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Is New Always Better?
The Case for License Renewal in the Next Generation

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"There is certainly a changing mood in the country, because nuclear [energy] is carbon free, that we should look at it with new eyes."
– Stephen Chu, Secretary of Energy[1]

I. INTRODUCTION

Imagine, if you will, the Great Pyramid in Giza, Egypt. When it was completed, it stood more than 480 feet, the tallest building in the world for 3,800 years.[2] The building's mass has been estimated at 5.9 million tons, and its volume is roughly 2.5 million cubic meters.[3] Even in 2009, the Pyramid stands as a remarkable achievement in size and engineering.

Now, imagine a Great Pyramid of carbon. The size of the pyramid might be roughly comparable to one-eighth the amount of carbon dioxide gas a coal-fired plant generates in a year.[4]

In 2006 alone, the Nuclear Energy Institute estimated that the nation's 104 operating nuclear power plants displaced about 138 million metric tons of carbon.[5] With increasing concerns over global climate change – and the role that carbon emissions play in the rising problem – nuclear power has a serious role to play in the country's shift to a "greener" economy. Simply

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1. *Chu Nomination*: *Hearing Before the Comm. on Energy and Natural Resources*, 111th Cong. 24 (2009) (statement of Stephen Chu), *available at* http://frwebgate.access.gpo.gov/cgibin/getdoc.cgi?dbname=111_senate_hearings&docid=f:47253.pdf.

2. Charles William Johnson, *The Great Pyramid: Measurements*, EARTH/MATRIX, May 31, 1998, *available at* http://www.earthmatrix.com/great/pyramid.htm.

3. JANEY LEVY, THE GREAT PYRAMID OF GIZA: MEASURING LENGTH, AREA, VOLUME, AND ANGLES 14-17 (2005).

4. *See Carbon Dioxide Emissions from Power Plants Rated Worldwide*, SCIENCE DAILY, Nov. 15 2007, *available at* http://www.sciencedaily.com/releases/2007/11/071114163448.htm.

5. Nuclear Energy Institute, *Policy Brief: Nuclear Energy Plays Essential Role in Reducing Greenhouse Gas Emissions*, at 2, Jan. 2009, *available at* http://www.nei.org/keyissues/protectingtheenvironment/policybriefs/nuclearenergyreducinggreenhousegasemissions.

put, if the country is to make meaningful strides in reducing its carbon emissions, nuclear power must be an important part of the energy portfolio.

The policy shift towards a "greener" energy portfolio occurs at a time when most energy planners predict a seventeen percent growth in demand over the next ten years.[6] Accordingly, much has been made of the thirty new nuclear plants that may be built and operational by 2030, and the industry is suggesting that a "renaissance" of sorts is occurring. But existing nuclear plants must be available to provide "clean" energy while new designs are constructed. Because the licenses for these plants are due to run out after forty years, relicensing them is a vital part of the country's strategy.[7]

Current Nuclear Regulatory Commission (NRC) projections envision a plant life of sixty, or even eighty, years for these plants, with proper relicensing procedures. This article explores the long-term viability of the NRC's strategy. In the first section, I explain the historical background and regulatory underpinnings of license renewal. In the second section, I look at the current round of relicensing efforts. In the third section, I will review the opportunities and risks associated with long term licensing renewal. Finally I will discuss the policy and political issues that should support license renewal as an important component in the country's quest for energy independence.

II. HISTORICAL BACKGROUND

It is nearly impossible to appreciate the need for nuclear power plants and license renewal without an understanding of the political and social underpinnings of the country's nuclear program. Certainly, no other industry has been so simultaneously glorified and demonized.

6. *See* NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION, 2008 LONG-TERM RELIABILITY ASSESSMENT 2008-2017 at 23 (Jan. 27, 2009) http://www.nerc.com/files/LTRA 2008%20v1.1.pdf. For those in the power planning business, this is a scary number. If electricity demand grows at about 1.6 percent annually, the United States will need to *add* at least – eight to twelve new gigawatts to grid capacity per year. *See* OFFICE OF NUCLEAR ENERGY, SCIENCE AND TECH. DEP'T OF ENERGY, ENERGY SUPPLY AND CONSERVATION 50 (2008), *available at* http://www.ne.doe.gov/budget/budgetpdfs/fy2007NeEsCongressional BudgetFinal.pdf.

7. *See generally* ENERGETIC INC., LIFE BEYOND 60 WORKSHOP SUMMARY REPORT (2008), *available at* http://www.ne.doe.gov/pdfFiles/LifeAfter60WorkshopReport.pdf.

A. "Atoms for Peace" and Commercial Development

The commercial nuclear industry in the United States can be traced back to Dwight Eisenhower's "Atoms for Peace" speech at the United Nations.[8] There, the new president and former Supreme Allied Commander promised:

> The more important responsibility of this atomic energy agency would be to devise methods whereby this fissionable material would be allocated to serve the peaceful pursuits of mankind. Experts would be mobilized to apply atomic energy to the needs of agriculture, medicine and other peaceful activities. A special purpose would be to provide abundant electrical energy in the power-starved areas of the world . . .
>
> The United States would be more than willing – it would be proud to take up with others "principally involved" the development of plans whereby such peaceful use of atomic energy would be expedited.[9]

Before this speech, U.S. and global nuclear development focused largely on military development. Military agencies throughout the world owned and developed fissionable materials, and built "defensive" stockpiles of nuclear weapons. Work on nuclear propulsion for U.S. Naval ships and submarines was also well underway. Even construction of the first commercial nuclear power plant, at Shippingport, PA, was overseen by Navy legend Hyman Rickover.[10]

Commercial nuclear development began with the original Atomic Energy Act of 1946, which enabled the development of non-military nuclear applications, like the experimental breeder reactors that powered four light bulbs and eventually the city of Arco, Idaho.[11] Congress revised the Atomic Energy Act in 1954, paving the way for civilian government oversight of most national nuclear applications and creating the Atomic Energy Commission.[12] By the 1960's, though, the AEC was seen more as a shill for a secretive industry than an advocate for safe nuclear regulation.

8. President Dwight D. Eisenhower, Address at the 470th Plenary Meeting of the U.N. General Assembly (Dec. 8, 1953), *available at* IAEA.org; History: Atoms for Peace, http://www.iaea.org/About/history_speech.html.

9. *See id.*

10. JENNIFER TRAINER & MICHIO KAKU, NUCLEAR POWER: BOTH SIDES 19 (1983).

11. JOSEPH A. ANGELO JR., NUCLEAR TECHNOLOGY 52, 83 (Greenwood Publ'g Group 2004).

12. *Id.* at 62.

Accordingly, Congress abolished the agency in 1974, creating in its stead the NRC and parts of the Department of Energy.

During the sixties and early seventies, the commercial nuclear industry enjoyed steady growth. It peaked in 1973, when fifty orders for new nuclear plants were submitted. More than 100 plants were either built, under construction, or seeking operating permits in the United States by 1979. But the industry was constantly plagued with cost overruns and lengthy permitting requirements; its popularity as an alternative to coal-fired generation began to wane by the late seventies.[13] Additionally, the political landscape for commercial nuclear growth worsened as the threat of nuclear war with the Soviet Union began to intensify. During the Carter administration, several policies aimed at limiting the growth of nuclear weapons also minimized the ability of the commercial industry to function efficiently.[14] The ultimate blow came when a series of operational and communication errors led to a partial meltdown of the core in a unit at the Three Mile Island nuclear plant in March of 1979.[15] Although that accident resulted in no damaging releases of radiation, the industry had lost the faith of the public and the utilities. Since then, no new plants have been ordered.

More than 100 plants were licensed during this period and 104 continue to operate in 2009. Improvements in plant efficiency and power output have contributed to the viability of the nuclear industry in the United States, but not its vitality. In fact, the best way to describe the industry before 2005 was moribund. It was not dead, but the business of operating a nuclear power plant was the stuff of high drama (The China Syndrome[16] or Atomic Twister[17]) or low comedy (The Simpsons[18]).

