariwa 7	NA	1,796
South Korea	Yongwang 5 & 6	2004/2005	2,308

Nuclear construction cost estimates here in the United States have been notoriously inaccurate. The estimated construction costs of nuclear units have frequently been off the mark by factors of two or more. The "initial" cost estimates for 75 nuclear units[59] are listed in Exhibit 3 compared to the actual costs. These cost figures are taken from a U.S. Department of Energy study and are adjusted to exclude the effects of inflation and interest. The total *estimated* cost for this group of plants was $45 billion (in 1990 dollars). The actual cost turned out to be $145 billion (in 1990 dollars). This cost overrun of $100 billion is to more than 200 percent above the initial cost estimate. Had these outcomes been anticipated, even as plausible sensitivities to the costs of the plants, the bases for decisions to pursue some of these facilities would have been weakened and some of the most costly projects might have been abandoned in sufficient time to avoid serious utility and ratepayer financial losses.

Clearly, cost estimation for nuclear power plant construction projects is subject to uncertainties – both technical and institutional. Moreover, these uncertainties are not symmetrical. The probabilities and magnitude of high-side risks dwarf those of under runs.

If there is a next round of nuclear power plant construction in the United States, it is conceivable that it will avoid the type of cost overruns experienced with the first round of nuclear construction projects, but such an outcome is hardly assured. Investors and planners, who have experience dealing with risks, will not be as optimistic about the construction costs as are the nuclear industry's engineers or the authors of the University

[58] "Economic Future of Nuclear Power," The University of Chicago for the U.S. DOE, August 2004, page 2-14.
[59] These 75 are the sample analyzed in the EIA's 1986 study "An Analysis of Nuclear Power Plant Construction Costs."

of Chicago's study. In public statements, even Exelon appears to agree that lenders will be skeptical about the prospects for the nation's first few new nuclear plants.[60]

Indeed, there is literature available on the traditionally poor cost analyses associated with "mega-projects" – multi-billion dollar projects. The book "Megaprojects and Risk: An Anatomy of Ambition"[61] notes that "many [of these] projects have strikingly poor performance records in terms of economy, environment and public support." In 1988, the RAND Corporation studied the performance of 52 megaprojects including several nuclear power plants. Though a number of factors influenced the increase in costs experienced by these projects, the four largest were (1) number of regulatory problems (that is, not regulation itself, but a lack of accounting for the effects that regulations would have on the projects), (2) if the project was publicly owned, (3) if new materials/construction methods were used and (4) if first-of-a-kind technology was used.[62] Because of regulatory problems, nuclear plants as a group "experienced the worst cost growth [i.e., the most]."[63] The study concluded "the data on cost growth, schedule slippage and performance shortfalls of megaprojects are certainly sobering, but the most chilling statistic is that only about one in three of these projects is meeting its profit goals…Megaprojects take so long to develop from concept to reality that the need or opportunity for profits that originally spawned them may have passed by the time they are ready to begin producing."[64] I therefore caution both regulators and companies interested in developing new nuclear power plants, particularly those based upon a conceptual design that has never been built, to be keenly aware of the risk of underestimating costs. Optimistic vendor estimates and generic "contingencies" are frequently inadequate measures of potential costs.

Given the significant uncertainty associated with the overnight costs of new nuclear power plants, it is likely more accurate to turn towards estimates based upon actual experience. The 2003 MIT Study, "The Future of Nuclear Power," provides such an estimate. The "merchant cost model" used in the study employed "assumptions that commercial investors would be expected to use today, with parameters based on actual experience rather than engineering estimates of what might be achieved under ideal conditions."[65] The study concluded that the levelized cost of energy for a new light-water reactor would be 6.7 cents per kWh, assuming an economic life of 40 years and an 85% capacity factor. The authors make clear that "it should be emphasized, that the cost improvements required to make nuclear power competitive with coal are significant: 25% reduction in construction costs; greater than a 25% reduction in non-fuel O&M costs

---

[60] Lambrecht, Bill. "Nuclear industry shows signs of revival." March 14 2005, *St. Louis Post-Dispatch*, available at http://www.kansascity.com/mld/kansascity/news/politics/11132100.htm.

