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General Comment

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Attachments

DeclarationGundersen

DeclarationCompaan

DeclarationCooper

Comments for PBNP draft EIS

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

In the Matter of NextEra Energy Point Beach, LLC (Point Beach Nuclear Plant, Units 1 and 2)	Docket Nos. 50-266 and 50-301 NRC–2021–0021 March 23, 2021

DECLARATION OF ARNOLD GUNDERSEN

Under penalty of perjury, I, Arnold Gundersen, declare as follows:

1. My name is Arnold Gundersen. I am sui juris. I am over the age of 18-years-old.

2. Physicians for Social Responsibility Wisconsin (PSR-WI) has retained Fairewinds Associates, Inc to review a license application to the nuclear regulatory commission to extend the licensed life of NextEra's Point Beach nuclear reactors until they have operated for 80-years and a related Environmental Report for NextEra Energy Point Beach, LLC's Point Beach Nuclear Plant, Units 1 and 2. My observations and conclusions are offered to a reasonable degree of scientific certainty based on my experience and relevant information sources.

3. This declaration examines and analyzes the technical and environmental issues regarding the License Renewal Request by NextEra for 20-more-years of operation extending the operating life of Point Beach Units 1 and 2 from a 60-year license to an 80-year license.

4. I have more than 50 years of experience in Nuclear Engineering, beginning in 1971 when I earned my Bachelor Degree in Nuclear Engineering (BSNE) from Rensselaer Polytechnic Institute (RPI) cum laude. I earned my Master Degree in Nuclear Engineering (MENE) from RPI via an Atomic Energy Commission Fellowship.

Cooling tower operation and cooling tower plume theory were my areas of study for my Nuclear Engineering Master Degree.

4.1. I began my career as a reactor operator and instructor in 1971 and progressed to the position of Senior Vice President for a nuclear licensee prior to becoming a nuclear engineering consultant and expert witness. My Curriculum Vitae is Attachment 1.

4.2. I have testified as an expert witness to the Nuclear Regulatory Commission (NRC) Atomic Safety and Licensing Board (ASLB) and Advisory Committee on Reactor Safeguards (ACRS), in Federal Court, the State of Vermont Public Service Board, the State of Vermont Environmental Court, the Florida Public Service Commission, and the California Public Utility Commission (CPUC).

4.3. I am an author of the first edition of the Department of Energy (DOE) Decommissioning Handbook.

4.4. I have more than 50-years of professional nuclear experience, *including and not limited to*: Cooling Tower Operation, Cooling Tower Plumes, Consumptive Water Loss, Nuclear Plant Operation, Nuclear Management, Nuclear Safety Assessments, Reliability Engineering, In-service Inspection, Criticality Analysis, Licensing, Engineering Management, Thermohydraulics, Radioactive Waste Processes, Decommissioning, Waste Disposal, Structural Engineering Assessments, Nuclear Fuel Rack Design and Manufacturing, Nuclear Equipment Design and Manufacturing, Prudency Defense, Employee Awareness Programs, Public Relations, Contract Administration, Technical Patents, Archival Storage and Document Control, Source Term Reconstruction, Dose Assessment, Whistleblower Protection, and NRC Regulations and Enforcement.

4.5. I am the chief engineer for Fairewinds Associates, Inc, an expert witness and paralegal services firm specializing in nuclear engineering, nuclear operations, and nuclear power plant safety analysis and assessment.

5. **Declaration Executive Summary:**

5.1. NextEra's Point Beach Units 1 and 2 were designed and built more than a half a century ago and are an obsolete and unsafe atomic reactor design. If a corporation applied today to build and operate these reactors, their design would not be approved, as the engineering configuration is unacceptable by today's standards. The reactors do not meet basic licensing requirements that protect the safety of nearby communities. Moreover, the Point Beach reactors' continued operation in their aged and unstable condition put nearby neighborhoods and the people who live and work in those communities at an increased risk for significant radiation exposure due to old, outdated, and poorly maintained equipment. Point Beach (PB) also uses water taken from Lake Michigan to cool its reactors. However, when the reactors finish using Lake Michigan water for cooling, each atomic reactor returns the heated wastewater to the Lake killing hundreds of millions of aquatic organisms yearly. Such actions show these reactors are environmental superpredator.

5.2. Additionally, electricity generated by NextEra's Point Beach reactors is more expensive than any form of electricity generated by renewable and sustainable sources, like wind and solar. Closing Point Beach and replacing that electric generating equipment with wind farms or other renewables enables much cheaper sustainable power generators to use the existing Point Beach transmission lines to send much more affordable renewable electricity into Wisconsin's Electric Grid. Closing NextEra's Point Beach Units 1 and 2 and replacing those vulnerable outmoded atomic reactors with renewables will significantly decrease the cost of electricity in Wisconsin and increase overall employment in Wisconsin. In contrast to continued operation of two aging atomic power plants, replacing that power with renewables would increase income to farmers, and such an arrangement would also maintain Wisconsin's tax revenues.

6. **The Point Beach Reactors Are Obsolete:**

6.1. I am 72 years old. In 1964, when I was in 9th grade, the initial engineering began on the two Point Beach design nuclear power reactors. Late in 1970, Point Beach Unit 1 began generating electricity, and three years later, in 1973, Point Beach Unit 2 also began generating electricity. During those years between 1970 and 1973, I earned my Bachelor of Science (BS) in Nuclear Engineering (BSNE), my Master of Engineering (ME) in Nuclear Engineering (MENE), and my AEC Atomic Energy Commission Reactor Operators License. Using a slide rule for calculations, as that was the equipment we all had, I began work at another early nuclear reactor that is now permanently scrapped because it was no longer considered safe.

6.2. When Point Beach was being designed and constructed during the mid to late 1960s, most engineering calculations used slide rules. The analyses that launched John Glenn into orbit and sent men to the moon, as detailed in the movie Hidden Figures, also were conducted using slide rules.[1] Mandatory seatbelt laws for automobiles were not promulgated until 1968, and at that time, there were also no pollution controls required on auto engine exhaust. Rivers were so polluted that they caught fire[2]. As a result of increased air and water pollution, a nascent environmental movement began while Point Beach was under construction. Congress created the Environmental Protection Agency during the very early 1970s due to the grave ecological challenges throughout the entire U.S. The EPA began its environmental reviews after Point Beach Unit 1 was operating.

6.3. During the mid to late 1960s, when Point Beach was designed and constructed, *no large nuclear plants were in operation – large is defined as an electric power output greater than 400 megawatts-electric (MWe)*. Therefore, there was no template of a successful, safe nuclear power plant to use as a guide.

[1] https://www.imdb.com/title/tt4846340/
[2] https://www.smithsonianmag.com/history/cuyahoga-river-caught-fire-least-dozen-times-no-one-cared-until-1969-180972444/

6.4. Regulatory guidance and oversight were sadly lacking during the construction of Point Beach. The Atomic Energy Commission (AEC), the predecessor to the Nuclear Regulatory Commission (NRC), issued 10CFR50 Appendix A, the first set of General Design Criteria for atomic power plant construction during the early 1970s after construction on Point Beach Unit 1 was already almost complete. More importantly, the AEC implemented 10CFR50 Appendix B as law to ensure Quality Assurance requirements for the construction of all nuclear power plants well after PB Unit 1 started operation.

6.5. Due to its weak oversight of new atomic plant design as PB was being designed and constructed and began operation, Congress replaced the AEC with the NRC in 1975. According to the current website of the Nuclear Regulatory Commission:

> Before the NRC was created, nuclear regulation was the responsibility of the AEC, which Congress first established in the Atomic Energy Act of 1946. Eight years later, Congress replaced that law with the Atomic Energy Act of 1954, which for the first time made the development of commercial nuclear power possible. The act assigned the AEC the functions of both encouraging the use of nuclear power and regulating its safety. **The AEC's regulatory programs sought to ensure public health and safety from the hazards of nuclear power without imposing excessive requirements that would inhibit the growth of the industry.** This was a difficult goal to achieve, especially in a new industry, and within a short time the AEC's programs stirred considerable controversy. An increasing number of critics during the 1960s charged that the AEC's regulations were insufficiently rigorous in several important areas, **including radiation protection standards, reactor safety, plant siting, and environmental protection…**
>
> By 1974, the AEC's regulatory programs had come under such strong attack that Congress decided to abolish the agency. **Supporters and critics of nuclear power agreed that the promotional and regulatory duties of the AEC should be assigned to different agencies.** The Energy Reorganization Act of 1974 created the Nuclear Regulatory Commission; it began operations on January 19, 1975.[3] **[Emphasis Added]**

[3] https://www.nrc.gov/about-nrc/history.html

6.6. Despite all the unknown elements of the untested PB design, the AEC granted Point Beach a license to operate for its original 40 year design life.

6.7. Therefore, I conclude that Point Beach was designed and constructed during a period of insufficient regulatory oversight. At that time, the Atomic Energy Commission (AEC) was fulfilling its charter to actively promote new, untested atomic reactor designs, like that of Point Beach, without the benefit of adequate safety and environmental guidance.

6.8. Many US atomic reactors have closed or are planning to close shortly due to the inability to operate profitably without the high risk of a meltdown and a considerable investment to adhere to more stringent safety requirements. To date, there are 94 atomic reactors currently operating in the US with an average age of 39 years[4].

6.9. The oldest US atomic reactor in operation is Nine Mile Point Unit 1, a Fukushima type reactor design located in upstate New York that went online one year before PB Unit 1 in December 1970.[5]

6.10. At 50 years old, PB is ten years older than the average US nuclear plant and one of the oldest atomic power sites in the United States.

6.11. In 2004, PB applied for a 20-year extension to its initial 40-year license approved by the NRC. Even then, it was clear that there is absolutely no factual basis to indicate that energy corporations can safely operate nuclear power plants as they approach 60-years of operation. Today, the data clearly shows that no nuclear plant anywhere in the United States has performed beyond 51-years.

6.12. Now, PB chooses to apply for an additional license extension to operate until it is 80-years-old. There is no scientific basis to assure that a 50-year-old atomic

[4] https://www.eia.gov/tools/faqs/faq.php?id=228&t=21
[5] https://www.eia.gov/tools/faqs/faq.php?id=228&t=21

facility like PB that was originally designed to operate for only 40-years can remain safe to run for 80-years.

7. **PB is Unsafe**

7.1. No nuclear plant in the US could be licensed today to operate with the outmoded safety systems included in PB's design. The NRC has already determined that the design of Point Beach is not safe for newer reactors.

7.2. There are numerous flaws at the Point Beach reactors that make it unsafe for this agency to approve the NextEra license extension to operate Point Beach for 80 years. Therefore, the license extension should be denied.

7.3. **The First Problem Is Its Tangential Turbine Hall**

7.3.1. Historically, Point Beach and many other early reactors have a turbine hall that is tangential to the reactor building and control room.

7.3.2. In this Point Beach photo (below), you will see the tall rectangular reactor buildings and the shorter, more extended rectangular turbine halls tangential to the reactor and nearer to the lake.[6]

[6] https://madison.com/wsj/news/local/environment/point-beach-owner-seeks-to-run-wisconsins-last-nuclear-plant-for-80-years/article_d50ba0b6-f3ca-5129-81c2-757405a7bec8.html

7.3.3. This tangential design was inexpensive and was later determined to be unsafe. This approach is no longer an acceptable design anywhere in the world.

7.3.4. The PB design is unsafe because a turbine failure will send 600 lb. pieces of shrapnel hurtling at 600 mph into the containment, safety-related components, and the control room.

7.3.5. Construction of reactors built after Point Beach changed the turbine hall's orientation to be radially outward from the containment to protect the control room and its operators, the safety-related components, and the containment from the threat of turbine shrapnel.

7.3.6. The picture below is of the Callaway nuclear facility in Missouri, which incorporates this vital safety improvement.[7]

7.3.7. By reorienting the direction of the turbine hall to the radially outward design, the shrapnel would fly into the parking lot rather than the safety-related equipment, control room, and containment building in the event of a turbine failure.

[7] https://www.themaneater.com/stories/outlook/proposed-bill-would-fund-callaway-nuclear-plant

7.3.8. Turbine failures are likely events. Fermi 2 in Michigan experienced turbine failure, as have other nuclear plants and airplane jet engines.

7.3.9. I have reviewed publicly available photos of the PB turbine hall and see no indication that shielding from turbine missile shields has been implemented. While PB cannot rotate its entire turbine hall to assure that a turbine failure does not result in safety-related consequences, there is a solution. To mitigate the impact of a turbine failure, PB could install an inexpensive "Energy Absorbing Turbine Missile Shield, US Patent #4397608A[8]. I conclude that to reduce the risk of damage to safety-related systems, structures, and components, PB should be required to install an energy-absorbing turbine missile shield around its turbine.

7.4. **What Is Embrittlement?**

7.4.1. Even before Point Beach's design, scientists had discovered that neutron radiation from inside the nuclear core would gradually destroy the thick metal nuclear reactor that surrounds that core. This phenomenon is called neutron embrittlement. If embrittlement becomes extensive, the dense metallic nuclear reactor can shatter like glass. The NRC has identified that NextEra's Point Beach Reactors are the most embrittled operating reactors in the United States.

7.4.2. For a video further explaining these phenomena, see: https://www.fairewinds.org/nuclear-energy-education/nuclear-crack

7.4.3. Reactor embrittlement can cause an atomic reactor to shatter like glass, creating what the Nuclear Regulatory Commission (NRC) calls a Class 9 Accident, which is the worst nuclear catastrophe presently acknowledged by the NRC. When the nuclear core leaves the atomic reactor and melts down into the containment, as it did at three of the atomic reactors at the

[8] https://patents.google.com/patent/US4397608A/en

Fukushima Daiichi site in Japan beginning on March 11, 2011, the NRC calls each one of these nuclear calamities a Class 9 Accident.

7.4.4. According to the Nuclear Regulatory Commission,

> Reactor pressure vessels, which contain the nuclear fuel in nuclear power plants, are made of thick steel plates that are welded together. Neutrons from the fuel in the reactor irradiate the vessel as the reactor is operated. This can embrittle the steel, or make it less tough, and less capable of withstanding flaws which may be present. Embrittlement usually occurs at a vessel's "beltline," that section of the vessel wall closest to the reactor fuel. Pressurized water reactors (PWRs) are more susceptible to embrittlement than are boiling water reactors (BWRs). ...Steels with a higher proportion of copper and nickel will tend to be more susceptible to embrittlement, than are steels with lower proportions of these two elements... [9]

7.4.5. Nuclear energy corporations cannot prevent neutron embrittlement of metal; it is similar to a spreading cancer in that engineers can monitor embrittlement progress. To create a viable monitoring program, *engineers had numerous samples of the exact metal inside each reactor placed inside the reactor prior to operation.* These samples are called *coupons*, and several are withdrawn periodically and measured in a laboratory to determine the progress of embrittlement.

7.4.6. Engineers designed the Point Beach reactors to operate for 40 years, and the reactors contained enough *sample coupons to last for 40 years of operation*. Now that the PB reactors are licensed to operate for 60-years, there are not enough coupons in the reactor core to test for embrittlement, let alone for an additional 20 years for the license extension request for 80 years to operate Point Beach.

7.4.7. Ten years after Point Beach became operational in 1981, personnel in the Office of the Governor of California were aware that nuclear reactor

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[9] *NRC Fact Sheet on Reactor Pressure Vessel Issues, Embrittlement*, http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/prv.html

embrittlement with its associated risk of a nuclear reactor failure and radiation leak was a serious problem.

7.4.7.1. Peter H. Gleick, a specialist in the office of Gov. Edmund G. Brown's assistant for energy and environment, wrote a Letter to the Editor of the *New York Times* dated November 7, 1981.

7.4.7.2. In that letter, Mr. Gleick said that nuclear reactor embrittlement "...may be the most serious known problem facing existing nuclear power plants... which could cause failure of the pressure vessel containing nuclear fuel." Mr. Gleick's full letter is inserted below.

> To the Editor:
>
> ***If The Pressure Vessel Of A Reactor Cracks***
>
> Your Oct. 24 editorial "Brittle Metal and Nuclear Safety" correctly calls attention to what may be the most serious known problem facing existing nuclear power plants - "pressurized thermal shock," which could cause the failure of the pressure vessel containing the nuclear fuel.
>
> Although progressive embrittlement of the pressure vessel has always been anticipated, it now appears that many such vessels will become susceptible to cracking long before reaching their 30- to 40-year lifespan. This problem, however, is neither as avoidable nor as correctable as you suggest.
>
> As you stated, both overcooling and high pressurization must exist before a vessel can crack. Yet there are situations where rapid cooling together with high pressurization is required in order to avoid a serious accident. The operator actions needed to avoid a serious reactor accident may be completely contradictory to those required to avoid cracking the pressure vessels.
>
> For this reason, the Nuclear Regulatory Commission has taken the position that relying on operator action is not an acceptable solution to the risk of pressure vessel failure.
>
> Similarly, the statement that correcting this problem involves catching the flaw early is accurate but misleading. Pressurized thermal shock is a problem that is most severe in the older generation of reactors - those built before the

> mid-1970's (newer pressure vessels have better materials characteristics and are less susceptible to embrittlement).
>
> As a consequence, catching the flaw early is not possible for most of these older reactors, which are already close to reaching unacceptable levels of embrittlement. Moreover, the "solution" described in the editorial, annealing of the vessel, requires emptying the entire core of nuclear fuel and heating the highly radioactive pressure vessel to several hundred degrees above its normal operating temperature for a very long period - perhaps up to several months.
>
> Theoretically, the strength of the vessel is then recovered. In practice, however, no commercial nuclear reactor vessel has ever been annealed, and there are serious questions about the time required, the economic costs, the radiation exposure to workers and, in fact, whether or not this process will be successful.[10]

7.4.8. Mr. Gleick's 1981 letter to the *New York Times* was prescient except that he researched and wrote it 10-years after Point Beach Unit 1 began operation.

7.4.9. From the documents I reviewed, it is evident that nuclear industry experts and the Nuclear Regulatory Commission (NRC) have known the seriousness of reactor embrittlement and the radiation release consequences for the public should that failure occur.

7.4.10. In 1982, Demetrios L. Basdekas, an NRC Reactor Safety Engineer, expressed his concerns and frustrations in his letter to the editor, also published in the *New York Times*:

> "There is a high, increasing likelihood that someday soon, during a seemingly minor malfunction at any of a dozen or more nuclear plants around the United States, the steel vessel that houses the radioactive core is going to crack like a piece of glass. The result will be a core

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[10] *New York Times*, November 7, 1981 *New York Times*, November 7, 1981 **http://www.nytimes.com/1981/11/07/opinion/l- if-the-pressure-vessel-of-a-reactor-cracks-084005.html**

> meltdown, the most serious kind of accident, which will injure many people, and probably destroy the nuclear industry with it."[11]

7.5. **How Does Embrittlement Lead To The Failure Of The Atomic Reactor?**

7.5.1. If the nuclear reactor were to suddenly shut down during one of the dozens of atomic power mishaps that nuclear reactor design engineers and the NRC anticipate will happen, the safety system would immediately inject cool water into the reactor vessel in an attempt to cool the reactor core in hopes of preventing a meltdown.

7.5.2. However, in a seriously embrittled reactor like Point Beach, when that cool water is injected and comes in direct contact with the hot reactor vessel, it can cause "*Pressurized Thermal Shock*" (PTS). After this, the 8-inch thick steel reactor vessel may crack from PTS, causing it to break open and release massive radioactivity into the surrounding area and the environment. The sudden breach of the nuclear power reactor would dramatically increase the pressure inside the containment causing this last radiation barrier to fail also. Should this event occur, the Nuclear Regulatory Commission (NRC) has estimated that it will cause at least 7,000 cancer deaths and $112 Billion in today's dollars in property damage.[12]

7.5.3. While *no atomic reactor mishap*, or accident as the industry names them, *should be called routine*, this rapid cooling and sudden pressurization sequence can cause a radioactive disaster, yet the NRC and nuclear power industry have named them a "routine accident".

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[11] *New York Times,* March 29, 1982

[12] *Projected Impacts of Large-scale Radiological Releases at Atomic Reactors in the U.S. Calculation of Reactor Accident Consequences (CRAC-2)* report by U.S. NRC & Sandia National Lab, 1982

7.5.4. There have been several historical precursor sequences that prove that abrupt temperature and pressure changes do occur at operating nuclear power plants.

7.5.4.1. The first such precursor event happened at California's Rancho Seco atomic power reactor on March 20, 1978. When a worker dropped a light bulb, it, in turn, caused a cascade of electrical faults.

7.5.4.1.1. Instruments in the control room went haywire, leaving the reactor operators with no accurate instrumentation to rely upon while attempting to control the reactor.

7.5.4.1.2. The temperature inside the reactor dropped from 582ºF to 285ºF in one hour. The reactor pressure dropped from 2,200 psi to 1,600 psi. The reactor pressure jumped back to over 2,000 psi but at a low temperature when the reactor operators injected cold water.

7.5.4.2. The Rancho Seco "transient", as industry nuclear engineers call it, was a near miss that made it clear that reactors like Point Beach are susceptible to abrupt changes in temperature and pressure. Fortunately, while the abrupt changes in temperature and pressure severely stressed the nuclear reactor vessel welds, the Pressurized Thermal Shock (PTS) and nuclear vessel failure were avoided at Rancho Seco. *Why?* A major catastrophe was avoided at Rancho Seco because the reactor was new, and unlike Point Beach, the welds at Rancho Seco were not yet embrittled by long-term neutron bombardment that would have caused the reactor to shatter like glass.

7.5.5. More recent analyses show that an atomic reactor vessel can crack even when it is not under pressure. Hence, the damage the nuclear power industry has named "pressurized" thermal shock is now as clearly understood as damage from thermal shock. Clipped below is testimony to the NRC's Advisory Committee on Reactor Safeguards in 2014.

> "Mr. Kirk: well, they're - and that's one of the - in fact, that was very much a surprise because in the - in the early analysis - in the 1980s analysis the no-pressure events were a priori screened out. But what we found in running the calculation is you can run a crack pretty much all the way through the wall.
>
> Member Skillman: just with temperature.
>
> Mr. Kirk: just with temperature.
> Member Skillman: just with temperature.
>
> Mr. Kirk: yes." [13]

7.5.6. The NRC identified Point Beach as the most embrittled reactor still operating in the US[14].

7.5.7. The six most embrittled nuclear reactors in the United States are:

- 7.5.7.1. Yankee Rowe (permanently closed 1992)
- 7.5.7.2. Genkai-1 (Japan, permanently closed 2015 after discovering coupon samples indicated much higher embrittlement that analysis predicted)
- 7.5.7.3. Point Beach
- 7.5.7.4. Palisades (closing in 2022)
- 7.5.7.5. Indian Point 3 (closing in 2021)
- 7.5.7.6. Diablo Canyon 1 (closing in 2024)
- 7.5.7.7. Beaver Valley (Scheduled to close in 2021 unless Pennsylvania approves more than a hundred million dollar yearly subsidy.)

7.5.8. Therefore, five of the six most embrittled reactors in the US have already been shuttered or will be closed during the next three years rather than addressing the safety-related embrittlement issue. Only the Point Beach reactors are not scheduled to be closed.

7.6. **<u>Is There A Solution To Nuclear Reactor Embrittlement</u>?**

7.6.1. It is disturbing to note that the *NRC and NextEra's alleged solution* to protect Point Beach against cracking and radiation releases from its

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[13] Advisory Committee on Reactor Safeguards, top of p.33, Oct. 16, 2014 transcript
[14] NRC ADAMS Accession No. ML13077A156

increasing neutron embrittlement is simply to develop new operator administrative controls. These administrative controls are requirements that the atomic reactor operators at Point Beach must implement during a reactor emergency to avoid cracking the 8" thick steel atomic power reactor vessel.

7.6.1.1. These administrative controls require the reactor operators to raise the reactor's temperature before increasing the pressure, and unless the operators implement these controls perfectly, the reactor vessel will experience cracking.

7.6.1.2. This situation is analogous to a tractor-trailer driver being informed by his boss that the brakes on the tractor-trailer will fail at speeds above 50 miles per hour. However, rather than fix the brakes, the trucking company's administrative solution is to insist that the truck driver never exceed 49 miles per hour. Just as reactor vessel embrittlement gets significantly worse over time, bad brakes on the truck would demand that the driver reduce his speed further every year, or the truck would be pulled off the road and sold for scrap.

7.7. **How Is Reactor Embrittlement Determined?**

7.7.1. To measure embrittlement, when the Point Beach reactor vessels were manufactured, identical metallic samples, called coupons, were manufactured as well and were installed in the Point Beach reactors when the reactors were placed on site. The same system is used at other reactors to monitor embrittlement progression.

7.7.2. Originally, Point Beach was designed and anticipated to operate for only 40 years, so only 40-years-worth of coupon samples were manufactured and installed in the reactors. Now there are not enough sample coupons to remove from the reactor and test for embrittlement until the 60-year-license expires, let alone for an additional 20 more years for an 80-year-license to operate.

7.7.3. Unnervingly and without any scientific proof to do so, the Nuclear Regulatory Commission (NRC) has repeatedly modified its calculations allowing aging, embrittled nukes to continue to operate well past their lifespan and certainly in risky uncharted territory.

7.7.4. The process of determining the Nil-ductility transition temperature (the temperature below which the vessel will shatter) is not an exact science. A paper written, by Nikolaeva et al., in 2000 supports my assessment of uncertainty and complexity in the development of the embrittlement calculations:

> The radiation embrittlement of reactor vessel materials is a **complex process**, which depends upon the conditions of a radiation in the microstructure and chemical composition of the steel. It is universally acknowledged that phosphorus, copper, nickel intensify the radiation embrittlement of vessel material the most... **The presence of a synergistic interaction of elements in the irradiation process and the complex interaction of metallurgical factors and the radiation conditions make it difficult to determine the degree to which impurities and alloying elements influence radiation embrittlement**. [15] **[Emphasis Added]**

7.7.5. The NRC and the Point Beach reactors rely on using engineering analysis to extend the *useful life* of embrittled nuclear reactors, which has the net effect of reducing the safety margin of Point Beach. A paper written in 2000 by the Nuclear Energy Agency Nuclear Science Committee states that safety margins will be reduced by extending the "useful life" of embrittled reactors.

> As many commercial light water reactors begin to approach the end of their licensed lifetime, nuclear utilities have started to investigate the possibility of extending the operating life of reactors beyond the originally licensed 30-40 years. **Longer reactor operating times mean higher neutron and gamma fluence levels and/or smaller safety margins ...** High energy

[15] Embrittlement of Low-Alloy Structural Steel by Neutron Irradiation, Atomic Energy, Vol. 88, No.4, 2000: Nikolaeva, Nikolaev, Kevorkyan, Kryukov & Korolev, http://link.springer.com/article/10.1007%2FBF02673611#page-2

> neutron bombardment degrades the structural integrity of RPVs[16]. **[Emphasis Added]**

7.7.6. Robert Pollard, a senior nuclear engineer with the Union of Concerned Scientists, was one of the world's first scientists to identify the danger and degree of uncertainty in embrittlement calculations within the nuclear engineering and scientific community.

> If you really want a good fight, ask people about the reliability of those safety estimates. **The method the NRC and the industry uses is called probabilistic risk assessment. It's designed to get around a rather impressive lack of concrete evidence**... In a probabilistic risk assessment, you estimate the likelihood of an event that initiates a transient, then estimate the likelihood of the reaction to that event, the reaction to that reaction, and so on down the line. Westinghouse, for example, has a model that starts with 17 possible initiators and runs through event trees to more than 8,200 end points... But there are inevitable differences of opinion about the value of those calculations... Not everyone agrees with the calculations. **"The NRC may consult its Ouija board and come up with a number", says Robert Pollard of the Union of Concerned Scientists, "but the error bands are so large that it is essentially useless."** ... "There's no dispute that current emergency systems would not be able to cope with the fracture of the reactor vessel... The defense in depth argument disappears when you talk about pressurized thermal shock." [**Emphasis Added**][17]

7.8. Even though neutron embrittlement of the Point Beach reactors present a clear and present danger, the NRC and Point Beach have relied upon error-prone analytical calculations rather than use all the tools available to identify just how serious the embrittlement threat has become as Point Beach ages.

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[16] *Prediction Of Neutron Embrittlement In The Reactor Pressure Vessel*, Nuclear Energy Agency Nuclear Science Committee, 2000 https://www.oecd-nea.org/science/docs/2000/nsc-doc2000-5.pdf

[17] *Thermal shock-new nuclear-reactor safety hazard?* Edward Edelson, *Popular Science*, June 1983, http://static1.1.sqspcdn.com/static/f/356082/25715973/1417195845950/June+1983+Popular+Science.pdf?token=a42WKwrX5fEjMEeVND6FGLOKmWc%3D

7.8.1. A review of the publicly available files in the NRC's ADAMS database indicates that the NRC has granted waivers for each of the five most embrittled reactors still operating to avoid testing their actual embrittlement through the measurement of their actual metallurgical coupons. *At Diablo Canyon, the NRC has allowed the unit to avoid testing any coupon samples for almost two decades*, and at Palisades, Indian Point, and Point Beach, I could find no record of coupon samples being tested for at least ten years. When Yankee Rowe was completely dismantled in 1992, it is unfortunate for the safety of the whole industry that the vessel was not tested to determine how significant its embrittlement was. With so many embrittled atomic reactors closing during the next several years (Indian Point Unit 3 in April 2021, Palisades in 2022, and Diablo Canyon 1 in 2024), we are provided with significant and vital opportunities to perform nuclear *autopsies* (comprehensive analyses) on those badly embrittled Reactor Pressure Vessels (RPVs) to learn lessons and provide real world physical data for an accurate analysis of the PB 80-year license extension application process.

7.8.2. As the US nuclear fleet ages, the NRC has systematically removed conservative calculational aspects of the embrittlement process to allow continued operation. The NRC has not incorporated the actual data from coupons in the remaining five worst atomic power reactors in the U.S. to be used for the embrittlement analysis applied to NextEra's Point Beach reactors to allow their continued operation. Instead of evaluating Point Beach's specific metallurgy, the NRC has allowed Point Beach and its cohorts to use analytical techniques that ignore the data from sample coupons it could readily test. Additionally, there is no scientific basis by which the Point Beach reactors should continue operating unless there is a complete physical analysis of the coupons from its reactors and the five other reactors that are its embrittled cohorts.

7.8.3. Therefore I conclude that Point Beach's continued operation violates 10CFR50 Appendix A, Criterion 14.

> Criterion 14—Reactor coolant pressure boundary. The reactor coolant pressure boundary shall be designed, fabricated, erected, and tested so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture.

7.8.4. During the last 50 years of operation, Point Beach has failed to develop an adequate coupon program to physically test the integrity of the RPV for PB's operational life. As defined in Appendix A Criterion 14, "testing" obviously does not include analytical techniques prone to error. There is inadequate coupon data specific to PB to justify its continued operation beyond its 50th year, let alone until it reaches 80. BP has been violating GDC 14 by not testing coupons and relying on analytical handwaving instead!

7.8.5. The NRC already knows the Point Beach reactor vessel to be the most embrittled vessel in the nation. PB was not "designed and fabricated… to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture." Thus the NRC's acknowledgment proves that the Point Beach reactors fail to meet Criterion 14.

8. **Waivers**

8.1. With Point Beach's first license renewal application to change from 40 to 60 years and its most recent license renewal application to operate from 60 to 80 more years, NextEra Corporation has not made any commitments to improve the reactors' physical condition to meet modern safety standards. Instead, NextEra is proposing to create a checklist at the Point Beach reactors that allows for periodically monitoring the degrading state of concrete, pipes, wires, and other systems designed to prevent radiation releases in a disaster that may occur at PB.

8.2. This is an important distinction. Point Beach was designed in 1965 with a design life of 40-years. In its latest application to operate for 80-years, PB is not

committing to meet any new safety criteria. Instead, PB agrees to monitor its mid-1960s design to identify any further degradation in a facility designed before the Nuclear General Design Criteria were implemented and before Nuclear Quality Assurance standards even existed.

8.3. Since there are no nuclear reactors older than 51 years old, PB's proposed monitoring and inspection program is an academic exercise that is not based upon physical or scientific data.

8.4. It is essential to ask what happens when an aging nuclear facility like PB uses this license extension inspection process and identifies material degradation exceeding its license extension commitments? When this occurs, the reactor owner asks for a *waiver* from the NRC to continue to operate even though it has failed to meet its extended license requirements.

8.5. As current reactors age beyond their original 40-year design life and the NRC approves 40-60 year license extensions, the waiver process allows these degrading and unsafe reactors to continue running even after inspections have identified degradation beyond anticipated levels. The NRC has never closed a nuclear facility when the initial extended inspection plan indicates an exceeded inspection parameter.

8.6. Granting a license extension based upon an academic analysis of potential degradation for 80 years of operation must not allow exceedances to be glossed over by future NRC waivers. When an energy corporation, like NextEra, exceeds its license extension plan, the NRC must commit to immediate plant closure.

9. **<u>Superpredator</u>**

9.1. Power plants that killed fish and other aquatic organisms were not regulated when the Point Beach reactors were commissioned and designed. There was no Environmental Protection Agency to promulgate regulations of cooling water

intake from and heated water discharges to Lake Michigan. The EPA finally recognized the thermal pollution effects from atomic reactors after Point Beach was already in operation.

9.2. Nuclear reactors are the least efficient means of electric production because they discharge more heat into the environment than any other electricity production method. The so-called iconic image of two giant hyperbolic cooling towers frequently defines atomic power plants. Cooling towers are associated with nuclear power plants (NPPs) because NPPs have the lowest Carnot Cycle Efficiency of any form of electric generation, meaning that atomic power reactors create a disproportionately large amount of waste heat for the electricity they produce when compared to coal, oil, and natural gas.

9.3. Cooling towers exist for two reasons: first, to prevent the entrainment and death of fish eggs and larva in the high temperatures that exist within the PB condensers, and second, to ensure the tremendous amount of waste heat *is not* discharged directly into Lake Michigan, where it can significantly damage aquatic species like spawning fish, plankton, and other biota upon which all marine species are dependent for survival. The environmental damage caused by the waste heat from Point Beach to the Lake Michigan ecosystem is staggering, making it a superpredator.

9.4. More stringent environmental laws are now in place than in 1965 concerning the discharge of waste heat, and those laws are effectively applied to stop license renewal at other NPPs that are destroying their cooling water source with their waste heat.

9.5. Significant public and State opposition requiring the use of cooling towers as a condition for any 20-year operating extension has already occurred at three U.S. atomic power reactor sites. Rather than spend the money necessary to retrofit those plants and install cooling towers as demanded by appropriate state water control authorities, the reactor owners chose to close the reactors.

9.6. Oyster Creek, located on Barnegat Bay in New Jersey and owned by Exelon Corporation, applied *successfully* for a 20-year license extension from the NRC in 2009 but was denied the ability to discharge its waste heat into the Bay at the State permit level. Environmental groups, the State of New Jersey, and Exelon then negotiated an agreement that the plant would close by 2019 rather than operate until 2029 with a 20-year license extension, and Exelon would not install cooling towers for Oyster Creek. Exelon chose to give up the additional 10-years of operation of Oyster Creek and those profits rather than installing cooling towers.