B. Relicensing and Continued Operation

Before we can understand the importance of nuclear power in the nation's energy future, we need to identify the major regulatory and political scenes that allow us to consider continued operation as a viable option for the current fleet of plants:

13. *See* HARRY HENDERSON, NUCLEAR POWER: A REFERENCE HANDBOOK 7 (2000).

14. *See id.*

15. *See* OFFICE OF PUBLIC AFFAIRS, NUCLEAR REGULATORY COMM'N, THREE MILE ISLAND ACCIDENT (2009), *available at* http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.pdf.

16. THE CHINA SYNDROME (IPC Films 1979).

17. *Atomic Twister* (Once Upon a Time Films 2002).

18. *The Simpsons* (20th Century Fox Television 1989).

- The way that the NRC looks at plant management and maintenance.
- The NRC's emphasis on safety and continued inspection of operating plants.
- Environmental reviews and alternatives analysis.
- Public participation and public perception.

The NRC issues licenses for a forty-year period under the Atomic Energy Act.[19] The time period is largely an arbitrary one, and not related to any construction, safety, or environmental concerns related to operating a nuclear plant.[20] Utilities understood that the financing of large electric projects were generally amortized over a period of forty years. Further, Congress understood the licensing concept from its experience with the Communications Act of 1934, which allows licenses to run for a number of years with an opportunity for renewal.[21] Thus, a nuclear plant operator can operate a plant for forty years and – at its discretion – apply for renewal of up to twenty additional years.[22]

The NRC's licensing process requires a safety review and an environmental review, as outlined below. In contrast to the broad plant design and site environmental reviews for new plants, the renewal process is relatively streamlined.[23] The license review, promulgated at 10 CFR Part 54, focuses its two-part inquiry on one question: Can the plant continue to operate safely during extended operation?[24]

19. *See* Nuclear Energy Institute, Nuclear Power Plant License Renewal, http://www.nei.org/keyissues/reliableandaffordableenergy/factsheets/plantlicenserenewal (last visited Mar. 16, 2009).

20. Nuclear Energy Institute, Nuclear Power Plant License Renewal: Why Nuclear Plants Have 40-Year Licensing Terms, http://www.nei.org/keyissues/reliableandaffordable energy/factsheets/plantlicenserenewalpage2 (last visited Mar. 16, 2009).

21. *Id.*

22. Nuclear Energy Institute, Nuclear Power Plant License Renewal: NRC's License Renewal Requirements, http://www.nei.org/keyissues/reliableandaffordableenergy/factsheet s/plantlicenserenewalpage3 (last visited Mar. 16, 2009).

23. *Compare* 10 C.F.R. Pt. 52 (2008) (regulations covering the new plant licensing process) *and* NEI.org, LICENSING NEW NUCLEAR POWER PLANTS FACT SHEET (Jan. 2009) *available at* http://www.nei.org/resourcesandstats/documentlibrary/newplants/factsheet/licen singnewnuclearpowerplants *with* 10 C.F.R. Pt. 54 (2008) (regulations covering license renewal) *and* NEI.org, NUCLEAR POWER PLANT LICENSE RENEWAL (2008) *available at* http://www.nei.org/keyissues/reliableandaffordableenergy/factsheets/plantlicenserenewal/.

24. Requirements for Renewal of Operating Licenses for Nuclear Power Plants, 10 C.F.R. pt. 54 (2008).

1. Licensing Basis and the Maintenance Rule

Because we are not concerned with the current operating issues of a nuclear plant, I have not explained the regulatory structure under which the plant operates on a daily basis. Simply put, each plant is assigned a resident inspector, an NRC employee whose job it is to ensure that the operator is complying with the requirements of the license. These operational requirements are included in the plant's original operating license, and they are changed as the NRC issues updated requirements, or new technology and operating experience suggests an improvement in plant management. Collectively, they are known as the plant's "licensing basis."[25] Any new licensing basis becomes part of the plant's license.[26]

Existing programs, studies, and databases can also provide reliable information on the current safety of the operating plant. For example, the "maintenance rule" requires operators to monitor the performance or condition of systems, structures, and components (SSC) against licensee-established goals to provide assurance that the SSC are capable of fulfilling their intended functions.[27] When the performance or condition of an SSC does not meet the operator's established goals, appropriate corrective action must be taken. These programs are similar to the requirements for license renewal; in fact, the initial scoping requirements for license renewal are virtually identical to the maintenance rule. Additionally, programs used to identify existing performance goals will also lead to relevant license renewal information such as reactor aging management plans and other maintenance efforts.

The NRC has also gathered regulatory information that can streamline relicensing. The Generic Aging Lessons Learned (GALL) report evaluates existing aging reports so the NRC staff can determine when a plant's existing aging program is adequate or if it needs augmentation as part of the

25. U.S. CONGRESS, OFFICE OF TECH. ASSESSMENT, AGING NUCLEAR POWER PLANTS: MANAGING PLANT LIFE AND DECOMMISSIONING 11 (1993), *available at* http://www.princeton.edu/~ota/disk1/1993/9305/9305.PDF.

26. Requirements for Renewal of Operating Licenses for Nuclear Power Plants, 10 C.F.R. § 54.3 (2008).

27. U.S. Nuclear Regulatory Commission, Staff Reports: Standard Review Plan for Review of License Renewal Applications for Nuclear Power Plants (NUREG-1800) (July 2001), *available at* http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1800/ [hereinafter NUREG 1800].

relicensing process.[28] The Standard Review plan also offers guidance on topics that will be evaluated by the NRC.

2. Safety Review

Before we look hard at the requirements for the safety component of the license renewal, it's important to clarify that nuclear plants are managed essentially like other large industrial facilities. Some components are replaced on more frequent schedules, while others are designed to last the "life" of the plant. Upgrades to equipment, while strictly regulated, occur frequently. In addition, a plant's fuel source is generally replaced every eighteen to thirty-six months. During this refueling or maintenance period (called an "outage"), operating equipment can be replaced, or technological advancements are incorporated into the operating structure.[29] "Long lived" structures include the reactor building, piping, steam generators, and other components that are not replaced on a regular schedule.[30]

Two assumptions also inform the safety analysis. First, the rule considers that:

> with the possible exception of the detrimental effects of aging on the functionality of certain plant systems, structures, and components in the period of extended operation and possibly a few other issues related to safety only during the period of extended operation, the regulatory process is adequate to ensure that the licensing bases of all currently operating plants provides and maintains an acceptable level of safety so that operation will not be inimical to public health and safety or common defense and security.[31]

Second, the rule assumes the plant-specific licensing basis will be maintained during the renewal term in the same manner and to the same

28. U.S. Nuclear Regulatory Comm'n, NUREG 1801: Standard Review Plan for Review of License Renewal Applications for Nuclear Power Plants(Feb. 23, 2007), *available at* http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1801/v1/index.html [hereinafter NUREG 1801].

29. U.S. Nuclear Regulatory Comm'n, NUREG 1437: Section 2.2.6, Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Abstract (Feb. 23, 2007), *available at* http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/v1/index.html#abstract [hereinafter NUREG 1437].

30. Requirements for Renewal of Operating Licenses for Nuclear Power Plants, 10 C.F.R. § 54.21(a)(1)(ii) (2008).

31. Nuclear Power Plant License Renewal, 60 Fed. Reg. 22,464 (May 8, 1995) (to be codified at 10 C.F.R. pt. 2, 51, 54).

extent as during the original licensing term. The focus of the safety review is on providing reasonable assurance that the effects of aging on the functionality of the "long lived" structures at the plant meet the licensing basis design conditions so that the plant continues to operate safely during the period of extended operation.