[61] Flyvbjerg, Bent, Nils Bruzelius and Werner Rothengatter. "Megaprojects and Risk: An Anatomy of Ambition." Cambridge University Press, 2003. Available at http://assets.cambridge.org/052180/4205/sample/0521804205WS.pdf.

[62] Merrow, Edward W. *Understanding the Outcomes of Megaprojects: A Quantitative Analysis of Very Large Civilian Projects.* RAND Corporation, March 1998.

[63] Ibid, page 40.

[64] Ibid, page 60.

[65] "The Future of Nuclear Power – Summary Report." MIT, 2003. Available at http://web.mit.edu/nuclearpower/pdf/nuclearpower-summary.pdf.

compared to recent historical experience, reducing the construction time from 5 years (already optimistic) to 4 years, and achieving an investment environment in which nuclear power plants can be financed under the same terms and conditions as can coal plants. Moreover, under what we consider to be optimistic, but plausible assumptions, nuclear is never less costly than coal."[66]

Clearly 6.7 cents per kWh does not meet the standard set out by EPRI that "for utilities to purchase new nuclear plants, their median busbar costs [must] be 'sufficiently less than 43 mills/kWh' ($0.043/kWh) in 1994 dollars (about $0.055 per kWh in 2004 dollars)."[67]

At 6.7 cents per kWh, nuclear generation would not be competitive with wind power generation or a combination of renewables and fossil-fuel fired generation (and/or energy efficiency). The RAI response, dated September 23, 2004, estimates that wind power costs 5.7 cents per kWh, gas 4.7 cents per kWh, coal 4.9 cents per kWh and solar 4 - 5 cents per kWh.[68] The source for this information is not clear. AEO 2004 is consistent with the costs of gas and coal generation and with wind power only if one assumes a less favorable wind resource and that the PTC is not extended. As a note of clarification, it seems likely, based on the magnitude of the costs per kWh mentioned in this section, that these are the *subsidized* costs of gas, coal and nuclear power. It would, therefore, make sense to compare these costs to the subsidized cost of wind power as well. As AEO states, "[T]he levelized value of the PTC to the project owner is approximately 2 cents per kilowatt-hour," which makes "it easy to see how the PTC could make wind plants an attractive investment in the current electricity market."[69] I could not confirm the figure of 4-5 cents per kWh and I doubt we have reached the point at which solar energy is more competitive than wind, gas *or* coal. At any rate, the cost of 5.7 cents per kWh is likely very conservative for wind power. Xcel Energy (Northern States Power) in Minnesota *purchases* wind power at an average price of 3.5 cents per kWh. Assuming the owners of these wind power projects are making any profit, the cost of producing this electricity should be even less.

C. Baseload Power

Exelon argues that generation from a wind power facility is variable and it is therefore not a source of baseload electricity.[70] Based on this incorrect understanding of system operations and reliability, Exelon claims that in comparing the economics of wind to nuclear it would be necessary to back up the wind capacity with fossil fuel capacity. The amount of fossil backup capacity would, according to Exelon, have to be equivalent to the amount of nuclear capacity that is being replaced.

[66] "The Future of Nuclear Power – Summary Report." MIT, 2003, page 41. Available at http://web.mit.edu/nuclearpower/pdf/nuclearpower-summary.pdf.
[67] Affidavit of Maher and Bagnall, § IV.
[68] RAI Response at 17.
[69] Energy Information Administration, "Annual Energy Outlook 2004." Available at http://www.eia.doe.gov/oiaf/archive/aeo04/pdf/0383(2004).pdf.
[70] RAI Response at 8.

> Wind or solar power combined with a fossil-fueled facility, such as a natural gas-fired or coal facility, has the potential to produce an amount of baseload power equivalent to that of the EGC ESP facility. The fossil-fueled portion of the combination can produce the needed power during those periods when the sun is not shining or the wind is not blowing. The coal or natural gas-fired generation would be displaced when the wind and/solar resource is producing power. It would be necessary to construct coal or natural gas-fired facilities that have a peak capacity of 2,180 MW in combination with wind and/or solar facilities to produce baseload power equivalent to the EGC ESP facility. Whenever the wind/solar generation is less than 2,180 MW, the coal or natural gas-fired generation would need to run to bring the total generation output to 2,180 MW.[71]

This approach to comparing resources is, simply stated, incorrect for several reasons. These have to do with the contribution of intermittent resources to system reliability, the recognition from grid operators of the capacity value of intermittent resources, the grid reliability impacts of large nuclear units, and the extra capacity and energy value of the "combination alternative" that Exelon's comparison fails to recognize.