9.7. On January 9, 2017, Entergy Corp, the State of New York, and environmental groups agreed to close the Indian Point Units 2 and 3 nuclear reactors in 2020 and 2021 rather than install cooling towers for Entergy's proposed licensure venture. The negotiated settlement determined that Entergy would not build cooling towers during the last three and four years of proposed operation prior to Indian Point's final shutdown, and Entergy would not seek to operate either reactor beyond 2021.

9.8. The situation at Point Beach Units 1 & 2 is strikingly similar to the failed attempts at Oyster Creek and Indian Point Units 2 & 3 to continue to operate without cooling towers despite significant environmental damage. When environmental groups, state environmental boards, and state attorneys general oppose 20-year license extensions, most nuclear power plants in the U.S. do not successfully receive the final 20-year license extension. Back fitting a cooling system that will mitigate ongoing environmental damage from nuclear power waste heat is critical to saving aquatic life, fishing, and survival of lakes, rivers, and ocean bays for other important community and financial purposes.

9.9. Nukes are the most thermodynamically inefficient way of producing electricity (Carnot efficiency). As such, they discharge an enormous amount of waste heat (hot water), and they consume a massive amount of cold water.

9.10. The PB reactors were designed well before NEPA (the National Environmental Policy Act) when killing fish and other aquatic organisms were not a concern. More modern designs require cooling towers.

9.11. Hundreds of millions of gallons of cold lake water containing fish, millions of fish larva, and other aquatic organisms are removed from the lake, heated by 30 degrees in the condenser, and killed each day; hence PB is a superpredator.

9.12. Additionally, abnormally hot chemically treated water is discharged back into the lake every day, allowing non-native species that thrive on warmer water to invade Point Beach environs and multiply in Lake Michigan.

9.13. Other aging nukes were forced to install cooling towers to continue past their original 40-year licensure. Diablo Canyon, Oyster Creek, Indian Point, others and chose to close rather than protect the environment.

9.14. There is a solution to save the aquatic biome of Lake Michigan. Require NextEra to install cooling towers for the two Point Beach atomic reactors.

10. **Cost Of Alternatives**

10.1. The economic case presented by NextEra PB in the Environmental Reports to justify its continued operation is flawed.

10.2. Due to competitive pressures from renewable and sustainable energy, old operating nuclear plants no longer produce electricity at competitive prices.

10.3. While building new nuclear plants costs tens of billions of dollars, old nuclear plants like PB have almost no market value. Most recently, Entergy sold its 838 MWe Fitzpatrick nuclear plant in upstate New York to Exelon. The sale price was $110M, which included fresh nuclear fuel, 600 trained employees, and the

transfer of hundreds of millions of dollars to Exelon from the Fitzpatrick decommissioning fund.[18] Fitzpatrick was given away.

10.4. Even if the initial cost to build an atomic plant is zero, the operating cost (salaries, fuel, repairs) is more expensive than the renewable alternatives. As Amory Lovins frequently notes:

> Most U.S. nuclear power plants cost more to run than they earn. Globally, the *World Nuclear Industry Status Report 2019* documents the nuclear enterprise's slow-motion commercial collapse—dying of an incurable attack of market forces. Yet in America, strong views are held across the political spectrum on whether nuclear power is essential or merely helpful in protecting the Earth's climate—and both those views are wrong. In fact, building new reactors, or operating most existing ones, makes climate change worse *compared with spending the same money on more-climate-effective ways to deliver the same energy services.* Those who state as fact that rejecting (more precisely, declining to bail out) nuclear energy would make carbon reduction much harder are in good company, but are mistaken… Nuclear owners strive to beat coal and gas while their allies often disparage or suppress renewables. Yet most US nuclear plants are uneconomic just to run, so many are closing. To keep milking those old assets instead, their powerful owners seek and often get multi-billion-dollar bailouts from malleable state legislatures for about a tenth of the nuclear fleet so far, postponing the economic reckoning by shooting the market messenger.[19]

10.5. Because PB has entered into a very favorable power purchase agreement for itself and NextEra with the State of Wisconsin, Wisconsin ratepayers subsidize the Point Beach reactors.

10.6. Point Beach's Environmental Report ignores the option of replacing the reactors with wind turbines, whose total cost (install/operate) is much lower than the price just to continue to operate the Point Beach reactors. Additionally, installing wind power would be much safer for the environment and surrounding

[18] https://www.bizjournals.com/albany/news/2016/08/09/entergy-selling-upstate-nuclear-power-plant-for.html

[19] https://www.forbes.com/sites/amorylovins/2019/11/18/does-nuclear-power-slow-or-speed-climate-change/?sh=7b7c0a27506b

communities rather than continuing to operate old aging and unsafe atomic reactors way past the time they were designed to run.

10.7. Thus, PB's continued operation will increase the cost of power to consumers compared to if it were to be replaced by renewables.

10.8. PB's Environmental Report ignores the existing transmission lines emanating from the current facility that provides a significant economic incentive to build local wind farms.

10.9. While closing PB will involve job changes for the PB staff, the staff has the correct skill set such that the new robust wind industry will provide them with jobs if they choose to remain in the electric generation field and want to stay locally.

10.10. Wind farms to replace PB will provide economic incentives for struggling farmers through yearly payments to use their land. This incentive to local farmers more than offsets the effect of Point Beach's closure on the local community.

10.11. Wind farms create taxable assets to offset most of the taxes paid by the NextEra facilities.

10.12. Additional construction jobs will be created for half a decade as Point Beach is decommissioned and dismantled.

10.13. Electric rates in Wisconsin will be lower if renewable alternatives replace PB.

10.14. Replacing an atomic facility with renewables has already begun to happen at a recently closed nuclear reactor owned by NextEra in Iowa. In an article entitled "*Huge solar farm planned for decommissioned Duane Arnold nuclear plant site*", the *Iowa Gazette* outlines NextEra's plans to replace the aging nuclear plant with a 3,500-acre solar farm.

> For more than four decades, the name of former Cedar Rapids utility executive Duane Arnold has been synonymous with nuclear power in Iowa. Now it could have a new connotation: a massive solar energy project planned for 2023 near the now-idle Duane Arnold Energy Center… It is expected to produce up to 690 megawatts of solar energy — even more than the single-unit nuclear plant generated.[20]

11. In my opinion, closing NextEra Point Beach and installing renewable generation like wind and solar by using PB's existing transmission lines will lower electric rates in Wisconsin, create jobs, increase farmers' income, maintain the tax base, and create a more viable future for local communities.

–END–

Attachments:
Attachment 1 – Curriculum Vitae

I declare under penalty of perjury that the preceding is true and correct.

Executed this 23rd day, March 2021 in Charleston, South Carolina

_____/s/_____

Arnold Gundersen, Chief Engineer, Fairewinds Associates, Inc
MENE [Master Engineering Nuclear Engineering], RO [Reactor Operator]

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[20] https://www.thegazette.com/subject/news/business/duane-arnold-nuclear-plant-solar-farm-nextera-energy-palo-ia-20210318

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Arnold Gundersen 3/23/21

[20] https://www.thegazette.com/subject/news/business/duane-arnold-nuclear-plant-solar-farm-nextera-energy-palo-ia-20210318

Arnold Gundersen, Curriculum Vitae
Chief Engineer, Fairewinds Associates, Inc
March 2021

Education and Training

ME NE — Master of Engineering Nuclear Engineering
Rensselaer Polytechnic Institute, 1972
U.S. Atomic Energy Commission Fellowship
Thesis: Cooling Tower Plume Rise

BS NE — Bachelor of Science Nuclear Engineering
Rensselaer Polytechnic Institute, Cum Laude, 1971
James J. Kerrigan Scholar

RO — Licensed Reactor Operator, U.S. Atomic Energy Commission,
License # OP-3014

Patents

Energy Absorbing Turbine Missile Shield – U.S. Patent # 4,397,608 – 8/9/1983

Honors

U.S. Atomic Energy Commission Fellowship, 1972
B.S. Degree, Cum Laude, RPI, 1971, 1st in nuclear engineering class
Tau Beta Pi (Engineering Honor Society), RPI, 1969 – 1 of 5 in sophomore class of 700
James J. Kerrigan Scholar 1967–1971
Publicly commended to U.S. Senate by NRC Chairman, Ivan Selin, in May 1993 – "It is true...everything Mr. Gundersen said was absolutely right; he performed quite a service."

Expert Qualifications – including and not limited to:

- Chief Engineer, Fairewinds Associates, Inc, 2003 to present
- Nuclear Engineering, Safety, and Reliability Expert
- Federal and Congressional hearing testimony, Expert Witness testimony, Public Utility Commission Testimony, state legislative hearings, community stakeholder expert witness
- Vermont Community Research Fellow, University of Vermont
- Former Senior Vice President Nuclear Licensee
- Former Licensed Reactor Operator
- Atomic Energy Commission Fellow
- 50 years of nuclear industry experience and oversight

Publications

Co-author — *Radioactive Isotopes Measured at Olympic and Paralympic Venues in Fukushima Prefecture and Tokyo, Japan, Journal of Environmental Engineering Science* Volume 38, Number 2, 2021, Mary Ann Liebert, Inc., DOI: 10.1089/ees.2020.0139
Co-author with corresponding author Dr. Marco Paul Johann Kaltofen, Department of Physics, Worcester Polytechnic Institute (WPI), Worcester, MA, USA and Maggie Gundersen, Founder of Fairewinds Energy Education, Charleston, SC, USA.

Co-author — *Science of the Total Environment* (STOTEN) published a peer-reviewed article entitled: *Radioactively-hot particles detected in dusts and soils from Northern Japan by combination of gamma spectrometry, autoradiography, and SEM/EDS analysis and implications in radiation risk assessment*. Co-authored with Dr. Marco Kaltofen, Worcester Polytechnic Institute (WPI), it details the analysis of radioactively hot particles collected in Japan following the Fukushima Dai-ichi meltdowns. [http://www.sciencedirect.com/science/article/pii/S0048969717317953]

Published Lecture — *The Lessons of the Fukushima Daiichi Nuclear Accident* published in the *International Symposium on the Truth of Fukushima Nuclear Accident and the Myth of Nuclear Safety,* August 30, 2012 University of Tokyo, Iwanami Shoten Publishers, Tokyo, Japan

Published Lecture -- *Crisis Without End: The Medical and Ecological Consequences of the Fukushima Nuclear Catastrophe, from the Symposium at the New York Academy of Medicine, The New Press, 2014, Chapter 12, What Did They Know and When*

Author — *The Echo Chamber: Regulatory Capture and the Fukushima Daiichi Disaster, Lessons from Fukushima,* February 27, 2012, Greenpeace International

Author — *Fukushima Daiichi: Truth and The Way Forward,* Shueisha Publishing, February 17, 2012, Tokyo, Japan.

Co-author — *DOE Decommissioning Handbook, First Edition*, 1981-1982, invited author.

Presentations, Events, & Media (located @ end of CV)

Committee Memberships

Current member and founding member, Board of Directors, Fairewinds Energy Education Corp, 501(c)3

Vermont Yankee Public Oversight Panel, appointed 2008 by President Pro-Tem Vermont Senate

National Nuclear Safety Network – Founding Board Member

Three Rivers Community College – Nuclear Academic Advisory Board

Connecticut Low Level Radioactive Waste Advisory Committee – 10 years, founding member

Radiation Safety Committee, NRC Licensee – founding member

ANSI N-198, Solid Radioactive Waste Processing Systems

University Fellowship, Teaching, and Academic Administration

University of Vermont Community Research Fellow, appointed January 2016 through 2018

Community College of Vermont – Mathematics Professor – 2007 through Spring 2013

Rensselaer Polytechnic Institute (RPI) – Advanced Nuclear Reactor Physics Lab

Expert Witness Testimony and Nuclear Engineering Analysis and Consulting

Before The United States Of America Nuclear Regulatory Commission Office of The Secretary

Declaration Of Arnold Gundersen To Support The Motion To Reopen Proceeding And Request To Amend Contention By The Blue Ridge Environmental Defense League And Its Chapter Concerned Citizens Of Shell Bluff Regarding Southern Nuclear Operating Company's Request For A License Amendment And Exemption For Unit 3 Auxiliary Building Wall 11 Seismic Gap Requirements, Lar-20-001, December 7, 2020. In the Matter of the Southern Nuclear Operating Company License

Amendment Application for Combined License NPF-91 at the Vogtle Electric Generating Plant Unit 3. Docket No. 52-025-LA-3

Before The United States Of America Nuclear Regulatory Commission Office of The Secretary
In the Matter of the Southern Nuclear Operating Company License Amendment Application for Combined License NPF-91 at the Vogtle Electric Generating Plant Unit 3. Docket No. 52-025-LA-3
Declaration of Arnold Gundersen to Support The Petition For Leave To Intervene And Request For Hearing By The Blue Ridge Environmental Defense League And Its Chapter Concerned Citizens Of Shell Bluff Regarding Southern Nuclear Operating Company's Request For A License Amendment And Exemption For
Unit 3 Auxiliary Building Wall 11 Seismic Gap Requirements, Lar-20-001

Before the State of Vermont Public Utilities Commission, *Surrebuttal Testimony of Arnold Gundersen.* December 1, 2017. VTPUC Docket 8880, Joint Petition of NorthStar Decommissioning Holdings, LLC.

Before the State of Vermont Public Utilities Commission, *Testimony of Arnold Gundersen Supporting the New England Coalition: An Evaluation of The Financial Risks to Vermont In the Proposed Sale of The Entergy Nuclear Vermont Yankee Power Plant Site to NorthStar Decommissioning Holdings, LLC.* August 30, 2017. VTPUC Docket 8880, Joint Petition of NorthStar Decommissioning Holdings, LLC.

Before the United States District Court Northern District Of Illinois, *Steve Lawson And Darla Lawson, Other Similar Situated Individuals, Plaintiffs, Vs. General Electric, And Does 1-200, Defendants. Expert Witness Report by Arnold Gundersen, Prepared for Plaintiffs Attorney: Charles A. Bonner, Esq. Sb# 85413*. May 25, 2017. Analysis of radiation exposure to GE journeyman welder.

Before the Public Utilities Commission of The State of California – January 27, 2017 – *Prepared Direct Testimony of Arnold Gundersen of Fairewinds Associates, Inc., For San Luis Obispo Mothers for Peace* regarding the: Application of Pacific Gas and Electric Company for Approval of the Retirement of Diablo Canyon Power Plant, Implementation of the Joint Proposal, and Recovery of Associated Costs Through Proposed Ratemaking Mechanisms Application 16-08-006 (Filed August 11, 2016*)*

Nuclear Regulatory Commission Before the Secretary – May 2, 2016, – *Declaration of Arnold Gundersen To Support the Petition for Leave to Intervene And Request For Hearing By The Blue Ridge Environmental Defense League Regarding Southern Nuclear Operating Company's Vogtle Electric Generating Plant Units 3 And 4 Request For License Amendment And Exemption: Containment Hydrogen Igniter Changes (LAR-15-003)*
Fairewinds Energy Education Report Submitted to NRC in Response to an Advance Notice of Proposed Rulemaking for Regulatory Improvements for Decommissioning Power Reactors: – March 17, 2016, *The Nationwide Failures of Decommissioning Regulation: Decommissioning Trust Funds or Slush Funds?*

Fairewinds Energy Education Report Submitted to NRC for Public Comment to Staff Regarding the Decommissioning of the Vermont Yankee Atomic Reactor – March 23, 2015, *Vermont Yankee's Decommissioning as an Example of Nationwide Failures of Decommissioning Regulation*

NRC Before the Atomic Safety and Licensing Board (ASLB) – December 1, 2014, *Gundersen Declaration Palisades Embrittlement,* Docket No. 50-255, Entergy, Palisades, *Petition to Intervene*

and for A Public Adjudication Hearing of Entergy License Amendment Request for Authorization to Implement 10 CFR §50.61a, Alternate Fracture Toughness Requirements For Protection Against Pressurized Thermal Shock Events.

NRC Before the Commission – November 6, 2014, *Second Supplemental Declaration of Arnold Gundersen*, In the Matter of Florida Power & Light Co., Docket No. 50-389, St. Lucie Plant, Unit 2.

NRC Atomic Safety and Licensing Board (ASLB) – October 10, 2014 – *Diablo Canyon Nuclear Power Plant, Units 1 and 2 – Gundersen Affidavit Supporting Friends of the Earth's Petition to Intervene: In the matter of Pacific Gas & Electric Company Docket No. 50-275-LR & Docket No. 50-323-LR, License Renewal Application*.

NRC Hearing Request – *Declaration of Arnold Gundersen Supporting Hearing Request*, March 10, 2014 – retained by Southern Alliance for Clean Energy (SACE) in the matter of Florida Power & Light Co., Docket No. 50-389, St. Lucie Plant, Unit 2

NRC ASLB Proceeding Fermi Unit 3 52-033-COL – October 30, 2013 – Retained by Don't Waste Michigan, Beyond Nuclear et al, Oral Expert Witness Testimony regarding Contention 15: Quality Assurance.

State of Utah Seventh District Court of Emory County – September 25, 2013 – Retained by HEAL Utah et al as an expert witness testifying on cooling tower consumptive use of water for a proposed nuclear power plant owned by Blue Castle Holdings and located on the Green River. Defendants were Kane County Water Conservancy District.

Canadian Nuclear Safety Commission – May 29-30, 2013 – Retained by Durham Nuclear Awareness to present expert witness testimony in hearings regarding the proposed life extension for the Pickering Nuclear Station owned Ontario Power Generation.

Nuclear Regulatory Commission – May 30, 2013 – Expert witness report Before the Secretary NRC *in the Matter of Detroit Edison Nuclear Power Station: Rebuttal Testimony of Arnold Gundersen Supporting of Intervenors' Contention 15: DTE COLA Lacks Statutorily Required Cohesive QA Program.* Retained by Don't Waste Michigan, Beyond Nuclear et al.

Nuclear Regulatory Commission – May 20, 2013 – Expert witness report Before the Secretary NRC *in the Matter of Davis Besse Nuclear Power Station: Expert Witness Report of Arnold Gundersen to Support the Petition for Leave to Intervene and Request for Hearing by Beyond Nuclear, Citizens Environment Alliance Southwest Ontario Canada, Don't Waste Michigan, and The Sierra Club.* Retained by Beyond Nuclear, Citizens Environment Alliance Southwest Ontario Canada, Don't Waste Michigan, and The Sierra Club.

Nuclear Regulatory Commission – May 6, 2013 – Expert witness report Before the Secretary NRC: *Expert Witness Report of Arnold Gundersen to Support the Petition for Leave to Intervene and Request for Hearing by The Blue Ridge Environmental Defense League, Bellefonte Efficiency and Sustainability Team, And Mothers Against Tennessee River Radiation.* Retained by BREDL et al.

Nuclear Regulatory Commission – April 30, 2013 – Expert witness report to Atomic Safety and Licensing Board: *Testimony of Arnold Gundersen Supporting of Intervenors Contention 15: DTE*

Cola Lacks Statutorily Required Cohesive QA Program. Retained by Don't Waste Michigan, Beyond Nuclear et al.

Canadian Nuclear Safety Commission (CNSC) – April 29, 2013 – Expert witness report to Canadian Nuclear Safety Commission (CNSC): *Analysis of The Relicensing Application for Pickering Nuclear Generating Station*. Retained by Durham Nuclear Awareness.

Nuclear Regulatory Commission – January 16, 2013 – Expert witness presentation to NRC Petition Review Board: *2.206 Presentation San Onofre Units 2 and 3 Replacement Steam Generators Meeting with Petitioner Friends of the Earth, Requesting Enforcement Action Against Southern California Edison Under 10 CFR 2.206*

Expert Witness Report for Friends of The Earth – July 11, 2012 – *San Onofre's Steam Generators: Significantly Worse Than All Others Nationwide,* Fairewinds Associates, Inc

Expert Witness Report for Friends of the Earth – May 15, 2012 – *San Onofre Steam Generator Failures Could Have Been Prevented*, Fairewinds Associates, Inc

Expert Witness Report for Friends of the Earth – April 10, 2012 – *San Onofre Cascading Steam Generator Failures Created by Edison: Imprudent Design and Fabrication Decisions Caused Leaks,* Fairewinds Associates, Inc

Expert Witness Report for Friends of the Earth – March 27, 2012 – *Steam Generator Failures at San Onofre: The Need for A Thorough Root Cause Analysis Requires No Early Restart,* Fairewinds Associates, Inc

Expert Witness Report for Greenpeace – February 27, 2012 – *Lessons from Fukushima: The Echo Chamber Effect,* Fairewinds Associates, Inc

Nuclear Regulatory Commission – December 21, 2011 – Expert witness report to Atomic Safety and Licensing Board: *Prefiled Direct Testimony of Arnold Gundersen Regarding Consolidated Contention RK-EC-3/CW-EC-1 (Spent Fuel Pool Leaks)*

New York State Department of Environmental Conservation – November 15-16, 2011 – Expert witness report for Riverkeeper: hearing testimony regarding license extension application for Indian Point Units 2 and 3 – contention: tritium in the groundwater.

Nuclear Regulatory Commission – November 10, 2011 – Expert witness report entitled: *Fukushima and the Westinghouse-Toshiba AP1000, A Report for the AP1000 Oversight Group by Fairewinds Associates, Inc,* and Video. Submitted to NRC by the AP1000 Oversight Group.

Nuclear Regulatory Commission – October 7, 2011 – *Testimony to the NRC Petition Review Board Re: Mark 1 Boiling Water Reactors*, Petition for NRC to shut down all BWR Mark 1 nuclear power plants due to problems in containment integrity in the Mark 1 design.

New York State Department of Environmental Conservation – October 4, 2011 – *Prefiled Rebuttal Testimony of Arnold Gundersen On Behalf of Petitioners Riverkeeper, Inc., Scenic Hudson, Inc., And Natural Resources Defense Council, Inc. To The Direct Testimony of Matthew J. Barvenik (Senior Principal GZA Geoenvironmental, Inc.) Regarding Radiological Materials*

Southern Alliance for Clean Energy (SACE) submission to TVA Board of Directors – August 3, 2011– Expert witness report entitled: *The Risks of Reviving TVA's Bellefonte Project,* and Video prepared for the Southern Alliance for Clean Energy (SACE).

New York State Department of Environmental Conservation, July 22, 2011 – Prefiled Direct Testimony of Arnold Gundersen On Behalf of Petitioners Riverkeeper, Inc., Scenic Hudson, Inc., And Natural Resources Defense Council, Inc. Regarding Radiological Materials

Nuclear Regulatory Commission – May 10, 2011 – *Comment to the proposed rule on the AP1000 Design Certification Amendment Docket ID NRC-2010-0131 As noticed in the Federal Register on February 24, 2011* Retained by Friends of the Earth as Expert Witness.

Nuclear Regulatory Commission – May 10, 2011 – *Comment to the proposed rule on the AP1000 Design Certification Amendment Docket ID NRC-2010-0131 As noticed in the Federal Register on February 24, 2011* Retained by Friends of the Earth as Expert Witness.

NRC Advisory Committee on Reactor Safeguards (ACRS) – May 26, 2011 – Lessons learned from Fukushima and Containment Integrity on the AP1000.

Vermont Energy Cooperative (VEC) – April 26, 2011 – Presentation to the Vermont Energy Cooperative Board of Directors, *Vermont Yankee – Is It Reliable for 20 more years?*

Vermont State Nuclear Advisory Panel (VSNAP) – February 22, 2011 – Testimony and presentation entitled the *Vermont Yankee Public Oversight Panel Supplemental Report* regarding management issues at the Vermont Yankee Nuclear Power Plant to the reconvened Vermont State Nuclear Advisory Panel.

Vermont State Legislature Senate Committee on Natural Resources and Energy – February 8, 2011. Testimony: *Vermont Yankee Leaks and Implications*. (http://www.leg.state.vt.us/jfo/envy.aspx)

Vermont State Legislature – January 26, 2011 – House Committee on Natural Resources and Energy, and Senate Committee on Natural Resources and Energy – Testimony regarding Fairewinds Associates, Inc's report: *Decommissioning the Vermont Yankee Nuclear Power Plant and Storing Its Radioactive Waste* (http://www.leg.state.vt.us/jfo/envy.aspx). Additional testimony was also given regarding the newest radioactive isotopic leak at the Vermont Yankee nuclear power plant.

Vermont State Legislature Joint Fiscal Committee Legislative Consultant Regarding Entergy Nuclear Vermont Yankee – *Decommissioning the Vermont Yankee Nuclear Power Plant and Storing Its Radioactive Waste* January 2011. (http://www.leg.state.vt.us/jfo/envy.aspx).

U.S. Nuclear Regulatory Commission Advisory Committee on Reactor Safeguards (NRC-ACRS) AP1000 Sub-Committee – *Nuclear Containment Failures: Ramifications for the AP1000 Containment Design,* Supplemental Report submitted December 21, 2010. (http://fairewinds.com/reports)

Vermont State Legislature Joint Fiscal Committee Legislative Consultant Regarding Entergy Nuclear Vermont Yankee – *Reliability Oversight Entergy Nuclear Vermont Yankee, December 6, 2010.* Discussion regarding the leaks at Vermont Yankee and the ongoing monitoring of those leaks and ENVY's progress addressing the 90-items identified in Act 189 that require remediation. (http://www.leg.state.vt.us/jfo/envy.aspx).

U.S. Nuclear Regulatory Commission Atomic Safety and Licensing Board (NRC-ASLB) – *Declaration of Arnold Gundersen Supporting Blue Ridge Environmental Defense League's Contention Regarding Consumptive Water Use at Dominion Power's Newly Proposed North Anna Unit 3 Pressurized Water Reactor* in the matter of Dominion Virginia Power North Anna Power Station Unit 3 Docket No. 52-017 Combined License Application ASLBP#08-863-01-COL, October 2, 2010.

U.S. Nuclear Regulatory Commission Atomic Safety and Licensing Board (NRC-ASLB) – *Declaration of Arnold Gundersen Supporting Blue Ridge Environmental Defense League's New Contention Regarding AP1000 Containment Integrity on the Vogtle Nuclear Power Plant Units 3 And 4* in the matter of the Southern Nuclear Operating Company Vogtle Electric Generating Plant, Units 3&4 Combined License Application, Docket Nos. 52-025-COL and 52-026-COL and ASLB No. 09-873-01-COL-BD01, August 13, 2010.

Vermont State Legislature Joint Fiscal Committee Legislative Consultant Regarding Entergy Nuclear Vermont Yankee – July 26, 2010 – Summation for 2009 to 2010 Legislative Year for the Joint Fiscal Committee Reliability Oversight Entergy Nuclear Vermont Yankee (ENVY) Fairewinds Associates 2009-2010. This summary includes an assessment of ENVY's progress (as of July 1, 2010) toward meeting the milestones outlined by the Act 189 Vermont Yankee Public Oversight Panel in its March 2009 report to the Legislature, the new milestones that have been added since the incident with the tritium leak and buried underground pipes, and the new reliability challenges facing ENVY, Entergy, and the State of Vermont. (http://www.leg.state.vt.us/jfo/envy.aspx)

U.S. Nuclear Regulatory Commission Atomic Safety and Licensing Board (NRC-ASLB) – *Declaration of Arnold Gundersen Supporting Blue Ridge Environmental Defense League's Contentions* in the matter of Dominion Virginia Power North Anna Station Unit 3 Combined License Application, Docket No. 52-017, ASLBP#08-863-01-COL, July 23, 2010.

Florida Public Service Commission (FPSC)
Licensing and construction delays due to problems with the newly designed Westinghouse AP1000 reactors in *Direct Testimony in Re: Nuclear Plant Cost Recovery Clause by The Southern Alliance for Clean Energy (SACE)*, FPSC Docket No. 100009-EI, July 8, 2010.

U.S. Nuclear Regulatory Commission Advisory Committee on Reactor Safeguards (NRC-ACRS) AP1000 Sub-Committee – Presentation to ACRS regarding design flaw in AP1000 Containment – June 25, 2010 Power Point Presentation: http://fairewinds.com/content/ap1000-nuclear-design-flaw-addressed-to-nrc-acrs.

U.S. Nuclear Regulatory Commission Atomic Safety and Licensing Board (NRC-ASLB) – *Second Declaration of Arnold Gundersen Supporting Supplemental Petition of Intervenors Contention 15: DTE COLA Lacks Statutorily Required Cohesive QA Program* – June 8, 2010.

NRC Chairman Gregory Jaczko, ACRS, Secretary of Energy Chu, and the White House Office of Management and Budget – *AP1000 Containment Leakage Report Fairewinds Associates - Gundersen, Hausler, 4-21-2010.* This report, commissioned by the AP1000 Oversight Group, analyzes a potential flaw in the containment of the AP1000 reactor design.

Vermont State Legislature House Committee on Natural Resources and Energy – April 5, 2010 – Testified to the House Committee on Natural Resources and Energy – regarding discrepancies in Entergy's TLG Services decommissioning analysis. See *Fairewinds Cost Comparison TLG Decommissioning* (http://www.leg.state.vt.us/jfo/envy.aspx).

Vermont State Legislature Joint Fiscal Committee Legislative Consultant Regarding Entergy Nuclear Vermont Yankee – February 22, 2010 – The Second Quarterly Report by Fairewinds Associates, Inc to the Joint Legislative Committee regarding buried pipe and tank issues at Entergy Nuclear Vermont Yankee and Entergy proposed Enexus spinoff. See two reports: *Fairewinds Associates 2nd Quarterly Report to JFC* and *Enexus Review by Fairewinds Associates*. (http://www.leg.state.vt.us/jfo/envy.aspx).

Vermont State Legislature Senate Natural Resources – February 16, 2010 – Testified to Senate Natural Resources Committee regarding causes and severity of tritium leak in unreported buried underground pipes, status of Enexus spinoff proposal, and health effects of tritium.

Vermont State Legislature Senate Natural Resources – February 10, 2010 – Testified to Senate Natural Resources Committee regarding causes and severity of tritium leak in unreported buried underground pipes. http://www.youtube.com/watch?v=36HJiBrJSxE

Vermont State Legislature Senate Finance – February 10, 2010 – Testified to Senate Finance Committee regarding *A Chronicle of Issues Regarding Buried Tanks and Underground Piping at VT Yankee.* (http://www.leg.state.vt.us/jfo/envy.aspx).

Vermont State Legislature House Committee on Natural Resources and Energy – January 27, 2010 – *A Chronicle of Issues Regarding Buried Tanks and Underground Piping at VT Yankee*. (http://www.leg.state.vt.us/jfo/envy.aspx).

Submittal to Susquehanna River Basin Commission, by Eric Epstein – January 5, 2010 – *Expert Witness Report of Arnold Gundersen Regarding Consumptive Water Use of the Susquehanna River by The Proposed PPL Bell Bend Nuclear Power Plant* in the Matter of RE: Bell Bend Nuclear Power Plant Application for Groundwater Withdrawal Application for Consumptive Use BNP-2009-073.

U.S. Nuclear Regulatory Commission Atomic Safety and Licensing Board (NRC-ASLB) – *Declaration of Arnold Gundersen Supporting Supplemental Petition of Intervenors Contention 15: Detroit Edison COLA Lacks Statutorily Required Cohesive QA Program*, December 8, 2009.

U.S. NRC Region III Allegation Filed by Missouri Coalition for the Environment – Expert Witness Report entitled: *Comments on the Callaway Special Inspection by NRC Regarding the May 25, 2009*

Failure of its Auxiliary Feedwater System, November 9, 2009.

Vermont State Legislature Joint Fiscal Committee Legislative Consultant Regarding Entergy Nuclear Vermont Yankee – Oral testimony given to the Vermont State Legislature Joint Fiscal Committee October 28, 2009. See report: *Quarterly Status Report - ENVY Reliability Oversight for JFO* (http://www.leg.state.vt.us/jfo/envy.aspx).

Vermont State Legislature Joint Fiscal Committee Legislative Consultant Regarding Entergy Nuclear Vermont Yankee – The First Quarterly Report by Fairewinds Associates, Inc to the Joint Legislative Committee regarding reliability issues at Entergy Nuclear Vermont Yankee, issued October 19, 2009. See report: *Quarterly Status Report - ENVY Reliability Oversight for JFO* (http://www.leg.state.vt.us/jfo/envy.aspx).

Florida Public Service Commission (FPSC) – Gave direct oral testimony to the FPSC in hearings in Tallahassee, FL, September 8 and 10, 2009 in support of Southern Alliance for Clean Energy (SACE) contention of anticipated licensing and construction delays in newly designed Westinghouse AP 1000 reactors proposed by Progress Energy Florida and Florida Power and Light (FPL).

Florida Public Service Commission (FPSC) – NRC announced delays confirming my original testimony to FPSC detailed below. My supplemental testimony alerted FPSC to NRC confirmation of my original testimony regarding licensing and construction delays due to problems with the newly designed Westinghouse AP 1000 reactors in *Supplemental Testimony in Re: Nuclear Plant Cost Recovery Clause by The Southern Alliance for Clean Energy*, FPSC Docket No. 090009-EI, August 12, 2009.

Florida Public Service Commission (FPSC) – Licensing and construction delays due to problems with the newly designed Westinghouse AP 1000 reactors in *Direct Testimony in Re: Nuclear Plant Cost Recovery Clause by The Southern Alliance for Clean Energy (SACE)*, FPSC Docket No. 090009-EI, July 15, 2009.

Vermont State Legislature Joint Fiscal Committee Expert Witness Oversight Role for Entergy Nuclear Vermont Yankee (ENVY) – Appointment from July 2009 to May 2010. Contracted by the Joint Fiscal Committee of the Vermont State Legislature as an expert witness to oversee the compliance of ENVY to reliability issues uncovered during the 2009 legislative session by the Vermont Yankee Public Oversight Panel of which I was appointed a member along with former NRC Commissioner Peter Bradford for one year from July 2008 to 2009. At the time, Entergy Nuclear Vermont Yankee (ENVY) was under review by Vermont State Legislature to determine if it should receive a Certificate for Public Good (CPG) to extend its operational license for another 20-years. Vermont was the only state in the country that had legislatively created the CPG authorization for a nuclear power plant. Act 160 was passed to ascertain ENVY's ability to run reliably for an additional 20 years.

U.S. Nuclear Regulatory Commission – Expert Witness Declaration regarding Combined Operating License Application (COLA) at North Anna Unit 3 *Declaration of Arnold Gundersen Supporting Blue Ridge Environmental Defense League's Contentions* (June 26, 2009).

U.S. Nuclear Regulatory Commission – Expert Witness Declaration regarding Through-wall Penetration of Containment Liner and Inspection Techniques of the Containment Liner at Beaver Valley Unit 1 Nuclear Power Plant *Declaration of Arnold Gundersen Supporting Citizen Power's*

Petition (May 25, 2009).
U.S. Nuclear Regulatory Commission – Expert Witness Declaration regarding Quality Assurance and Configuration Management at Bellefonte Nuclear Plant *Declaration of Arnold Gundersen Supporting Blue Ridge Environmental Defense League's Contentions in their Petition for Intervention and Request for Hearing*, May 6, 2009.