Any license renewal application must also include any new technical specifications that will enhance the operator's aging management program during the licensing period.[32]

3. Environmental Review

The NRC considers license renewal for a nuclear power plant a major federal action for the purposes of the National Environmental Policy Act (NEPA). As a result, the NRC prepares a supplemental environmental impact statement (SEIS) to evaluate the impacts of relicensing. The standard for environmental reviews is set forth in 10 CFR Part 51.[33] Like the safety review, the SEIS will take into account the current environment at the plant using the site-specific environmental monitoring information developed as part of the operating requirements.

The NRC's "NEPA obligation" was recently defined:

> NEPA has the dual goals of requiring an agency "to consider every significant aspect of the environmental impact of a proposed action [and] ensur[ing] that the agency will inform the public that it has indeed considered environmental concerns in its decisionmaking process."[34] In furtherance of these goals, NEPA requires federal agencies to prepare an environmental impact statement (EIS) prior to any major federal action significantly affecting the environment (42 U.S.C. § 4332(2)(C)). An EIS must include, inter alia, a detailed statement on the environmental impact of the proposed action, any adverse environmental effects that cannot be avoided if the proposal is implemented, and alternatives to the proposed action (ibid.). If the agency is uncertain whether an action is a major federal action significantly affecting the environment, it must first prepare an

32. Nuclear Energy Institute, Key Issues: Nuclear Power Plant License Renewal, http://www.nei.org/keyissues/reliableandaffordableenergy/factsheets/plantlicenserenewal (last visited Mar. 25, 2009).

33. Environmental Protection Regulations for Domestic Licensing & Related Regulatory Functions, 10 C.F.R. § 51 (2009).

34. *See e.g.*, Baltimore Gas & Elec. Co. v. Natural Res. Def. Council, 462 U.S. 87, 97 (1983) (internal citation omitted).

environmental assessment (EA) (40 C.F.R. § 1501.4). No EIS is necessary if the EA concludes with a "finding of no significant impact," which briefly presents the reasons why the proposed action will not significantly impact the environment (40 C.F.R. §§ 1501.4(e), 1508.13; see Dep't of Transp. v. Public Citizen, 541 U.S. 752, 756-58 (2004)).[35]

The NRC has also made generic assumptions about nuclear plant impacts on the facility site, based on more than thirty years of operating experience. This "generic environmental impact statement" (GEIS) assesses ninety-two environmental issues from the scope of impacts evaluated during the operation of nuclear plants.[36] These issues are then set into categories, and classified according to the standardized impacts.[37] A certain aspect of a plant may have the same impact at any site, or identical significance, or may be mitigated in the same fashion. These generic environmental impacts will not be reviewed by the NRC staff, since experience shows that individual re-evaluations of the site are not necessary. Of the ninety-two issues addressed by the NRC, sixty-nine were considered to be generic to all plants (Category 1). Twenty-one remaining issues are not generic; and two more (environmental justice and the effect of electromagnetic fields) must be reviewed on a site-specific basis.[38]

Using these categories, the renewal applicant and the NRC look for new and significant information about the issues. If an issue is not addressed in the GEIS then the NRC determines its significance[39] and documents its analysis in the SEIS. For example, aquatic resources are similarly affected by the operation of a nuclear power plant at any site. The GEIS concludes that the environmental impacts would be "small" as a

35. In the Matter of Pacific Gas & Electric (Diablo Canyon Power Plant Independent Spent Fuel Storage Installation) Order (Granting NRC Staff's Unopposed Motion for Summary Disposition) LBP-08-07, n.1 (Docket No. 72-26-ISFSI, ASLBP No. 08-860-01-ISFSI-BD01, May 14, 2008) *available at* http://www.nrc.gov, ADAMS Accession No. ML081350480.

36. NUREG 1437.

37. N.J. Dep't of Envtl. Prot. v. U.S. Nuclear Regulatory Comm'n, No. 07-2271, 2009 WL 819482 (3d Cir. Mar. 31, 2009).

38. NUREG 1437, Supplement 38, Generic Environmental Impact Statements for License Renewal of Nuclear Plants Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3 (Mar. 20, 2009) http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/supplement38/.

39. The significance of environmental impacts is identified as Small, Moderate, or Large, ranging from undetectable to impacts that destabilize the environment. *See* 10 C.F.R. § 51 app. at B.

general rule.[40] The NRC staff would assess the environmental information at the site, and determine if any new or significant information required a different assessment. If no additional information is found, the NRC simply adopts the findings of the GEIS. On the other hand, a different finding may require additional site-specific analysis or mitigation alternatives.

No environmental review is complete without a review of the alternatives to license renewal. The GEIS makes no conclusions about the reasonableness of any alternatives to license renewal. Instead these must be assessed on a site-specific basis. The alternatives must "provide an option that allows for power generation capability beyond the term of a current nuclear power plant operating license to meet future system generating needs, as such needs may be determined by State, utility, and, where authorized, Federal (other than NRC) decision makers."[41] Generally, alternatives will compare the impacts from potential generation alternatives, such as coal-fired generation, natural gas-fired generation, renewable energy technologies, conservation, and a combination of alternatives (like coal, wind and solar). The cumulative impacts of continued operation must also be reviewed.

4. Public Participation and License Renewal

The controversies surrounding license renewal of particular plants can routinely be traced to the NRC's failure to adequately communicate with the affected parties. In fact, studies have shown that failure to communicate scientific principles – like nuclear fission – leads to a "crisis of trust," and increasing "skepticism about the pronouncements of scientists on science-related policy issues of all types."[42]

40. NUREG 1437 § 3.5, http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/v1/part03.html#_1_65.

41. U.S. Nuclear Regulatory Comm'n, Regulatory Guide 4.2S1 - Supplement 1 to Regulatory Guide 4.2 Preparation of Supplemental Environmental Reports for Applications to Renew Nuclear Power Plant Operating Licenses (2000), *available at* http://www.nrc.gov/reading-rm/doc-collections/reg-guides/environmental-siting/active/04-002/ ; *see* U.S.Nuclear Regulatory Comm'n, NUREG 1555, Supp. 1 at 1.2-3, Environmental Standard of Review Plan, *available at* http://www.nrc.gov/reading-rm/doccollections/nuregs/staff/sr1555/sr1555s1.pdf.

42. House of Lords, Select Committee on Science & Technology, Third Report, Science and Society Summary (Feb. 23, 2000), *available at* http://www.publications.parliament.uk/pa/ld199900/ldselect/ldsctech/38/3802.htm; House of Lords, Select Committee on Science & Technology, Third Report, Chapter 2: Public Attitudes and Values (Feb. 23, 2000), *available at* http://www.publications.parliament.uk/pa/ld199900/ldselect/ldsctech/38/3804.htm.

Recent polls have noted an increasing acceptance of nuclear power as an alternative source for baseload energy. For example, a Nuclear Energy Institute poll conducted in November 2008, found seventy-four percent of respondents in favor of nuclear power.[43] These polls generally attribute "acceptance" to an interest in carbon-free energy, national energy security and independence, or reliability.[44] In fact, industry polls show a whopping eighty-one percent of respondents support license renewal, while smaller percentages support construction of new plants.[45]

This is a remarkable change of attitude, given the deep hole the nuclear power industry dug for itself in the thirty years since the Three Mile Island accident.[46] Has this change occurred because the NRC and the utilities have gotten better at public relations? Probably not. The NRC has made great strides in communicating the risk and opportunities of nuclear operations. The utilities are for-profit entities that, under deregulation, must operate their nuclear fleet for the benefit of the shareholders. Further, the NRC has had a reputation, however unjustified, of "rubber-stamping"

43. Ann S. Bisconti, *U.S. Public Support For Nuclear Energy Soars to Record High*, NUCLEAR ENERGY INSTITUTE, Nov. 2008, *available at* http://www.nei.org/filefolder/POPO November2008.pdf.