First, intermittent resources such as wind and solar power do in fact contribute significantly to system reliability. Indeed, the capacity value of wind and solar generation can have capacity value that, on a per MWh basis, is equal to or greater than the capacity value of a nuclear plant. In other words, a wind farm with an installed capacity rating of 1,000 MW, for example, may have a capacity factor of 30 percent, indicating that in the course of a year it will produce 2,628 GWH and that its average hourly production would be 300 MW. It would be inappropriate to ascribe 1,000 MW of system capacity value to this facility. But its true system capacity value will likely be in the neighborhood of 300 MW. It could be higher or lower depending upon factors such as the correlation between the renewable resource (wind or sun) and hourly load patterns, the amount of existing renewable generation on the system with similar generating patterns, and other resource and system specific considerations. I participated in a research project for the US Department of Energy in which we found that the capacity value of wind was very significant, and exceeded the average capacity output of the wind facility under the case study conditions.[72]

With regard to solar generation, the correlation with loads is generally quite high. That is, during the times of the year and the times of the day when electricity loads are highest, the sun tends to be shining, and solar generating equipment will tend to be generating at its highest level output. For such facilities, the contribution to system reliability (i.e., the

---

[71] Statement of Material Fact # IV.C.1., paragraph lettering and footnotes omitted.

[72] Bernow, Stephen, Bruce Biewald, Jeffrey Hall and Daljit Singh. "Modelling Renewable Electric Resources: A Case Study of Wind." Tellus Institute under contract for the Oak Ridge National Laboratory, October 1994.

capacity value on a per MWH basis) will be much higher than that of nuclear power plant capacity.

Grid operators recognize that intermittent resources have capacity value. For example, in PJM,[73] absent information on the hourly outputs of wind, the regional transmission organization automatically assigns a capacity credit of 20% to wind generation.[74] As annual hourly output data becomes available for individual wind farms, PJM will begin to use that data. The NYISO pays wind resources for their capacity based on historic capacity factors adjusted for maintenance.[75] MISO currently has no capacity markets and therefore no permanent policy on capacity values assigned to wind or any other type of generation.

Large nuclear units pose their own set of challenges to grid operators with implications for system reliability. In recent years (1999-2003) the average forced outage rates for nuclear units in the U.S. have been approximately 5%.[76] The immediate and unplanned loss of 1000 MW can cause system reliability problems. These considerations are factored into system margins for operations and for planning. A system dominated by large generating units will, with all other things equal, be required to have greater operating and planning capacity margins than a system with smaller generating units.

The approach that Exelon takes for comparing intermittent resources with nuclear is biased strongly against the intermittent resources in that it ignores the capacity and energy value of the backup fossil generation. Consider for example a case (see Table 5) in which a 2,180 MW nuclear addition is being compared to a mix of 1,500 MW of wind and 2,180 MW of fossil-fired generation.

Table 5. Illustrative Comparison of Nuclear Generation and Alternative Combination

Type of Capacity	**Installed Capacity Rating**	**Capacity Factor**	**Effective Capacity* (MW)**	**Generation (GWh)**
Nuclear	2,180	90%	2,180	17,187
Combination:				
Wind	1,500	35%	450	4,599
Fossil	2,180	85%	2,180	16,232
Combination	3,680	NA	2,630	20,831

*We assume for purposes of this illustrative example that nuclear and fossil "effective capacity" is equal to their installed capacity.

---

[73] PJM is a regional transmission organization governing all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia

[74] "How Wind Generators Participate in PJM Markets." A presentation by Joseph J. Kerecman of PJM to the Utility Wind Interest Group Fall Technical Conference, October 27, 2004.