Pennsylvania Statehouse – Expert Witness Analysis presented in formal presentation at the Pennsylvania Statehouse, March 26, 2009 regarding actual releases from Three Mile Island Nuclear Accident. Presentation may be found at: http://www.tmia.com/march26

Vermont Legislative Testimony and Formal Report for 2009 Legislative Session – As a member of the Vermont Yankee Public Oversight Panel, I spent almost eight months examining the Vermont Yankee Nuclear Power Plant and the legislatively ordered Comprehensive Vertical Audit. Panel submitted Act 189 Public Oversight Panel Report March 17, 2009 and oral testimony to a joint hearing of the Senate Finance and House Committee on Natural Resources and Energy March 19, 2009. http://www.leg.state.vt.us/JFO/Vermont%20Yankee.htm

Finestone v Florida Power & Light Company (FPL) (11/2003 to 12/2008) Federal Court – Plaintiffs' Expert Witness in United States District Court for the Southern District of Florida. Retained by Plaintiffs' Attorney Nancy LaVista, from Lytal, Reiter, Fountain, Clark, Williams, West Palm Beach, FL. Case# 06-11132-E. This case involved two plaintiffs in cancer cluster of 42 families alleging that illegal radiation releases from nearby nuclear power plant caused children's cancers. Production request, discovery review, preparation of deposition questions and attendance at Defendant's experts for deposition, preparation of expert witness testimony, preparation for Daubert Hearings, ongoing technical oversight, source term reconstruction and appeal to Circuit Court.

U.S. Nuclear Regulatory Commission Advisory Committee Reactor Safeguards (NRC-ACRS) – Expert Witness providing oral testimony regarding Millstone Point Unit 3 (MP3) Containment issues in hearings regarding the Application to Uprate Power at MP3 by Dominion Nuclear, Washington, and DC. (July 8-9, 2008).

Appointed by President Pro-Tem of Vermont Senate Shumlin (later elected as Vermont Governor) to Legislatively Authorized Nuclear Reliability Public Oversight Panel – To oversee Comprehensive Vertical Audit of Entergy Nuclear Vermont Yankee (Act 189) and testify to State Legislature during 2009 session regarding operational reliability of ENVY in relation to its 20-year license extension application. (July 2, 2008 to present).

U.S. Nuclear Regulatory Commission Atomic Safety and Licensing Board (NRC-ASLB) –Expert Witness providing testimony regarding *Pilgrim Watch's Petition for Contention 1 Underground Pipes* (April 10, 2008).

U.S. Nuclear Regulatory Commission Atomic Safety and Licensing Board (NRC-ASLB) – Expert Witness supporting *Connecticut Coalition Against Millstone in Its Petition for Leave to Intervene, Request for Hearing, And Contentions Against Dominion Nuclear Connecticut Inc.'s Millstone Power Station Unit 3 License Amendment Request for Stretch Power Uprate* (March 15, 2008).

U.S. Nuclear Regulatory Commission Atomic Safety and Licensing Board (NRC-ASLB) – Expert Witness supporting *Pilgrim Watch's Petition for Contention 1*: *specific to issues regarding the integrity of Pilgrim Nuclear Power Station's underground pipes and the ability of Pilgrim's Aging Management Program to determine their integrity*. (January 26, 2008).

Vermont State House – 2008 Legislative Session –

- House Committee on Natural Resources and Energy – Comprehensive Vertical Audit: *Why NRC Recommends a Vertical Audit for Aging Plants Like Entergy Nuclear Vermont Yankee (ENVY)*
- House Committee on Commerce – Decommissioning Testimony

Vermont State Senate – 2008 Legislative Session –

- Senate Finance – testimony regarding Entergy Nuclear Vermont Yankee Decommissioning Fund
- Senate Finance – testimony on the necessity for a Comprehensive Vertical Audit (CVA) of Entergy Nuclear Vermont Yankee
- House Committee on Natural Resources and Energy – testimony regarding the placement of high-level nuclear fuel on the banks of the Connecticut River in Vernon, VT

U.S. Nuclear Regulatory Commission Atomic Safety and Licensing Board (NRC-ASLB) – MOX Limited Appearance Statement to Judges Michael C. Farrar (Chairman), Lawrence G. McDade, and Nicholas G. Trikouros for the "Petitioners": Nuclear Watch South, the Blue Ridge Environmental Defense League, and Nuclear Information & Resource Service in support of *Contention 2: Accidental Release of Radionuclides, requesting a hearing concerning faulty accident consequence assessments made for the MOX plutonium fuel factory proposed for the Savannah River Site*. (September 14, 2007).

Appeal to the Vermont Supreme Court (March 2006 to 2007) – Expert Witness Testimony in support of *New England Coalition's Appeal to the Vermont Supreme Court Concerning: Degraded Reliability at Entergy Nuclear Vermont Yankee as a Result of the Power Uprate*. New England Coalition represented by Attorney Ron Shems of Burlington, VT.

State of Vermont Environmental Court (Docket 89-4-06-vtec 2007) – Expert witness retained by New England Coalition to review Entergy and Vermont Yankee's analysis of alternative methods to reduce the heat discharged by Vermont Yankee into the Connecticut River. Provided Vermont's Environmental Court with analysis of alternative methods systematically applied throughout the nuclear industry to reduce the heat discharged by nuclear power plants into nearby bodies of water and avoid consumptive water use. This report included a review of the condenser and cooling tower modifications.

U.S. Senator Bernie Sanders and Congressman Peter Welch (2007) – Briefed Senator Sanders, Congressman Welch and their staff members regarding technical and engineering issues, reliability and aging management concerns, regulatory compliance, waste storage, and nuclear power reactor safety issues confronting the U.S. nuclear energy industry.

State of Vermont Legislative Testimony to Senate Finance Committee (2006) – Testimony to the Senate Finance Committee regarding Vermont Yankee decommissioning costs, reliability issues, design life of the plant, and emergency planning issues.

U.S. Nuclear Regulatory Commission Atomic Safety and Licensing Board (NRC-ASLB) – Expert witness retained by New England Coalition to provide Atomic Safety and Licensing Board with an independent analysis of the integrity of the Vermont Yankee Nuclear Power Plant condenser (2006).

U.S. Senators Jeffords and Leahy (2003 to 2005) – Provided the Senators and their staffs with periodic overview regarding technical, reliability, compliance, and safety issues at Entergy Nuclear Vermont Yankee (ENVY).

10CFR 2.206 filed with the Nuclear Regulatory Commission (July 2004) – Filed 10CFR 2.206 petition with NRC requesting confirmation of Vermont Yankee's compliance with General Design Criteria.

State of Vermont Public Service Board (April 2003 to May 2004) – Expert witness retained by New England Coalition to testify to the Public Service Board on the reliability, safety, technical, and financial ramifications of a proposed increase in power (called an uprate) to 120% at Entergy's 31-year-old Vermont Yankee Nuclear Power Plant.

International Nuclear Safety Testimony – Ten Days advising the President of the Czech Republic (Vaclav Havel) and the Czech Parliament on their energy policy for the 21st century.

Nuclear Regulatory Commission (NRC) Inspector General (IG) – Assisted the NRC Inspector General in investigating illegal gratuities paid to NRC Officials by Nuclear Energy Services (NES) Corporate Officers. In a second investigation, assisted the Inspector General in showing that materially false statements (lies) by NES corporate president caused the NRC to overlook important violations by this licensee.

State of Connecticut Legislature – Assisted in the creation of State of Connecticut Whistleblower Protection legal statutes.

Federal Congressional Testimony –

- Publicly recognized by NRC Chairman, Ivan Selin, in May 1993 in his comments to U.S. Senate, "It is true...everything Mr. Gundersen said was absolutely right; he performed quite a service."
- Commended by U.S. Senator John Glenn, Chair NRC Oversight Committee for public – for testimony to NRC Oversight Committee

PennCentral Litigation – Evaluated NRC license violations and materially false statements made by management of this nuclear engineering and materials licensee.

Three Mile Island Litigation – Evaluated unmonitored releases to the environment after accident, including containment breach, letdown system and blowout. Proved releases were 15 times higher than government estimate and subsequent government report.

Western Atlas Litigation – Evaluated neutron exposure to employees and license violations at this nuclear materials licensee.

Commonwealth Edison – In depth review and analysis for Commonwealth Edison to analyze the efficiency and effectiveness of all Commonwealth Edison engineering organizations, which support the operation of all of its nuclear power plants.

Peach Bottom Reactor Litigation – Evaluated extended 28-month outage caused by management breakdown and deteriorating condition of plant.

Presentations, Events, & Media

- *Three Mile Island (TMI)* Presentations and Events, March 23 through March 27, 2019
  - *A Legacy of Lies,* PennState TMI 40th Commemoration Keynote, March 27, 2019, followed by 4-TV interviews, available on CSPAN
  - NBC TV Andrea Mitchell Interview, filmed 2019-3-26, aired March 28, 2019
  - Presentation Pennsylvania State House Rotunda, Harrisburg, PA*,* March 25, 2019
  - TMI Survivors Banquet, Keynote and Q&A, March 23, 2019
  - Media Interviews with WHP 21 (CBS), WGAL (NBC), WHP 27 (ABC)
  - Keynote Harrisburg Historical Society, keynote, Harrisburg, Pennsylvania March 23, 2019
- *The Fukushima Vogtle Connection,* hosted by Georgia Wand and Nuclear Watch South, March 9, 2019
- *Power Lines* Documentary Premier at Emory University, Atlanta, GA, October 2018
- CCTV, Nuclear Free Future TV with host Margaret Harrington, *Picking Up the Pieces from Atoms for Peace*, May 10, 2018
- CCTV, Nuclear Free Future TV with host Margaret Harrington, Nuclear Update with Fairewinds Energy Education - March 10, 2018
- Chicago, NIRS meetings and group presentations November 28 to December 4, 2017
- Radio Interviews, November 2017: David Goodman, October 25, 2017; Project Censored with Mickey Huff, November 2017
- Fukushima Prefecture, Japan, September 7-18, 2017, Arnie Gundersen and Dr. Marco Kaltofen, research and data review technical meeting with the Deputy Director General and the Senior Associate with the Japanese Atomic Energy Agency (JAEA). Trip to Japan was organized and funded by Fairewinds Energy Education.
- CCTV, Nuclear Free Future TV with host Margaret Harrington, *Fukushima, Three Mile Island, and Chernobyl,* March 30, 2017
- Radio Ecoshock, Alex Smith Interview*, Nuclear Power Is Not a Climate Change Solution,* January 26, 2017
- *38 Years and Five Meltdowns Later: The Real Lessons from TMI (Three Mile Island),* March 25, 2017, keynote presentation hosted by Three Mile Island Alert, Harrisburg, PA
- *Arnie Gundersen speaks with Margaret Prescod*, March 14, 2017, Sojourner Truth Radio, Pacifica Radio on the Sixth-Year Commemoration of the Fukushima Daiichi nuclear power disaster.
- *Arnie Gundersen interviewed on Radiation Rattles Robot in Fukushima, Newsday - BBC World Service*, High levels of nuclear radiation have forced a robot to cut short its investigations of the Fukushima reactor in Japan. The probe's mission was to clean a passage to enable further robotic exploration, February 10, 2017.
- *Extreme Nuclear Dangers, Radio Ecoshock host Alex Smith interviews Arnie Gundersen*, the relationship between the nuclear power industry and nuclear weapons development, February 2, 2017.

- *Arnie Gundersen Appears on Project Censored with Dan Simon, Ted Rall, and Maggie Gundersen,* November 27, 2016
- *Arnie Gundersen Appears on Solartopia's Green Power and Wellness Hour,* November 16, 2016
- *Nuclear Power Is Not "Green Energy": It Is a Fount of Atomic Waste,* Published in Truthout, November 14, 2016
- *Powerstruggle Sneak Preview Panel Discussion,* Northampton, MA (October 23, 2016) Brattleboro, VT (Nov 3, 2016), organized by Turning Tide Productions
- *Is Solar Power in Nuclear Disaster Exclusion Zones Advisable?* published in *The Bulletin of the Atomic Scientists*, September 15, 2016
- *CO2 Smokescreen Presentation,* Montreal, Canada, invited speaker at the World Social Forum at the University of Quebec at Montreal (August 8, 2016) & McGill University, (August 10, 2016)
- *Gendai Business Online* exclusive interview with Fairewinds Chief Engineer Arnie Gundersen entitled: *American nuclear expert warns: "There is a possibility that now in Fukushima recontamination is occurring."*, June 14, 2016.
- *Seacoast Anti-Pollution League Annual Meeting,* Seabrook, NH, organized by the Seacoast Anti-Pollution League, open to the public, May 16, 2016
- *Arnie Gundersen Appears on Project Censored with Medea Benjamin,* March 30, 2016
- *Pilgrim Coalition Decommissioning Forum*, Plymouth, MA, organized by the Pilgrim Coalition, March 23, 2016
- *Osaka Global Environment Forum 2016*, in Osaka City, Japan, organized by Choetsu Kiko Association of Osaka and Friends of the Earth, February 27, 2016
- *Peace Forum Presentation*, in Kobe City, Japan, organized by YMCA, UNICEF, and Kobe Cooperative, February 22, 2016
- *Nuclear and Human Beings after Fukushima Event*, in Hiroshima City, Japan organized by Hiroshima YMCA, and Hiroshima Cooperative HANWA (Hiroshima Alliance for Nuclear Weapons Abolition), February 20, 2016
- *Peace Event at Jimmy Carter Civic Center*, in Konu-town Miyoshi, Hiroshima, Japan organized by Peace Platform, February 17, 2016
- *Middlebury College Student Global Affairs Conference: Power and Protest*, Middlebury, VT at Middlebury College, invited speaker for a student organized event, January 22, 2016
- *Ready for the Big One? Diablo Canyon Earthquake Vulnerability*, San Luis Obispo, invited guest of the San Luis Obispo Mothers for Peace, December 2, 2015
- *Expect the Unexpected: Nuclear Power's Unlearned Lessons*, California Polytechnic Institute, December 1, 2015
- *World in Danger: From Fukushima to California*, University of California at Berkeley, in conversation with Joanna Macy, November 22, 2015
- *World in Danger: The Fukushima - California Connection*, Point Reyes Station, in conversation with Mary Beth Brangan, November 21, 2015
- *World in Danger: Fukushima,* Sonoma State University, in conversation with Majia Nadesan, November 18, 2015
- *Fukushima's Impact at Five Years,* World Uranium Symposium 2015: Fukushima Workshop, April 2015, Quebec, Canada
- *Did Tesla Just Kill Nuclear Power?* May 1, 2015, Article written by journalist Jeff McMahon for *Forbes Magazine* that captures the excitement and buzz surrounding Tesla's big announcement and Arnie's auspicious speech
- *Building New Nukes Would Make Global Warming Worse* April 30, 2015, Presentation at Northwestern University, Chicago, IL

- *Fairewinds' Report: Vermont Yankee's Decommissioning As An Example of Nationwide Failures of Decommissioning Regulation presented to the Senate Committee for Natural Resources and Energy* April 22, 2015, Presentation Vermont Statehouse, Montpelier, VT
- *An Economic Analysis of the Cost of Nuclear Power* April 14, 2015, Presentation at the World Uranium Symposium, Quebec City, Quebec, Canada, Keynote Speaker
- *Commemoration of Meltdown at Fukushima Daiichi: 4-Years Later* March 11, 2015, Presentation to the House of Commons in London, England
- *Should Nuclear Energy Be Expanded to Help Create a More Sustainable Future?* November 20, 2014, Invited guest speaker in Debate at Hofstra University
- *Radiation Knows No Borders* August 2, 2014, Invited speaker at The Wave Conference, Life Chiropractic West, San Francisco, CA
- *Thirty-Five Years and Five Meltdowns Later: The Real Lessons of Three Mile Island* March 28, 2014, Three Mile Island at 35 (TMI@35) Symposium at Penn State, Harrisburg, PA, Keynote Speaker
- *The Nuclear Renaissance? Is It Too Big To Fail?* November 20, 2013, University North Carolina, Chapel Hill, NC.
- *Speaking Truth to Power* October 22, 2013 – Clarkson University, Potsdam, NY
- *The United States at A Crossroads: Two Futures* October 17 2013, Global Forum, Waitsfield, Vermont
- *A Road Less Taken*: *Energy Choices for the Future* – October 16, 2013, Johnson State College, Johnson, Vermont.
- *Fukushima: Ongoing Lessons for Boston* – October 9, 2013 – Boston, Massachusetts State House. Speakers were Arnie Gundersen, Former Japanese Prime Minister Naoto Kan, Former NRC Chair Gregory Jaczko, Former NRC Commissioner Peter Bradford, and Massachusetts State Senator Dan Wolf.
- *Fukushima: Ongoing Lessons for New York* – October 8, 2013 – New York City 82nd Street YMCA. Speakers were Arnie Gundersen, Riverkeeper President Paul Galley, Former Japanese Prime Minister Naoto Kan, Former NRC Chair Gregory Jaczko, Former NRC Commissioner Peter Bradford, and Ralph Nader.
- *Fukushima: Ongoing Lessons for California* – June 4, 2013 – New York City 82nd Street YMCA. Speakers were Arnie Gundersen, Riverkeeper President Paul Galley, Former Japanese Prime Minister Naoto Kan, Former NRC Chair Gregory Jaczko, Former NRC Commissioner Peter Bradford, and Friends of the Earth Nuclear Campaigner Kendra Ulrich.
- *What Did They Know and When? Fukushima Daiichi Before and After the Meltdowns,* Symposium: The Medical and Ecological Consequences of the Fukushima Nuclear Accident, The New York Academy of Medicine, New York City, NY, March 11, 2013
- *A Mountain of Waste 70 Years High,* Presentation: Old *and New Reactors*, University of Chicago, December 1, 2012
- Congressional Briefing September 20, 2012; invited by Representative Dennis Kucinich
- Presentations in Japan August/September 2012: Presentation at University of Tokyo (August 30, 2012), Presentation at Japanese Diet Building (members of the Japanese Legislature - August 31, 2012), Presentation to citizen groups in Niigata (September 1, 2012), Presentations to citizen groups in Kyoto (September 4, 2012), Presentation to Japanese Bar Association (September 2, 2012), and Presentation at the Tokyo Olympic Center (September 6, 2012)
- Multi-media Opera: *Curtain of Smoke,* by Filmmaker Karl Hoffman, Composer Andrea Molino, and Dramatist Guido Barbieri, Rome, Italy (2012-5-21,22)
- Curtain of Smoke Symposium (2012-5-21), with Dr. Sherri Ebadi 2004 Nobel Laureate

- The Italian National Press Club Rome (2012-5-21) with Dr. Sherri Ebadi 2004 Nobel Laureate: the relationship between nuclear power and nuclear weapons,
- Radio 3 Rome (2012-5-21) Discussion of Three Mile Island and the triple meltdown at Fukushima Daiichi (Japan),
- Sierra Club Panel Discussions (2012-5-5): Consequences of Fukushima Daiichi with Paul Gunter and Waste Disposal with Mary Olson,
- Physicians for Social Responsibility Seattle (2012-3-17),
- Fukushima Daiichi Forum with Chiho Kaneko, Brattleboro, VT (2012-3-11),
- Physicians for Global Responsibility Vancouver (2012-3-11) Skype Video Lecture,
- University of Vermont (2 – 2011),
- Boston Nuclear Forum, Boston Library (6/16/11),
- Duxbury Emergency Management (6/15/11),
- Vermont State Nuclear Advisory Panel (VSNAP),
- New Jersey Environmental Federation (5/14/11),
- Press Conference for Physicians for Social Responsibility (5/19/11),
- St. Johnsbury Academy – Nuclear Power 101.

More than 200 Educational videos on nuclear safety, reliability and engineering particularly Fukushima issues. Videos may be viewed @ fairewinds.org (501c3 non-profit)

Expert commentary (hundreds of TV, radio, print media, and internet interviews): CNN (8), The John King Show (16), BBC, CBC, Russia Today, Democracy Now, Al Jazeera America, KPBS (Radio & TV) VPR, WPTZ, WCAX, WBAI, CCTV, NECN, Pacifica Radio, CBC (radio & TV) (4), Rachel Maddow Show, *Washington Post*, *New York Times*, *Tampa Bay Times, The Guardian*, *Bloomberg* (print & TV), *Reuters*, *Associated Press*, *The Global Post*, *Miami Herald*, *Orange County Times, LA Times, Al Jazeera* (print)*, The Tennessean*, The Chris Martinson Show, *Mainichi News*, TBS Japan, *Gendai Magazine*, NHK television, *Scientific American*. *Huffington Post* (Paris) named Fairewinds.com the best go to site for information about the Fukushima Daiichi accident (5/9/11).

Special Remediation Expertise:

Director of Engineering, Vice President of Site Engineering, and the Senior Vice President of Engineering at Nuclear Energy Services (NES) Division of Penn Central Corporation (PCC)

- NES was a nuclear licensee that specialized in dismantlement and remediation of nuclear facilities and nuclear sites. Member of the radiation safety committee for this licensee.
- Department of Energy chose NES to write *DOE Decommissioning Handbook* because NES had a unique breadth and depth of nuclear engineers and nuclear physicists on staff.
- Personally, I wrote the "Small Bore Piping" chapter of the DOE's first edition Decommissioning Handbook, personnel on my staff authored other sections, and I reviewed the entire Decommissioning Handbook.
- Served on the Connecticut Low Level Radioactive Waste Advisory Committee for 10 years from its inception.
- Managed groups performing analyses on dozens of dismantlement sites to thoroughly remove radioactive material from nuclear plants and their surrounding environment.
- Managed groups assisting in decommissioning the Shippingport nuclear power reactor. Shippingport was the first large nuclear power plant ever decommissioned. The decommissioning of Shippingport included remediation of the site after decommissioning.

- Managed groups conducting site characterizations (preliminary radiation surveys prior to commencement of removal of radiation) at the radioactively contaminated West Valley site in upstate New York.
- Personnel reporting to me assessed dismantlement of the Princeton Avenue Plutonium Lab in New Brunswick, NJ. The lab's dismantlement assessment was stopped when we uncovered extremely toxic and carcinogenic underground radioactive contamination.
- Personnel reporting to me worked on decontaminating radioactive thorium at the Cleveland Avenue nuclear licensee in Ohio. The thorium had been used as an alloy in turbine blades. During that project, previously undetected extremely toxic and carcinogenic radioactive contamination was discovered below ground after an aboveground gamma survey had purported that no residual radiation remained on site.

Additional Expert Qualifications – including and not limited to:

- Nuclear engineering management assessment, prudency assessment, contract administration, assessment and review
- Nuclear power plant licensing and permitting – assessment and review
- Decommissioning experience: including radioactive waste processes, storage issue assessment, and waste disposal
- Nuclear safety and risk assessment, source term reconstruction, dose assessments, criticality analysis, and thermohydraulic assessment (i.e. power plant steam generation)
- Systems engineering and structural engineering assessments
- Cooling tower operation, cooling tower plumes, thermal discharge assessment, and consumptive water use
- Technical patents, nuclear fuel rack design and manufacturing, and nuclear equipment design and manufacturing
- Reliability engineering, & aging plant management assessments, in-service inspection
- Employee awareness programs, whistleblower protection, and public communications
- Quality Assurance (QA) & records

Nuclear Engineering Experience 1970 to Present

Expert witness testimony in nuclear litigation and administrative hearings in federal, international, and state court and to Nuclear Regulatory Commission, including but not limited to: Three Mile Island, US Federal Court, US NRC, NRC ASLB, ACRS, and Petition Review Board, California Public Utilities Commission, Canadian Nuclear Safety Commission (CNSC), Diet (Parliament) Japan, House of Commons (UK), Vermont State Legislature, Vermont State Public Service Board, Vermont Public Utility Commission, Florida Public Service Board, Czech Senate, Connecticut State Legislature, Western Atlas Nuclear Litigation, U.S. Senate Nuclear Safety Hearings, Peach Bottom Nuclear Power Plant Litigation, and Office of the Inspector General NRC, and numerous Congressional Briefings and Hearings.

Nuclear Engineering, Safety, and Reliability Expert Witness 1990 to Present

- Fairewinds Associates, Inc – Chief Engineer, 2005 to Present
- Arnold Gundersen, Nuclear Safety Consultant and Energy Advisor, 1995 to 2005
- GMA – 1990 to 1995, including expert witness testimony regarding the accident at Three Mile Island.

Nuclear Energy Services, Division of PCC (Fortune 500 company) 1979 to 1990

Corporate Officer and Senior Vice President - Technical Services – Responsible for overall performance of the company's Inservice Inspection (ASME XI), Quality Assurance (SNTC 1A), and Staff Augmentation Business Units – up to 300 employees at various nuclear sites.

Senior Vice President of Engineering – Responsible for the overall performance of the company's Site Engineering, Boston Design Engineering and Engineered Products Business Units. Integrated the Danbury based, Boston based and site engineering functions to provide products such as fuel racks, nozzle dams, and transfer mechanisms and services such as materials management and procedure development.

Vice President of Engineering Services – Responsible for the overall performance of the company's field engineering, operations engineering, and engineered products services. Integrated the Danbury-based and field-based engineering functions to provide numerous products and services required by nuclear utilities, including patents for engineered products.

General Manager of Field Engineering – Managed and directed NES' multi-disciplined field engineering staff on location at various nuclear plant sites. Site activities included structural analysis, procedure development, technical specifications and training. Have personally applied for and received one patent.

Director of General Engineering – Managed and directed the Danbury based engineering staff. Staff disciplines included structural, nuclear, mechanical and systems engineering. Responsible for assignment of personnel as well as scheduling, cost performance, and technical assessment by staff on assigned projects. This staff provided major engineering support to the company's nuclear waste management, spent fuel storage racks, and engineering consulting programs.

New York State Electric and Gas Corporation (NYSE&G) — 1976 to 1979

Reliability Engineering Supervisor – Organized and supervised reliability engineers to upgrade performance levels on seven operating coal units and one that was under construction. Applied analytical techniques and good engineering judgments to improve capacity factors by reducing mean time to repair and by increasing mean time between failures.

Lead Power Systems Engineer – Supervised the preparation of proposals, bid evaluation, negotiation and administration of contracts for two 1300 MW NSSS Units including nuclear fuel, and solid-state control rooms. Represented corporation at numerous public forums including TV and radio on sensitive utility issues. Responsible for all nuclear and BOP portions of a PSAR, Environmental Report, and Early Site Review.

Northeast Utilities Service Corporation (NU) — 1972 to 1976

Engineer – Nuclear Engineer assigned to Millstone Unit 2 during start-up phase. Lead the high velocity flush and chemical cleaning of condensate and feedwater systems and obtained discharge permit for chemicals. Developed Quality Assurance Category 1 Material, Equipment and Parts List. Modified fuel pool cooling system at Connecticut Yankee, steam generator blowdown system and diesel generator lube oil system for Millstone. Evaluated Technical Specification Change Requests.

Associate Engineer – Nuclear Engineer assigned to Montague Units 1 & 2. Interface Engineer with NSSS vendor, performed containment leak rate analysis, assisted in preparation of PSAR

and performed radiological health analysis of plant. Performed environmental radiation survey of Connecticut Yankee. Performed chloride intrusion transient analysis for Millstone Unit 1 feedwater system. Prepared Millstone Unit 1 off-gas modification licensing document and Environmental Report Amendments 1 & 2.

Rensselaer Polytechnic Institute (RPI) — 1971 to 1972

Critical Facility Reactor Operator, Instructor – Licensed AEC Reactor Operator instructing students and utility reactor operator trainees in start-up through full power operation of a reactor.

Public Service Electric and Gas (PSE&G) — 1970

Assistant Engineer – Performed shielding design of radwaste and auxiliary buildings for Newbold Island Units 1 & 2, including development of computer codes.

Additional Publications (continued from front page)

Co-author — *Fairewinds Associates 2009-2010 Summary to JFC, July 26, 2010* State of Vermont, Joint Fiscal Office, (http://www.leg.state.vt.us/jfo/envy.aspx).

Co-author — *Supplemental Report of the Public Oversight Panel Regarding the Comprehensive Reliability Assessment of the Vermont Yankee Nuclear Power Plant July 20, 2010,* to the Vermont State Legislature by the Vermont Yankee Public Oversight Panel.

Co-author — The Second Quarterly Report by Fairewinds Associates, Inc to the Joint Legislative Committee regarding buried pipe and tank issues at Entergy Nuclear Vermont Yankee and Entergy proposed Enexus spinoff. See two reports: *Fairewinds Associates 2nd Quarterly Report to JFC* and *Enexus Review by Fairewinds Associates.*

Co-author — Fairewinds Associates, Inc *First Quarterly Report to the Joint Legislative Committee*, October 19, 2009.

Co-author — *Report of the Public Oversight Panel Regarding the Comprehensive Reliability Assessment of the Vermont Yankee Nuclear Power Plant*, March 17, 2009, to the Vermont State Legislature by the Vermont Yankee Public Oversight Panel.

Co-author — *Vermont Yankee Comprehensive Vertical Audit – VYCVA – Recommended Methodology to Thoroughly Assess Reliability and Safety Issues at Entergy Nuclear Vermont Yankee, January 30, 2008 Testimony to Finance Committee Vermont Senate.*

Co-author — *Decommissioning Vermont Yankee – Stage 2 Analysis of the Vermont Yankee Decommissioning Fund – The Decommissioning Fund Gap*, December 2007, Fairewinds Associates, Inc. Presented to Vermont State Senators and Legislators.

Co-author — *Decommissioning the Vermont Yankee Nuclear Power Plant: An Analysis of Vermont Yankee's Decommissioning Fund and Its Projected Decommissioning Costs*, November 2007, Fairewinds Associates, Inc.

Media Organizations - including and not limited to:

Featured Nuclear Safety and Reliability Expert (1990 to present) for Television, Newspaper, Radio, & Internet – Including, and not limited to: CNN: JohnKingUSA, CNN News, Earth Matters; DemocracyNow, NECN, WPTZ VT, WTNH, VPTV, WCAX, RT, CTV (Canada), CCTV Burlington, VT, CAN TV (Chicago Access), ABC, TBS/Japan, Bloomberg: EnergyNow, KPBS, Japan National Press Club (Tokyo), Italy National Press Club (Rome), The Crusaders, Front Page, Five O'Clock Shadow: Robert Knight, Mark Johnson Show, Steve West Show, Anthony Polina Show, WKVT, WDEV, WVPR, WZBG CT, Seven Days, AP News Service, Houston Chronicle, Christian Science Monitor, Reuters, The Global Post, International Herald, The Guardian, New York

Times, Washington Post, LA Times, Miami Herald, St. Petersburg Times, Brattleboro Reformer, Rutland Herald, Times-Argus, Burlington Free Press, Litchfield County Times, The News Times, The New Milford Times, Hartford Current, New London Day, Vermont Daily Briefing, Green Mountain Daily, EcoReview, Huffington Post, DailyKos, Voice of Orange County, AlterNet, Common Dreams, Gendai Media, Truthout, Progressive Radio Network, Project Censored and numerous other national and international blogs

Public Service, Cultural, and Community Activities

2008 to Present –Fairewinds Energy Education Corp 501(C)3 non-profit board member

2005 to Present – Public presentations and panel discussions on nuclear power safety, reliability, economics, waste disposal, and decommissioning at numerous universities and colleges in the US, Canada, and Japan – including: DePaul University, Plymouth State University, Northwestern University, Life Chiropractic West, Middlebury College, McGill University, Hofstra University, New York School of Medicine, Cal Poly, Sonoma State, Amherst College, University of Vermont, Vermont Law School, Tokyo University, and before the Nuclear Regulatory Commission in hearings, Federal Court, Town and City Select Boards, Legal Panels, Local Schools, and via National & International Media: Television, Radio, Print, & Internet.

2007-2008 – Energy Production – created concept of Solar Panels on Burlington High School; worked with Burlington Electric Department and Burlington Board of Education Technology Committee on Grant for installation of solar collectors for Burlington Electric peak summer use; Grant was developed with assistance from Senator Sanders.

Vermont State Legislature – Public Testimony to Legislative Committees regarding nuclear power and energy issues

NNSN – National Nuclear Safety Network, Founding Advisory Board Member, meetings with and testimony to the Nuclear Regulatory Commission Inspector General (NRC IG)

New York State Electric & Gas (NYSE&G) Speakers Club speaking about nuclear waste issues.

Northeast Utilities Representative Conducting Public Lectures on Nuclear Safety Issues with the Northeast Utilities Speakers Bureau

End

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the Matter of	)	Docket Nos. 50-266 and 50-301 NRC–2021–0021
NextEra Energy Point Beach, LLC	)	March 23, 2021
(Point Beach Nuclear Plant, Units 1 and 2)	)	
	)	

* * * * *

DECLARATION OF ALVIN COMPAAN, PH. D.

Under penalty of perjury, I, Alvin Compaan, declare as follows:

1. My name is Alvin Compaan. I reside in the Toledo, Ohio metropolitan area. I hold a Ph.D. in Physics from the University of Chicago and am a Professor Emeritus of physics from the University of Toledo. I presently am the President of Lucintech Inc., a research and development company with numerous patents in photovoltaics technology and thin-film neutron detectors. I have extensive academic and practical experience in photovoltaic solar power and its commercial applications both land-based and aerospace-based. I have been active in educating the public through TEDx and similar talks and through scientific presentations across the nation, State of Ohio, and to the Ohio legislature. I am the inventor of 12 patents in the area of solar and nuclear detectors and have authored more than 270 publications in refereed professional journals and conference proceedings. Between 1987 and 2009 at the University of Toledo I was the principal advisor to 20 Ph.D. and M.S. students and 13 postdoctoral fellows. My curriculum vitae is attached as Exhibit 7 to this Declaration.

2. I was asked by Physicians for Social Responsibility-Wisconsin to review the Environmental Report for NextEra Energy Point Beach, LLC's Point Beach Nuclear Plant, Units 1 and 2. What follows are my observations and conclusions, offered to a reasonable degree of scientific certainty based on my experience and relevant information sources.

The Case for Solar Electric Power to Replace Point Beach Nuclear

3. Contention: Solar Electric (Photovoltaic) Power. The Next Era Point Beach (hereinafter, NEPB) Environmental Report [*Applicant's Environmental Report Subsequent Operating License Renewal Point Beach Nuclear Plant Units 1 and 2*] fails to adequately evaluate the full potential for renewable energy sources, such as solar electric power or

photovoltaics (hereinafter "solar power"), to offset the loss of energy production from NEPB, and to make the requested license renewal action from 2030 to 2053 unnecessary. In violation of the requirements of 10 C.F.R. §51.53(c)(3)(iii) and of the GEIS § 8.1, the NEPB Environmental Report (§ 7.2) treats all of the alternatives to license renewal except for a) new nuclear, and b) the combination of natural gas combined cycle and 25MW on-site solar with battery storage as unreasonable and does not provide a substantial analysis of the potential for significant alternatives, such as a full solar power plus storage, in the Region of Interest for the requested relicensing period of 2030 to 2053. The scope of the Supplemental Environment Impact Statement (SEIS) is improperly narrow, and the issue of the need for NEPB as a means of satisfying demand forecasts for the relicensing period must be revisited due to dramatically-changing circumstances in the regional energy mix that are currently underway already during this decade of NEPB's remaining operating license (2013 to 2033), and can especially be expected to accelerate and materialize over two decades to come covering NEPB's requested license extension period extending to 2053.