44. *See id.*

45. Ann S. Bisconti, *Public Supports Climate Change Action, But Is Unclear on Nuclear Energy's Role in Preventing Greenhouse Gases*, NUCLEAR ENERGY INSTITUTE, May 2007, *available at* http://www.nei.org/filefolder/popo-may.pdf.

46. Three Mile Island (TMI) is a nuclear plant in central Pennsylvania. In the early morning of March 28, 1979, the main feedwater pumps at the second unit (TMI-2) stopped running. This prevented the steam units from removing heat from the reactor coolant water. The steam turbine, and then the reactor shut down. Pressure in the reactor began to build, and a pressure relief valve opened - and stayed opened when it should have closed. As a result, water poured out of the reactor core and the reactor began to overheat. When the alarms began to sound, the operators (who were unaware that the pressure valve was still open) assumed that there was *too much* coolant in the system and reduced the water flow even further. Without enough water to transfer the heat of the nuclear reactions, the fuel assemblies' zirconium cladding ruptured and the fuel pellets began to melt. About one-third of the reactor core melted. However, any radiation that escaped the plant boundaries did not exceed background doses, and the reactor vessel remained intact. TMI-2 has been permanently shut down, with the coolant water drained, any reactive water has been decontaminated and the radioactive waste has been shipped offsite. *See*, U.S. NUCLEAR REGULATORY COMMISSION, 25TH ANNIVERSARY OF THREE MILE ISLAND UNIT 2 PRESENTATION (Mar. 3, 2004), *available at* http://www.nrc.gov/reading-rm/doc-collectio ns/commission/tr/2004/20040303a.pdf. TMI-1 continues to operate and its owner has recently applied for license renewal. *See* Three Mile Island Unit 1 Application Information, http://www.nrc.gov/reactors/operating/licensing/renewal/applications/threemile-island.html# appls.

renewal applications.[47] Internal NRC reviews have admitted that the agency lacks a clear and consistent communications strategy. On the other hand, nuclear utilities have well-oiled public information machines. As a result, the current controversies over used fuel storage and cooling at existing plants, illustrates a still-remarkable level of distrust over the ways that utilities and the NRC manage information. In fact, there is still a perception of the old "decide-announce-defend" strategies that have limited nuclear projects in the past.[48]

Actually, public perception of a project has much to do with the public perception of the risk. Neither the Commission nor the utilities are getting significantly better at disseminating their message. Environmental groups that are clamoring for fewer operating plants and no new nuclear facilities are likewise not getting any worse than the utilities at "staying on message." Frankly, each party operates in its own echo chamber. On the other hand, public participants (at least those answering the polling questions) are recognizing the risks of short-term energy insecurity (commonly known as the "U.S. reliance on Foreign Oil"), climate change, and energy costs. When faced with these risks, a change in public perception of nuclear energy from a monolithic danger to a part of a larger solution makes more sense.

Public perception of nuclear energy has changed, in part because the public can actually participate in the licensing and operation of the plant, and the NRC does a generally good job of demystifying the science behind

47. This reputation was probably earned because most early renewal applications sailed through the process with little or no opposition. The Commission also promulgated a streamlined hearing process that arguably limits the way in which renewal applications can be challenged. For example, in *Spano v. U.S. Nuclear Regulatory Comm'n*, 293 F. App'x 91 (2d Cir. 2008), the petitioners requested that the NRC revise its nuclear power plant licensing regulations so that the renewal of a license would be subject to the same standards imposed on initial applications for a license. The court found for the NRC, noting that pursuant to 10 C.F.R. § 2.803, "[n]o hearing will be held on [a] petition [for rulemaking] unless the Commission deems it advisable." The Second Circuit further noted that "in light of the NRC's determination that the issues raised by petitioners had already been 'considered at length in developing the license renewal rule.' 71 Fed. Reg. 74,848, 74,850 (Dec. 13, 2006). There was nothing unreasonable in the NRC's decision to forgo an evidentiary hearing and fact-finding.

48. My friends in the Office of Public Affairs (OPA) at the NRC may shun me at the next American Nuclear Society meeting for writing this. In their defense, the OPA has made great strides in public participation. Public meetings are successfully conducted but they are generally well-attended by the same stakeholders who have a pretty consistent message. The public meetings thus become echo chambers for supporters and opponents of the licensing action, and often people who are not able to attend the meetings in person feel disenfranchised.

nuclear generation. Moreover, time has a strange way of changing the dynamic of the argument. More than a generation has passed since the first reactors were built, and nearly a generation has passed since Three Mile Island and Chernobyl.[49] A more immediate series of disasters appears to have refocused the perception of nuclear to a less dangerous form of energy than coal, and certainly a more reliable energy source (both in cost and security) than natural gas.

III. ISSUES FOR LONG-TERM MANAGEMENT OF REACTORS

Existing nuclear plants are valuable assets, both for the nation's energy structure and for the utilities that own them. The cost and time required for building replacement capacity, coupled with the time and infrastructure necessary for new generation, will test the current technical and economic skills of the industry. It makes sense that the existing plants continue operations – if only to bridge the gap between the energy demands of the next twenty years.

But three serious issues should be addressed. Many of the reactors are rapidly approaching the end of their licensing period. Used fuel storage (and the storage of more used fuel from future operations) still poses safety concerns for communities surrounding plants. Finally, the security of these plants has often been called into question; given the possibility of potential terrorist attacks, careful attention should be paid to the security of the plant and the used fuel stored at the facility. These concerns, however, should not impede the continued efforts to renew licenses for currently operating plants.

49. Chernobyl was so much worse than TMI that any comparison of the two incidents is unfair. The units at Chernobyl were not designed with containment structures around them. Graphite, not water, was used as the moderator within the core. Unlike the reactor at TMI, if coolant at the Chernobyl reactor was lost, the nuclear reactions would *speed up*. Consequently, when the meltdown at Chernobyl occurred, the graphite caught fire, and the reactor exploded, sending a plume of radioactive smoke 3,000 feet into the air. With no containment structure, the intense radioactivity spread beyond the plant boundaries, administering a dose more than 200 times that of background radiation to the population within a ten-mile radius. *See* WILLIAM TUCKER, TERRESTRIAL ENERGY: HOW NUCLEAR POWER WILL LEAD THE GREEN REVOLUTION AND END AMERICA'S ENERGY ODYSSEY 49-50 (Bartleby Press 2008).

A. Methods for Managing Material Degradation (Reactor Aging)

This author is all too aware that things wear out. She would love to report that she still averages a six-minute mile during races, but a sprained knee and a gamey hip will not cooperate. Industrial facilities, including nuclear power plants, suffer the same fate. Materials deteriorate; plant maintenance is a major issue for all large facilities. Most aging structures have a maintenance program that deploys new technology, permitting the facility to continue profitable operations for lengthy periods of time. Aggressive inspection and replacement are important parts of any such maintenance strategy. But, like the author, the structure (the concrete, reinforcing steel, and piping, for example) itself must continue to support the new parts. Now, the effects a new knee or hip would have on the author's continued ability to run a six-minute mile are well known. A new knee or hip might improve her ability to run, but the author still must deal with an aging skeletal structure, and other things that are not as easily replaced may fail.