[75] "Integrating Wind Resources into the New York Power Grid." A presentation by Mollie Lampi of NYISO to the Utility Wind Interest Group Fall Technical Conference, October 27, 2004.

[76] North American Electricity Reliability Council, Generating Unit Statistical Brochure 1999-2003, October 2004.

The 2,180 MW of nuclear capacity, if operated at an optimistic 90% capacity factor, would generate 17,187 GWH per year and have capacity value of about 2,180 MW. With a wind capacity factor and capacity value of 35%, and a fossil capacity factor of 85% and capacity value of 100%, the 3,680 MW mix of wind and fossil generation would generate 20,831 GWH per year and have a total capacity value of 2,630 MW. Clearly this is higher than the effective capacity of the 2,180 MW nuclear plant. Furthermore, if one takes into account the capacity value of wind, the amount of backup fossil fuel-fired generation need not be equal to the capacity of the nuclear unit. But Exelon's method ignores this additional value. Maher's calculation of the cost of a coal or gas-fired facilities illogically reduces the capacity factor of the plant to "60% (due to the availability of solar and wind power)."[77] Exelon effectively assumes that when the wind is blowing and the sun is shining and the renewables capacity is generating that the valuable and available fossil generating equipment would sit idle. This is absurd, and inconsistent with the desire and expectation of the investors in the equipment to get full economic value from it.

In the example above, if the fossil unit were available 90% of the time but was not needed for economic reasons (e.g., other generating units with lower operating costs are available to meet system loads), then the fossil capacity would operate at a somewhat lower capacity factor, and the total amount of generation from the mix might in some cases be lower than the total amount of generation from the 2,180 MW of nuclear capacity. To the extent that this is the case, however, the fossil generation will be producing its electricity during periods with higher hourly prices. The per MWh value of the generation from the "combination" would in these cases be higher than the per MWh value of the generation from the nuclear units. The only situation in which this increase in the market value for lower fossil plant capacity factors would not occur is if the fossil generation were constrained inappropriately and uneconomically to operate only when the renewable capacity is *not* generating.

Exelon's approach to comparing intermittent resources with nuclear power is inaccurate and does not reflect the realities of system reliability or generating unit operating economics. Fossil and nuclear generating units have forced outage rates that can be predicted in a general sense for planning purposes, but specific events take system operators by surprise. Grid operators do not conclude from this that each fossil or nuclear plant needs a dedicated capacity backup. Nor do they conclude that fossil and nuclear capacity make no contribution to system reliability. Grid operators and planners ascribe value to fossil-fuel and nuclear capacity based upon what the resources contribute to system reliability, and grid operators and planners make provisions for "backing up" fossil and nuclear capacity in the rules and protocols for operating and planning reserves. The same approach can and will be taken with regard to resources such as wind and solar. But Exelon's approach effectively assumes irrational and counterproductive behavior by grid operators who inexplicably assign zero capacity value to intermittent resources and decide not to operate available and economic fossil generating capacity because the wind happens to be blowing or the sun happens to be shining.

[77] Affidavit of Maher and Bagnall, § V.C.3.b.

D. Costs of Combinations as an Alternative to Nuclear Power

The cost of combinations[78] which can serve as an alternative to nuclear power are far below the price of new nuclear plants (as taken from the MIT study). In the tables shown below, the costs of wind and gas-fired power are taken from AEO 2005. In order to offer a conservative assessment, I have included both AEO 2005's low and high estimates for the cost of wind power. Because of the NEMS model's treatment of wind power, I would expect the upperbound estimate to be an overestimate of the actual costs of wind power. Despite this, the annual output of a combination of wind power and gas capacity is still at least $301 million cheaper (Table 6), in addition to the fewer environmental impacts from wind and gas-fired power.