4. Applicant Misconceptions Apparent in Solar Analysis in Environmental Report--The entire discussion of solar power in the NEPB application for renewal is reproduced below. This illustrates the shallow, cursory, and often out-of-date treatment of this very viable alternative to extending operation of NEPB to 80 years.

From: *NEPB Environmental Report (pp. 7-8, 7-9)*

7.2.2.2.2 Solar

Solar PV systems consist of interconnected PV cells that convert sunlight into electricity. Concentrated solar power (CSP) systems utilize mirrors to reflect and concentrate sunlight onto receivers to convert solar energy into thermal energy that in turn produces electricity. Solar PV can make use of both direct solar radiation and diffuse horizontal radiation, which is one reason PV is technically feasible in more areas of the United States than CSP technologies. The amount of direct and horizontal solar irradiation varies across the United States with northernmost states, including Wisconsin, experiencing the lowest annual solar irradiation in the United States. The annual average direct solar irradiation for Wisconsin is less than 4.0 to 4.4 kWh/m2/day and horizontal solar irradiance is less than 4.0 to 4.25 kWh/m2/day (NREL 2018a; NREL 2018b). The solar irradiance factors into the generating capacity of a facility. EIA estimated the generating capacity factor for solar generation for U.S. facilities at 30 percent (EIA 2020a); however, NEER estimated the generation capacity for the PB solar facility co-located with PBN to be 19.77 to 23.19 percent. (PB Solar 2019, Section 2.1). In contrast, the generation capacities of nuclear and natural gas-fired generation facilities are approximately 90 and 87 percent, respectively (EIA 2020a).

> Solar generation is intermittent by nature with no generation during nighttime hours. During the day, generation can fluctuate from hour to hour as solar irradiance varies. For a solar power facility to replace a baseload energy source, energy storage would have to be included for the solar facility. Energy storage technology has progressed in recent years, increasing the potential for solar facilities coupled with energy storage such as battery storage to mitigate solar's intermittent generation. For example, FPL has implemented a utility-scale battery storage facility to provide energy storage for one of its solar farms located in Florida (FPL 2019).
>
> A solar facility with the generating capacity to replace PBN's baseload generation would require a large amount of land and multiple sites. The Point Beach solar PV facility, a facility without energy storage, is approximately 565 acres with an installed capacity of 100 MW. (PB Solar 2019, Sections 1.1.1.3 and 2.1) The ratio of the acreage of the PB solar facility to its capacity can be used as a planning guide for the acreage needed to site a solar facility in Wisconsin. Using this ratio of 5.65 acres per 100 MW, the acreage needed for solar to replace PBN generation would be 6,780 acres. To consider solar as a replacement for a baseload energy source, battery storage, or other energy storage means, would have to be added at the facilities. Energy storage would require additional acreage. Due to the amount of solar generating capacity needed to replace the entire PBN baseload generation and the lower efficiencies in producing electricity from solar power versus nuclear power, the land acreage required to install solar generation would be significant. Depending on the location of the solar facilities, the land use disturbances could result in MODERATE to LARGE impacts on wildlife habitats, vegetation, land use, and aesthetics.
>
> Solar by itself is not considered a reasonable alternative for the replacement of the PBN generation because it cannot provide baseload energy. Solar with battery storage could be a reasonable alternative; however, its generation capacity is far less than nuclear generation. Furthermore, the solar generation capacity estimated for a Wisconsin location is also approximately two-thirds of that estimated by EIA as a U.S. average. The generation capacity would require the facilities to encompass more than 6,780 acres. Thus, discrete solar is an unreasonable alternative to the proposed action given that (1) solar must be coupled with energy storage to provide baseload energy; (2) the generation capacity of solar is significantly lower than other generation sources and lower still due to Wisconsin's solar irradiation levels; and (3) while solar coupled with energy storage could provide baseload energy, more than 6,780 acres would be converted to solar generation, which would result in significant impacts to wildlife habitats, vegetation, land use, and aesthetics at multiple sites. Solar with energy storage is a component of both combination alternatives and was not considered further as a discrete alternative due to the acreage requirements.

5. In the following discussion, we will introduce and support the following claims regarding misconceptions apparent in the above solar analysis in the Environmental Report of the NextEra Energy Point Beach Nuclear (hereinafter NEPB) License Renewal Application:

    a. <u>The NEPB Environmental Report fails to adequately assess the solar option</u>--We add comments and corrections to several details of the NEPB Environmental Report on the solar alternative. These include improved estimates for solar electricity production for modern solar panels based on the solar irradiation resource for Wisconsin. We use these to obtain an improved estimate of land area required to

fully replace NEPB with solar. We will show in subsequent claims that the NEPB's conclusion of "…MODERATE to LARGE impacts on wildlife habitats, vegetation, land use, and aesthetics" are wholly unsupported and should be assessed as MINIMAL.

b. Solar is low cost and available--The supply of modules is growing rapidly and cost of solar power has been falling dramatically so that today solar power is the lowest cost electricity in many regions of the U.S. and internationally. In contrast even with established nuclear, this declining cost curve provides a strong incentive to examine the solar option in detail.
c. Solar is suited to Wisconsin--Suitability of solar in the NEPB territory. NEPB's discussion of the solar resource appropriate for flat solar modules (kWh of sunlight per square meter per day) in Wisconsin is approximately valid but we have used a more appropriate estimation method that includes optimally tilted panels and the small losses that occur with inverters that convert DC to AC power
d. Land and rooftop space is readily available for Solar—In this section, we directly address NEPB's conclusion that discrete Solar must be rejected because of excessive "acreage requirements" and consequent impacts on "wildlife habitats, vegetation, land use, and aesthetics."
e. Several excellent options are available for energy storage--A variety of energy storage technologies is available today to balance the intermittency of solar. These include pumped hydroelectricity and battery storage. We choose to focus on battery storage since the technology of large-scale batteries for electricity energy storage has been improving rapidly and the costs have been dropping quickly. This makes solar plus battery storage a very attractive and adaptable alternative to replace NEPB nuclear power
f. Solar + Storage is scalable and adaptable--Modern electricity usage requires adaptability which Solar + storage is ideally suited to provide much better than baseload nuclear. Solar power is an intermittent power source, as discussed in the NEPB Environmental Report, however, the delivery of solar power closely follows the time-of-day demand curve, which can mitigate some of the need for baseload power.
g. Solar has minimal environmental impacts--Solar has extremely low environmental impacts even compared with existing nuclear plants. Nuclear power from existing nuclear plants is often considered to be carbon free but this is not true when the complete fuel cycle of nuclear power is considered. Actually, solar power has a CO_2 footprint that is smaller than the full fuel chain of nuclear, even for existing nuclear power plants such as NEPB.

a. The NEPB Environmental Report fails to adequately assess the solar option.

6. Solar panels collect energy directly from the sun but also light energy indirectly scattered from clouds and the blue sky. For Wisconsin the optimum solar energy collection, averaged over a year, occurs with panels facing south and tilted about 30 degrees from

the horizontal. This maximizes energy collection over the year. We have used NREL's online PV Watts Calculator to calculate typical power produced from standard solar panels, after converting to alternating current by inverters. [https://pvwatts.nrel.gov/] This analysis shows that for Wisconsin, a capacity factor for solar of 20% is reasonable, as suggested in the NEPB Environmental Report. The NEPB report also does not discuss the derating of typically 14% in converting DC solar power to AC power. Our calculation using PV Watts includes this. We do agree with the NEPB report on the need for electricity energy storage to create baseload power and we calculate this storage requirement.

7. NEPB used the PB Solar facility example to estimate required land area of 565 acres per 100 MW of solar. (The stated 5.65 acres per 100 MW is a typo; it should be 5.65 acres per 1 MW. However, the calculated result of needing 6780 acres for a 1200 MW peak solar facility is about right.) Recent industry experience near Minneapolis showed 5.0-5.4 acres per MW for fixed rack solar and 6 acres for single-axis tracking mounts. [conversation with Brian Burandt, V.P. Power Supply and Business Development, Connexus Energy https://www.connexusenergy.com/]

8. However, we strongly disagree with the conclusion stated in the final paragraph on p. 7-9 which states: "Thus, discrete solar is an unreasonable alternative to the proposed action [second license renewal]…and was not considered further as a discrete alternative due to the acreage requirements." (emphasis added). In Claim 3 below, we complete the calculation of solar power and estimated land area needed to establish solar + storage as a baseload replacement for 1200 MW of baseload power and show that land and rooftop space entirely located in Wisconsin is not a constraint for the solar + storage alternative.

9. Consequently, we argue that the NEPB Environmental Report is seriously deficient in its consideration of solar power as a viable alternative power source for NEPB customers. The full rationale for this conclusion is elaborated in Claims **b** through **g** below.

b. Solar is low cost and available

10. Many utilities and electricity generators have seen the rapid drop in costs for solar panels and have recognized the opportunities associated with solar electricity for feeding power into the electricity grid. The attached chart (Exhibit 1) presents the experience curve for PV module prices since 1976. Experience curves plot price vs. cumulative production on logarithmic scales with several years highlighted on the graph. [Ketan Joshi in Cosmos Newsletter April 16, 2017, https://cosmosmagazine.com/technology/hurdles-on-the-path-to-a-solar-powered-world/] Note the price drop from $3.00/watt in 2008 to $0.25/watt in 2020. This stunning drop in price in the worldwide market is a major reason for the rise in installations of solar systems in the last decade. Solar now often provides the cheapest source of electricity to the consumer.

11. As manufacturing volume increases and price drops, solar systems have become the generation technology of choice for U.S. utilities and consumers. This is illustrated in Exhibit 2 which shows the electricity capacity additions to the U.S. electrical grid between 2010 and 2020. The data show that for many of the last five years solar systems accounted for the largest amount of additions to the electrical grid capacity. Solar accounted for 43% of all additions to the grid in 2020. The increase in solar is larger than for wind and also for natural gas, with coal and nuclear accounting for negligible additions.

12. To appreciate the scale and rate of growth in the amount of solar which has been added to the US electricity grid in recent years, consider Exhibit 3 which provides historical data and projections on three different types of solar installations: large utility-scale installations, medium size commercial rooftop installations, and smaller residential rooftop installations. The total amount of solar generation capacity added in 2020 was approximately 20,000 megawatts or 20 gigawatts. Note that total U.S. solar installations in 2020 are many times larger than the 1.2 GW power output of the Point Beach Nuclear generating facility. This demonstrates that the manufacturing supply and installation capacity for solar systems could easily accommodate the installation of solar that could replace Point Beach Nuclear facility by 2030 or 2033. The data of Exhibit 3 also confirm the consistent growth rate of 30% to 40% annually, and that growth is projected to continue over the next decade.

13. To appreciate the rate of growth of solar in the United states and its potential impact on the utility industry, we quote from a report appearing in Greentech Media on March 12, 2021. This is from an analysis of a market report by Collin Smith of the firm Wood MacKenzie: [https://www.greentechmedia.com/articles/read/so-big-its-boring-the-rise-of-utility-scale-solar?utm_medium=email&utm_source=Daily&utm_campaign=GTMDaily]

> "In the second quarter of 2020, the U.S. hit 50 gigawatts of cumulative operating utility solar, without much pause to consider how momentous a milestone it was. In 2011, utility solar reached 1 gigawatt. It took roughly nine years for the country to hit 50 gigawatts, but now it's on track to reach 100 gigawatts by the end of 2023. Under Wood Mackenzie's current forecast, U.S. utility solar will surpass 250 gigawatts by 2029 and reach more than 1 terawatt of utility PV somewhere between 2042 and 2045."

c. Solar is suited to Wisconsin and the NEPB territory.

14. It is commonly believed that the desert southwest is the only region of the U.S. for which solar systems are economically viable for grid electricity and that northern states including Wisconsin are not attractive for solar power. There is some truth to the belief that the most promising geographic area for the expansion of PV systems is the West; however, dismissing the potential of solar in Wisconsin is based on a common misperception that solar energy from flat modules, the most common type of photovoltaic panel, is only generated from direct (clear sky) radiation from the sun, so-called "direct solar" irradiance.

However, all flat panel modules collect light quite well over much of the sky, which is particularly important on cloudy and partly cloudy days. Thus, the appropriate measure of photovoltaic solar energy production is the full-sky or global irradiance, not just the direct solar irradiance. To illustrate this, Exhibit 4 gives the NREL map of global solar irradiance for the U.S. Note that more than half of Wisconsin has annual global solar irradiance as good as the northern tip of California, and only 10% less than northern Florida and eastern Texas. Exhibit 4 also shows that the ratio of global solar irradiance in southern California or west Texas to southern Wisconsin is about 1.25, so that a southern Wisconsin system will generate 80% of the annual energy of the same size system in some of the best locations in the U.S.

15. At the state level, California, Texas, and Florida have recognized the benefits of solar and have moved aggressively to promote solar. This is illustrated by the table of Exhibit 5 which is taken from Wood Mackenzie's U.S. Solar Market Insight Report 2020 available at: www.woodmac.com/research/products/power-and-renewables/us-solar-market-insight/. All three states installed about 3,000 MW of solar just in the year 2020. This is a peak power 2.5 times the power of Point Beach Nuclear.

16. To be accurate about the annual energy production of solar in Wisconsin, we have used the modeling program from the National Renewable Energy Laboratory (NREL), NREL's PV Watts (https://pvwatts.nrel.gov/) to determine the energy production near Madison and near Green Bay. Energy production was calculated for ground-mounted arrays facing south tilted at 30 degrees above horizontal. This is close to the optimum configuration. The PV Watts model includes typical inverter efficiency and therefore calculates the annual AC energy output for a 1.0 MW(DC) array of 1,357 MWh for Madison and 1,380 MWh for Green Bay. When the Green Bay output is averaged over 24 hr x 365 days (=8760 hr), the average output per hour is 0.157 MW (alternating current power from the inverter). Thus to replace the baseload 1200 MW Point Beach Nuclear with solar system(s) requires a total solar system(s) capacity of

(1200 MW/0.157 MW) x 1 MW (peak) = 7643 MW (peak DC).

17. Assuming a typical land area requirement of 5.5 acres/MW, we estimate the total land area needed for these solar systems would be 42,000 acres. In one giant array, this would occupy 65.7 square miles or a square 8.1 miles per side. This array size seems prohibitive, but in the following section (Claim **d**) we discuss several options for configurations that are eminently reasonable including commercial and residential rooftops, as well as using non-farmed land from the U.S. Conservation Reserve Program which totals nearly 100,000 acres in Wisconsin.

18. Solar technology is already proven for Wisconsin. Relatively large solar farms are already successfully operating in the state. As of May 2020, BlueEarth Renewables alone was operating 23 MW of solar farms in Wisconsin with sizes ranging from 1.1 MW to 7.45 MW. [https://blueearthrenewables.com/projects/butter-solar-projects/] In addition, on

March 17, 2021, three of Wisconsin's largest utilities announced plans to spend $446 million on a second large-scale solar farm with battery storage. [Wisconsin utilities planning second large solar-plus-storage project : Institute for Energy Economics & Financial Analysis] The 250 MW solar field would occupy about 2000 acres and include battery storage with capacity of 300 MWh.

19. It is clear that utility operators, municipal authorities, as well as large numbers of merchant businesses and homeowners recognize the value of moving to renewable electricity generation from solar including adding a storage option with batteries. It is now appropriate to consider carefully some of the most attractive places for locating that solar.

d. Land and rooftop space is readily available for solar in Wisconsin

20. Preceding claims have established that solar power is a very viable replacement for Point Beach Nuclear power for several reasons: 1) Solar is one of the cheapest options for providing electricity and the costs are continuing to decline. 2) Manufacturing capacity is easily capable of supplying quantities needed for full replacement of the Point Beach Nuclear capacity. And 3) solar radiation in Wisconsin is completely sufficient for the needed solar generation. In addition to these major benefits, however, it is important to consider where the solar modules can be located and have minimal environmental impact, even though in general, the environmental impact of solar is very low. In this section, we consider two opportunities for the location of solar to illustrate solar's adaptability. Note that solar is not constrained by needing access to cooling water. The first opportunity is to place solar on commercial and residential rooftops. The second opportunity is to place solar on farmland which is already set aside from production and is participating in the US Conservation Reserve Program.

21. The National Renewable Energy Laboratory has recently built a modeling tool to determine the available rooftops which are oriented properly and free of shading and other obstructions to serve as suitable locations for solar rooftop installations. This tool is called the State and Local Planning for Energy or SLOPE. [https://www.energy.gov/eere/slsc/downloads/state-and-local-planning-energy-slope-platform-overview] For the State of Wisconsin, this tool shows that residential rooftops could provide suitable space for average generation (over 24 hours) of 1382 MW of solar electric (total annual energy generation of 12,111,240 MWh). Commercial rooftop space suitable for solar panels could deliver average generation of 1760 MW (total annual energy generation of 15,415,280 MWh). For comparison, PB Nuclear operating at 1200 MW for a full year of 8760 hours would generate a total electric energy of 10,512,000 MWh. Thus, we observe that the SLOPE tool demonstrates that either residential rooftops alone or commercial rooftops alone could host solar panels sufficient to cover all of the yearly electricity energy output of the PB Nuclear.

22. A second attractive location for placing solar modules, perhaps the most attractive, would

be to place the modules on land which has already been removed from active producing farmland and set aside in the US Conservation Reserve Program. Almost 100,000 acres in Wisconsin are currently enrolled in the conservation program. Using the ratio of 5.5 acres per 1 megawatt of solar, the Conservation Reserve Program land in Wisconsin could accommodate more than 18,000 MW of solar generation power. At a capacity factor of 20%, this 18,000 MW of solar peak power would generate a total electric energy per year of 31,536,000 MWh or three (3) times the annual energy output of PB Nuclear. This opportunity and other benefits of using conservation program land for solar have been analyzed in detail by the organization, Renew Wisconsin.

23. Renew Wisconsin states: https://www.renewwisconsin.org/solar-and-agricultural-land-use/

> ***Farm Land: Energy Production & Conservation***
>
> Our research turned up another unexpected fact: many farmers today are already in the energy production business. About 37% of the corn already grown in Wisconsin is used for ethanol, a common form of biofuel. Another way to look at this is that more than one million acres of farmland are allocated each year, on average, for the production of corn for biofuel.
>
> If just 11% of that land was allocated for solar PV, rather than ethanol production, we would generate enough power to supply 50% of our state's electricity demand exclusively from solar. Incorporating solar onto the farm is simply another form of Wisconsin-made energy that farmers can provide our state.
>
> Not only would the footprint of land to meet 50% of our electricity needs be small relative to other uses, it is a more efficient use of land as well. One acre of corn produces enough ethanol for an E15 vehicle to travel about 11,000 miles over the course of a year. One acre of solar PV provides enough energy equivalent to power 715,000 miles worth of battery electric vehicle travel.
>
> It is also worth keeping in mind that federal taxpayers are already paying to take cropland out of production through the U.S. Conservation Reserve Program. Today in Wisconsin, nearly 100,000 acres are not being farmed in order to preserve the land, but also to reduce the total amount of crops produced in order to manage oversupply.
>
> Farmland preservation programs require subsidy through tax dollars paid to the federal government. In contrast, utility-scale solar projects provide very similar land preservation and conservation benefits as the Conservation Reserve Program, but do not require taxpayer dollars. In fact, they inject money into the host communities through host lease payments, the county and municipal aid distribution formula and utility aid distribution formula found under Wisconsin's Shared Revenue Formula, and increased local spending.

24. To summarize this Claim on where to place the large amount of solar needed to replace PB Nuclear, we have provided two examples: one for rooftops and a second for Conservation Reserve land. However, these are only two examples. In general, a mixture of lo-

cations is likely to be the best solution. That would include traditional solar farms from 10 to 100 megawatts or more each, high voltage power line transmission easements, awnings, parking lot canopies, landfills, brownfields, and on highway rights-of-way, as well as rooftop installations and installations on Conservation Reserve land. The beauty of solar generation is that it is adaptable to a wide variety of configurations. Furthermore, on Conservation Reserve Land, landfills, brownfields, easements, and rights-of-way, the ground under the solar modules can be used for growing native grasses and other wildlife habitat, further reducing the already low environmental footprint.

e. Several excellent options are available for energy storage

25. The intermittency of solar and its related low capacity factor of ~20% means that energy storage is very important for solar to be a replacement for the baseload power from PB Nuclear. It must be pointed out, however, that nuclear plants do not have a 100% capacity factor but under ideal conditions must periodically be shut down for refueling. Other events or "excursions" often lead to additional shutdowns so that the nominal baseload power is not always available; Typically the nuclear plant capacity factor is about 90%. This means that the utility grid must be able to fill in for the periods when refueling and other outages occur and nuclear power is not available. These outages may extend for several weeks.

26, Furthermore, nuclear plants are unable to follow the demand curve of usage which typically peaks in the daytime and is very low at night. In the 1970's when several nuclear plants were built in Michigan, the utilities also constructed a pumped-water energy storage facility on the top of a dune near Ludington. This pumped hydro facility allowed Detroit Edison to send excess power from their Fermi II reactor more than 200 miles across the State of Michigan at nighttime to the Ludington facility to pump water from Lake Michigan to be released during daytime hours when peak demand occurs. The installation of new, more powerful turbines at the Ludington facility is scheduled for completion in 2021 to allow the facility to continue to serve nuclear plants as well as the increasing solar and wind installations in Michigan. [https://en.wikipedia.org/wiki/Ludington_Pumped_Storage_Power_Plant] (Note that the distance from Point Beach Nuclear plant to Ludington is only 60 miles across Lake Michigan.)

27. This example illustrates that variable demand, intermittent output from power plants is an issue that generators and utilities have dealt with for many years. Storage of energy is not new even for electricity which is generally difficult to store. In 2020 there are several different technologies that can be used to store utility-scale electricity. These include pumped hydro, underground compressed air energy storage [https://www.sciencedirect.-com/science/article/pii/B9780128034408000063], electrolysis of water to produce hydrogen, and battery storage. In this Claim we will focus on battery energy storage which is becoming increasingly popular in combination with solar and wind. This battery technology is continually improving, and costs are dropping rapidly.

28. One example of the complementarity between large-scale battery storage and large-scale solar is the power plant now under construction by Florida Power and Light, which is a

subsidiary of NextEra Energy, the owner of Point Beach Nuclear. This FPL project now under construction was highlighted recently by Energy Storage News. [https://www.energy-storage.news/news/work-begins-on-409mw-900mwh-florida-battery-project-to-ease-natural-gas-pla]

29. An excerpt from the February 2, 2021, article follows:

> Construction work has begun in the US on what is claimed to be the world's biggest solar-charged battery storage project, by utility company Florida Power & Light (FPL).
>
> FPL, which is a subsidiary of major US power producer NextEra Energy, announced its plans for the 409MW / 900MWh project, FPL Manatee Energy Storage Center in Manatee County, Florida, back in March 2019. The battery energy storage system (BESS) is co-located with FPL's existing Manatee Solar Energy Center ground-mounted solar PV plant and is expected to be up and running towards the end of this year.
>
> The BESS is being deployed by the utility along with a number of smaller solar and energy storage projects nearby to enable to retirement of two ageing natural gas plants built in the 1970s, which have a combined generation capacity of over 1,600MW. FPL said that in addition to resulting in carbon dioxide emissions reductions, the Manatee battery project will also save its customers some US$100 million over the lifetime of the project by offsetting fuel costs and running on sunshine.

30. The worldwide numbers for battery energy storage deployed in 2020 show 3500 MWh of batteries installed usually with solar or wind. This report is from Wood MacKenzie and the U.S. Energy Storage Association (ESA). We quote from the article: [https://www.renewableenergyworld.com/storage/new-energy-storage-deployment-topped-record-3500-mwh-in-2020-esa-report-shows/]

> "2020 is the first year that advanced energy storage deployments surpassed gigawatt scale—a tremendous milestone on the path to our aspiration of 100 GW by 2030," said Jason Burwen, U.S. Energy Storage Association Interim CEO. "With continuing storage cost declines and growing policy support and regulatory reform in states and the federal government, energy storage is on an accelerating trajectory to enable a resilient, decarbonized, and affordable electric grid for all."

31. In conclusion, it should be clear that with recent advances in battery storage technology, increasing manufacturing scale, and reductions in costs, battery energy storage is a very viable option to combine with solar to provide a durable and reliable solution to the limited capacity factor of solar.

f. Solar + Storage is scalable and adaptable

32. The time period for this subsequent license renewal application for Point Beach Nuclear extends from 2030 to 2050 and in this period of time it is quite likely that requirements for electricity generation on the grid will change dramatically. In general, modern electricity usage requires adaptability which Solar + Storage is ideally suited to provide, much better than baseload nuclear. The increasing adoption of energy efficiency

standards and incentives, increasing adoption of wind and solar, and demand-side management, will all have important effects on the demand curve for electricity.

33. One example of this type of change is shown by recent demand in the California ISO. California has been a leader in providing incentives for adoption of wind and solar for their environmental advantages. In Exhibit 6 we show the demand for electricity on the CAISO which illustrates how these environmentally sustainable and intermittent energy generation sources such as wind and solar change the need for baseload power. The graph of Exhibit 6 shows that demand for electricity in megawatts (MW) on the CAISO interconnect for March 18, 2021. The orange trace shows the actual demand; the black trace shows the net demand after the wind power and solar power have been subtracted. Note that, for March 18 without wind and solar, CAISO could have accommodated a baseload of 20,000 MW, but with wind and solar the baseload was only 11,000 MW. Although the maximum demand was well over 25,000 MW the minimum demand on March 18 was only 11,000 MW. As the amount of solar and wind increase, this minimum demand could go all the way to zero so that no baseload power would be required in the middle of the day, for some days on the CAISO interconnect. This is the reason that the State of California provides strong incentives, and in some cases regulations, for battery storage to be installed together with solar and wind. Note that a large nuclear power plant like Point Beach, or for that matter a large coal-fired power plant, cannot be cycled down and up in power fast enough to follow this demand curve. There is too much thermal energy stored in a 600 MW energy generation facility to dial back the steam generation so quickly. So it is quite possible that by 2030 a 1200 MW supply of baseload power to replace PB Nuclear may be entirely superfluous.

34. The type of changes to the electricity demand curve experienced in California will inevitability come to other regions of the United states. This will likely include the State of Wisconsin and the other states served by the Midwest ISO interconnect. Recent appointments made by the Governor to Wisconsin's Public Service Commission point toward impending changes. In 2020, Tyler Huebner was appointed to the PSC of Wisconsin and some of these changes were described in a recent article in the online journal Utility Dive (July 6, 2020). https://www.utilitydive.com/news/taking-charge-wisconsins-newest-utility-commissioner-on-the-states-util/580494/

> Gov. Evers is also utilizing an opportunity to reshape the state's Public Service Commission. In March, he made his second commissioner appointment on the three-person commission, nominating Tyler Huebner, who served as executive director of renewable energy advocacy group RENEW Wisconsin from 2013 until his appointment this spring. Before RENEW, Huebner worked at the U.S Department of Energy's Office of Energy Efficiency and Renewable Energy, as well as the Wisconsin Division of Energy Services…..
>
> …
>
> Going into his new role, Huebner was very focused on what strategies would be needed to decarbonize the energy sector, he told Utility Dive.

"How is this transition going to happen in a way that's balanced? You've got the utilities, we've got ratepayers, we've got the switch to renewables," he said. "I had a lot of experience in that world coming into this role."

Huebner was assigned to oversee the state's Office of Energy Innovation and Focus on Energy programs, where he will work on improving energy efficiency policies as well as integrating new technologies such as electric vehicle charging infrastructure and other distributed energy resources. And part of the question, he says, as the state faces a rapidly changing power grid is how to continue ensuring utilities are incentivized to be part of this shift.

"One of the things that's top of mind for us is how does energy efficiency and demand response and distributed resources fit into this utility-scale changeover," he said.

"How do we do energy efficiency or demand response or customer-side renewables in a way that can count towards the utility's actual capacity and energy needs so that they're part of the plan"

g. Solar has minimal environmental impacts

35. Although nuclear power has low carbon dioxide emissions during power production, the carbon emissions from the overall fuel and power plant lifecycle are significant. An analysis of more than 100 lifecycle emission studies was done by B. Sovacool and published in Energy Policy **36**, 2950-2963 (2008). The best estimate of greenhouse gas emissions from already-constructed nuclear power plants was given as 66 grams of CO_2 equivalent per kWh. These emissions come mostly from the mining, milling, enrichment, waste management and disposal, and decommissioning. Solar power also has no emissions during power generation. Again there are some emissions during manufacture, mining, milling and purification. Several groups have analyzed emissions from PV power, most recently Kim and Fthenakis. [V.M. Fthenakis, H.C. Kim, and E. Alsema, Environ. Sci. Technol. 42, 2168-2174 (2008).] Their analyses include emissions from all energy sources including from mining, purification, materials suppliers and the electricity used in module production. For energy used in solar module production, Kim and Fthenakis used the average generation mix currently in the U.S. Their results show even lower CO_2 equivalent emissions from solar power than from nuclear. Of the solar technologies, crystalline silicon wafer-based modules had greenhouse gas emissions of 50 g of CO2-equivalent and thin-film cadmium telluride modules had only 20 g of CO2-equivalent emissions per kWh. Since 2008, the average manufactured module efficiencies have increased by about 20%, so the emissions per kWh are estimated for solar as ranging from 16 to 40 grams of CO2-equivalent, well below that of nuclear power.

36. Considerations of time-of-day availability of PV and details of the fuel mix will vary from state-to-state. On average the GHG [greenhouse gas] emissions will be less than derived without consideration of these factors. However, it is likely that carbon cap and trade policies will be implemented during the time frame of the requested NEPB license

extension and these would place a premium on generation sources with the lowest emissions. This would further favor solar power.

CONCLUSION

37. In conclusion, over the last decade technological advancements, manufacturing growth, deployment experience, and rapidly dropping prices have all established solar photovoltaics and battery storage as the most attractive technologies for grid power in Wisconsin. Not only does solar plus battery storage have compelling economic advantages today, solar plus battery storage has the lowest environmental footprint of any technology. It can power today's modern grid with the flexible and nimble response times that are demanded from a modern grid where voltage and frequency stability are of utmost importance. For these reasons and all the other environmental issues presented in the preceding discussion, we contend that the 20-year subsequent operating license renewals for the Point Beach Nuclear Plant units 1 and 2 should be denied.