The effects of decades of radioactive bombardment on a nuclear power plant's "passive components" likewise cause a certain amount of wear and tear. The effect of radioactivity on materials is known as "degradation," and standards have been suggested to assess its effect on passive and active components alike.[50] Conservative compensatory measures are often taken to minimize risk of failures due to degradation, requiring in-service inspection to detect unexpected events, detection methodologies, and testing.[51] But, decades of operating experience have also allowed operators to identify changes in materials and trends that are precursors to degradation. Operators can now study stressors and material interactions

50. *See, e.g.,*Industry Codes & Standards, 64 Fed. Reg. 51,370, 51,386 (Sept. 22, 1999); *See also* U.S. Nuclear Regulatory Comm'n, Fatigue Crack Tolerance in Nuclear Power Plant Piping: A Basis for Improvements to ASME Code Section XI, Appendix L (May 2007), *available at* http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr6934 [hereinafter NUREG/CR 6934]. At the risk of oversimplification, "passive components" are components such as pressure vessels, reactor buildings, and piping. Like the author's skeleton, muscles, and circulatory system, they perform their intended functions without moving parts or any change in configuration or properties. They are periodically inspected for potential failure. "Active components" are called upon to perform a given function (like a valve) on demand. To continue the analogy to its absurd conclusion, the author's active components would be her heart's valves or skeletal system joints.

51. *See* Luis A. Reyes, *Policy Issue: Status of Staff's Proposed Regulatory Structures for New Plant Licensing and Potentially New Policy Issues*, NUCLEAR REGULATORY COMMISSION, Aug. 30, 2004, *available at* http://www.nrc.gov/reading-rm/doccollections/commission/secys/2004/secy2004-0157/2004-0157scy.pdf.

for early detection of property changes (such as crack growth) that might not be detected by conventional measures. This and similar methods are essentially *reactive*, in that they must approach a problem that has already started to occur.[52]

In order to assess the long-term management requirements for nuclear power plants, operators should look to the methods and technologies that have emerged in other areas where long-term management is the norm. The digital revolution can have broad application in existing nuclear operations in providing on-line monitoring and diagnostics as well as prognostics. For example, digital systems in chemical plants and fossil fuel power plants have supported major advances in instrumentation, controls, and monitoring.[53] These advanced technologies and methods can provide enhanced data and materials management for the nuclear industry as well, improving safety and risk assessments for existing plants. Additionally, they are conservative without running the risk of "surprises during outages or unplanned shut-downs. Long-term assessments should then include on-line monitoring and condition-based maintenance to increase operational awareness and enhance safety.[54]

1) Diagnostics

Since the 1970's, degradation and material failure has been quantified using nondestructive testing and evaluation (NDT / NDE).[55] Measurements for performance were identified in terms of specific detection limits. However, recent efforts have led to an understanding of performance as the

52. For example, corrosion in the steel structure that encases the reactor plant (a "dry well") can be detected using visual testing (to look for rust) or ultrasonic testing (to determine if the thickness of the dry well wall). *See* In re AmerGen Energy Company, LLC (License Renewal for Oyster Creek Nuclear Generating Station) Initial Decision (Rejecting Citizens' Challenges to AmerGen's Application to Renew its Operating License) LBP-07-17 (Docket No. 50-0219-LR, ASLBP No. 06-844-01-LR, Dec. 18, 2007) *available at* ADAMS Accession No. ML 073520402.

53. Bond, L.J., et al., Keynote Address, *Improved Economics of Nuclear Plant Life Management,* Pacific Northwest National Laboratory, Richland, Washington 1, 4 (2008), *available at* http://pmmd.pnl.gov/program/reports/IAEA-Improved-Economics-100307.pdf).

54. Leonard J. Bond et.al., Improved Economics of Nuclear Plant Life Management, Keynote Address at the Pacific Northwest National Laboratory, Richland, Washington (2008), *available at* http://pmmd.pnl.gov/program/reports/IAEA-Improved-Economics100307.pdf.

55. Leonard J. Bond et. al., *Proactive Management of Materials Degradation For Nuclear Power Plant Systems*, PROGNOSTICS AND HEALTH MANAGEMENT 1, 3 (2008), *available at* http://pmmd.pnl.gov/program/reports/IEEE-PMMD-forPHM081508.pdf.

probability of detection. This new approach suggests that there are ways to assess deterioration before defects become apparent through more traditional means of detection. Nuclear operators are already implementing digital diagnostic equipment to active component upgrades and safety systems.[56] These upgrades can help significantly to adopt condition-based maintenance at existing facilities. Moreover, license extensions are granted on the licensee's commitment to manage degradation where no accepted or reliable method assessing the probability of detecting degradation is available.[57] Materials science and advancements in NDE strategies are converging to allow operators to develop programs that provide the necessary reliability for regulators while identifying potential degradation.

2) Prognostics

"Prognostics (for machinery) is the prediction of a remaining safe or service life, based on an analysis of system or material condition, stressors and degradation phenomena."[58] In contrast to diagnostics, which are based on observable data, "prognostics" move towards predictions of life and technologies for structural health. Although they have not been developed for nuclear power systems, prognostics are being developed for non-nuclear applications.[59] Prognostics are more commonly applied at the design phase, where programs can be developed with the designer and information and controls personnel. However, there are opportunities to use prognostics in existing plants, if there is remaining life in the plant.[60]

56. *Id.* at 2.

57. *See* U.S. Nuclear Regulatory Comm'n, NUREG 1801: Vol. 1, Generic Aging Lessons Learned (GALL), (Sept. 2005) http://adamswebsearch2.nrc.gov/nrcws/nrcdoccontent.aspx?Library=PU_ADAMS^PBNTAD01&LogonID=9946aa039e8dc60ae676874aeb45ca4&DocID=052700153 [hereinafter NUREG 1801].

58. *See* Bond et.al., Keynote, *supra* note 54, at 2.

59. *Id.*

60. *Id.* Prognostic methodology uses a "bathtub curve" to assess the useful life of a product or facility. If one imagines the curve of an old-fashioned claw-foot tub, at one end, where the water faucet might be attached, is the "burn-in" region. This is the time when installation faults or imperfections in the design manifest, and they can be quickly remedied. The tub's bottom is the "useful life," where there is a constant failure rate, but there is also reliability as long as the facility is maintained. Finally, the backrest is that point in the life cycle where the components of the facility begin to wear out more rapidly. Now imagine a line about two-thirds along this curve, a little before the backrest begins to curve up. The distance between that line and the backrest is the remaining useful life of a plant, and the ideal time to consider predictive maintenance and plans to extend the life of the plant.

3) Proactive Management of Materials Degradation (PMMD)

Long-term nuclear power plant operation requires proactive approaches.[61] While diagnostics identify observable degradation, and prognostics predict a plant's remaining useful life or intervention points, PMMD is a collection of strategies that "sense" material changes that are precursors to degradation ultimately detected by NDT.[62] Diagnostics and prognostics are largely reactive; they recognize problems at a time when damage has already occurred, or is imminent. PMMD, on the other hand, extends the available time to mitigate problems, or detect damage before it starts.[63]

In the context of license renewal, reactive management strategies may ultimately limit the safety margin. The inherent limitations in reactive strategies could lead to incomplete resolution of a problem that might have been identified and resolved more effectively and at lower cost. Because renewal applicants must commit to aging management, extended operation is necessarily dependent on a program that understands how stressors can drive damage, thus detecting and mitigating degradation that has not yet happened. Here, proactive management strategies incorporate what operators know about plant operations into a larger aging management program.[64]

In a program combining diagnostics, prognostics, and PMMD approaches, on-line monitoring and observable data (diagnostics) become essential to applying a proactive approach to extending the life of existing plants.[65] Frankly, any kind of proactive approach is the best way to optimize maintenance and improve reliability and competitiveness of new and existing nuclear power plants. Significant research in these methodologies must be performed, and there are limitations and gaps in the approach, at least for the nuclear power community. On the other hand, proactive approaches are common at large industrial facilities. These plants (including fossil fuel power plants) have already developed advanced diagnostic and prognostic methods. Lessons learned from the "outside" can be an important factor in determining proactive degradation management strategies for the nuclear industry.