Table 6. Costs of Nuclear Power vs. a Combination of Wind and Gas-Fired Capacity

Type of Capacity	**Installed Capacity Rating**	**Capacity Factor**	**Generation (GWh)**	**¢/kWh Cost (2003$)[79]**	**Total Cost of GWh Generated (2003$)**
Nuclear	2,180	90%	17,187	6.8	$1,169 million
Combination:					
Wind	1,500	35%	4,599	4.5 - 6.0	$207 - $276 million
Gas	1,691	85%	12,588	4.7	$592 million
Combination	3,296	NA	17,187	4.6 - 5.0	$799 - $868 million

In its Draft EIS, the NRC Staff analyzed the environmental impacts of a combination of resource alternatives that included demand side management (or energy efficiency). I would like to extend that example to point out that the cost of the annual output of a combination of alternative energy sources that includes energy efficiency[80] (Table 7) is also less than the cost of nuclear power and even less than the cost (by at least $363 million) of just using supply-side resources alternatives (i.e., wind and gas-fired capacity). As I discussed previously, as an added benefit, the implementation of demand-side management measures actually *avoids* most environmental impacts.

[78] The levelized costs of each resource were taken from different sources and therefore may have minor inconsistencies.
[79] The cost of nuclear power was converted to 2003 dollars using the Gross Domestic Product Implicit Price Deflator.
[80] The cost of saved energy is the upper bound of the range of costs shown in the ACEEE report "Five Years In: An Examination of the First Half-Decade of Public Benefits Energy Efficiency Policies" available at http://www.aceee.org/pubs/u041.pdf.

Table 7. Cost of Nuclear Power vs. a Combination of Wind and Gas-Fired Capacity and Demand-Side Management

Type of Capacity	**Installed Capacity Rating**	**Capacity Factor**	**Generation (GWh)**	**¢/kWh Cost (2003$)**	**Total Cost of GWh Generated (2003$)**
Nuclear	2180	90%	17,187	6.8	$1,169 million
Combination:					
Wind	1500	35%	4,599	4.5 - 6.0	$207 - $276 million
Gas	1220	85%	9,084	4.7	$427 million
Efficiency	NA	NA	3,504	4.4	$154 million
Combination	NA	NA	17,187	4.7	$788 - $806 million

IV. Conclusion

Wind power and natural gas-fired generation have fewer environmental impacts than nuclear power, cost less than a new nuclear unit and can serve as a baseload alternative to nuclear power. The addition of demand-side management measures to the mix further reduces costs and environmental impacts.

Exelon and the NRC Staff's analyses of the environmental impacts of nuclear power do not adequately and appropriately compare the proposed nuclear capacity to alternatives. The analyses are inadequate, biased, inaccurate, and based upon out-of-date information. Significant adverse environmental impacts of nuclear generation are trivialized while the impacts of alternatives, particularly wind power generation, are exaggerated. A more reasonable and balanced summary of the impacts of nuclear, wind and natural gas-fired power and demand-side management is presented in Table 8.

Similarly, in Exelon's economic analysis the costs and risks of nuclear construction are underplayed or ignored. In reality there are renewable generating alternatives and combinations of alternatives that are environmentally and economically preferable to generation from new nuclear capacity at Exelon's Clinton site.

Table 8. Impacts of EGC ESP facility vs. Alternate Sources of Generation

Impact Category	EGC ESP facility	Wind Generation	Natural Gas-Fired Capacity	Demand-Side Manageme
Air Impacts	Greenhouse gases from manufacture of plant equipment, refining of uranium fuel, construction of plant Radionuclides released from waste products	Greenhouse gases emitted from manufacture of plant equipment and construction of plant	Greenhouse gases from manufacture of plant equipment and construction of plant; during operation: SO_2: 88 tons/yr; NOx: 284 tons/yr; CO: 60 tons/yr; PM: 284 tons/yr	Zero air emissions, displac system air emissions from o resources
Bird Kills	Variable depending on site, historical kills were as much as 236 birds per year, additional impacts possible from fuel-cycle	Variable depending on the site, but ~ 2 birds killed per turbine per year on average	No information available, additional impacts possible from extraction and transportation of natural gas	None
Noise	55 dB at 1,000 feet (equivalent to the noise of a coffee percolator or a dishwasher)[81]	35 - 45 dB at 1,100 feet (equivalent to the noise of a reading room at a library)	Variable depending on acoustical design of the plant	None
Aesthetic Impacts	Variable depending on site	Variable depending on site	Variable depending on site	None
Water Quality	Variable use depending on design, Exelon believes 49,000 gallons per minute), discharged at maximum 90-day average of 99°F and contains biocides, anti-corrosion and anti-scaling chemicals	No significant water use	None to 500 gpm per MWe[82] depending on cooling system, some drift may be expected depending on the cooling system used, discharged water may include chemicals used in scaling, fouling and pH control	No water use, displaces wate from other resources
Land Use	About 2-3 acres/MWe (includes the fuel-cycle)	1 – 1.5 acres/MWe (accounts for land with second uses)	1.95 acre/MWe (includes the fuel cycle)	None
Waste Management	Spent nuclear fuel and low-level radioactive waste from operations & decommissioning must be dealt stored, transported & disposed of	None	Virtually no waste.	None
Accidents	Variable impacts on human and environmental health depending on severity	Not applicable	Not applicable	Not applicable