March 22, 2021
Date

Alvin Compaan

Exhibit 1 Source: Ketan Joshi in Cosmos Newsletter April 16, 2017, https://cosmosmagazine.com/technology/hurdles-on-the-path-to-a-solar-powered-world/

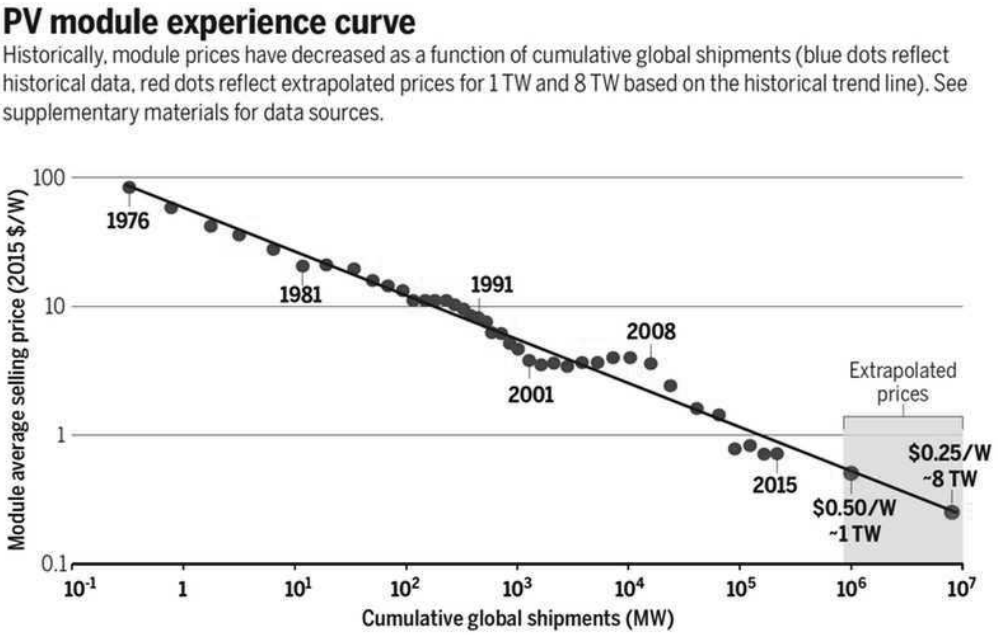
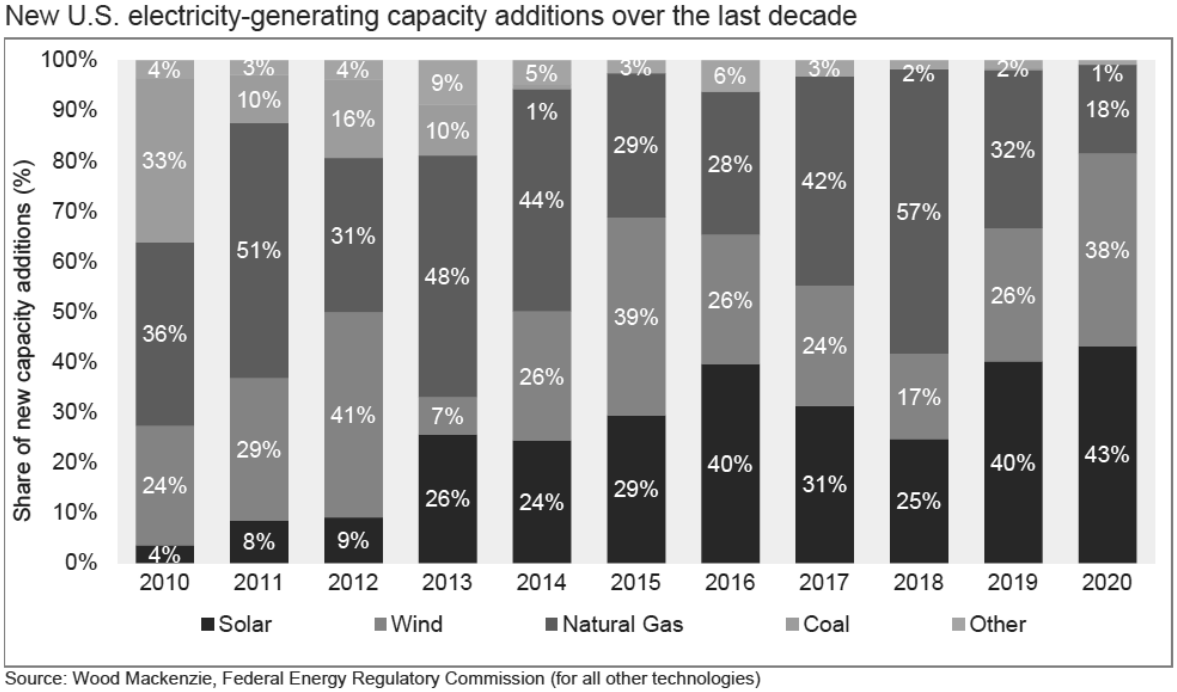


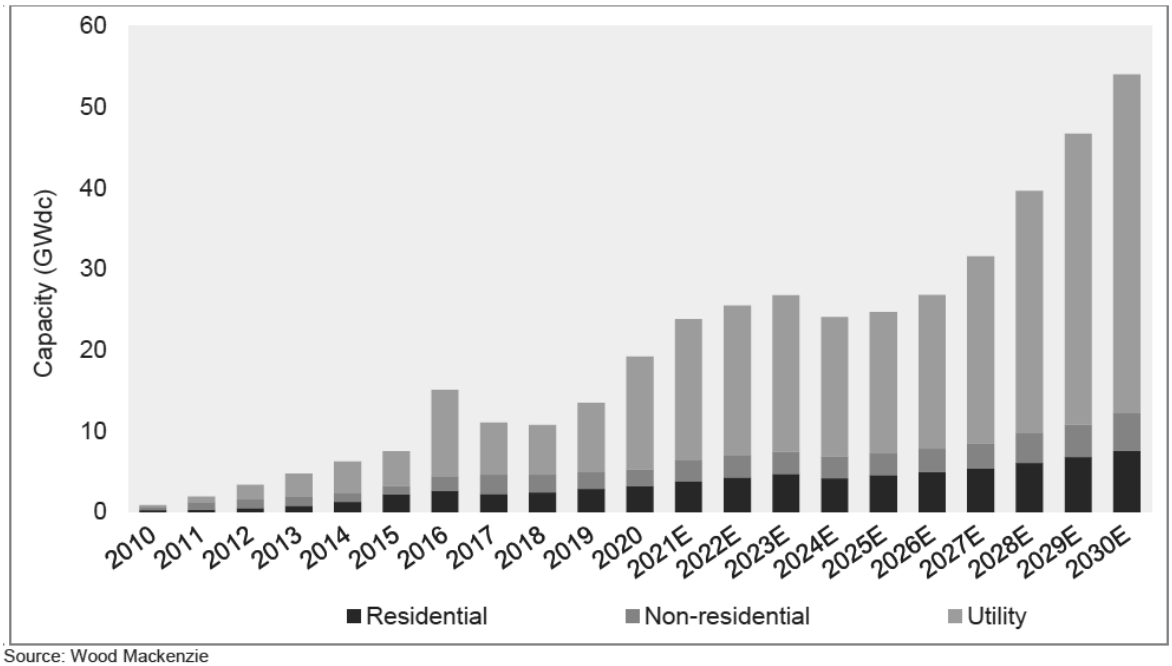
Exhibit 2 from: https://www.woodmac.com/news/opinion/four-ways-us-solar-broke-records-in-2020/?utm_campaign=pandr&utm_medium=email&utm_source=pardot&utm_content=four-ways-us-solar-broke-records-in-2020



Source: Wood Mackenzie, Federal Energy Regulatory Commission (for all other technologies)

Exhibit 3 from: https://www.woodmac.com/news/opinion/four-ways-us-solar-broke-records-in-2020/?utm_campaign=pandr&utm_medium=email&utm_source=pardot&utm_content=four-ways-us-solar-broke-records-in-2020

U.S. solar PV installations and forecast, 2010-2030E



Source: Wood Mackenzie

Exhibit 4 from: https://www.nrel.gov/gis/assets/images/solar-annual-ghi-2018-usa-scale-01.jpg

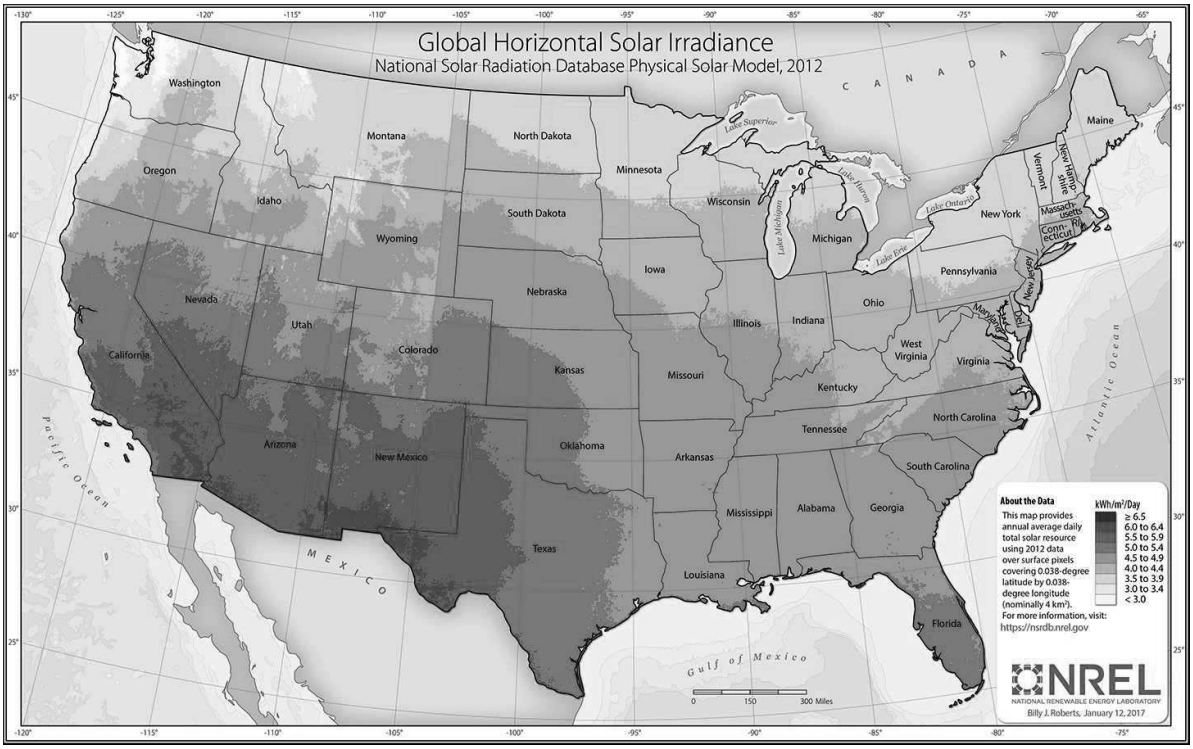


Exhibit 5 from: Wood MacKenzie U.S. Solar Market Insight Report 2020 available at: www.woodmac.com/research/products/power-and-renewables/us-solar-market-insight/.

State solar PV installation rankings, 2020

	Rank			Installations (MW_{dc})		
State	2018	2019	2020	2018	2019	2020
California	1	1	1	3,236	3,103	3,904
Texas	2	2	2	1,010	1,412	3,425
Florida	4	3	3	865	1,366	2,822
Virginia	14	19	4	142	132	1,406
North Carolina	3	4	5	935	965	785
South Carolina	13	7	6	151	516	617
New York	6	8	7	441	473	544
Arizona	9	5	8	343	916	503
Utah	26	20	9	55	122	427
New Jersey	8	9	10	380	451	387

Exhibit 6: chart constructed by A. Compaan using data downloaded on 3/19/21 from: http://www.caiso.com/todaysoutlook/pages/default.aspx

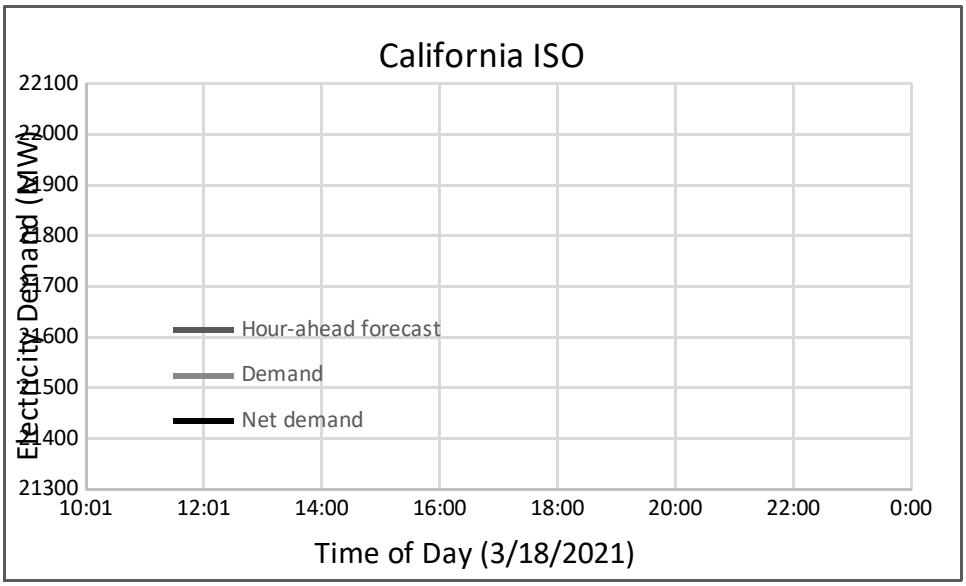


Exhibit 7: Alvin D. Compaan, Curriculum Vitae

NAME: Alvin Compaan
DEGREES: A.B., Calvin College, 1965
M.S., University of Chicago, 1966
Ph.D., University of Chicago, 1971

EXPERIENCE:
Teaching Assistant, University of Chicago, 1965-66
NDEA Title IV Fellow, University of Chicago, 1968-69
NSF Trainee, University of Chicago, 1969-1971
Research Associate, New York University, 1971-1973
Assistant Professor, Kansas State University, 1973-1977
Associate Professor, Kansas State University, 1977-1981
Professor, Kansas State University 1981-1987
Alexander von Humboldt Fellow, (Guest Scientist Max Planck Institute für Festkörperforschung - Stuttgart) 1982-1983
Professor of Physics, The Univ. of Toledo 1987-2005
Director, Thin Films Research Inst., 1991-96
TUBITAK Distinguished Senior Visitor, Bilkent U., Ankara, July-Aug. 1994
Guest Scientist: National Research Council--Ottawa (with J.J. Dubowski), Oct-Dec. 1994
Director, Center for Materials Science and Engineering, 1996-
Chair, Dept. of Physics and Astronomy, July 2004-2008
Distinguished University Professor of Physics, The Univ. of Toledo, 2005-2009
Distinguished University Professor of Physics, Emeritus 2009-
Chief Technology Officer and Co-Founder, Xunlight 26 Solar, LLC, 2008
President and CEO, Lucintech Inc, 2012-

HONORARY AND PROFESSIONAL SOCIETIES:
American Physical Society, A.A.A.S., International Society for Optical Engineering (SPIE),Union of Concerned Scientists, Materials Research Society, Sigma Xi, Sigma Pi Sigma

FIELDS OF RESEARCH COMPETENCE:
Resonant Raman Scattering, Semiconductor Physics, Laser Annealing of Semiconductors, Ion Implantation Studies, Thin Film Solar Cells, Laser Scribing, RF Sputtering, Pulsed Laser Deposition

REFEREE FOR:
Physical Review, Physical Review Letters, Journal of Applied Physics, Applied Physics Letters, J. Vacuum Science & Technology, Surface Science, Physica Scripta, NSF, ARO, DOE, Research Corp

PATENTS AWARDED: 12 U.S. utility patents

EXTRAMURAL FUNDING:

Research Corporation - "Spectroscopic Studies of Pure and Implanted Cuprous Oxide Using Tunable Lasers" ($10,000) 6/75 - 6/76.
NSF - "Raman and Photoluminescence Studies of Pure and Implanted Cuprous Oxide" ($48,000) 12/76 - 5/79
NSF - "Laser Light Scattering Studies of Exciton and Free Carrier Relaxation in Pure and Implanted Semiconductors" ($27,700) 2/79 -7/80.
IBM - "Design, Construction and Test of a Pupillary Response Visibility Meter (PRVM)" ($28,194) 3/80 - 9/80 (with C. Bennett, P.I.).
ONR - "Raman Studies of Surface Temperature in Laser-Heated Semiconductors" ($360,759) 4/80 - 9/84.
NSF (Science in Developing Countries) - "Pulsed Laser Annealing of Some Elementary and Compound Semiconductors" ($9,625) 3/83 - 2/85.
NSF (Chemical Instrumentation) - "A Tunable Pulsed Dye Laser Facility" ($101,700) 2/84 - 1/85 (with K. Klabunde, P.I., and five others).
USAF - UES "Summer Faculty Research" ($9,052) 5/85-7/85.
USAF - UES "Below-Melt-Threshold Excimer-Laser-Annealing of GaAs" ($20,000) 10/85-9/86.
USARO-BATTELLE "Excimer Laser Processing of HgCdTe", ($14,389), 4/87-8/87.
NSF - International Travel Grant to attend "Workshop on Advanced Raman Spectroscopy" in Kanpur, India, 7-11 Dec. 1987 ($1,641).
OBOR Grant - Research Challenge Program - "Central Materials Facility," 7/88 - 12/89 ($10,000) (with S. A. Lee, R. G. Bohn and C. Y. Tai).
Ohio's Thomas Edison Program and Glasstech, Inc., "Advanced Processing for Thin Film Solar Cells", 6/89 - 6/91 ($500,000) (with C.Y. Tai, co-investigator).
Ohio's Thomas Edison Program and Solar Cells, Inc., "Laser Processing for CdTe Solar Cells", 6/89 - 6/90 ($100,000) (with R.G. Bohn, co-investigator).
Solar Energy Research Institute (with collaborative efforts from Glasstech, Solar Cells, and Glasstech Solar), "Cadmium Telluride Solar Submodules Using Laser-Driven Vapor Deposition," 07/90-12/93 ($475,407) with R. G. Bohn as Co-Investigator.
Co-Investigator on SBIR grant with Principal Investigator from AVCA Corp. (Vaughn Baltzly). (Funded for $50,000, 6 months, starting September 1990).
Ford Motor Company - "Solar Photovoltaics," 10/91 - 9/92 ($30,000).
NASA, "Photophysics and Hydrogen Processing of Interstellar Carbon Solids," with A. N. Witt as Principal Investigator and C. Y. Tai, ($66,877), 8/92-.
National Renewable Energy Laboratory (NREL) "High Efficiency Thin Film CdTe-Based Solar Cells" (1/21/94-1/20/97) $374,848 (with R.G. Bohn and Y. Rajakarunanayake as co-investigators).
NSF, "High Resolution Spectroscopy for Undergraduates," 9/94-9/96, ($23,566 with UT match of $23,566) (with A.N. Witt and L.J. Curtis as co-PIs)
OBOR Research Challenge Program, "Semiconductor Thin Films for Large-Area Photo-Assisted Field Emission," $30,300 (6/94-6/95) with B.G. Bagley as co-PI.
NREL, "Optimization of Laser Scribing for Thin-Film PV Modules," ($255,000; 4/95 - 10/97), three lower-tier subcontractors: Solar Cells Inc., (Toledo, OH), International Solar Electric Technologies (ISET), (Los Angeles, CA), and C J Laser Corp., (Dayton, OH).
NREL, "High Efficiency Thin Film CdTe-Based Solar Cells" (extension) ($124,000; 1/21/97-3/31/98) (with R.G. Bohn as co-I)
NSF, "U.S.-Mexico Cooperative Research: Thin-Film Materials for Photovoltaics," INT-9901383, ($28,500 6/99-6/02)
NREL, "High Efficiency Thin-Film Cadmium Telluride and Amorphous Silicon Based Solar Cells," ($870,000; 2/1/98 - 1/30/01) (with X. Deng as Co-P.I. and R.G. Bohn as co-I)
NREL, "Acquisition of Hot-wire Deposition Chamber and In Situ Optical Absorption measurement for Thin Film Solar Cell Fabrication," $98,450 (funded 50/50 NREL and UT) 7/1/98--6/30-00.
NREL, "High Efficiency Thin-Film Cadmium Telluride and Amorphous Silicon Based Solar Cells," (2/1/98 - 1/30/01) [addition of $54,000), (with X. Deng as Co-P.I. and R.G. Bohn as co-I).
Solar Cells Inc., "Electrical and Optical Characterization of Photovoltaic Materials," 1/20/97 - 7/31/98 ($66,936).
Solar Cells Inc., "Laser Scribing and Optical Characterization of Photovoltaic materials," ($15,214.50 to date).
Electro Plasma Inc., "Collaborative Research on Color Plasma Displays with Enhanced Brightness," 1/1/99—8/25/00 ($109,274) (with X. Deng as Co-I)

Electro Plasma Inc., "Collaborative Research on Color Plasma Displays with Enhanced Brightness," 4/01 – 3/02 ($112,990) (Compaan, P.I.)

NREL, "High Efficiency Thin-Film Cadmium Telluride and Amorphous Silicon Based Solar Cells," funded extension 3/5/01 to 10/15/01, $115,000.(*Compaan and Deng co-P.I.s, Bohn, co-I*)

NREL High Performance Photovoltaics Program, "Polycrystalline Thin-Film II-VI top cells for tandem photovoltaics,"($768,749 for 24 months, 4/3/01 – 6/3/03) (with V. Karpov and X. Deng as co-investigators and with First Solar, LLC, as a lower-tier subcontractor)

NREL "The fabrication and physics of high efficiency CdTe thin-film solar cells," ($770,265, 9/01-8/04) (Compaan and Karpov, co-P.I.s, Deng, Bohn, & Giolando as co-Is)

NSF "Partnership for Innovation "Northwest Ohio Partnership on Alternative Energy Systems" (Frank J. Calzonetti, P.I., Coleman, Compaan, Deng, Stuart, co-Is)[$600,000, 10/1/02—9/30/05]

First Solar "Development of On-line diagnostics," ($15,805, 10/31/03—12/31/03) Compaan, P.I.

Air Force Research Lab-Kirtland, "Light-weight and flexible thin-film solar cells based on a-Si and CdTe," $1,647,545 11/20/02 – 12/31/06 (Compaan, P.I., Deng co-P.I., co-Is: Collins, Giolando, Marsillac, Karpov)

NREL "Sputtered II-VI alloys and structures for tandem PV," ($780,000, 11/1/03—2/28/07)(Compaan, P.I., co-investigators: Karpov, Collins, Giolando)

NSF-STTR-through ITN Energy Systems, "P-type CdSe for thin-film top cells enabling high-efficiency monolithic tandem photovoltaics," $50,000, 8/1/03--7/31/04 (Compaan, UT P.I.)

Air Force Research Lab-Wright Patterson (via Universal Technologies Corp), "Photovoltaic hydrogen for portable, on-demand power," $1,620,000, 8/1/03—7/31/06 (Deng, P.I., co-Is: Compaan, Coleman, Giolando, Lipscomb)

Ohio Department of Development—"Center for Photovoltaic Electricity and Hydrogen," $2,000,000 for capital equipment (1/1/04—6/30/07), Compaan, P.I., with co-Is: Giolando, Deng, Karpov

Air Force Research Lab-Kirtland, "Light-weight and flexible thin-film solar cells based on a-Si, CdTe, and CIGS" $2,517,932, 11/20/02-11/17/07 (Compaan, P.I., Deng co-P.I., co-Is: Collins, Giolando, Marsillac, Karpov)

Ohio Department of Development—"Center for Photovoltaic Electricity and Hydrogen-Enhanced Activities," $99,920 (7/1/05—6/30/07) Compaan, P.I., with co-Is: Giolando, Deng, Collins, Karpov

NREL "The fabrication and physics of CdTe devices by sputtering," ($1,155,546, 3/1/05-4/30/08) (Compaan and Karpov, co-P.I.s, Collins & Giolando as co-Is)

Ohio Department of Development-- "Wright Center of Innovation: Photovoltaics Innovation and Commercialization" (6/1/07-5/30/10, $18.6 M, R. Collins, P.I.; Compaan one of 15 co-investigators) [UT is the lead institution ($9.3M) with Ohio State University ($6.8M) and Bowling Green State U ($2.5M)]

U.S. Dept. of Energy, University Photovoltaic Process and Product Development Support program, "Improved CdTe PV Modules by APVD," R. Collins, P.I., Compaan, co-P.I., with co-Is Giolando, Marsillac and two industrial partners, Calyxo, USA, and Pilkington. $1,164,175 (05/15/08 – 5/14/11)

Xunlight 26 Solar/Ohio Dept. of Development-Advanced Energy Program—"Flexible Thin-Film CdTe PV Modules," Collins, P.I., $360,000 (06/01/08 – 05/30/10)

Garland/Ohio Dept. of Development-Advanced Energy Program—"Garland BIPV Systems," Compaan, P.I., $300,000 (6/01/08 – 5/30/10)

Ascent Solar/SBIR Phase II—"CdSe top cells for CdSe/CIGS Tandems," K. Wieland, P.I., Compaan co-I, $200,000 (7/1/09 - 6/30/10)

Triton, Inc/SBIR phase II—"Laser Scribing Studies—Phase II," $31,593 (6/1/08 - 12/30/09)

Air Force Research Lab-Kirtland, "Rapidly Deployable Solar Electricity and Fuel Sources," $3,343,571, 4/8/08-10/1/09 (Marsillac, P.I., Deng co-P.I., Collins, co-PI, Compaan, co-PI, Giolando, Bigioni, Amar, Khare) [Additional 12 month funded extension to 10/1/2010, $2,980,860.]

Ohio Department of Development, Ohio Research Scholars Program, "Northwest Ohio Innovators in Thin Film Photovoltaics," R.W. Collins, P.I., Co-P.Is: S. Marsillac, A. Compaan, F. Calzonetti, (July 2008-June 2013; $8,038,462)

PEER-REVIEWED PUBLICATIONS:

1. A. Compaan, L. Q. Lambert and I. D. Abella, Phys. Rev. Lett. 20, 1089 (1968) "Photon-Echo Dependence on Intensity."
2. L. Q. Lambert, A. Compaan and I. D. Abella, Phys. Ltrs. 30A, 153 (1969) "Modulation and Fast Decay of Photon-Echoes in Ruby."

3. A. Compaan, L. Q. Lambert and I. D. Abella, Optics Communications 3, 236 (1971) "Level Crossing Effects and Spin-Dependent Decay of Circularly Polarized Photon Echoes in Ruby."
4 A. Compaan and I. D. Abella, Phys. Rev. Ltrs. 27, 23 (1971) "Evidence of Strong Optical Super-radiant Damping in Ruby."
5. L. Q. Lambert, A. Compaan and I. D. Abella, Phys. Rev. A4, 2022 (1971) "Effects of Nearly Degenerate States on Photon-Echo Behavior."
6. A. Compaan, Phys. Rev. B5, 4450 (1972) "Concentration-Dependent Photo-Echo Decay in Ruby."
7. A. Compaan and H. Z. Cummins, Phys. Rev. B6, 4753 (1972) "Raman Scattering, Luminescence and Exciton-Phonon Coupling in Cu_2O."
8. A. Compaan and H. Z. Cummins, Phys. Rev. Ltrs. 31, 41 (1973) "Resonant Quadrupole-Dipole Raman Scattering at the 1S Yellow Exciton in Cu_2O."
9. A. Compaan, W. D. Langer, D. Eden and H. L. Swinney, Astrophysical Journ. 185, L105 (1973) "Collisional Excitation of CO by H_2."
10. A. Compaan, L. Q. Lambert and I. D. Abella, Phys. Rev. A8, 1641 (1973) "Short Time-Interval Behavior of Photon Echoes in Ruby Near Level Crossings."
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Shanli Wang	7/02-6/05
Xavier Mathew	7/05-7/06
Jennifer Drayton	1/06-1/07
Xiangxin Liu	6/07--
Snigdha Gupta	3/07—3/08
James Walker	3/07-8/07
Kristopher Wieland	7/07--

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the Matter of	)	Docket Nos. 50-266 and 50-301 NRC–2021–0021
NextEra Energy Point Beach, LLC	)	March 23, 2021
(Point Beach Nuclear Plant, Units 1 and 2)	)	
	)	

* * * * *

DECLARATION OF MARK COOPER, PH. D.

Under penalty of perjury, I, Mark Cooper, declare as follows:

1. BACKGROUND

A. Biography

My name is Dr. Mark Cooper. I am a Senior Fellow for Economic Analysis at the Institute for Energy and the Environment at Vermont Law School. I hold a Ph.D. from Yale University. I am also Director of Research at the Consumer Federation of America, where I served for two decades as Director of Energy. I have testified over 400 times on energy and telecommunications issues at federal and state regulatory and legislative bodies in over forty jurisdictions in the U.S. and Canada. My *curriculum vitae* is attached to this Declaration as MNC-1.

I was asked by Physicians for Social Responsibility-Wisconsin to review the application for a 20 year subsequent operating license extension for NextEra Energy Point Beach, LLC's Point Beach Nuclear Plant, Units 1 and 2. Unit 1 would be extended from 2030 to 2050, and Unit 2 would be extended from 2033 to 2053. What follows are my observations and conclusions, offered to a reasonable degree of economic certainty based on my qualifications, experience and relevant information sources.

Although I have been analyzing the electricity sector in general and nuclear power, in particular, for over 35 years, in the past decade I have focused on the challenge of building a low cost, low carbon sector. In the first five years I focused on the construction of new nuclear reactors because the "nuclear renaissance" aspired to build dozens of huge, expensive reactors that, it was claimed, were extremely low carbon emitters that would anchor the electricity system for decades. I showed that new nuclear reactors were far from the least cost option around which to center a low carbon electricity sector by analyzing the economics of alternatives, efficiency and non-hydro renewable resources.

The "nuclear renaissance" evaporated, with billions of dollars wasted on abandoned plans and projects and is now reduced to a mere two reactors under construction and likely to be the most expensive source of electricity ever. For the past five years I have added a much more intensive analysis of how a 21st century low carbon electricity sector would be built and operated and have examined the role of aging reactors in the transition to that sector.

Attachment MNC-1 shows academic publications, testimony, and research reports I have authored in the past decade dealing with the electricity sector and the role of nuclear power in it, among the many topics I have analyzed and testified on over the years.

B. My Conclusion

With numerous articles, dozens of reports and pieces of testimony and a book, there is a mountain of material that could be reviewed. For the purpose of this analysis, I have included only updated versions of a few key general observations that represent the basic argument on and analysis of the transformation of the electricity system. General analyses apply to Wisconsin and all other states.

The bottom line is simple. Nuclear power is far too costly to include in a 21st century electricity system based on efficiency, distributed and renewable resources that deliver lower cost

and much less pollution while effectively decarbonizing the sector. Where I make a specific observation about Wisconsin, I include a data point for Wisconsin and one of the states I have looked at in detail, California, Illinois and New York. Every one of those analyses involved the extension of nuclear reactors beyond their economic life.

Adding Wisconsin to the list is a "no brainer." Compared to these other states, Wisconsin is underperforming in efficiency and renewables. Under the purchased power agreement, [1] I estimate that compared to 21st century alternatives, ratepayers will bear unnecessary charges of about $5 billion.

Of particular note is my recent book on the electricity sector (*The Political Economy of Electricity: Progressive Capitalism and the Struggle to Build a Sustainable Power Sector*).[2] In that book, I concluded a chapter entitled "The Nuclear War Against the Future" with the following observation on the role (or lack thereof) of nuclear power:

> Once the direction of a least-cost route to a decarbonized economy is set by the superiority of renewables, it becomes impossible for nuclear power to participate in the ultimate portfolio. The idea of pursuing an "all-of-the-above" scenario runs afoul of the fundamental differences between the 20th-century baseload fossil fuel approach and 21st-century renewable energy approach. The two technologies simply do not mix well because nuclear is not flexible. The vigorous attack on renewables launched by advocates of nuclear power in an effort to secure favorable treatment of aging reactors is testimony to the incompatibility between the two...
>
> This analysis leads to three interrelated recommendations for policymakers.
>
> - Policy should move to quickly adopt the necessary institutional and physical infrastructure changes needed to transform the electricity system into the 21st-century approach.
> - Policy should not subsidize nuclear reactors, old or new. In the long term, their large size and inflexible operation makes them a burden, not a benefit in the 21st-century system.

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1 Point Beach Nuclear Plant Power Purchase Agreement Between FPL Energy Point Beach, LLC and Wisconsin Electric Power Company, dated as of December 19, 2006, A-1.

2 *The Political Economy of Electricity: Progressive Capitalism and the Struggle to Build a Sustainable Power Sector, Praeger*, 2017.

- Nuclear's technological characteristics combined with the industry's political efforts to undermine the development of the 21st-century system makes nuclear a part of the problem, not the solution.[3]

In the four years since I reached those conclusions, the evidence supporting them has continued to mount in crucial aspects. The cost of alternatives has continued to plummet, while the cost of nuclear power has continued to rise. Confidence in the ability to manage a grid based on alternatives, distributed energy, and intense management and matching of supply and demand to meet needs has been demonstrated and has continued to grow at the conceptual and practical levels. Lower cost alternatives are increasingly available and their ability to reliably meet demand has been demonstrated.

Given this basic economic evidence of the prospective superiority of the alternatives, the great threat of maintaining the output of nuclear reactors is the obstacle they present to the development of the alternative. The longer they continue their massive, inflexible output with uneconomic subsidies, such as the Point Beach Purchased Power Agreement and/or unjustified preference in dispatch, the more difficult it is for the alternatives to take root and achieve their potential.

Nuclear power has always been uneconomic, more costly than the alternatives with which it is competing. However, the current problem of nuclear power is different and much greater. In the past, it was the least attractive of the alternatives, not only the most costly, but also the least flexible of the central station technologies. Nevertheless, it was part of the existing system. Today, it is not only too costly, but it is an obstacle to the development of a lower cost, more flexible 21st century system.

C. Testimony Outline

[3] *Id.*, pp. 201-202

My testimony is organized as follows. In Section 2, I present an overview of the argument, addressing three issues: 1) the nature of the ongoing technological revolution in the electricity sector, 2) the threat and challenge that nuclear power poses to the transformation of the sector, and 3) the important policies that regulators involved in, or affected by, the decision to extend the license of Point Beach nuclear power station should implement to promote the transformation. In the remainder of this testimony I present the evidence that leads me to the conclusion.

In Section 3, I update the analysis of the cost of alternatives, which is the launchpad for consideration of whether Point Beach should be allowed to continue to operate. This discussion shows that the continued operation of Point Beach, not to mention an extension of its commercial operation, is unjustified.

In Section 4, I address the question of whether the 21st century approach to organizing the electricity sector that relies on alternative generation, demand reduction, and intense management of supply and demand can deliver reliable power. I begin with this focus on the alternative 21st century electricity system for the simple reason that it is necessary to correct the affliction from which the Licensee suffers, which I call "baseload myopia." I conclude that the lead time necessary to ensure the operation of a 21st century system is more than adequate between now and 2030 (for Point Beach Unit 1) and 2033 (for Point Beach Unit 2), not to mention the two decades of operation during the license extension. Finally, I explain why nuclear power should play no role in the least cost, low-carbon, low-pollution, future electricity system.

In Section 5, I described the problems with nuclear power in general and small modular reactors in particular. Here I actually agree with the licensee, that building new nuclear reactors of any size is absurd as an economic proposition, as well as a carbon reduction strategy. I

explain why the large block of inflexible power that nuclear demands is a major obstacle to building the alternative system. The license extension creates a strategic overhang that the licensee will exploit in an effort to prevent its asset from being displaced.

2. THE TRANSITION TO A 21ST CENTURY ELECTRICITY SYSTEM

A. The Technological Revolution in the Electricity Sector

The potential transformation of the electricity system has been created by a technological revolution that has occurred over the past three decades. This revolution has resulted in a dramatic decline in the cost of alternative resources, a sustained decline in cost equal to decline in cost of any vital input in the history of the main technologies in past industrial revolutions. As shown in Attachment MNC-2, which is an update of the first figure I included in my recent book on the electricity sector, the costs of solar and batteries are projected to decline about 5 percent per year in the 30 years from 2000 to 2030. The cost of wind is estimated to decline by over 2 percent per year for the 50-years between 1980 and 2030. In contrast, the cost of nuclear power has increased by almost 3 percent per year over that same, 50-year period. Cost trends in the decade since the publication of the data on which the attachment is based reinforce and magnify those cost changes, as I discuss below.

While the cost of key generation resources (wind, solar and batteries) are important, there are also two key technological revolutions that have also taken place on the demand side. First and foremost the technologies of grid management, information, computer capacity, and advanced control technologies have made it possible to manage and integrate demand, matching it more closely with supply with much greater precision. This has directly lowered the costs of the system, but it has also yielded a transformation dividend, a reduction in the size of the system needed to meet demand. By replacing large units and dynamically managing the grid to better match supply and demand, a dividend of 15% or more is widely recognized and achieved.

It is also clear that the cost of efficiency, the use of technologies to lower energy consumption and therefore the cost of operating energy-consuming durable goods, has remained low for decades and there is every indication that the cost of efficiency is not rising. In fact, the same type of technological revolution has affected demand reduction, with the economically attractive opportunities expanding as new technologies convert what was known as "technical potential" into "economically attractive."

As shown in Attachment MNC-2, an updated version of the first table of my book, the link between electricity consumption and economic growth has been broken. In contrast to the three decades after World War II (1950-1980) where electricity consumption per dollar of per capita GDP grew by almost 3 percent, the figure was flat between 1980 and 1995, and declined by 1.2 percent per year between 1995 and 2015. Between 2015 and 2019, it declined by 3% per year, in spite of very strong growth in GDP/capita.

B. The Threat of Nuclear Power to the Transformation of the Electricity Sector

Having described the potential of the alternatives, I will turn to the problem of nuclear power and the threat to the transformation it represents. The issue is not simply backing out coal and petroleum from our economy. The 21st century energy sector requires decentralized facilities that can be managed to dynamically match supply and demand, a shift away from central station facilities altogether. My research also shows that nuclear power is the antithesis of what is needed. Nuclear plants are the largest and least flexible of the current generation units. They are, and have always been, extremely expensive to build. As they age, they have become more costly to operate than the renewable resources entering the market. They are heavy users of water and raise numerous public health and environmental issues.

Promises that a new generation of "small modular" nuclear technologies will do better are doubtful at best. They will be much more expensive than the alternatives already available

and take decades to deploy. Their costs will likely create pressures to demand priority in dispatch, which frustrates flexibility. They leave serious doubts about security and pollution. Thus, nuclear power should be held to strict economic standards, without any subsidies. If it cannot compete on cost, it cannot be part of the 21st century energy sector.

C. Regulators Must Promote the Transformation by Blunting the Nuclear Threat

The Nuclear Regulatory Commission can play a key role in nullifying the threat of nuclear power by denying the license extension. It should reject the baseload power myopia from which the licensee suffers because it is obviously in the economic interest of the licensee to claim that only baseload power should be considered. However, it is not in the interest of the regulator, who is supposed to represent the public interest.

Ironically, the licensee is half right in this instance. It makes absolutely no sense to build new nuclear reactors, as discussed below. Large central station reactors, two of which are under construction in the U.S. and dozens of which have failed, are costly and difficult, taking a decade or more to build.

From the point of view of the transformation to a 21st century electricity sector, small modular reactors do not change things much and represent the same challenges.

- Small modular rectors have never been built in the U.S. and have experienced a classic doubling of costs projection before they get off the drawing board.
- They are likely to undergo even larger cost increases, if they ever go into construction.
- The idea of building 21 of them to replace the capacity of Point Beach is absurd.
- The decade or more it would take to build the fleet to replace Point Beach 1 and 2 will mean a great deal of reduction in emissions will be foregone.