61. Bond et.al., *Proactive Management supra* note 55.
62. *Id.* at 2.
63. *Id.*
64. *Id.*
65. *Id.*

B. Storage and Security in License Renewal

One of the difficulties associated with license renewal is the adequate communication of the risk associated with used fuel storage. Because the United States does not reprocess and recycle its used fuel, nuclear operating companies must store it at the plant site.[66]

1) The Nature of Nuclear Fuel

This article has turned into a short primer on the properties of nuclear power, mainly for the convenience of the reader. Nuclear fission is a complicated scientific process (not mysterious, just complicated). The process of turning uranium into fissionable material is also complicated. The following descriptions provide a very brief overview of the process:

- Boiling water reactors and pressurized water reactors use essentially the same uranium fuel.
- Before its use in a reactor, uranium must undergo four processing steps to convert it from an ore to solid ceramic fuel pellets. These processes are: mining and milling, conversion, enrichment and fabrication.
- Uranium miners use several techniques to obtain uranium: surface (open pit), underground and in-situ leach mining. Uranium also is a byproduct of other mineral processing operations.
- Solvents remove the uranium from mined ore or in-situ leaching, and the resulting uranium oxide – called yellowcake – undergoes filtering and drying.
- The yellowcake then goes to a conversion plant, where chemical processes convert it to uranium hexafluoride. The uranium hexafluoride is heated to become a gas and loaded into cylinders. When it cools, it condenses into a solid.
- Uranium hexafluoride contains two types of uranium, U-238 and U-235. The percentage of U-235, which is the type of uranium that fissions easily, is less than 1 percent. To make the uranium

66. Nuclear Energy Institute, Key Issues: Nuclear Waste Disposal, Recycling Used Nuclear Fuel, http://www.nei.org/keyissues/nuclearwastedisposal/recyclingusednuclearfuel/ (last visited Mar. 18, 2009); Nuclear Energy Institute, Nuclear Waste: Amounts and On-Site Storage, http://www.nei.org/resourcesandstats/nuclear_statistics/nuclearwasteamountsandon sitestorage/ (last visited Mar. 18, 2009).

usable as a fuel, its U-235 content is increased to between 3 percent and 5 percent. This process is called enrichment. The concentration of U-235 is so low in enriched uranium that an explosion is impossible.

- After the uranium hexafluoride is enriched, a fuel fabricator converts it into uranium dioxide powder and presses the powder into fuel pellets. The fabricator loads the ceramic pellets into long tubes made of a noncorrosive material, usually a zirconium alloy. Once grouped together into a bundle, these tubes form a fuel assembly.
- A single fuel assembly for a boiling water reactor (BWR) is approximately 14.5 feet high and weighs approximately 704 pounds. A single fuel assembly for a pressurized water reactor (PWR) is approximately 13 feet high and weighs approximately 1,450 pounds. The PWR fuel assembly weighs more because it contains 264 fuel tubes, while the BWR fuel assembly contains 63.[67]

For another look at the process:

> Once mined, the uranium ore is sent to a processing plant to be concentrated into a useful fuel. There are 16 processing plants in the US, although eight are inactive. Most uranium concentrate is made by leaching the uranium from the ore with acids. (Sometimes the concentrate is made underground, without removing the uranium ore.) When finished, the uranium ore is turned into U3O8, the fuel form of uranium, and formed into small pellets. The pellets are packed into 12-foot long rods, called fuel rods. The rods are bundled together into fuel assemblies, ready to be used in the core of a reactor.
>
> American utilities used 42.7 million pounds of U3O8 in 1998, but 83 percent of this was imported. Canada supplied 40 percent of uranium fuel used in the US, followed by Russia (13 percent), United States (12 percent), Australia (10 percent), and Uzbekistan (9 percent). The nuclear industry in the US often argues that nuclear power reduces imports of foreign oil, saving us money. In fact, very little oil is used for electricity generation and very little electricity is used for

67. Nuclear Energy Institute, Nuclear Energy Institute, How It Works, Nuclear Power Plant Fuel, http://nei.org/howitworks/nuclearpowerplantfuel/ (last visited Mar. 11, 2009).

transportation. Nuclear power displaces coal, not oil, and almost all coal used in the US comes from the US. Even more ironic, uranium fuel imports created a $362 million trade deficit in 1998.[68]

2) Used Fuel Management

Uranium fuel assemblies create energy in a challenging environment. Along with the intense neutron and gamma radiation activity, the assemblies create huge amounts of heat while in contact with coolant. The fission process also releases gases, both as a result of fission and because the fuel also contains oxides – there are a couple of atoms of oxygen in each uranium molecule. During fission, the oxygen atoms are freed, creating intense pressure on the metal components of the fuel assembly. This pressure continues to build until the assembly's integrity is challenged.[69] Since the prime safety objective of nuclear power is to keep the uranium pellets from coming into contact with the coolant, the assemblies are removed from the reactor every eighteen months to three years. The fission process does not stop once the assemblies are removed from the reactor. As a result, they must be stored in an environment that will continue to transfer the heat until the elements can be reprocessed and the remaining active uranium is recycled into a new assembly.

The consistency of used nuclear fuel is similar to small ceramic pellets. "All the used nuclear fuel produced by the U.S. nuclear energy industry in nearly fifty years – if stacked end to end – would cover an area the size of a football field to a depth of less than ten yards."[70] Used nuclear fuel is currently stored at nuclear plant sites. It can either be found in steel-lined concrete vaults filled with water or in airtight concrete containers with steel inner canisters. Safety is ensured with diligent monitoring and maintenance. The U.S. Nuclear Regulatory Commission has determined that used fuel could remain in safe storage at plant sites for 100 years.[71]

Storage was never meant to be a permanent solution to used fuel management. In the early part of the first nuclear power era, the commercial nuclear industry and the NRC's predecessor experimented with

68. Union of Concerned Scientists, Nuclear Power Technology, How Nuclear Power Works, http://www.ucsusa.org/nuclear_power/nuclear_power_technology/how-nuclear-power-works.html (last visited Feb. 2, 2003).

69. *Id.*

70. Nuclear Energy Institute, Integrated Used Fuel Management, http://www.nei.org/keyissues/nuclearwastedisposal/integratedusedfuelmanagement/ (last visited Mar. 11, 2009).

71. *Id.*

various reprocessing technologies at facilities in New York and South Carolina. At the risk of oversimplification, a byproduct of reprocessing is plutonium – the key ingredient in nuclear weapons. By the 1970's, some theorists and writers began linking the commercial fuel cycle with the proliferation of nuclear weapons, and guessed that the fuel cycle could be "raided" by terrorists bent on building a nuclear weapon, or a "dirty" bomb.[72] Accordingly, in 1977, President Jimmy Carter ended the recycling program, calling it "an assault on our attempts to control dangerous nuclear materials. . . . It marches our nuclear policy exactly in the wrong direction."[73]

By 1982, the loop had closed on used fuel management. The Nuclear Waste Policy Act prohibits recycling, treats used fuel as "waste," and identifies and underground repository for the commercial industry's used fuel at Yucca Mountain in Nevada.[74] Because Yucca Mountain hasn't yet opened (a topic for another paper), commercial operators must hold the fuel assemblies in approved storage facilities onsite at the nuclear plant.[75]

3) License Renewal and Used Fuel

License extension is a vital part of the nation's energy strategy. These extended plants will continue to replace used fuel, and will still need a place to put it. Current storage pools were originally designed to store waste for one or two decades, in anticipation of reprocessing or a long term disposal

72. These thoughts are not too far off the mark: In 1974, India exploded its first nuclear bomb after stealing it from a research reactor given to the government by the Canadians. Pakistan started its nuclear program by smuggling an entire enrichment facility from Europe, and fired test weapons as recently as 1998. In 2004, Pakistan's director of nuclear programs, Abdul Qadeer Khan, confessed to running an international ring that sold centrifuges to North Korea, Iran, and Libya. *See* George Perkovich, *India Explodes A 'Peaceful' Nuclear Device*, *in* INDIA'S NUCLEAR BOMB: THE IMPACT ON GLOBAL PROLIFERATION 161, 184-189 (1999); The Nuclear Threat Initiative, India Profile, Nuclear Chronology 1974-1975, http://www.nti.org/e_research/profiles/india/nuclear/2296_6267.html (last visited Mar. 29, 2009) (providing a history of India's nuclear use, including the 1974 explosion at Pokhran); SHARON SQUASSONI & FOREIGN AFFAIRS, DEFENSE & TRADE DIVISION, CONGRESSIONAL RESEARCH SERVICE: INDIAN AND PAKISTANI NUCLEAR WEAPONS (updated Feb. 17, 2005); Daniel A. Pinkston, *North Korea's Nuclear Weapons Program and the Six-Party Talks*, THE NUCLEAR THREAT INITIATIVE, Apr. 2006, *available at* http://www.nti.org/e_research/e376.html (citing David E. Sanger, *Pakistan Leader Confirms Nuclear Exports*, N.Y. TIMES (Sept. 13, 2005).