[81] Noise Center of the League for the Hard of Hearing, available at http://www.lhh.org/noise/decibel.htm

[82] California Energy Commissions, "Comparison of Alternate Cooling Technologies for California Power Plants: Economic, Environmental and Other Tradeoffs." February 2002, page 1-9, Available at http://www.energy.ca.gov/reports/2002-07-09_500-02-079F.PDF

State of Massachusetts
County of Middlesex

I declare under penalty of perjury that the foregoing affidavits and the matters stated therein are true and correct to the best of my knowledge, information and belief.

____
Bruce Biewald

Subscribed and sworn before me this _____th day of April, 2005, personally appeared ________________, proved to me through satisfactory evidence of identification, which were ________________________________, to be the person whose name is signed on the preceding document.

____
Notary Public

My Commission Expires:

Exhibit 2
Affidavit of Bruce Biewald

From the Nuclear Regulatory Commission's Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants (NUREG-1437 Vol. I)

4.3.5.2 Bird Collisions with Cooling Towers

This section addresses the significance of avian mortality resulting from collisions of birds with natural-draft cooling towers at nuclear plants. Natural-draft towers, which are tall structures, cause some mortality, whereas mechanical-draft towers cause negligible mortality and are not addressed here. This issue was evaluated by reviewing the general literature for avian collision mortality associated with all types of man-made objects, as well as the monitoring studies conducted at six nuclear plants. The literature review is presented in Section 4.5.6.2. The significance of the mortality caused by cooling towers is determined by examining the actual numbers and species of birds killed and comparing this mortality with the total avian mortality resulting from other man-made objects and with the abundance of bird populations near the towers.

4.3.5.2.1 Overview of Impacts

Throughout the United States, millions of birds are killed annually when they collide with man-made objects, including radio and TV towers, windows, vehicles, smoke stacks, cooling towers, and numerous other objects. An overview of collision mortality for all types of man-made objects is included in the discussion of transmission lines in Section 4.5.6.2.

Avian mortality due to man-made structures is of concern if the stability of the local population of any bird species is threatened or if the reduction in the numbers within any bird population significantly impairs its function within the local ecosystem. Avian mortality resulting from collisions of birds with cooling towers is considered to be of small significance if the losses do not threaten the stability of local populations of any species and if there is no noticeable impairment of its function within the local ecosystem.

4.3.5.2.2 Plant-Specific Analysis

Monitoring of bird collisions has been done at several nuclear plants with natural draft cooling towers, including the Susquehanna plant near Berwick on the Susquehanna River in eastern Pennsylvania, the Davis-Besse plant on the shore of Lake Erie in north central Ohio, the Beaver Valley plant on the Ohio River in extreme western Pennsylvania, the Trojan Plant on the Columbia River in extreme northwestern Oregon, the Three Mile Island plant near Harrisburg in southeastern Pennsylvania, and the Arkansas Nuclear One plant on Dardanelle Lake in northwestern Arkansas. The following information was obtained from nuclear plant annual monitoring reports and from a few other sources, as cited.