However, while building new nuclear baseload is absurd, that is only the first step. Other options for replacing the aging reactors at Point Beach should be considered. At a minimum, the NRC should find the application deficient because it fails to consider the full range of

alternatives. If the utility refuses to accept the challenge of considering genuine alternatives that undoubtedly will be much less costly than operating two small, old reactors, or of building a fleet of new ones, the NRC should reject the license extension because it has no basis for licensing technologies that are grossly uneconomic and antithetical to the operation of an efficient, modern electricity system.

The state regulator has a role to play, too. The existing grossly expensive Point Beach Purchased Power Agreement that imposes billions of dollars of excess costs on Point Beach ratepayers is unconscionable. At a minimum state regulators should make it clear that no such above-market power purchase contract will be signed in the future. Moreover, the regulator should consider how to mitigate the impact of the current purchased power agreement. Above all, if the regulator has the obligation under state law to ensure consumers get the benefit of least cost power, that should trump any utility signed contract. Economic dispatch should take precedence.

3. THE ECONOMIC ADVANTAGE OF THE ALTERNATIVES

A. Supply-Side Costs

I begin the analysis with an update of the long-run cost of acquiring resources to meet demand. We should begin with the long run costs because that is where the system will end up. Short-run costs matter too, especially if they differ dramatically from long-run costs. If such a difference exists, then a trade-off must be made between short-run and long-run costs. It turns out that with respect to electricity resources at present, there is no difference and no need to make a trade off.

The economic dynamics of the electricity sector at the start of the 21st century have put immense pressure on nuclear power and central station generation in the United States and globally, pressure that ultimately falls on aging reactors. As Attachment MNC-4 shows, with

respect to long-run costs, at present the three main resources on which the 21st century electricity system relies – efficiency, onshore wind, and utility photovoltaics – are projected to be considerably lower in cost than central station generation, even without taking the reduction of pollution and carbon emission into account.

I use Lazard here,[1] as I have done since their first publication of levelized costs, a decade ago for a number of reasons.

- First and foremost, Lazard's projections have tracked the actual development of costs over the past decade much more closely than others.
- From the outset, Lazard's analysis included efficiency.
- Lazard's was among the first of the comprehensive analyses to note the strong downward trend in the cost of solar and to begin arguing that solar was cost-competitive for peak power in some major markets.
- The analysis always included estimates for coal with carbon capture and storage, and later added an estimate for the cost of natural gas with carbon capture and storage.
- The analysis includes regional estimates for resources whose economics vary by location.
- The more recent analysis adds important storage technologies, utility-scale solar with storage, and utility-scale battery storage. It also presents a cost trend for storage that is similar to the trends from other renewable and distributed sources.
- The analysis always included natural gas peaking capacity costs and, in a recent analysis, added a cross-national comparison of peaking technologies that might displace gas as the peaker resource.
- The analysis has also recently added comparisons of carbon abatement costs, as the determination to deal with climate change has grown.

- Most recently, Lazard has made the case that new build alternatives are less costly than the operating (marginal) cost of traditional, central station facilities.

Therefore, selecting resources that minimize long-term costs are the same as resources selected to minimize short term costs.

I have added two sets of externality costs to Lazard's estimates, the cost associated with non-carbon pollution and carbon emissions valued at $30 per ton (which is the midpoint of the range used by Lazard in an analysis that shows that a price on carbon would "increase the LCOE

[1] Lazard, *Lazard's Levelized Cost of Energy Analysis – Version 14.0*, October 2020,

[levelized cost of electricity] for certain conventional generation technologies above those of onshore wind and utility-scale solar."[2] In fact, even without externalities, efficiency is the least cost option and wind and solar are much less costly than coal and nuclear, while they are competitive with gas combined cycle. The superiority of the key alternatives is strengthened when one considers a cost of carbon attributed to nuclear due to its extremely long construction period.

Beyond adding in the cost of externalities which makes the alternatives more attractive, there is a second factor implicit in Lazard's analysis that leads to an underestimation of the cost of traditional central station technologies. As is the case with almost all cost estimates, Lazard uses a high capacity factor for all three of the traditional technologies, which is well above the actual average observed in the U.S. As a result, costs are underestimated. The lower capacity factor reflects reality. In the case of nuclear, the lifecycle experience of nuclear new builds that takes a decade to work the bugs out, lowers the lifetime load factor by 10 percent. In the case of coal and gas, the entry of renewables causes some facilities using conventional fuels to not be utilized.

Much the same conclusion emerges from the short-term analysis shown in the lower graph of attachment MNC-4. Lazard compares the full cost of new build wind or solar to the marginal cost of existing conventional generation. This is a very demanding comparison, since it is a comparison of all-in costs for alternatives to marginal costs for central station technologies. Nevertheless, the conclusion Lazard reaches is that "certain renewable energy generation technologies have an LCOE [levelized cost of electricity] that is competitive with the market cost of existing conventional generation.

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[2] Id., p. 7.

To give a sense of a comparison that is "apples-to-apples," marginal for both types of resources, I have included the estimate of the operating cost provided in the long-run analysis. Needless to say, renewables are very attractive. I have also included the cost of operating aging reactors as expressed in recent subsidy proceedings, at only their cost of operation. Necessary capital costs would increase their total near-term cost by almost 50%. I also note external costs, which should be included in the short term analysis, since there are emissions.

The point is that the short-term comparisons are not at odds with the long-term results. Since the alternatives are least cost in the long term and competitive in the short term there is no tradeoff necessary. The alternatives are preferable.

B. Demand-Side Savings

In the resource analysis I have included efficiency as the least cost resource. Estimates of the large potential for efficiency have been consistent for three decades, as shown in the upper graph of Attachment MNC-5. In the lower graph of Attachment MNC-5, the forward looking cost is about $.03/kWh, below the backward looking cost.[1] The reason for the stable and slightly declining cost is learning by doing, economies of scale, and improving technology. There is also a significant reduction in electricity demand that occurs from the effect of shifting to decentralized technologies that better match supply and demand, which I call the transformation dividend. Thus, efficiency is cost competitive with the other alternatives and makes a substantial contribution to meeting need.

I have prepared a detailed analysis of the potential for efficiency and renewables to meet the need in analysis of New York, Illinois and California.[2] Given the performance and

[1] *See* Mark Cooper, *Energy Efficiency Performance Standards: Driving Consumer and Energy Savings in California,* California Energy Commission's Energy Academy, February 20, 2014, pp. 30-31, and the underlying studies.

[2] On New York *see*, Mark Cooper, *The Green New Deal, Nuclear Power and Other Potholes to avoid on the Road to a Progressive, Capitalist, Least Cost, Low Carbon, Clean, Electricity Sector*, April, 2019, pp. 31-37; On California and Illinois *see*, Cooper, *the Political Economy*

endowment of Wisconsin to exploit these various resources, I am confident that those conclusions apply here, as Attachment MNC-6 shows. The upper graph shows that each of the three states I have examined in detail rank higher on energy efficiency programs than Wisconsin. The right side of the table and the table and the graph show that Wisconsin is lagging and that all of the states can do much better.

4. OPERATING RELIABLE ALTERNATIVE SYSTEMS TO MEET DEMAND

Baseload myopia has been rejected on the basis of cost. Can it be salvaged by the claim that it is the only means of meeting the need for power at an affordable cost? The answer is an emphatic NO! The tools to meet demand with low cost, low carbon, low pollution resources are more than adequate and becoming increasingly available.

A. Integration Cost

Recalling the cost advantage that renewables enjoy today, and the even larger cost advantage that they are expected to enjoy in the mid-term, these factors make the 21st-century electricity system based on alternatives the least-cost approach in a low-carbon environment by a wide margin. The finding that the cost of the integration of distributed supply and actively managed demand are quite small enjoys a strong consensus in the literature. [1] It is reflected in the DOE analysis *Wind Vision,* which provides a simple explanation. The DOE *Wind Vision* analysis argues that "wind generation variability has a minimal and manageable impact on grid reliability and related costs."[2] DOE believes that operational challenges that could arise with much higher levels of wind penetration can be easily overcome by expanding the use of techniques that have

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of Electricity, pp. 169-201.

1 Hannele Holttinen, *Design and Operation of Power Systems with Large Amounts of Wind Power*, Final Report, IEA Wind Task 25, 2009; Jing Wu et al., "Integrating Solar PV (Photovoltaics) in Utility System Operations: Analytical Framework and Arizona Case Study," *Energy* 85 (2015); Jason Rauch, "Price and Risk Reduction Opportunities in the New England Electricity Generation Portfolio," *Electricity Journal* 27 (2014).

2 U.S. Department of Energy, *Wind Vision*, xxiii.

been found effective in the past. “Such challenges can be mitigated by various means including increased system flexibility, greater electric system coordination, faster dispatch schedules, improved forecasting, demand response, greater power plant cycling, and—in some cases—storage options.”[1] These highlight the impact and necessity of changes to the grid,[2] and the prospect of achieving reliability that equals or exceeds current levels with the alternative approach is increasingly seen as quite good.[3]

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1 U.S. Department of Energy, *Wind Vision*, xlii.

2 For academic studies on system integration generally see, for example, Xi Lu *et al.*, “Optimal Integration of Offshore Wind Power for a Steadier, Environmentally Friendlier, Supply of Electricity in China,” *Energy Policy* 62 (2013): 131–138; P. Veena *et al.*, “Review of Grid Integration Schemes for Renewable Power Generation System,” *Renewable and Sustainable Energy Reviews* 34 (2014); N. Phuangpornpitak and S. Tia, “Opportunities and Challenges of Integrating Renewable Energy in Smart Grid System,” *Energy Procedia* 34 (2013); M. S. Jamel, A. Abd Rahman, and A. H. Shamsuddin, “Advances in the Integration of Solar Thermal Energy with Conventional and Non-Conventional Power Plants,” *Renewable and Sustainable Energy Reviews* 20 (2013); J. P. Chaves-Avila, R. A. Hakvoort, and A. Ramos, “The Impact of European Balancing Rules on Wind Power Economics and on Short-Term Bidding Strategies,” *Energy Policy* 68 (2014). On resource diversity, see for example, Tascikaraoglu, A., and M. Uzunoglu, “A Review of Combined Approaches for Prediction of Short-Term Wind Speed and Power,” *Renewable and Sustainable Energy Reviews* 34 (2014), Wolf D. Grossmann, Iris Grosssman, and Karl W. Seininger, “Solar Electricity Generation Across Large Geographic Areas, Part II: A Pan-American Energy System Based on Solar,” *Renewable and Sustainable Energy Reviews* 32 (2014).

3 See for example, Martin I. Hoffert, “Farewell to Fossil Fuels?” *Science* 329 (2010); Bettencourt, Trancik, and Kaur, “Determinants of Pace”; Dalibor Petković *et al.*, “Adaptive Neuro-Fuzzy Maximal Power Extraction of Wind Turbine with Continuously Variable Transmission,” *Energy* 64 (2014); Toshiyuki Sueyoshi and Mika Goto, “Photovoltaic Power Stations in Germany and the United States: A Comparative Study by Data Envelopment Analysis,” *Energy Economics* 42 (2014); Ksenia Chmutina and Chris I. Goodier, “Alternative Future Energy Pathways: Assessment of the Potential of Innovative Decentralised Energy Systems in the UK,” *Energy Policy* 66 (2014); Trieu Mai et al., “Envisioning a Renewable Electricity Future for the United States,” *Energy* 65 (2014); Katerina Tatiana Marques Santiago, Fernando Menezes Campello de Souza, and Diego de Carvalho Bezerra, “A Strong Argument for Using Non-Commodities to Generate Electricity.” *Energy Economics* 43 (2014); Erik Paul Johnson, “The Cost of Carbon Dioxide Abatement from State Renewable Portfolio Standards,” *Resource and Energy Economics* 36 (2014): 332–350; and Zheng and Daniel M. Kammen, “Innovation-Focused Roadmap.” There are a growing number of scenario analyses at the global level (Jacobson and Delucchi, “Technologies”; Jacobson *et al.*, “Examining the Feasibility of Converting New York State’s All-Purpose Energy Infrastructure to One Using Wind, Water and Sunlight,” *Energy Policy* 57 (2013); Delucchi and Jacobson, “Reliability”; Budischak *et al.*, “Cost-Minimized Combinations of Wind Power, Solar Power, and Electrochemical Storage, Powering the Grid up to 99.9% of the Time,” *Journal of Power*

In the early years of the transition, costs rise slightly because new generation resources are being deployed. The increasing cost of electricity is primarily the result of the need to replace aging and polluting generation with low-carbon alternatives, but "Wind generation variability has a minimal and manageable impact on grid reliability and related costs."[1] The potential for extremely rapid balancing, innovative battery technologies, and microgrids, which address the core problem of reliability in the digital age, have only begun to be appreciated.[2] In sum, careful analysis shows that reliability is a nonissue; the conflict is about the future of the techno-economic structure of the electricity sector in the 21st century.

The DOE explicitly laid out the process in the case of transmission.[3] The *Wind Vision* analysis argues that transmission costs are constantly being incurred by the electricity system. In the early years, those costs are reallocated from supporting central station generation (which is shrinking) to supporting new renewable resources. There is only a slight net increase in transmission investment. As time goes on and the share of renewables grows, transmission costs increase. However, they are complementary to the deployment of renewables, whose capital and operating costs have been declining and are much lower than the nonrenewable, low-carbon alternatives.

B. System Values

The U.S. Energy Information Administration (EIA) recognized the increasing complexity of selecting generation resources as very different technologies began to compete for investment resources. It summarized the approach to system value at a workshop in 2013, where it argued

Sources 225 (2013); Mark A. Delucchi and Mark Z. Jacobson, "Meeting the World's Energy Needs Entirely with Wind, Water, and Solar Power," *Bulletin of the Atomic Scientists* 69 (2013); Cochran, Mai and Bazilian, "Renewable Energy Scenarios."

1 U.S. Department of Energy, *Wind Vision*, xv.

2 Shrimali, Lynes and, Indvik, "Wind Energy Deployment," 454, Allal M. Bouzid et al., "A Survey on Control of Electric Power Distributed Generation Systems for Micro Grid Applications," *Renewable and Sustainable Energy Reviews* 44 (2015), 753.

3 U.S. Department of Energy, *Wind Vision*, xxxvi.

"that levelized cost of electricity (LCOE)…reflects both the capital and operating costs of deploying and running new utility-scale generation capacity… [but] the direct comparison of LCOE across technologies….is problematic and potentially misleading."[1] The EIA analysis focused on a comparison of the marginal value to the system of individual resources and these calculations were added to its *Annual Energy Outlook.* [2]

> Conceptually, a better assessment of economic competitiveness can be gained through consideration of avoided cost, a measure of what it would cost the grid to generate the electricity that is otherwise displaced by a new generation project, as well as its levelized cost. Avoided cost, which provides a proxy measure for the annual economic value of a candidate project, may be summed over its financial life and converted to a level annualized value that is divided by average annual output of the project to develop its "levelized" avoided cost of electricity (LACE). The LACE value may then be compared with the LCOE value. [3]

I call the difference between LCOE and LACE "inflexibility waste" to capture the key concept.[4] The avoided cost is less than the levelized cost because resources are inflexible, i.e. unable to adapt their output to the needs of the system. The system cost would be lower if technologies that better fit system needs are used. Inflexibility waste can be lowered in two ways – reducing levelized cost or decreasing avoided costs (*i.e.*, a better fit between output and system needs).

After extensively discussing the EIA system value approach to improving comparisons between alternatives, analysts at two national laboratories (Lawrence Berkeley National Laboratory and Argonne), suggested an alternative approach that rested on system costs. The

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1 EIA, 2013, *Assessing the Economic Value of New Utility-Scale Electricity Generation Projects,* Workshop Discussion Paper: LCOE and LACE, July, p. 1.

2 EIA, 2017, *Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2017*, p.3

3 EIA, 2013, *Assessing the Economic Value of New Utility-Scale Electricity Generation Projects,* Workshop Discussion Paper: LCOE and LACE, July, p. 1.

4 Johnson, *et al.*, 2017, "A reduced-form approach for representing the impacts of wind and solar PV deployment on the structure and operation of the electricity system," *Energy Economics* 64 estimate the system cost of ramping various resources as an "efficiency waste." The concept of "inflexibility waste" would include that cost plus the cost of larger reserves made necessary by the need to be able to replace the largest unit on the grid..

levelized cost of energy was the starting point and the most important factor, as in the system value approach, but the adjustment made was not by subtracting avoided costs from LCOE, but by adding estimates of the unique system cost of individual technologies to the LCOE. The former is a top down approach, the latter is a bottom up approach and the authors caution against double counting by combining the two.

> If properly defined, the 'system cost' of VRE [variable renewable electricity] (or any other resource) combined with the plant-level technology LCOE of VRE results in a 'total system LCOE', which can then be compared (with substantial caveats) to the 'total system LCOE' of any other technology to determine which resource has the lowest total system cost. An important point to make here is that this 'system cost' perspective is related to but distinct from the system value' perspective described earlier. An analyst may choose to use the 'system value' perspective or the 'system cost' perspective, but it is important to avoid double counting. Moreover, as discussed in more depth later, all resources have 'system costs', and so an exclusive focus on VRE alone is inappropriate.[1]

This approach was also advocated by a major research institution in Germany evaluating the aggressive transition to renewables being pursued in that nation.[2]

Attachment MNC-7 uses Lazard unsubsidized LCOE (from 2016) and also shows the operating and full costs of aging reactors developed earlier ($6/kWh and $9/kWh), rather than new nuclear reactors. The full cost is more appropriate.

To make a fair comparison between low carbon resources, I use the cost of natural gas combined cycle plants with 90% carbon capture. I have not included the cost of coal with 0% carbon capture because it is so far off the charts (50% higher than natural gas on LCOE) that it is not a contender and would distort the comparison between resources that should be considered for inclusion in the portfolio. Much the same is true of new nuclear, whose LCOE is more than twice gas, and whose carbon emissions are substantially higher than aging reactors because of

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1 Ryan, Wiser, Andrew Mills and Joachim Seel, 2017. *Impact of Variable Renewable Energy on Bulk Power System Assets, Pricing and Costs,* Argonne and Lawrence Berkeley National Laboratories, pp. 81-82.

2 Agora, Energiwende, *The Integration Costs of Wind and Solar Power: an Overview of the Debate on the Effects of Adding Wind and Solar Photovoltaic into Power Systems*, 2015.

the long construction period and intensive carbon emissions of construction. The LCOE costs are adjusted for EIA's estimate of system value, so the figure shows avoided cost.

I also include energy efficiency with the current LCOE of $35/MWh. I attribute system costs to efficiency equal to those for hydro, which is given a slight benefit in the EIA analysis. [1] Given all of the positive attributes of efficiency discussed above, this approach is likely to underestimate its benefit in terms of system costs.

The compelling conclusion of this analysis is quite clear, the renewables are preferable by far and all of the underlying trends reinforce these conclusions.[2] Renewable resource costs continue to fall, particularly for batteries, which would sharply increase their system value. Other advances in integration of renewables will also improve their value. In contrast, nuclear construction costs continue to rise. [3]

C. Tools to achieve Low Cost, Reliable Power

Attachments MNC-8 and MNC-9 show the many tools available to achieve low cost and reliable supply. I have included references to some of the extensive literature that supports the supply-side and demand-side tools. I treat storage as a demand-side strategy. This is unarguably true for distributed storage, although less so for dispatchable storage. Both are key to balancing

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1 This is consistent with Karier, Tom and John Fazio, 2017, "How hydropower enhances the capacity value of renewables and energy efficiency," *The Electricity Journal,* Vol. 30, Table 3 shows efficiency with much higher capacity values than natural gas. Johnson, 2017, *et al*. show gas with a 14% efficiency penalty. Resources available on-peak without ramping have capacity values of 1 and efficiency penalties of zero. All of these values suggest efficiency is a 1 on capacity and a zero on efficiency penalty.

2 A study by researchers at the Columbia University Center on Global Energy Policy applied this approach to the underlying EIA LCOE, Keith J. Benes, and Caitlin Augustin, 2016. "Beyond LCOE: A simplified framework for assessing the full cost of electricity," *The Electricity Journal*, Vol. 29 (8). Since the earlier EIA costs were out of touch with reality, the analysis leads to erroneous conclusions, although the impact of other system costs points to the same conclusions as in the above analysis.

3 The disruption of the transformation is one of the most important harms of extending the life of central station facilities, note by Lovins, A. *Do Coal and Nuclear Deserve Above-Market Prices?, The Electricity Journal,* Vol. 30, Issue 6, July 2017, pp. 22-30.

load and supply. Attachments MNC-8 band MNC-9 give primarily academic and trade literature citations. When pressed, utilities give the same answers.

California held a proceeding that challenged parties to think about how high levels of renewables could be integrated into the grid. Utilities offered a host of approaches and my summary concluded there were at least ten general ways to handle the challenge.[1]

1. Geographic diversity, particularly for wind, reduces extremes of generation, high or low output.
2. Technological diversity fosters a better fit with load.
3. Exploiting the best sites for renewable resources yields much larger economic value—three times the average.
4. Storage allows more energy to be captured and used when needed, both by reducing curtailment and by increasing demand (and therefore prices) during slack periods.
5. Demand shaping allows a better balance between supply and demand.
    - Demand reduction overall, and at the peak, through both reduction and load shifting.
    - Avoided capital cost in generation, transmission, and distribution.
    - Efficiency through reduction of line losses, reduced congestions, and transmission reinforcement.
    - Ancillary services by providing reserve support for energy, standby, and balancing.
6. Flexibility is a key attribute, achieved by
    - sub-hourly scheduling to reduce the magnitude and impact of forecasting error,
    - "quick start" generation, or
    - a portfolio approach that uses a mix of generation assets that can reduce the need for flexibility of individual assets.
7. Increasing regional coordination to create a large potential export market for excess energy.
8. Implementing a long-term, sustainable solution to address over-generation before the issue becomes more challenging with
    - promising technologies like storage (solar thermal with energy storage, pumped storage, other forms of energy storage including battery storage, electric vehicle charging, thermal energy storage) and
    - flexible loads that can increase energy demand during daylight hours (advanced demand response and flexible loads).
9. Optimizing the thermal generation fleet under high RPS [renewable portfolio standard].
10. A wide range of opportunities is opening up that can eliminate the wall between supply and demand behind which the 20th-century baseload model was built. Doing so re-

[1] Cooper, Green New Deal, *ibid.*

lies on the interrelationship of battery powered vehicles and the smart grid, the Internet of things, and having multiple roles for solar power.

The utility study identifies four "least regrets opportunities," and a number of opportunities for "research and development for technologies to address over-generation."[1] The transformation dividend is present in the utility analysis, which is equal to 10 percent of the capacity in the "unmitigated" PV system, and 15 percent of the capacity in the "mitigated" PV system.[2] This is consistent with the general finding of a transformation benefit.

I include these lengthy exhibits not only to show how much thinking has already gone into deployment of a new system, but also to underscore a simple fact. The Point Beach licensee refused to consider these remarkable developments because of its baseload myopia, which is unacceptable. If it wants to challenge the ability of the alternative system to meet need on a reliable basis, it can do so, although experience shows it will fail. It simply cannot ignore these developments, nor should the regulators at the federal and state levels.

5. NUCLEAR NIGHTMARES

A. The Fundamental Conflict

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1 E3, 2015. *Higher Renewables Portfolio Standard, E3. Investigating a Higher Renewables Portfolio Standard in California.* Energy and Environmental Economics, Inc., January, 2015.The four "least regrets" opportunities identified in this study include: "1. Increase regional coordination, 2. Pursue a diverse portfolio of renewable resources, 3. Implement a long-term, sustainable solution to address overgeneration before the issue becomes more challenging, 4. Implement distributed generation solutions." Additional measures are from Mills and Wiser, *Strategies for Mitigating*, put costs in the $5-$10/MWh range; Andrew Mills and Ryan Wiser, *Implications of Wide-Area Geographic Diversity for Short-Term Variability of Solar Power*, Lawrence Berkeley National Laboratory, 2010.

2 Jim Lazar, Teaching the "Duck" to Fly, Regulatory Assistance Project, January 2014; Steve Nadel, Conquering the Evening Peak, ACEEE, 2014. Mills AD, Wiser RH. 2015, Strategies to mitigate declines in the economic value of wind and solar at high penetration in California. Applied Energy 147:269--278; E3, 2015. Higher Renewables Portfolio Standard, E3. "Investigating a Higher Renewables Portfolio Standard in California," Energy and Environmental Economics, Inc., January, 2015; Staff White Paper, NYSERDA Energy Efficiency and Renewable Energy Potential Study of New York State, puts the figure at 10%.

The economic conflict of interest between nuclear power and the lower-cost, low-carbon alternatives is not limited to the cost of nuclear power. It is reinforced by fundamental differences between central station power and distributed resources, both in terms of technological competence and institutional requirements. Lovins elaborated earlier on these deep-seated sources of conflict, making it clear that a truce that tries to accommodate both sides is neither very likely, nor good policy.[1]

In short, this clash is inevitable and has given rise to a frontal assault by nuclear advocates on alternative resources and the institutions that support them. Responsible policymakers should reject the "all of the above" argument because the severely restricted market created by the forced presence of nuclear power will strangle the ability of non-hydro renewables to expand, which is likely to drive the market clearing price down, as resources compete for a smaller market. The nuclear carve out forces renewables to compete with much lower priced gas. If there had been no nuclear carve out, renewables could have competed for and won this load in an orderly fashion, avoiding another "crisis" at the termination of the

[1] Amory B. Lovins and Rocky Mountain Institute, *Reinventing Fire: Bold Business Solutions for the New Energy Era* (Boulder, CO: Rocky Mountain Institute, 2011), 216, "'All of the above' scenarios are . . . undesirable for several reasons. . . . First, central thermal plants are too inflexible to play well with variable renewables, and their market prices and profits drop as renewables gain market share. Second, if resources can compete fairly at all scales, some and perhaps much, of the transmission built for a centralized vision of the future grid could quickly become superfluous. Third, big, slow, lumpy costly investments can erode utilities and other provider's financial stability, while small, fast granular investments can enhance it. Competition between those two kinds of investments can turn people trying to recover the former investments into foes of the latter—and threaten big-plant owners' financial stability. Fourth, renewable, and especially distributed renewable, futures require very different regulatory structures and business models. Finally, supply costs aren't independent of the scale of deployment, so PV systems installed in Germany in 2010 cost about 56–67 percent less than comparable U.S. systems, despite access to the same modules and other technologies at the same global prices."

current subsidy, a "crisis" that the industry will inevitably invoke to demand another round of subsidies.[1]

B. Small Modular Reactors Do Not Solve the Problem

Small modular reactors are the latest in a long line of technologies that the advocates of nuclear power hope will be provide answers to the many problems that have afflicted their industry. Hyped as the dream solution, they turn into a nightmare. Small modular reactors that have been on the drawing board for at least a decade exhibit all of the characteristics of failure. Like the "nuclear renaissance" before it, the initial estimates of cost have doubled before they go into construction and cost overruns really only begin when construction does. While they can find companies to back them and governments to support them, and academics to explain the theory of why they should work, the one thing they cannot do is deliver low cost power.

While they claim to be safer than large units, they achieve that goal not by solving safety problems, but by being excused from safety rules (like exclusion zones). While they are low in carbon emissions during operation, they suffer from the problem that, even if the production of small units will be possible in the future, they will arrive long after the battle against climate change is lost. While they are small, they still need "must run" status and large numbers of units shipped in order to lower their cost. Small modular reactors are likely to be between three and five times as costly as the already available technologies to build a low cost, low carbon, low pollution electricity sector. As Ramana recently put it,

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[1] Lovins, *Do coal and nuclear*, *ibid.*. rebuts the argument for nuclear subsidies showing that "All 14 current rationales for mandating or subsidizing uncompetitive coal and nuclear plants lack technical merit or would favor competitors instead. Subsidizing distressed nuclear plants typically saves less carbon than closing them and reinvesting their saved operating cost into severalfold-cheaper efficiency. Carbon prices, not plant subsidies, best recognize decarbonizing attributes. Grid reliability needs careful integration of diverse, distributed demand-side and renewable resources, using competitive market processes and resilient architectures, but does not require 'baseload' plants.

> The estimated costs of the NuScale reactor design have been consistently going up. Just in the last five years, the estimated construction cost has gone up from around $3 billion in 2015 to $6.1 billion in 2020. Because the NuScale design might have to be modified to resolve the problems flagged by the Nuclear Regulatory Commission, there could be further cost increases even before construction starts. There is a long history of dramatic cost increases when paper designs are first constructed.[1]

Attachment MNC-10 describes the SMR cost problem. It updates my 2014 analysis by including two recent estimates. I have included the current estimate for the only active small modular reactors project. The high cost of nuclear power is apparent and there is nothing in the small modular reactor technology that suggests it will result in a cost revolution for nuclear. Using the math of the vendor, the first cost estimate was put at $0.055/kWh, so the current estimate is about twice that before construction cost overruns. In other words, it is at least 3 times as costly as the bundle of alternatives (efficiency, wind and solar) and likely to be even more if construction takes place. The economic failure of SMR technology should be the end of nuclear power, since a low-cost, low-carbon, low-pollution electricity system, in which it can play no role, should be in place before any of these reactors are constructed.

C. Subsidizing Aging Reactors is Also the Wrong Approach

The final chapter of the nuclear nightmare is the one on which the Point Beach Licensee would like the NRC to bet. Since the Licensee accepts the fact that it makes no sense to try to build new nuclear reactors to replace Point Beach, it concludes that it is best to extend its license for twenty years. Unfortunately for nuclear advocates, extending the lives of old reactors makes no more sense than new builds. The economic subsidy necessary to keep these aging reactors on line is massive.

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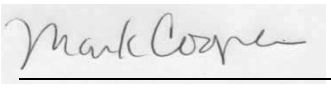
[1] M. V. Ramana, 2020, *Eyes Wide Shut: Problems with the Utah Associated Municipal Power Systems Proposal to Construct NuScale Small Modular Nuclear Reactors,* Oregon Physicians for Social Responsibility, September.

Attachment MNC – 11 makes this point. It overlays the "guaranteed" price for power from the Point Beach purchased power agreement on a recent analysis I did of the operating cost of aging reactors. I include the earlier analysis, since we do not know the operating cost of Point Beach, but it fits well within the range I had earlier estimated. The obvious implication of the analysis is that the purchased power agreement is totally uneconomic. In 2020, the price is $20/ MWh higher than the bundle of alternatives analyzed above. The overcharge mounts steadily to almost $100/MWh through 2030. The average excess is $55/MWh. The cumulative excess cost imposed on ratepayers is almost $5 billion for the period ending in 2030, which works out to over $3,000 per electricity customer, or $300 per year. .

With $5 billion and the remaining time between the early-2030s expirations of Point Beach Units 1 and 2, the net expected power generation from the plant during that period could be completely obviated by construction of renewables and implementation of efficiency. Given current cost of alternatives, the output of Point Beach would cost ratepayers over twice as much as a least cost, low carbon, low pollution approach. Thus, the purchased power agreement for Point Beach imposes enormous excess costs on Point Beach ratepayers and is unconscionable. By 2030 and 2033, but for the PPA, efficiency and renewable energy sources could have expanded and displaced this myopic baseload power plant. By 2030, Point Beach Units 1 and 2 will be completely redundant and obsolescent.

March 23, 2021



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ATTACHMENT MNC-1 CURRICULUM VITA OF MARK COOPER

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EDUCATION:

Yale University, Ph.D., 1979, Sociology
University of Maryland, M.A., 1973, Sociology
City College of New York, B.A., 1968, English

PROFESSIONAL EXPERIENCE:

President, Citizens Research, 1983 - present
Research Director, Consumer Federation of America, 1983-present
Senior Fellow for Economic Analysis, Institute for Energy and the Environment, Vermont Law School 2009-present
Associated Fellow, Columbia Institute on Tele-Information, 2003-2016
Fellow, Donald McGannon Communications Research Center, Fordham University, 2005-2015
Fellow, Silicon Flatirons, University of Colorado, 2009-2014
Fellow, Stanford Center on Internet and Society, 2000-2010
Principle Investigator, Consumer Energy Council of America, Electricity Forum, 1985-1994
Director of Energy, Consumer Federation of America, 1984-1986
Director of Research, Consumer Energy Council of America, 1980-1983
Consultant, Office of Policy Planning and Evaluation, Food and Nutrition Service, United States Department of Agriculture, 1981-1984
Consultant, Advanced Technology, Inc., 1981
Technical Manager, Economic Analysis and Social Experimentation Division, Applied Management Sciences, 1979
Research Associate, American Research Center in Egypt, 1976-1977
Research Fellow, American University in Cairo, 1976
Staff Associate, Checchi and Company, Washington, D.C., 1974-1976
Consultant, Division of Architectural Research, National Bureau of Standards, 1974
Consultant, Voice of America, 1974
Research Assistant, University of Maryland, 1972-1974

TEACHING EXPERIENCE:

Lecturer, Washington College of Law, American University, Spring, 1984 - 1986, Seminar in Public Utility Regulation
Guest Lecturer, University of Maryland, 1981-82, Energy and the Consumer, American University, 1982, Energy Policy Analysis
Assistant Professor, Northeastern University, Department of Sociology, 1978-1979, Sociology of Business and Industry, Political Economy of Underdevelopment, Introductory Sociology, Contemporary Sociological Theory; College of Business Administration, 1979, Business and Society
Assistant Instructor, Yale University, Department of Sociology, 1977, Class, Status and Power
Teaching Assistant, Yale University, Department of Sociology, 1975-1976, Methods of Sociological Research, The Individual and Society
Instructor, University of Maryland, Department of Sociology, 1974, Social Change and Modernization, Ethnic Minorities
Instructor, U.S. Army Interrogator/Linguist Training School, Fort Hood, Texas, 1970-1971

PROFESSIONAL ACTIVITIES:

Member, Advisory Committee on Appliance Efficiency Standards, U.S. Department of Energy, 1996 - 1998
Member, Energy Conservation Advisory Panel, Office of Technology Assessment, 1990-1991
Fellow, Council on Economic Regulation, 1989-1990
Member, Increased Competition in the Electric Power Industry Advisory Panel, Office of Technology Assessment, 1989
Participant, National Regulatory Conference, The Duty to Serve in a Changing Regulatory Environment, William and Mary, May 26, 1988
Member, Subcommittee on Finance, Tennessee Valley Authority Advisory Panel of the Southern States Energy Board, 1986-1987
Member, Electric Utility Generation Technology Advisory Panel, Office of Technology Assessment, 1984 - 1985

Member, Natural Gas Availability Advisor Panel, Office of Technology Assessment, 1983-1984

Participant, Workshop on Energy and the Consumer, University of Virginia, November 1983

Participant, Workshop on Unconventional Natural Gas, Office of Technology Assessment, July 1983

Participant, Seminar on Alaskan Oil Exports, Congressional Research Service, June 1983

Member, Thermal Insulation Subcommittee, National Institute of Building Sciences, 1981-1982

Round Table Discussion Leader, The Energy Situation: An Open Field For Sociological Analysis, 51st Annual Meeting of the Eastern Sociological Society, New York, March, 1981

Member, Building Energy Performance Standards Project Committee, Implementation Regulations Subcommittee, National Institute of Building Sciences, 1980-1981

Participant, Summer Study on Energy Efficient Buildings, American Council for an Energy Efficient Economy, August 1980

Member, University Committee on International Student Policy, Northeastern University, 1978-1979

Chairman, Session on Dissent and Societal Reaction, 45th Annual Meeting of the Eastern Sociological Society, April, 1975

Member, Papers Committee, 45th Annual Meeting of the Eastern Sociological Society, 1975

Student Representative, Programs, Curricula and Courses Committee, Division of Behavioral and Social Sciences, University of Maryland, 1973-1974

President, Graduate Student Organization, Department of Sociology, University of Maryland, 1973-1974

HONORS AND AWARDS:

Ester Peterson Award for Consumer Service, 2010

American Sociological Association, Travel Grant, Uppsala, Sweden, 1978

Fulbright-Hayes Doctoral Research Abroad Fellowship, Egypt, 1976-1977

Council on West European Studies Fellowship, University of Grenoble, France, 1975

Yale University Fellowship, 1974-1978

Alpha Kappa Delta, Sociological Honorary Society, 1973

Phi Delta Kappa, International Honorary Society, 1973

Graduate Student Paper Award, District of Columbia Sociological Society, 1973

Science Fiction Short Story Award, University of Maryland, 1973

Maxwell D. Taylor Award for Academic Excellence, Arabic, United States Defense Language Institute, 1971

Theodore Goodman Memorial Award for Creative Writing, City College of New York, 1968

New York State Regents Scholarship, 1963-1968

National Merit Scholarship, Honorable Mention, 1963

PUBLICATIONS:

ENERGY

Books and Chapters

The Political Economy of Electricity: Progressive Capitalism and the Struggle to Build a Sustainable Power Sector (Praeger, 2017)

"Energy Justice in Theory and Practice: Building a Pragmatic, Progressive Road Map," in Thijs de Graf, Benjamin K. Sovacool, Arunabha Gosh, Florian Kern, and Michael T. Klare (Eds.) *The Palgrave Handbook of the International Political Economy of Energy,* (PALGRAVE, Macmillan, 2016)

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Articles and Papers:

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"Renewable and distributed resources in a post-Paris low carbon future: The key role and political economy of sustainable electricity," *Energy Research & Social Science,* 19 (2016) 66-93.