73. President Jimmy Carter, Remarks at the President's News Conference (May 4, 1979) (transcript available at http://www.presidency.ucsb.edu/ws/index.php?pid=32289).

74. Nuclear Waste Policy Act of 1982, Pub. L. No. 97-425, 96 Stat. 2201 (codified as amended at 42 U.S.C. § 10101(2006)).

75. 10 C.F.R. pt. 72 (2009).

facility. For those nuclear plants that have exhausted space in the storage pools, operators have turned to Interim Spent Fuel Storage Installations (ISFSI).

The management strategy for ISFSIs is simple:

> Dry cask storage allows spent fuel that has already been cooled in the spent fuel pool for at least one year to be surrounded by inert gas inside a container called a cask. The casks are typically steel cylinders that are either welded or bolted closed. The steel cylinder provides a leak-tight containment of the spent fuel. Each cylinder is surrounded by additional steel, concrete, or other material to provide radiation shielding to workers and members of the public. Some of the cask designs can be used for both storage and transportation.[76]

What is not so simple is the various interpretations over the safety of pools and ISFSIs. The problem brings us to the environmental impacts of license renewal, and the social impacts of communicating risk ineffectively.

IV. THE ENVIRONMENTAL IMPACTS OF LICENSE RENEWAL

1) Impacts of Doing Nothing and Decommissioning the Fleet

When the NRC and affected parties assess impacts and alternatives for license renewal under NEPA, they must review and understand the impacts of doing nothing.[77] "Doing nothing," taking no action, means that the license is allowed to expire and the plant is decommissioned.[78] In addition, "doing nothing" means that the capacity of the defunct plant is taken off the grid, and ratepayers/customers will need to replace that capacity with other energy sources or conservation measures.

The question of environmental impacts of replacement energy sources is a thorny one. A nuclear plant generally produces over 1,000 MW of

76. U.S. Nuclear Regulatory Comm'n, Dry Cask Storage, http://www.nrc.gov/waste/spent-fuel-storage/dry-cask-storage.html.

77. 10 C.F.R. pt. 51 (2009).

78. *See* U.S. Nuclear Regulatory Comm'n, Office of Nuclear Regulatory Regulation, Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities, NUREG-0586, Final (Aug. 1988), http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0586/sr0586.pdf [hereinafter NUREG-0586]; U.S. Nuclear Regulatory Comm'n, Staff Reports: NUREG-1555, Supplement 1: Standard Review Plans For Environmental Reviews For Nuclear Power Plants (Oct. 1999) http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1555/s1/ [hereinafter NUREG-1555].

electricity and operates at about 90% capacity on about 1,000 acres of land, or two square miles. Accordingly, a NRC assessment usually reviews the energy sources needed to replace the capacity of the plant as well as the land use problems that arise when a replacement source is contemplated.

As a general rule, the NRC has found that replacement of the existing nuclear facility would result in unacceptable environmental impacts. For instance, new coal-fired facilities will require large land areas, as well as railroad spurs and other infrastructure development such as transmission lines and rights-of-way. There are adverse impacts from coal mining, and from operational pollution. Construction and operation will have ecological and social impacts, and will affect water resources as well. Finally, coal waste would also pose long-term negative effects.[79] Natural gas facilities may have less impact than coal, because of the technology and fuel source, but the adverse impacts of this energy source are still greater than those from an existing nuclear power plant.

Renewable energy sources are also available, but the NRC has generally found that these resources are either insufficiently developed to replace the huge capacity of the existing facility, or simply lack the replacement capacity. In such cases, the NRC usually reviews combinations of renewable energy sources. Some creative options include wind, solar, and baseload sources such as natural gas or coal-fired facilities. Where more than one reactor is on site some alternatives suggest continued operation of one unit along with wind and solar. But these combinations must also consider the impacts of the renewable source, particularly in terms of land use and availability. For example, most wind facilities operate at very low capacity; any replacement project would require a very large commitment of land and resources. Moreover, opposition to large wind farms has been strong nationwide, and NRC has doubted the likelihood of a large wind facility being constructed as a partial replacement for the lost nuclear capacity. Solar facilities are likewise intermittently useful, and are also land use intensive.

79. U.S. Nuclear Regulatory Comm'n, Staff Reports: Generic Environmental Impact Statement for License Renewal of Nuclear Plants Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3, NUREG 1437, Supp. 38, Ch. 8.2 (Dec. 2008), http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/supplement38 [hereinafter NUREG 1437].

2) Environmental Impacts of Terrorist Attacks and Other Worst- Case Scenarios

The 2001 attack on the World Trade Center has reopened the continuing controversy surrounding the security of nuclear facilities. Until then, no one outside of the intelligence community thought that a group of terrorists would operate under cover and work coherently to turn loaded passenger jets into weapons of mass destruction. If terrorists can do that, and countries or individuals are willing and able to sell their nuclear resources to the highest bidders, why wouldn't the two groups combine to annihilate their perceived enemies? Risk communication and probabilities discussions hold little weight when the enemy does not care whether he lives or dies in a cloud of radiation.

Some public stakeholders have since then questioned the wisdom of spent fuel storage at nuclear power plants.[80] These concerns have dovetailed with the security of license renewal as well, increasing the perception that a nuclear power plant is not only falling apart but, is a sitting duck for terrorist activities. [81] In addition, the safety and security of the increased populations surrounding older plants has raised some concerns on the part of emergency planners and local officials.[82]

While these concerns are justifiable, and I may get accused of drinking the Kool-Aid, each unfairly assumes that any risk in a nuclear facility is unacceptable. NRC regulations require full-scale emergency planning drills at each plant every two years.[83] These drills involve Federal, State, and Local law enforcement, and NRC and the Federal Emergency Management Agency (FEMA) are required to evaluate the drills for weaknesses in the emergency plan procedures. In more recent years, the NRC has reviewed and revised emergency planning guidance to ensure better uses of resources, communication, and drill programs, and plants are required to develop and execute Hostile Action Based emergency drills. Lessons learned from these drills are developed and posted on a restricted database

80. Mothers for Peace v. Nuclear Regulatory Comm'n, 449 F.3d 1016 (9th Cir. 2006).

81. Public Citizen, Energy Program: Nuclear Reactor License Renewals = 20 More Years of Risks, Waste, and Taxpayer Rip-offs! http://www.citizen.org/cmep/energyenviro nuclear/newnukes/extensions/articles.cfm?ID=10135 (last visited May 29, 2009).

82. *See* Petition for Rulemaking (PRM-54-2) from Andrew J. Spano, County of Westchester, New York, re: Amendment to 10 C.F.R. Pt. 54, (May 10, 2005).