At the Susquehanna plant, surveys were conducted on weekdays during spring and fall migration from 1978 through 1986. This plant's natural draft towers are 165 m (540 ft) tall and illuminated at the top with 480-V aircraft warning strobe lights. About 1500 dead birds (total for all survey years) of 63 species were found that had apparently collided with the cooling towers. Others were probably lost in the tower basin water during plant operation. Most of the birds were passerines (songbirds). Fewer collisions seemed to occur during plant operation, when cooling tower plumes and noise may have frightened birds away from the towers. From 1984 through 1986, eight dead bats were also found, including little brown myotis, red bat, and big brown bat.

At Davis-Besse, extensive surveys for dead birds were conducted from fall 1972 to fall 1979. Early morning surveys at the 152-m (499-ft-) tall cooling tower were made almost daily from mid-April to mid-June and from the first of September to late October. After the tower began operating in the fall of 1976, some dead birds were lost through the water outlets of the tower basin. A total of 1554 dead birds were found, an average of 196 per year. The dead birds included 1222 at the cooling tower, 222 around Unit 1 structures, and 110 at the meteorological tower. Most were night-migrating passerines, particularly warblers, vireos, and kinglets. Waterfowl that were abundant in nearby marshes and ponds suffered little collision mortality. Most collision mortalities at the cooling tower occurred during years when the cooling tower was not well illuminated (1974 to spring 1978). After completion of Unit 1 structures and the installation of many safety lights around the buildings in the fall of 1978, collision mortality was significantly reduced (average of 236 per year from 1974 through 1977, 135 in 1978, and 51 in 1979). Diffusion of light from these safety lights may illuminate the cooling tower in such a way that birds can see and avoid it. Lights at nuclear plants may not confuse birds to the extent sometimes caused by lights on radio or TV towers (Section 4.5.6.2). Lights illuminating the Pilgrim Nuclear Station in Massachusetts apparently were not a problem to migrating birds, which were monitored by radar. The orientation, flight speed, and altitude of these birds appeared unaffected by the lights, although on one of nine nights, flight direction at the station was different from that in a control area and flight altitude was higher (Marsden et al. 1980).

At Beaver Valley, surveys were conducted in spring and fall from 1974 through 1978 at the natural draft tower. A total of 27 dead birds were found. At the Trojan Plant, surveys were conducted weekly in 1984 and 1988 at the 152-m 499-ft-) tall cooling tower, meteorological tower, switch yard, and generation building. No dead birds were found. At the 113-m (371-ft-) tall cooling towers at Three Mile Island, a total of 66 dead birds were found from 1973 through 1975 (Temme and Jackson 1979). No dead birds were found at Arkansas Nuclear One, where monitoring at the natural-draft tower was done twice weekly from October 15 through April 15 in 1978-79 and 1979-80.

4.3.5.2.3 Conclusion

Existing data on cooling-tower collision mortality suggest that cooling towers cause only a very small fraction of the total bird collision mortality (see Section 4.5.6.2 for a review of this mortality). The relatively few nuclear plants having natural-draft towers in the

United States (approximately 32 units), combined with the relatively low bird mortality at individual natural draft towers, shows that (1) these nuclear plant towers are not greatly affecting bird populations (see Section 4.5.6.2.1) and (2) their contribution to the cumulative effects of bird collision mortalities is very small. Mechanical-draft cooling towers, which are not nearly as tall as natural-draft towers, and other facilities pose little risk to migrating birds.

Local bird populations are apparently not being significantly affected by collision with cooling towers. Waterfowl and other birds that are commonly present as permanent or summer residents around nuclear plants do not frequently collide with the towers. Instead, a very high percentage of the collision mortalities occur during the spring and fall bird migration periods and involve primarily birds migrating at night. Studies that have been conducted at six nuclear plants, in conjunction with literature reporting total collision mortality (Section 4.5.6.2), show that (1) avian mortality associated with cooling towers is a very small part of the total mortality and (2) local bird populations are not being significantly reduced. Data on collision mortality were found for only 6 of the 20 nuclear plants with natural-draft cooling towers. Collision mortality at one or more of these plants may be greater than at the plants where surveys were conducted.