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Energy Efficiency Performance Standards: Driving Consumer and Energy Savings in California.Presentation at the California Energy Commission's Energy Academy, February 20, 2014.

"Small modular reactors and the future of nuclear power in the United States," *Energy Research & Social Science,* 2014.

"The EPA carbon plan: Coal loses, but nuclear doesn't win," *Bulletin of the Atomic Scientists,* 70, 2014

"Multi-Criteria Portfolio Analysis of Electricity Resources: An Empirical Framework For Valuing Resource In An Increasingly Complex Decision-Making Environment"*, Expert Workshop: System Approach to Assessing the Value of Wind Energy to Society, European Commission Joint Research Centre, Institute for Energy and Transport*, Petten, The Netherlands, November 13-14, 2013

"Nuclear aging: Not so gracefully," *Bulletin of the Atomic Scientists,* 69, 2013

"Nuclear Safety and Affordable Reactors: Can We Have Both?," *Bulletin of the Atomic Scientists,* 68, 2012

"Nuclear Safety and Nuclear Economics, Fukushima Reignites the Never-ending Debate: Is Nuclear Power not worth the risk at any price?," *Symposium on the Future of Nuclear Power,* University of Pittsburgh, March 27-28, 2012

"Nuclear liability: the post-Fukushima case for ending Price-Anderson," *Bulletin of the Atomic Scientists,* October, 67, 2011.

"Prudent Resource Acquisition in a Complex Decision-Making Environment: Multidimensional Analysis Highlights the Superiority of Efficiency," *Current Approaches to Integrated Resource Planning, 2011 ACEEE National Conference on Energy Efficiency as a Resource*, Denver, September 26, 2011

"The Implications of Fukushima: The US perspective**,"** *Bulletin of the Atomic Scientists*, July/August 2011 67: 8-13

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"Risk, Uncertainty and Ignorance: Analytic Tools for Least-Cost Strategies to Meet Electricity Needs in a Complex Age," *Variable Renewable Energy and Natural Gas: Two Great Things that Go Together, or Best Not to Mix Them*. NARUC Winter Committee Meetings, Energy Resources, Environment and Gas Committee, February 15, 2011

"The Failure of Federal Authorities to Protect American Energy Consumers From Market Power and Other Abusive Practices," *Loyola Consumer Law Review,* 19:4 (2007)

"Too Much Deregulation or Not Enough," *Natural Gas and Electricity*, June 2005

"Real Energy Crisis is $200 Billion Natural Gas Price Increase," Natural Gas and Electricity, August 2004

"Regulators Should Regain Control to Prevent Abuses During Scarcity," Natural Gas*,* August 2003

"Economics of Power: Heading for the Exits, Deregulated Electricity Markets Not Working Well," *Natural Gas*, 19:5, December 2002

"Let's Go Back," Public Power, November-December 2002

"Conceptualizing and Measuring the Burden of High Energy Prices," in Hans Landsberg (Ed.), High Energy Costs: Assessing the Burden (Washington, D.C.: Resources For the Future, 1982)

"Energy Efficiency Investments in Single Family Residences: A Conceptualization of Market Inhibitors," in Jeffrey Harris and Jack Hollander (Eds.), *Improving Energy Efficiency in Buildings: Progress and Problems* (American Council for An Energy Efficient Economy, 1982)

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"The Role of Consumer Assurance in the Adoption of Solar Technologies," *International Conference on Consumer Behavior and Energy Policy,* August, 1982

"Energy and the Poor," *Third International Forum on the Human Side of Energy*, August, 1982

"Energy Price Policy and the Elderly," *Annual Conference, National Council on the Aging*, April, 1982

"Energy and Jobs: The Conservation Path to Fuller Employment," *Conference on Energy and Jobs conducted by the Industrial Union Department of the AFL-CIO,* May 1980

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50 by 2030: Why $3.00 Gasoline Makes the 50-Miles Per Gallon Car Feasible, Affordable and Economic, Consumer Federation of America, (May 2006)

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A Consumer Issue Paper on Electric Utility Restructuring (American Association of Retired Persons and the Consumer Federation of America, January, 1997)

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The Bigger the Better: The Public Interest in Building a Larger Strategic Petroleum Reserve, June 12, 1984

The Consumer Economics of CWIP: A Short Circuit for American Pocketbooks, April, 1984

Public Preference in Hydro Power Relicensing: The Consumer Interest in Competition, April 1984

Concept Paper for a Non-profit, Community-based, Energy Services Company, November 1983

The Consumer and Energy Impacts of Oil Exports, April 1983

Up Against the Consumption Wall: The Impact of Rising Energy Prices on Lower Income Consumers, March 1983

A Decade of Despair: Rising Energy Prices and the Living Standards of Lower Income Americans, September 1982

The Impact of Rising Energy Prices on the Delivery of Public Service by Local Governments, August 1982

The Impact of Rising Energy Prices on the Low-Income Population of the Nation, the South, and the Gulf Coast Region, July, 1982

A Comprehensive Analysis of the Impact of a Crude Oil Import Fee: Dismantling a Trojan Horse, April 1982

The Past as Prologue II: The Macroeconomic Impacts of Rising Energy prices, A Comparison of Crude Oil Decontrol and Natural Gas Deregulation, March, 1982

The Past as Prologue I: The Underestimation of Price Increases in the Decontrol Debate, A Comparison of Oil and Natural Gas, February 1982

Oil Price Decontrol and the Poor: A Social Policy Failure, February 1982

Natural Gas Decontrol: A Case of Trickle-Up Economics, January 1982

A Comprehensive Analysis of the Costs and Benefits of Low-Income Weatherization and Its Potential Relationship to Low Income Energy Assistance, June 1981

Summary of Market Inhibitors, February 1981

Program Models and Program Management Procedures for the Department of Energy's Solar Consumer Assurance Network Project: A Rapid Feedback Evaluation, February 1981

An Analysis of the Economics of Fuel Switching Versus Conservation for the Residential Heating Oil Consumer, October 1980

Energy Conservation in New Buildings: A Critique and Alternative Approach to the Department of Energy's Building Energy Performance Standards, April, 1980

The Basics of BEPS: A Descriptive Summary of the Major Elements of the Department of Energy's Building Energy Performance Standards, February, 1980

COMMUNICATIONS AND MEDIA

Books and Chapters

"The Future of Journalism: Addressing Pervasive Market Failure with Public Policy," in R.W. McChesney and Victor Picard (eds.), Will the Last Reporter Turn out the Lights (New York: New Press, 2011)

"Broadband in America: A Policy of Neglect is not Benign," in Enrico Ferro, Yogesh K. Dwivedi, J. Ramon Gil-Garcia, and Michael D. Williams, Eds., *Overcoming Digital Divides: Constructing an Equitable and Competitive Information Society,"* IGI Global Press, 2009.

"Political Action and Internet Organization:An Internet-Based Engagement Model," in Todd Davies and Seeta Pena Gangaharian, Eds., *Online Deliberation: Design, Research and Practice,* CSLI press.

"When Counting Counts: Marrying Advocacy and Academics in the Media Ownership Research Wars at the FCC," forthcoming in Lynn M. Harter, Mohan J. Dutta, and Courtney Cole, Eds., *Communicating for Social Impact: Engaging Communication Theory, Research, and Pedagogy,* Hampton Press.

The Case Against Media Consolidation (Donald McGannon Communications Research Center, 2007)

Open Architecture as Communications Policy (Stanford Law School, Center for Internet and Society: 2004)

Media Ownership and Democracy in the Digital Information Age: Promoting Diversity with First Amendment Principles and Rigorous Market Structure Analysis (Stanford Law School, Center for Internet and Society: 2003)

Cable Mergers and Monopolies: Market Power In Digital Media and Communications Networks (Washington, D.C.: Economic Policy Institute, 2002)

"When Law and Social Science Go Hand in Glove: Usage and Importance of Local and National News Sources, Critical Questions and Answers for Media Market Analysis,"forthcoming in, Philip Napoli, Ed. *Media Diversity and Localism: Meaning and Metrics, (*Lawrence Erlbaum, 2007)

"The Importance of Open Networks in Sustaining the Digital Revolution," in Thomas M. Lenard and Randolph J. May (Eds.) *Net Neutrality or Net Neutering*(New York, Springer, 2006)

"Reclaiming The First Amendment: Legal, Factual And Analytic Support For Limits On Media Ownership," Robert McChesney and Benn Scott (Eds), *The Future of Media* (Seven Stories Press, 2005)

"Building A Progressive Media And Communications Sector," Elliot Cohen (Ed.), News Incorporated: Corporate Media Ownership And Its Threat To Democracy (Prometheus Books, 2005)

"Hyper-Commercialism In The Media: The Threat To Journalism And Democratic Discourse," Snyder-Gasher-Compton-(Eds), *Converging Media, Diverging Politics: A Political Economy Of News In The United States And Canada*(Lexington Books, 2005)

"The Digital Divide Confronts the Telecommunications Act of 1996: Economic Reality versus Public Policy," in Benjamin M. Compaine (Ed.), *The Digital Divide: Facing a Crisis or Creating a Myth?* (Cambridge: MIT Press, 2001)

Articles and Papers:

"Business Data Services after the 1996 Act: Structure, Conduct, Performance in the Core of the Digital Communications Network The Failure of Potential Competition to Prevent Abuse of Market Power," Telecommunications Policy Research Conference, September, 2016.

with Gene Kimmelman, "Antitrust and Economic Regulation: Essential and Complementary Tools to Maximize Consumer Welfare and Freedom of Expression in the Digital Age," *Harvard Law & Policy Review* 9-2 (2015)

"The ICT Revolution in Historical Perspective: Progressive Capitalism as a Response to Free Market Fanaticism and Marxist Complaints in the Deployment Phase of the Digital Mode of Production." *Telecommunication Policy Research Conference Session on Innovation,* September 28, 2015.

"The Long History and Increasing Importance of Public Service Principles For 21st Century Public Digital Communications Networks," *Journal on Telecommunications and High Technology Law*, 2014

"From the Public Switched Telephone Network to the Public Digital Communications Network: Interconnection, Interoperability, Universal Service & Innovation at the Edge," *Interconnection Policy for the Internet Age, The Digital Broadband Migration: The Future of Internet-Enabled Innovation, Silicon Flatirons,* February 10-11, 2013

"Why Growing Up is Hard to Do: Institutional Challenges for Internet Governance in the "Quarter Life Crisis of the of the Digital Revolution," *Journal on Telecommunications and High Technology Law,* 2013. 11(1).

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"The Central Role of Wireless in the 21st Century Communications Ecology: Adapting Spectrum and Universal Service Policy to the New Reality," *Telecommunications Policy Research Conference*, September 2011

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"The Lack of Racial and Gender Diversity in Broadcast Ownership and The Effects of FCC Policy: An Empirical Analysis," *Telecommunications Research Policy Conference*, September 2007, with Derek Turner

"New Media and Localism: Are Local Cable Channels and Locally Focused Websites Significant New and Diverse Sources of Local News and Information? An Empirical Analysis," *Telecommunications Research Policy Conference*, September 2007, with Adam Lynn

"A Case Study of Why Local Reporting Matters: Photojournalism Framing of the Response to Hurricane Katrina in Local and National Newspapers," *International Communications Association*, May 2007.

"Will the FCC Let Local Media Rise from the Ashes of Conglomerate Failure," *International Communications Association*, May 2007.

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"Independent, Non-Commercial Video," *Beyond Broadcast,*Berkman Center, Harvard University, May 12, 2006

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"The Economics of Collaborative Production: A Framework for Analyzing the Emerging Mode of Digital Production," *The Economics of Open Content: A Commercial Noncommercial Forum,*MIT January 23, 2006

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"The Importance of Collateral Communications and Deliberative Discourse in Building Internet-Based Media Reform Movements," *Online Deliberation: Design, Research and Practice/DIAC,* November, 2005

"Collaborative Production in Group-Forming Networks: The 21st Century Mode of Information Production and the Telecommunications Policies Necessary to Promote It," *The State of Telecom: Taking Stock and Looking Ahead*, Columbia Institute on Tele-Information, October 2005

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"Limits on Media Ownership are Essential," *Television Quarterly,*Spring Summer 2004

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"Direct Testimony of Mark N. Cooper On Behalf of the Office of the People's Counsel of the District of Columbia," Before the Public Service Commission of the District of Columbia, In the Matter of Investigation Into the Impact of the AT&T Divestiture and Decisions of the Federal Communications Commission on the Chesapeake and Potomac Telephone Company's Jurisdictional Rates, July 14, 1995

"Comments of Consumer Action and the Consumer Federation of America," Before the Public Utilities Commission of California, Order Instituting Rulemaking on the Commission's Own Motion into competition for Local Exchange Service, Docket Nos. R. 95-04-043 and I. 95-04-044, May 23, 1995

"Testimony of Dr. Mark N. Cooper on Behalf of the Arkansas Attorney General," before the Arkansas Public Service Commission, In the Matter of an Earnings Review of Southwestern Bell Telephone Company, Docket NO. 92-260-U, April 21, 1995

"Promoting Competition and Ensuring Consumer Protection on the Information Superhighway, Testimony of Dr. Mark N. Cooper on Behalf of the American Association of Retired Persons and the Consumer Federation of America on Proposed Revisions of Chapter 364," Committee on Commerce and Economic Opportunities, Florida Senate, April 4, 1995

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"Promoting Competition and Ensuring Consumer Protection on the Information Superhighway, Testimony of Dr. Mark N. Cooper on Behalf of the American Association of Retired Persons and the Consumer Federation of America on Proposed Revisions of Chapter 364," Florida House of Representative, March 22, 1995

"Prepared Testimony of Dr. Mark N. Cooper on Behalf of the Office of the Attorney General State of Arkansas," Before the Arkansas Public Service Commission, In the Matter of an Earnings Review of GTE Arkansas Incorporated, Docket NO. 94-301-U, March 17, 1995

"Statement of Dr. Mark N. Cooper," DPUC Investigation into The Southern New England Cost of Providing Service, Docket No. 94-10-01, January 31, 1995

"Statement of Dr. Mark N. Cooper," DPUC Exploration of Universal Service Policy Options, Docket No. 94-07-08, November 30, 1994

"Statement of Dr. Mark N. Cooper," DPUC Investigation of Local Service Options, including Basic Telecommunications Service Policy Issues and the Definition of Basic Telecommunications Service, Docket No. 94-07-07, November 15, 1994

"Testimony of Dr. Mark N. Cooper on Behalf of Attorney General of the Commonwealth of Kentucky, Utility and Rate Intervention Division, before the Public Service Commission, Commonwealth of Kentucky, Case No. 94-121, August 29, 1994

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"Reply Testimony of Dr. Mark N. Cooper on Behalf of the Attorney General of Arkansas," before the Arkansas Public Service Commission, in the Matter of the Consideration of Expanded Calling Scopes and the Appropriate NTS Allocation and Return on Investments for the Arkansas Carrier Common Line Pool, Docket No. 93125-U, May 4, 1994

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"Comments of Dr. Mark N. Cooper on Behalf of Consumers Union, Southwest Regional Office, before the Public Utility Commission of Texas, Request for Comments on the Method by which Local Exchange Services are Priced, Project No. 12771, April 18, 1994

"Comments of Dr. Mark N. Cooper on Behalf of the American Association of Retired Persons,” Before the Tennessee Public Service Commission, Inquiry for Telecommunications Rule making Regarding Competition in the Local Exchange, Docket No. 94-00184, March 15, 1994

“Rebuttal Testimony of Dr. Mark N. Cooper on Behalf of the Virginia Citizens Consumer Council, Inc., before the State Corporation Commission at Richmond, Commonwealth of Virginia, In the Matter of Evaluating Investigating the Telephone Regulatory Case No. PUC930036 Methods Pursuant to Virginia Code S 56-235.5, March 15, 1994

"Testimony of Dr. Mark N. Cooper on Behalf of the Virginia Citizens Consumer Council, Inc., before the State Corporation Commission at Richmond, Commonwealth of Virginia, In the Matter of Evaluating Investigating the Telephone Regulatory Case No. PUC930036 Methods Pursuant to Virginia Code S 56-235.5, February 8, 1994

"Testimony of Dr. Mark N. Cooper on Behalf of The American Association of Retired Persons, Citizen Action Coalition, Indiana Retired Teachers Association, and United Senior Action, before the Indiana Utility Regulatory Commission, Cause No. 39705, December 17, 1993

"Testimony of Dr. Mark N. Cooper on Behalf of the Virginia Citizens Consumer Council, Inc.," before the State Corporation Commission at Richmond, Commonwealth of Virginia, In the Matter of Evaluating the Experimental Plan for Alternative Regulation of Virginia Telephone Companies, Case No. PUC920029, October 22, 1993

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"Direct Testimony of Dr. Mark N. Cooper on Behalf of the People's Counsel," before the Florida Public Service Commission, Comprehensive Review of the Revenue Requirement and Rate Stabilization Plan of Southern Bell Telephone and Telegraph Company, Docket No. 900960-TL, November 16, 1992

"Direct Testimony of Dr. Mark N. Cooper on Behalf of the American Association of Retired Persons," before the Florida Public Service Commission, Comprehensive Review of the Revenue Requirement and Rate Stabilization Plan of Southern Bell Telephone and Telegraph Company, Docket No. 900960-TL, November 16, 1992

"Testimony of Dr. Mark N. Cooper" before the Regulatory Flexibility Committee, General Assembly, State of Indiana, August 17, 1992

"Testimony of Dr. Mark N. Cooper On Behalf of the Consumer Advocate,” before the Public Service Commission of South Carolina, Petition of the Consumer Advocate for the State of South Carolina to Modify Southern Bell's Call Trace Offering, Docket No. 92-018-C, August 5, 1992

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"Testimony of Dr. Mark N. Cooper on Behalf of the Consumer Federation of America," before the Corporation Commission of the State of Oklahoma, In the Matter of the Corporation Commission's Notice of Inquiry Regarding Telecommunications Standards in Oklahoma, Cause No. PUD 1185, February 28, 1992

"Testimony of Dr. Mark N. Cooper on Behalf of the Consumer Federation of America," before the Georgia Public Service Commission, In the Matter of A Southern Bell Telephone and Telegraph Company Cross-subsidy, Docket No. 3987-U, February 12, 1992

"Testimony of Dr. Mark N. Cooper on Behalf of the Consumer Federation of America," before the Arkansas Public Service Commission, in the Matter of an Inquiry into Alternative Rate of Return Regulation for Local Exchange Companies, Docket No. 91-204-U, February 10, 1992

"Statement on Behalf of the Consumer Federation of America on HB 1076," before the Missouri General Assembly, January 29, 1992

"Testimony on behalf of the American Association of Retired Persons and the Consumer Federation of America," before the Legislative P.C. 391 Study Committee of the Public Service Commission of Tennessee, January 13, 1992

"Direct Testimony on Behalf of the "Consumer Advocate," Public Service Commission State of South Carolina, In the Matter of the Application of Southern Bell Telephone and Telegraph Company for Approval of Revision to its General Subscribers Service Tariff (Caller ID), Docket No. 89-638-C, December 23, 1991

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"On Behalf of the Office of Consumers Counsel," before the Public Utilities Commission of Ohio, In the Matter of the Application of the Ohio Bell Telephone Company to Revise its Exchange and Network Services Tariff, P.U.C.O. No. 1, to Establish Regulations, Rates, and Charges for Advanced Customer Calling Services in Section 8. The New Feature Associated with the New Service is Caller ID, Case No. 90-467-TP-ATA; In the Matter of the Application of the Ohio Bell Telephone Company to Revise its Exchange and Network Service Tariff, P.U.C.O. No 1, to Establish Regulations, Rates and Charges for Advanced Customer Calling Services in Section 8., The New Feature Associated with the New Service is Automatic Callback, Case No. 90-471-TP-ATA, September 3, 1991

"On Behalf of the American Association of Retired Persons," Before the Senate Select Telecommunications Infrastructure and Technology Committee, 119th Ohio General Assembly, July 3, 1991

"On Behalf of the Cook County State's Attorney," before the Illinois Commerce Commission, In Re: Proposed Establishment of a Custom Calling Service Referred to as Caller ID and Related Custom Service, Docket Nos. 90-0465 and 90-0466, March 29, 1991

"On Behalf of the Vermont Public Interest Research Group," before the Public Service BoardIn Re: Investigation of New England Telephone and Telegraph Company's Phonesmart Call Management Services, Docket No. 54-04, December 13, 1990

"On Behalf of the Office of Consumer Advocate," before the State of Iowa, Department of Commerce, Utilities Division, In Re: Caller ID and Related Custom Service, Docket No. INU-90-2, December 3, 1990

"On Behalf of the Office of Public Counsel," before the Florida Public Service Commission, In Re: Proposed Tariff Filings by Southern Bell Telephone and Telegraph Company When a Nonpublished Number Can be Disclosed and Introducing Caller ID to Touchstar Service, Docket No. 891194-TI, September 26, 1990

"On Behalf of the Office of Public Advocate," before the Public Service Commission, State of Delaware, In the Matter of: The Application of the Diamond State Telephone Company for Approval of Rules and Rates for a New Service Known as Caller*ID, PSC Docket No. 90-6T, September 17, 1990

"On Behalf of the Maryland People's Counsel," before The Public Service Commission of Maryland, In the Matter of Provision of Caller Identification Service by the Chesapeake and Potomac Company of Maryland, Case No. 8283, August 31, 1990

"On Behalf of the Office of Attorney General," before the Commonwealth of Kentucky, Public Service Commission, In the Matter of the Tariff Filing of GTE South Incorporated to Establish Custom Local Area Signaling Service, Case No. 90-096, August 14, 1990

"On Behalf of the Consumers' Utility Counsel," before the Georgia Public Service Commission Re: Southern Bell Telephone Company's Proposed Tariff Revisions for Authority to Introduce Caller ID, Docket No. 3924-U, May 7, 1990

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"On Behalf of the Office of Consumer Advocate" before the Pennsylvania Public Utility Commission in the Matter of Pennsylvania Public Utility Commission v. The Bell Telephone Company of Pennsylvania, Docket NO. R-891200, May 1989.

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"On Behalf of Manitoba Anti-poverty Organization, the Manitoba Society of Seniors and the Consumers Association of Canada (Manitoba)" before the Public Utilities Board in the Matter of the Request of Manitoba Telephone System for a General Rate Review, February 16, 1989

"On Behalf of the Ohio Consumers Counsel, In the Matter of the Application of GTE MTO Inc. for Authority to Increase and Adjust its Rates and Charges and to Change Regulations and Practices Affecting the Same, Case No. 87-1307-TP- Air," before the Public Utility Commission of Ohio, May 8, 1988

"On Behalf of the Evelyn Soloman, Proceeding on Motion of the Commission as to the Rates, Charges and Regulations of Niagara Mohawk Power Corporation, Case Nos. 29670 and 29671," before the State of New York Public Service Commission, February 16, 1988

"An Economic Perspective - The Status of Competition in the Telecommunications Industry and Its Impact on Taxation Policy," Before the Joint Subcommittee on the Taxation of The Telecommunications Industry, December 8, 1987

"On Behalf of the Office of Consumer Counsel, State of Washington," In the Matter of the Petition of AT&T Communications of Pacific Northwest, Inc. for Classification as a Competitive Telecommunications Company, March 24, 1987

"On Behalf of Manitoba Anti-poverty Organization and the Manitoba Society of Seniors," before the Public Utilities Board in the Matter of the Request of Manitoba Telephone System for a General Rate Review, March 16, 1987

"On Behalf of the Office of Consumers' Counsel, State of Ohio," In the Matter of the Application of the Ohio Bell Telephone Company for Authority to Amend Certain of its Intrastate Tariffs to Increase and Adjust the Rates and Charges and to Change its Regulations and Practices Affecting the Same, Case No. 84-1435-TP-AIR, April 6, 1986

"On Behalf of Manitoba Anti-poverty Organization and Manitoba Society of Seniors," before the Public Utilities Board in the Matter of the Request of Manitoba Telephone System for a General Rate Review, February 6, 1986

"On Behalf of Mississippi Legal Services Coalition, in the Matter of Notice by Mississippi Power and Light of Intent to Change Rates" Before the Mississippi Public Service Commission, April 15, 1985

"On Behalf of the Universal Service Alliance, in the Matter of the Application of New York Telephone Company for Changes in it Rates, Rules, and Regulations for Telephone Service, State of New York Public Service Commission, Case No. 28961, April 1, 1985

"On Behalf of North Carolina Legal Services, in the Matter of Application of Continental Telephone Company of North Carolina for an Adjustment of its Rates and Charges, Before the North Carolina Utilities Commission, Docket No. P-128, Sub 7, February 20, 1985

"On Behalf of the Consumer Advocate in re: Application of Southern Bell Telephone and Telegraph Company for Approval Increases in Certain of Its Intrastate Rates and Charges," Before the South Carolina Public Service Commission, Docket No. 84-308-c, October 25, 1984

"On Behalf of the Office of the Consumers' Counsel in the Matter of the Commission Investigation into the Implementation of Lifeline Telephone Service by Local Exchange Companies," Before the Public Utilities Commission of Ohio, Case No. 84-734-TP-COI, September 10, 1984

"On Behalf of North Carolina Legal Services Resource Center in the Matter of Application Southern Bell Telephone and Telegraph Company for an Adjustment in its Rates and Charges Applicable to Intra-state Telephone Service in North Carolina," Before the North Carolina Utilities Commission, Docket No. P-55, Sub 834, September 4, 1984

"On Behalf of Mississippi Legal Services Coalition in the Matter of the Citation to Show Cause Why the Mississippi Power and Light Company and Middle South Energy Should not Adhere to the Representation Relied Upon by the Mississippi Public Service Commission in Determining the Need and Economic Justification for Additional Generating Capacity in the Form of A Rehearing on Certification of the Grand Gulf Nuclear Project," Before the Mississippi Public Service Commission, Docket No. U-4387, August 13, 1984

"On Behalf of the Mississippi Legal Services Corporation Re: Notice of Intent to Change Rates of South Central Bell Telephone Company for Its Intrastate Telephone Service in Mississippi Effective January 1, 1984," before the Mississippi Public Service Commission, Docket No. U-4415, January 24, 1984

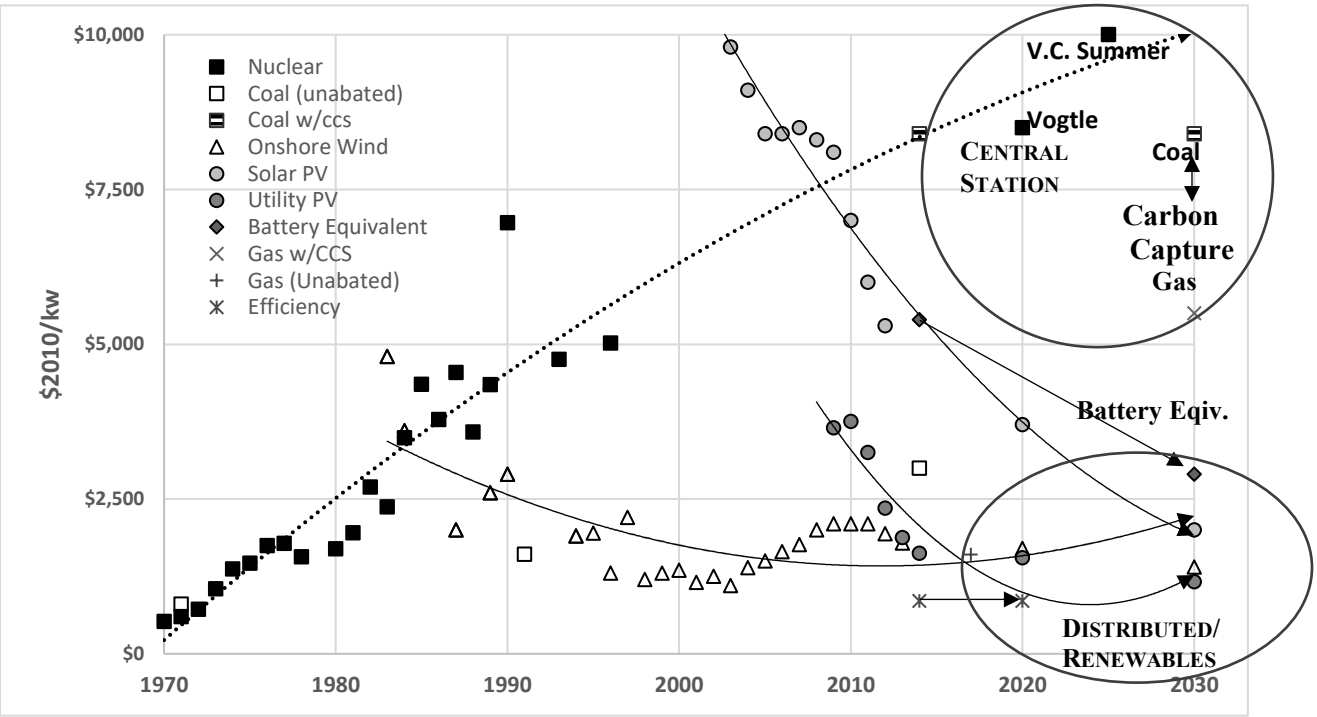
"The Impact of Rising Energy Prices on the Low Income Population of the Nation, the South, and the Gulf Coast Region," before the Mississippi Public Service Commission, Docket No. U4224, November 1982

"In the Matter of the Joint Investigation of the Public Service Commission and the Maryland Energy Office of the Implementation by Public Utility Companies Serving Maryland Residents of the Residential Conservation Service Plan," before the Public Service Commission of the State of Maryland, October 12, 1982

"The Impact of Rising Utility Rates on he Budgets of Low Income Households in the Region of the United States Served by the Mississippi Power Company and South Central Bell Telephone Company," before the Chancery Court of Forrest County, Mississippi, October 6, 1982

"The Impact of Rising Energy Prices on the Low Income Population of the Nation, the South and the Gulf Coast Region," before the Mississippi Public Service Commission, Docket No. U-4190, August 1982

ATTACHMENT MNC-2
PAST, PRESENT AND FUTURE COST OF NUCLEAR POWER V. ALTERNATIVES



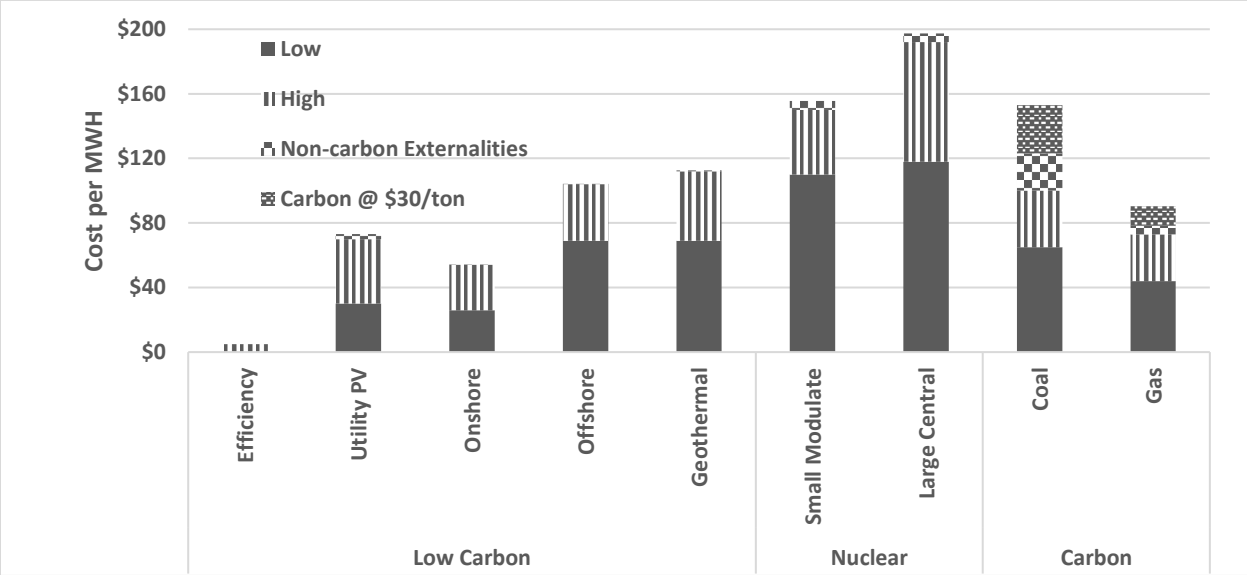
Source: Updated and adapted from Mark Cooper, *The Political Economy of Electricity: Progressive Capitalism and the Struggle to Build a Sustainable Sector* (Santa Barbara, Praeger, 2017), Figure 2.1 and accompanying text. (overnight cost for capital-intensive technologies, fuel-intensive technologies based on relative cost per kWh).