83. 10 C.F.R § 50.47(b) (2008).

shared by first responders and nuclear plant personnel. The site is managed by the Department of Homeland Security.[84]

Radiological consequences will be the same in a terrorist threat or from any other severe accident, and protection from such threats is required as part of an operator's continued operation.[85] In its external events planning, an operator must assess and plan for hostile acts.[86] Applicants for new plants and license renewal alike must prepare an assessment of the environmental impacts of severe accidents, and identify mitigation requirements. But, because license renewal reviews the process of aging on an operating reactor, it is simply redundant to make terrorism assessments a requirement for relicensing.

V. CONCLUSION AND AFTERWARD

Since the first version of this article was given at the Colloquium in October 2008, two controversial topics in license renewal have been laid to an uneasy rest.

The EPA's rules for intake structures and cooling systems, challenged by Riverkeeper and other groups in 2004 (collectively, "Riverkeeper"), were sustained in part by the U.S. Supreme Court.[87] Riverkeeper had objected to the rule, noting that § 316(b) did not allow the EPA to use a cost benefit analysis to determine the best technology available for intake structures. Further, they objected to the "performance based" standard, because it was not the "best technology available" (BTA) to prevent fish

84. Federal Emergency Management Agency, Lessons Learned Information Sharing, https://www.llis.dhs.gov/index.do (last visited Mar. 13, 2009).

85. 10 C.F.R. § 73.1 (2008).

86. It is recognized that the security at nuclear power plants is robust. In addition, current assessments indicate that licensee measures are available to mitigate the effects of terrorist acts. Consequently, such acts would not create an accident that causes a larger release or one that occurs more quickly than those already addressed by the EP planning basis. However, the condition of the plant after such an event could be very different from the usual condition practiced in more conventional nuclear power plant EP drills and exercises. In light of the foregoing and of the post-9/11 threat environment, licensees should exercise and test security based EP capabilities as an integral part of the licensee's emergency response capabilities.

> [S]ecurity-based events pose aspects that are different from the usual conditions traditionally practiced in EP drill and exercise programs. The emergency response organization is the primary organization trained to effectively mitigate damage caused by an event. As such, the NRC believes that the emergency response organization should practice response to security-based events.

See NRC Bulletin 2005-02, http://www.nrc.gov/about-nrc/emerg-preparedness/respond-to-emerg/hostile-action.html (last visited Mar. 29, 2009).

87. Entergy Corp. v. Riverkeeper, Inc., 556 U. S. ____ (2009).

mortality in the waterbodies near existing power plants. Closed-loop systems have been shown to decrease fish mortality by up to ninety-eight percent, where open-loop technology has been shown to reduce mortality by up to ninety percent. Riverkeeper argued that a mandatory closed-loop system should be designated as the BTA standard. EPA argued that it reasonably rejected mandatory closed-loop cooling because the typically high costs of converting existing facilities to compliant technology was generally too high to justify the extra eight percent reduction in mortality.

The Second Circuit Court of Appeals generally agreed with Riverkeeper, concluding that the section's silence on cost-benefit precluded EPA from performing such an exercise in determining the BTA for intake structures.[88] Upon appeal to the U.S. Supreme Court, various large power producers (including both nuclear and fossil fuel generators) and the EPA claimed that § 316(b)'s silence simply incorporated the accepted principle of cost-benefit analysis promulgated generally in the Clean Water Act. Thus, they argued, the agency is entitled to weigh the cost of compliance with the resulting environmental benefit, as the EPA did in its Phase II rulemaking.[89]

The Supreme Court agreed with EPA's reasoning. It asserted that, even though Section § 316(b) is silent on the matter of cost analysis, all four of the Clean Water Act's other technology standards include some kind of cost analysis. Further, the statute is silent on all potential factors for consideration. If its silence implies prohibition of any cost analysis, then § 316(b) must also prohibit consideration of all other factors as well. This, the Court noted, is a "legal impossibility." It is far more reasonable to conclude that the statute's silence is "meant to convey nothing more than a refusal to tie the agency's hands as to whether cost-benefit analysis should be used, and if so to what degree."[90]

A second case decided by the Third Circuit has likewise addressed the need for environmental review of possible terrorist attacks on operating plants.[91] In *N.J. Dep't of Envtl. Protection v. U.S. Nuclear Regulatory Comm'n, t*he court first underscored the agency's NEPA duties with a fairly standard assessment of the statute. Additionally, the court assessed the NRC's conclusion that there was no proximate causal relationship between

88. Riverkeeper, Inc. v. EPA, 358 F.3d 174 (2d Cir. 2004).

89. *See* 69 Fed. Reg. 41,576, 41,630 (July 9, 2004).

90. Entergy Corp. v. Riverkeeper, Inc., 556 U. S. ____ (2009).

91. N.J. Dep't of Envtl. Protection v. U.S. Nuclear Regulatory Comm'n, No. 07-2271, 2009 WL 819482 (3d Cir. Mar. 31, 2009).

a possible terrorist attack and the NRC's duty to protect the public and the environment from the consequences of such an attack.

This interesting tort-based approach rested on the *foreseeability* of any attacks at Oyster Creek generating stations in southern New Jersey. New Jersey claimed that any terrorist attack was foreseeable given the events of September 11, 2001. The court disagreed. The *risk* of an attack from extended operations at Oyster Creek was simply too attenuated to require NEPA review. For example, the court noted, NEPA does not require the agency to assess *every* impact or effect. Further, an agency is only required to assess impacts that have a reasonably close causal connection to a change in the physical environment. At Oyster Creek, this causal chain is interrupted by several matters beyond the NRC's control; thus breaking the chain of NRC's responsibility both under tort law and NEPA.

The court found similar situations in the 1993 World Trade Center bombings and the Oklahoma City bombing in 1995. There, courts had concluded that intervening matters precluded liability against the manufacturers of fertilizers used in the attacks. Such terrorist acts were not, as the courts noted, the natural or probable consequences of any design defect in the product. Rather, the terrorist plans were intervening causes that broke the causal chain between the fertilizer (an ingredient of the bomb) and the bombings themselves (the final event). The courts also suggested that the extraordinary nature of such attacks in the United States precluded their foreseeability.

Here, the court also noted that the NRC was not only unable to foresee that Oyster Creek would be the target of the terrorist attack (given that no terrorist attack has ever been attempted against a nuclear plant), but it could not be responsible for preventing such an attack. The NRC controls whether a facility's equipment is safe for continued operation and whether the facility could withstand a number of specified events (including an aircraft crash and sabotage) to prevent a reactor accident. But, the agency has no authority over the airspace above the plant, nor does it have the resources to conduct ongoing investigations of potential terrorist threats. Congress has delegated that authority to the Federal Aviation Administration (FAA), the Department of Homeland Security and the Department of Defense. Accordingly, if the agency had to assess environmental damages from a terrorist attack, it would have to assume the unlikely scenario that a terrorist cell wanted to attack Oyster Creek, and that all of the other agencies with the resources and expertise to assess such threats had failed utterly to do their job. New Jersey's arguments simply put the NRC in the unenviable position of identifying, protecting against, and resolving a situation that it

simply has no authority to prevent. These intervening obligations break the causal chain between the NRC's duties and the ultimate risk of environmental damage from a terrorist attack.

At the end of the day, the energy independence of the country must include continued operation and development of nuclear power. If the country had developed nuclear power throughout the last thirty years, achieving France's eighty percent reliance, we would find ourselves producing one-third less carbon. That would be the equivalent of taking all of our cars off the road. But let's get back to the Great Pyramid and our future energy needs. And, as we assess our ability to meet energy needs while combating climate change, nuclear power is the only technology capable of producing a reliable source of base-load power. It will satisfy growing energy needs without producing significant amounts of greenhouse gases. Existing plants are already amortized, and average more than ninety percent capacity, far greater than the best performance from wind and solar sources. These plants can continue to operate as the country moves away from fossil fuels, and towards a cleaner, less carbon-intensive, future.