Avian mortality resulting from collisions of birds with cooling towers involves sufficiently small numbers for any species that it is unlikely that the losses would threaten the stability of local populations or result in a noticeable impairment of the function of a species within local ecosystems. There is no reason to believe that the annual mortality rate resulting from collision of birds with any cooling tower would be different during the license renewal term. Thus, avian mortality resulting from collision with cooling towers is of small significance. A potential method of mitigating avian morality would be to illuminate natural draft cooling towers at night. Because it is unlikely that the numbers of birds killed from collision with cooling towers are large enough to affect local population stability or impair the function of a species within the local ecosystem, consideration of further mitigation is not necessary. Because any contributions of cooling tower collisions to overall bird mortality have already been expressed in species populations, it is not expected that there will be any incremental or cumulative impact on bird populations from cooling tower collision mortality due to relicensing of current nuclear plants. The cumulative effect of bird mortality is further considered with transmission lines in Section 4.5.6.2. Avian mortality resulting from collision with cooling towers is a Category 1 issue.

Estimated and Realized Nuclear
Construction Costs

Plant	Estimated Costs at Start of Construction(Millions of 1990$)	Realized Cost(Millions of 1990$)	Plant	Estimated Costs at Start of Construction(Millions of 1990$)	Realized Cost(Millions of 1990$)
Arkansas Nuclear 1	$375	$624	McGuire 1	$414	$1,299
Arkansas Nuclear 2	$460	$1,081	McGuire 2	$472	$1,269
Beaver Valley 1	$513	$1,176	Millstone 2	$474	$936
Beaver Valley 2	$913	$4,099	Millstone 3	$1,046	$3,998
Braidwood	$762	$2,723	Nine Mile Point 2	$1,008	$5,281
Browns Ferry 1	$303	$876	North Anna 1	$515	$1,555
Browns Ferry 2	$227	$657	North Anna 2	$445	$932
Browns Ferry 3	$227	$657	Palisades	$294	$422
Brunswick 1	$430	$718	Palo Verde 1	$1,234	$4,185
Brunswick 2	$352	$933	Palo Verde 2	$920	$2,291
Byron 1	$741	$2,518	Peach Bottom 2	$532	$1,418
Byron 2	$552	$2,072	Peach Bottom 3	$423	$560
Callaway	$1,136	$2,999	Perry 1	$981	$3,729
Calvert Cliffs 1	$357	$1,142	Rancho Seco	$389	$876
Calvert Cliffs 2	$287	$765	River Bend 1	$718	$4,091
Catawba 1	$559	$2,074	Salem 1	$462	$1,829
Clinton	$710	$4,058	Salem 2	$378	$1,497
Cooper	$378	$1,053	San Onofre	$1,134	$3,343
Crystal River 3	$362	$948	San Onofre 3	$1,056	$2,078
Davis-Besse 1	$484	$1,359	Sequoyah 1	$524	$1,560
Diablo Canyon 1	$445	$3,750	Sequoyah 2	$429	$1,276
Diablo Canyon 2	$459	$2,333	Shoreham	$300	$4,139
Donald C. Cook 1	$657	$1,303	St. Lucie 1	$365	$1,130
Duane Arnold	$340	$716	St. Lucie 2	$893	$1,876
Edwin I. Hatch 1	$417	$951	Surry 1	$419	$761
Edwin I. Hatch 2	$653	$922	Surry 2	$329	$437
Fermi 2	$596	$3,783	Susquehanna 1	$1,320	$2,654
Fort Calhoun 1	$222	$520	Susquehanna 2	$753	$2,274
Grand Gulf 1	$1,105	$3,473	Three Mile Island 1	$323	$1,008
Harris 1	$898	$3,999	Three Mile Island 2	$668	$1,287
Hope Creek	$1,592	$4,598	Trojan	$582	$1,145
Indian Point	$477	$859	Virgil Summer 1	$630	$1,707
Joseph M. Farley 1	$387	$1,463	Waterford 3	$617	$3,303
Joseph M. Farley 2	$406	$1,228	Wolf Creek 1	$1,143	$2,835
Kewaunee	$297	$559	WPSS 2	$786	$4,008
LaSalle 1	$715	$1,918	Zion 1	$593	$768
LaSalle 2	$532	$1,255	Zion 2	$430	$752
Limerick 1	$921	$3,980			
			Total	$45,247	$144,650