ATTACHMENT MNC-3
CHANGE IN U.S ELECTRICITY GENERATION (KWH) PER DOLLAR OF GDP (REAL)

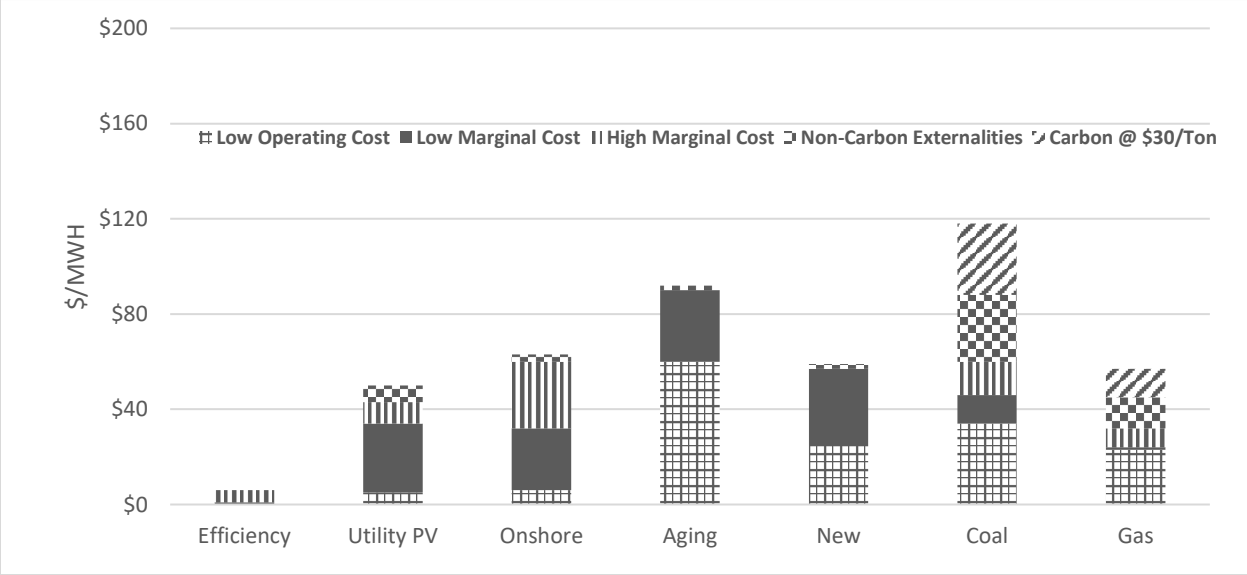
Period	Annual % Change Electricity	GDP/capita	Electricity/ GDP/capita
1950-1980	+6.4	+3.5	+2.89
1980-1995	+1.9	+2.2	-0.000
1995-2015	+0.1	+1.6	-0.012
2015-2019	+0.3	+3.5	-3.1

Source: U.S. Energy Information Administration, *Monthly Energy Review December 2015*, http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_5.pdf; *US Real GDP by Year,* http://www.multpl.com/us-gdp-inflation-adjusted/table.

Long Term Costs Per MWh



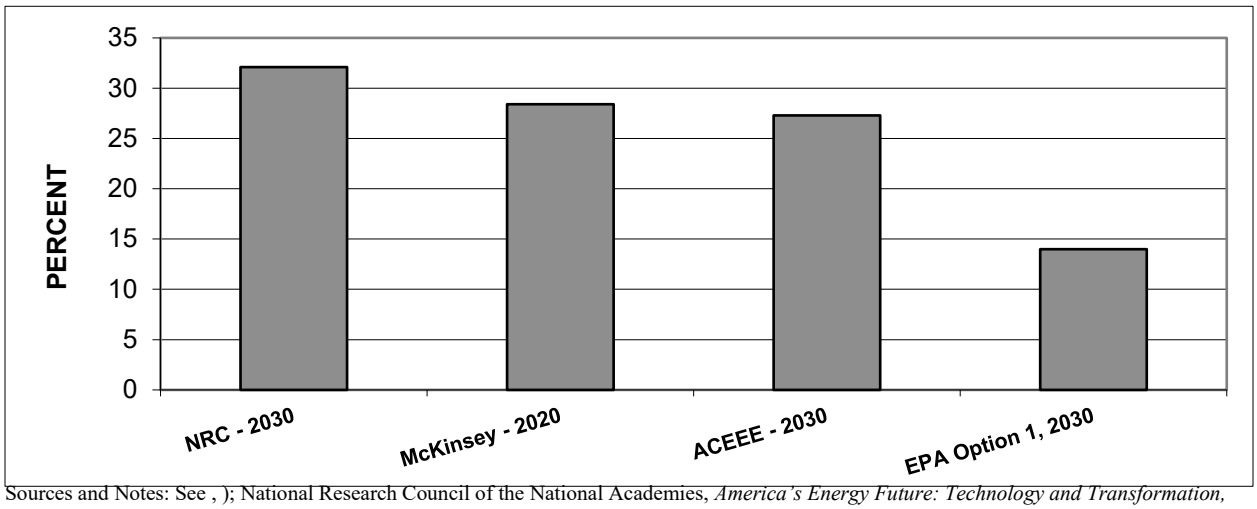
Short Term Costs Per MWh



Source: Lazard, *Lazard's Levelized Cost of Energy Analysis – Version 14.0,* October 2020, Long Terms Costs are from "Levelized Cost of Energy Key Assumptions. **Karkour, Selim, 2020,** Selim Karkour, et al., 2020, External-Cost Estimation of Electricity Generation in G20 Countries: Case Study Using a Global Life-Cycle Impact-Assessment Method," *sustainability,* March 5. See also, Dallas Burtraw, et. al., 2012, *Power: An Inventory of Methodologies to Support Future Decision making in Comparing the Cost and Competitiveness of Electricity Generation Technologies,* Resources for the Future, June, Table 1. Short term costs are from LZARD, Levelized Cost of Energy Comparison -- Renewable Energy Versus Marginal Cost of Selected Existing Conventional Generation," and Levelized cost of Energy Components – Low End," for low operating costs.

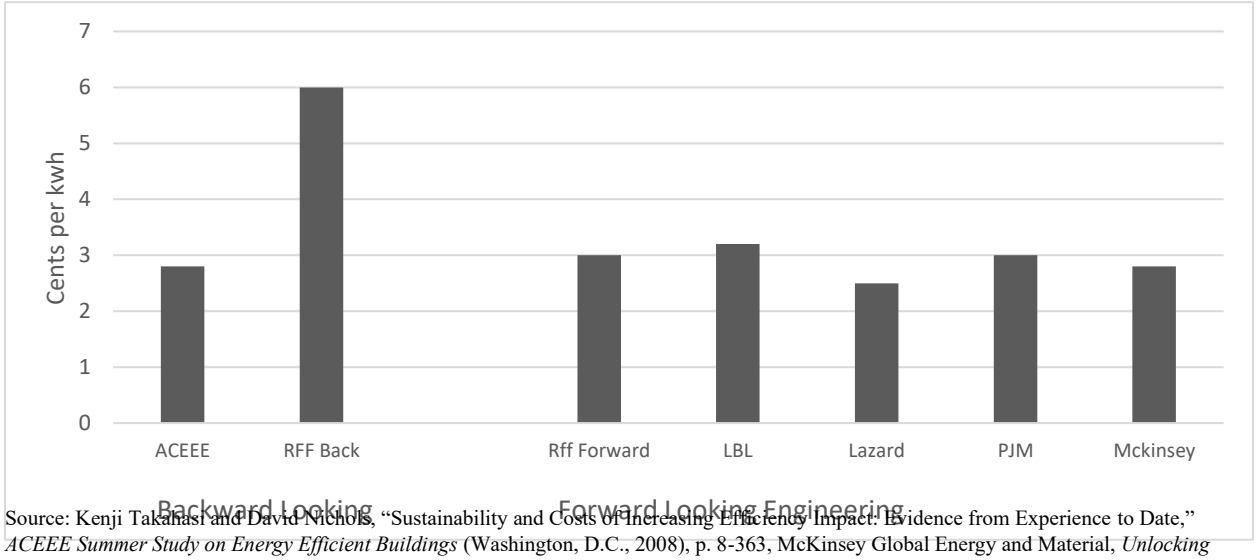
ATTACHMENT MNC-5
PLENTIFUL, LOW COST EFFICIENCY TO MEET FUTURE NEEDS

Efficiency Potential from Major National Studies Compared to EPA Option 1



Sources and Notes: See ,); National Research Council of the National Academies, *America's Energy Future: Technology and Transformation, Summary Edition* (Washington, D.C.: 2009). The NRC relies on a study by Lawrence Berkeley Laboratory for its assessment (Richard Brown, Sam Borgeson, Jon Koomey and Peter Biermayer, U.S. *Building-Sector Energy Efficiency Potential (*Lawrence Berkeley National Laboratory, September 2008). McKinsey Global Energy and Material, *Unlocking Energy Efficiency in the U.S. Economy* (McKinsey & Company, 2009; Gold, Rachel, Laura, et. al., *Energy Efficiency in the American Clean Energy and Security Act of 2009: Impact of Current Provisions and Opportunities to Enhance the Legislation*, American Council for an Energy Efficient Economy, September 2009); EPA, *Regulatory Impact Analysis,* 2004, Table 3-11.

The Cost of Saved Electricity

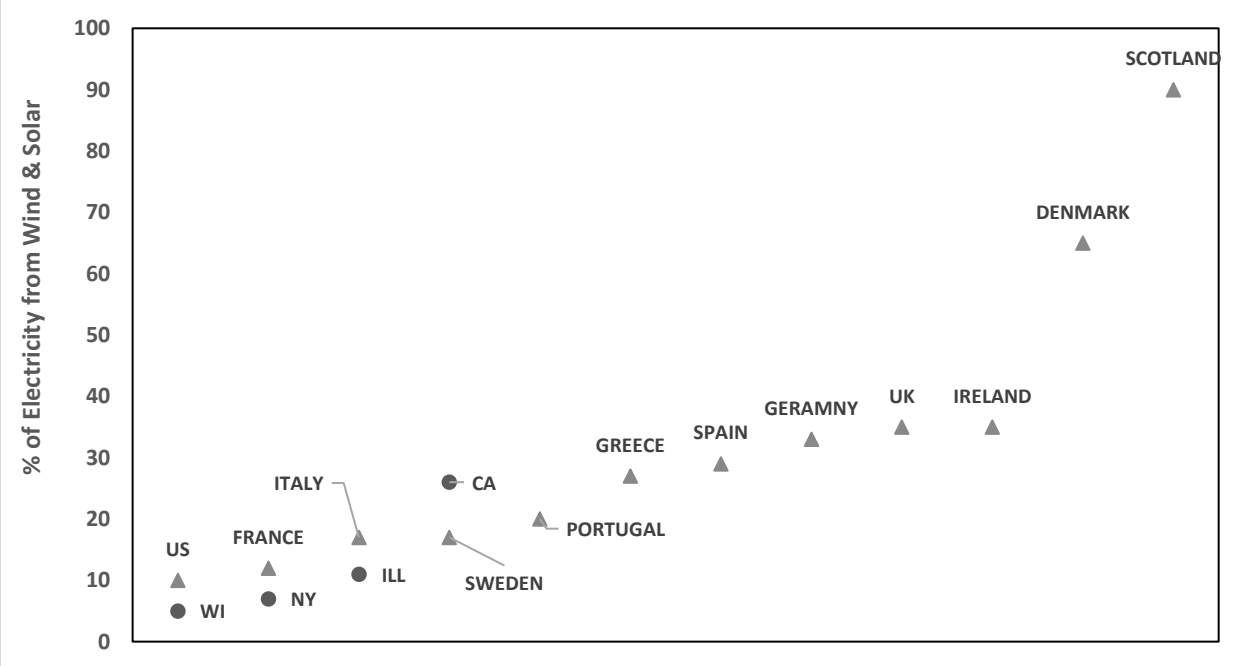


Source: Kenji Takahasi and David Nichols, "Sustainability and Costs of Increasing Efficiency Impact: Evidence from Experience to Date," *ACEEE Summer Study on Energy Efficient Buildings* (Washington, D.C., 2008), p. 8-363, McKinsey Global Energy and Material, *Unlocking Energy Efficiency in the U.S. Economy* (McKinsey & Company, 2009); National Research Council of the National Academies, *America's Energy Future: Technology and Transformation, Summary Edition* (Washington, D.C.: 2009). The NRC relies on a study by Lawrence Berkeley Laboratory for its assessment (Richard Brown, Sam Borgeson, Jon Koomey and Peter Biermayer, *U.S. Building-Sector Energy Efficiency Potential* (Lawrence Berkeley National Laboratory, September 2008).

	ACEEE Efficiency Scorecard 2020				NREL Wind and Solar	Current Use	
	Overall Rank	Utility Rank	Utility Score	Achieves Savings % of Sales	Potential GWh/ Capita	Current Use GWh/ capita	Projects per million
California	1	4	16.0	1.74	4.5	.37	6.3
New York	5	5	13.5	1.29	10.2	.55	4.2
Illinois	15	9	21.0	1.44	9.2	1.26	5.8
Average	7	6	16.8	1.49	8.0	.73	5.4
Wisconsin	26	18	7.5	0.64	6.3	.86	2.2

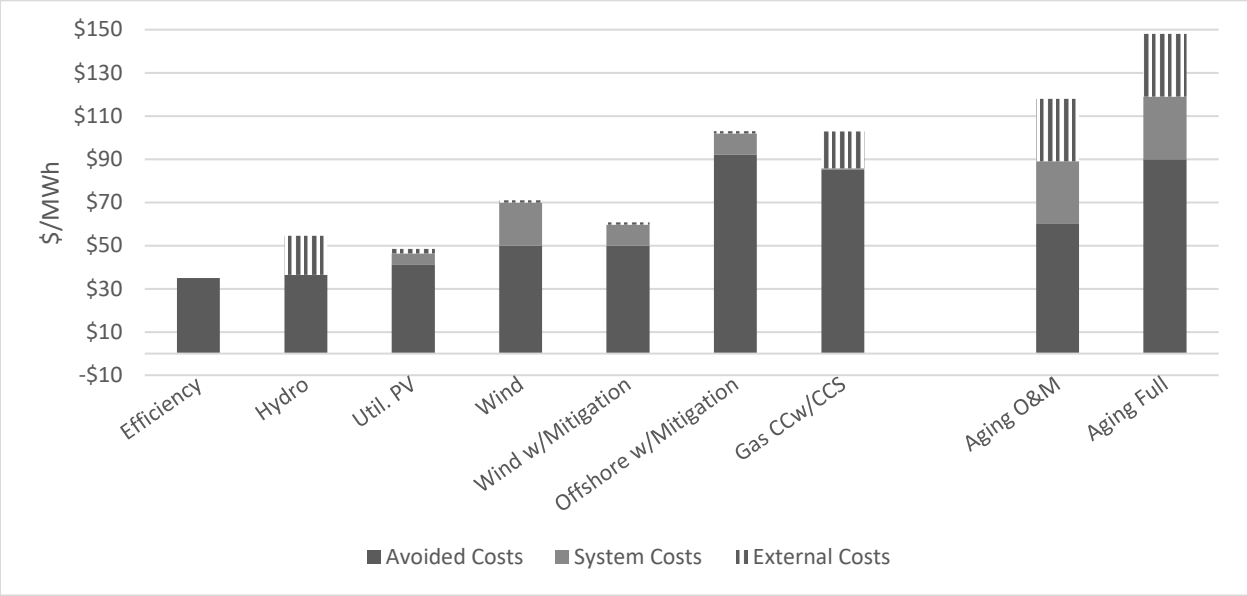
Sources: Berg, Weston, et al., 2020, *The State Energy Efficiency Scorecard*, American Council for an Energy Efficient Economy, December.Wind and Solar potential from Anthony Lopez, et al.,2012, U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis NREL Technical Report NREL/TP-6A20-51946 July. Projects from, Solar and Wind Energy Research Database, visited March 22, 2021.

Penetration of Generation from Wind and Solar



Energy Information Administration, Electric Supply Monthly, EMBER, *EU Power Sector is 2020.*

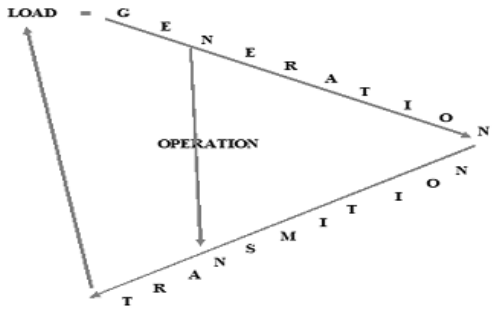
ATTACHMENT MNC-7: CURRENT ESTIMATES OF TOTAL SYSTEM COST



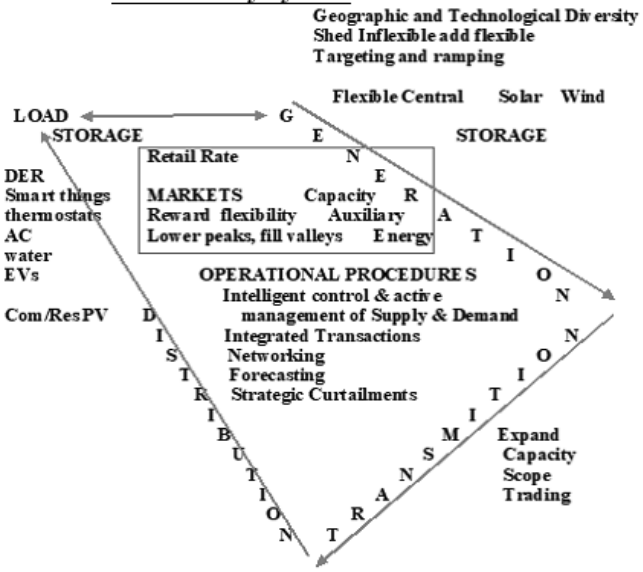
Source: EIA, 2018, *Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2018*, February Tables 2 and 3, for the adjustment to levelized costs to account for the value of output, using capacity weighted averages where available and unsubsidized costs. Wiser, Ryan, Andrew Mills and Joachim Seel, 2015. *Impact of Variable Renewable Energy on Bulk Power System Assets, Pricing and Costs,* Argonne and Lawrence Berkeley National Laboratories, Chapter 5. Lazard, 2018. Lazard's Levelized Cost of Energy Analysis – Version 12.0 for LCOE, 10. For carbon costs, NRC, 2010, *The Hidden Cost of Electricity*, for non-carbon pollution costs of gas, with other resources expressed as a multiple of gas.

ATTACHMENT MNC-8: CREATING THE 21ST CENTURY ELECTRICITY SYSTEMS:

20th Century System



21st Century system



Fundamental Differences between Centuries and Systems

Characteristic	20th Century	21st Century
Goal	Redundancy (as resilience)	Flexibility (resilience is a result)
Operational objective	Increase capacity to follow load	Integrate & match supply and demand
Configuration, size	Island set by economies of generations	Interconnection set by value
Supply-Demand	Segregation	Integration
Demand driver	Dumb load	Smart Retailer
System cost recovery	High, lumpy and fixed	Variable targeted and local
Organization	Centralized	Distributed
Challenges	Increase capacity to follow load	Integrate & match supply and demand
Flash point	50 most expensive hours (>$10,000)	50 least expensive hours (< $0)
Market power	High	Low
Optimization Target	Meet peaks	Shave peaks, Fill valleys (shed & shift)
End users role	Passive	Active
Flow: Output	Hub & Spoke, linear	Networked, Dynamic & Transparent
Information	Aggregate	Transparent, local
Resources: Physical	Fuel, Cement and Boiling Water	Steel, Silicon and Intelligence
Intellectual	Engineering judgement	Communications, Advanced Control
Capital	High for base, low for peak	Moderate for both
Energy intensity	High, concentrated	Low, diffuse

ATTACHMENT MNC - 9 : MEASURES TO MANAGE AN INTELLIGENT, DECENTRALIZED ELECTRICITY SECTOR AND REDUCE PEAK LOAD

Overall Effect[1]

Lower Cost (including externalities, e.g., uncertainty, choice[2]**)**

Smaller Systems[3] **(especially the transformation dividend**[4]**)**

Demand

Efficiency

Target efficiency to peak reduction

Aggressive demand response[5]

Manage devices (e.g., water heater loads to reduce peak.[6]

Smart controllers[7]

Shed inflexible baseload

Rates[8]

Target fixed-cost recovery to ramping hours

Time of use rates

Dispatchable storage[9]

Solar thermal electric with storage[10]

Utility storage in strategic locations[11]

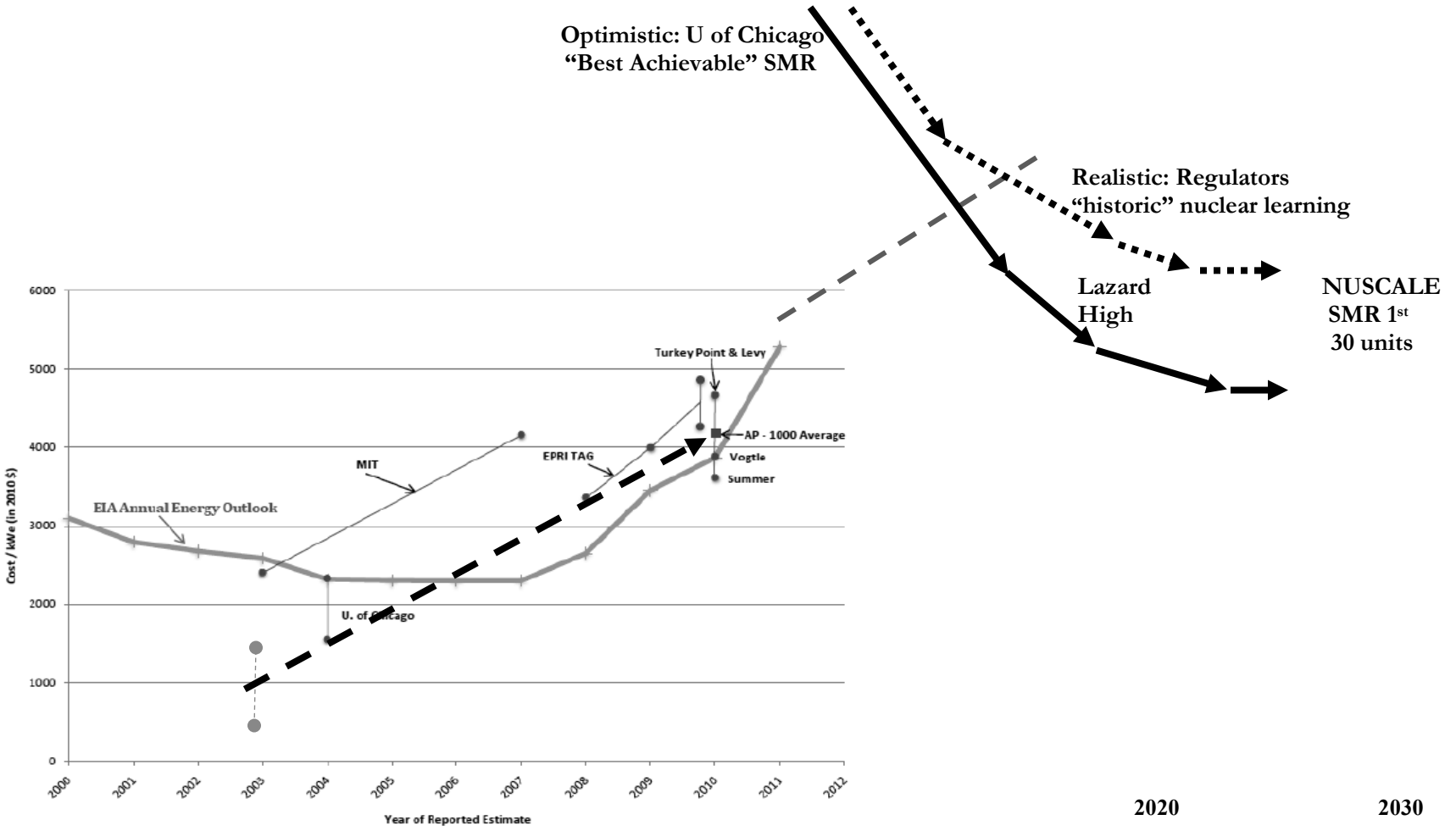
Distributed storage

Community & individual storage

Air conditioning water heating with storage

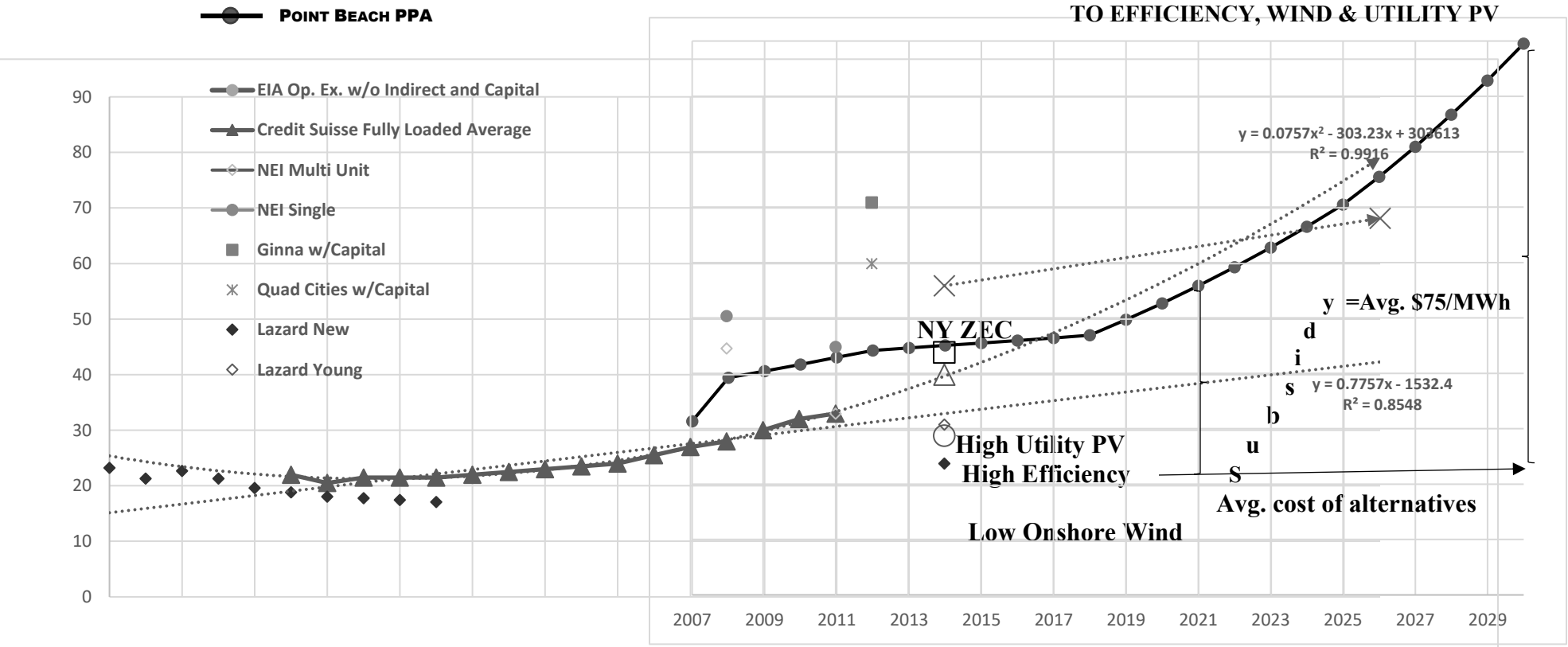
Electric vehicles[12]

ATTACHMENT MNC-10 - UNIVERSITY OF CHICAGO RECAP OF ENTHUSIAST/UTILITY ESTIMATES OF OVERNIGHT COST FOR NEW GW-SCALE NUCLEAR PLANTS AND SMRS



Sources: Mark Cooper**, "**Small modular reactors and the future of nuclear power in the United States," Energy Research & Social Science 3 (2014) 161; Rosner, Robert and Stephen Goldberg, 2011, *Small Modular Reactors – Potentially Key Contributors to Future Nuclear Power Generation in the U.S.*, Center for Strategic and International Studies, December 1; Rosner, Robert, et al., Analysis of GW-Scale Overnight Capital Costs, EPIC, University of Chicago, Technical Paper Nov. 2011. For the cost and other problems with the only active U.S. small modular Reactor see, h. V. Ramana, *2020, Eyes Wide Shut: Problems with the Utah Associated Municipal Power Systems Proposal to Construct NuScale Small Modular Nuclear Reactors,* Oregon Physicians for Social Responsibility.

ATTACHMENT MNC-11 OPERATING AND TOTAL COST OF AGING REACTORS COMPARED TO EFFICIENCY, WIND & UTILITY PV



Sources: Eggers, Dan, Kevin Cole, and Matthew Davis. Nuclear . . . The Middle Age Dilemma? Facing Declining Performance, Higher Costs, Inevitable Mortality. Credit Suisse, 2013; Lazard. Lazard's Levelized Cost of Energy Analysis12.0, November 2018, Nuclear Energy Institute, Nuclear Costs in Context, October, 2018; NEI Operating Cost (Nuclear Street News Team. "NEI Lays Out the State of Nuclear Power." Nuclearstreet.com. February 26, 2014); NEI Excludes Indirect (Nuclear Energy Institute, Operating Costs, http://www.nei.org/Knowledge-Center/Nuclear-Statistics/Costs-Fuel,-Operation,-Waste-Disposal-Life-Cycle/US-Electricity-Production-Costs-and-Components); Naureen S. Malik and Jim Poulson, "New York Reactors Survival Tests Pricey Nuclear," Bloomberg, January 5, 2015, p. 2. Quad Cities is based on a $580 million subsidy (Steve Daniels, "Exelon Puts an Opening Price Tag on Nuclear Rescue: $580 Million," Crains Chicago Business, September 24, 2014), converted to $25/MWH for output at risk reactors. Illinois Commerce Commission, Illinois Power Agency, Illinois Environmental Protection Agency, Illinois Department Commerce and Economic Opportunity, 2015, Response to The Illinois General Assembly Concerning House Resolution 1146, January 5, real price increase to break even, plus $11/MWH for capital. "Comments of Dr. Mark Cooper." In the Matter of Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, Environmental Protection Agency, RIN 2060-AR33, November 24, 2015. Comments by Alliance For A Green Economy and Nuclear Information and Resource Service, Proceeding on Motion of the Commission to Implement a Large-Scale Renewable Program and a Clean Energy Standard, Case 15-E-0302, April 22, 2016; RE: Case 15-E-0302- In the Matter of the Implementation of a Large-Scale Renewable Program and a Clean Energy Standard Re: Case 16-E-0270: Petition of Constellation Energy Nuclear Group, LLC; R.E. Ginna Nuclear Power Plant, LLC; and Nine Mile Point Nuclear Station, LLC to Initiate a Proceeding to Establish the Facility Costs for the R.E. Ginna and Nine Mile Point Nuclear Power Plants, July 22, 2016. Energy Information Administration, Electricity Annual, 2015, Table 8.4; Point Beach Nuclear Plant Power Purchase Agreement Between FPL Energy Point Beach, LLC and Wisconsin Electric Power Company, dated as of December 19, 2006, A-1.

Comments for NextEra Energy Point Beach, LLC; Point Beach Nuclear Plant, Units 1 and 2
Docket (NRC-2020-0277)

Comments and questions from a representative of Physicians for Social Responsibility Wisconsin:

1. I am concerned by the "segmentation" that is occurring in this EIS process. The division into separate parts or sections occurs in the Point Beach Nuclear Plant (PBNP) draft EIS and prevents a true comprehensive and cumulative analysis of impacts.

   I will provide an example of what I mean by segmentation to explain the issue. For example, let's say an agency is conducting an EIS for a 100-mile highway and only looking at the 20 miles proposed to be constructed first and this is before it crosses a protected wetland. This is not looking at the entirety of the effects of the highway as it is known it will be longer than 20 miles. To compare to PBNP, the EIS is only looking at the 20 years of the proposed next license, not the longer-term impact of operations and existence of the plant. To reference the example, PBNP's EIS is not looking at the rest of the highway.

   Then once the first 20 miles of the highway are constructed, it is easier for the agency to override the impacts on the next miles of the highway that crosses the wetland as it is economically feasible to do so or whatever reason the agency choses to get the 100-mile highway finished. This is what is happening repeatedly with Point Beach: the general EIS that is for all similar nuclear plants in the US, the EIS for the initial first license extension at PBNP and now the EIS for the proposed subsequent license extension at PBNP. It is continually putting pieces together, not a comprehensive analysis.

   Segmentation is also occurring in another facet, this EIS is not looking at other factors like safety or operations, as it is conveniently diverted to other processes by the NRC and not considered in the EIS. If the EIS were to truly take a hard look at the impacts of PBNP, safety issues and their consequences, such as embrittlement, would be covered in the EIS.

   Segmentation is a flaw and needs to be addressed.

2. Relying on data from NextEra for the effects on the aquatic ecosystem from the intake and discharges of waters at Lake Michigan is inadequate. Further quantitative data needs to be used and disclosed.

3. I request all 16 possible alternatives that were considered by the draft EIS authors to be listed, not just the 3 selected for further analysis. (Section 2.3.2)

4. I do not understand why SMRs were chosen out of the 16 possibilities for alternatives to the proposed action. SMRs are not commercially viable.
   https://www.ucsusa.org/sites/default/files/2019-10/small-isnt-always-beautiful.pdf

5. Why was an alternative of one reactor running while the other closing not considered?

6. I had trouble finding specifics on the deadline for the draft EIS comments. Frequently it is stated January 3, 2022, however this does not provide clarity. Are comments due by 11:59 CT on January 2, 2022, since comments are "due by January 3, 2022"? Or are comments due at 11:59 CT on January 3? With the timing, the NRC needs to consider time zones for the due date and time. What time zone are they using? As PBNP's physical location is in Wisconsin, it would be appropriate in Central Time, but I know NRC has used Eastern Time in the past. The public needs clarification on deadlines for public participation.

7. In reference to refurbishment activities (2.2.2), it appears the authors are purely relying on NextEra's analysis. "NextEra did not identify any major refurbishment activities necessary for the continued operation of Point Beach beyond the end of the existing operating licenses (NextEra 2020b)." The EIS authors should have a second source of information to verify this information. This situation happens through the EIS and NextEra's information needs to be verified by additional sources of information and data.

8. Why is the region of influence (2.3.2: 2-18) based on Wisconsin Electric Power Company's service area for energy alternatives? This forces a narrow analysis of energy alternatives. This inherently excludes offshore wind on Lake Michigan as well as the energy produced across Wisconsin, land availability and other opportunities.

9. It needs to be clear when the authors are relying on data from computer generated models not specific to PBNP. Even if the models are based on similarly designed nuclear reactors, there are still major differences: each reactor has likely different sourced building materials, different companies have managed each reactor and each reactor is in a different environment.

10. The general EIS that is used as a base EIS for all nuclear reactors needs to be updated if it is going to be used. With our advancement in technology, knowledge of environmental impacts and time for more research. The general EIS is not a sufficient analysis.

11. On reading 3-152, it seems that NextEra and NRC were only required to do an analysis of accidents once on a license extension application in 2004. Our knowledge of climate change related weather disasters has increased (for example look at derecho at Duane Arnold). As well, a physical structure can change in 17 years, due this timespan I don't see this analysis from 2004 as adequate.

12. I am attaching expert reports that should be considered and documented in the PBNP EIS process. The expert reports are from Arnold Gundersen, Mark Copper, PhD and Alvin Compaan, PhD.