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FINAL

BROWNS FERRY NUCLEAR (BFN) PLANT

SUBSEQUENT LICENSE RENEWAL ENVIRONMENTAL IMPACT STATEMENT

PUBLIC SCOPING REPORT

Prepared by:

Tennessee Valley Authority
Intersection of Nuclear Plant & Shaw Rd.
Athens, Alabama 35611

October 2021

J. Taylor Cates
NEPA Compliance Specialist
Tennessee Valley Authority
1101 Market Street, 2C-C
Chattanooga, TN 37402
Phone: 423-751-2732
jtcates@tva.gov

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Appendices

Symbols, Acronyms, and Abbreviations

ADEM	Alabama Department of Environmental Management
BFN	Browns Ferry Nuclear
CWA	Clean Water Act
EA	Environmental Assessment
EIS	Environmental Impact Statement
EJ	Environmental Justice
EO	Executive Order
EPU	Extended Power Uprate
GEIS	Generic Environmental Impact Statement
MWe	Megawatts electric
NEPA	National Environmental Policy Act
NOI	Notice of Intent
NRC	Nuclear Regulatory Commission
PNNL	Pacific Northwest National Laboratory
SEIS	Supplemental Environmental Impact Statement
SLR	Subsequent License Renewal
TVA	Tennessee Valley Authority
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

Browns Ferry Nuclear (BFN) Plant Supplemental Environmental Impact Statement (SEIS)

Public Scoping Report

July 2021

The Tennessee Valley Authority (TVA) proposes to submit a Subsequent License Renewal (SLR) Application to the Nuclear Regulatory Commission (NRC) requesting renewal of the Browns Ferry Nuclear (BFN) Plant operating licenses. Renewal of the NRC operating licenses will authorize the plant to continue to operate for an additional 20 years beyond the current 20 -year renewed operating licenses expiration dates of 2033, 2034, and 2036 for Units 1, 2, and 3, respectively. Subsequent NRC license renewal for the operating BFN facilities does not involve new major construction or modifications beyond normal maintenance and refurbishment. However, there are other proposed projects such as spent fuel storage expansion that is not directly related to NRC license renewal that are connected to, or could affect, license renewal. Therefore, TVA is initiating the preparation of a Supplemental Environmental Impact Statement (SEIS) pursuant to the National Environmental Policy Act (NEPA) to assess the environmental impacts of the proposed action.

Background

TVA operates BFN Units 1, 2, and 3 consistent with its mission as charged under the TVA Act of 1933. BFN consists of three General Electric boiling water reactors and associated turbine generators that collectively supply approximately 3,900 Megawatts electric (MWe) to the TVA transmission and distribution system.

In March 2002, TVA issued a Final SEIS followed by a Record of Decision in June 2002 for the operating license renewal of BFN. TVA submitted a License Renewal Application to the NRC in December 2003 for a 20-year extension of the operating licenses for each BFN unit. NRC prepared its own SEIS in consideration of TVA's license application. NRC's Final SEIS concluded that the impacts of license renewal would not be adverse and issued Supplement 21 regarding Browns Ferry Nuclear Plant Units 1, 2, and 3, to the Generic Environmental Impact Statement (GEIS) for License Renewal of Nuclear Plants (NUREG-1437) in June 2005. The NRC issued renewed operating licenses for Units 1, 2, and 3 in May 2006, allowing operation of the three BFN units until 2033, 2034, and 2036, respectively.

TVA submitted a license amendment request for extended power uprate (EPU) of approximately 15 percent for all three units in September 2015. The NRC issued a Draft Environmental Assessment (EA) in the Federal Register in December 2016 for public comment. In May 2017, the NRC issued the Final EA and Finding of No Significant Action related to the EPU license amendment. NRC issued the license amendment in August 2017. BFN Unit 3 reached EPU in Summer 2018, Unit 1 reached EPU in December 2018, and Unit 2 reached EPU in Spring 2019.

TVA's Objectives

The purpose of the proposed action is to help provide continued generation of baseload power from the BFN site between 2033 and 2056 by obtaining NRC license renewals to operate all three BFN units. BFN's current generation supports future forecasted baseload power needs, as outlined in TVA's 2019 Integrated Resource Plan, by helping to maintain grid stability and generating capacity for TVA's generation portfolio mix. As an integral part of TVA's current generation portfolio, in 2020, BFN produced approximately 20 percent of TVA's average generation. Renewal of the current NRC operating licenses would allow BFN to continue supplying approximately 3,900 MWe of safe, clean, reliable, and cost-effective baseload power for an additional 20 years. BFN license renewal is a key component of meeting TVA's goal of a net-zero carbon emissions generating system by 2050.

TVA must decide whether to submit a SLR Application to the NRC to extend the operating licenses of the three units for an additional 20 years beyond their current license terms. TVA is preparing an SEIS to inform TVA decision-makers and the public about the environmental consequences of the proposed action.

Proposed Alternatives

Several alternatives will be analyzed in addition to the continuing operation of BFN by license renewal for the generating capacity and energy needed to provide approximately 3,900 MWe of base load power between 2033 and 2053. Potential options for meeting TVA's purpose and need include the range of supply-side and demand-side actions identified in TVA's Integrated Resource Plan. While development of alternatives is a continuing process, preliminary internal scoping by TVA has identified the following four possible alternatives,

- **Alternative A: No Action** – TVA would not submit an application to NRC for SLR. The existing licenses would expire in 2033, 2034, and 2036 and TVA would begin the process of evaluating and planning for the necessary decommissioning of all three BFN units. The 3,900 MWe baseload generation would no longer produced by BFN.
- **Alternative B: BFN NRC Subsequent License Renewal** – TVA would submit a SLR Application to NRC for renewal of BFN Units 1, 2, and 3 licenses until 2053, 2054, and 2056 respectively.
- **Alternative C: Use of Existing Generating Assets** – TVA would cease operations at BFN, and BFN's generating baseload electricity would be replaced using existing generating assets, including natural gas, coal, hydro, nuclear, and storage.
- **Alternative D: Use of Existing and Construction of New Generating Assets** – TVA would cease operations at BFN, and BFN's generating baseload electricity would be replaced using a mix of existing and newly constructed generating assets, including solar, natural gas, nuclear, battery and hydro storage, etc.

Environmental Review Process

NEPA requires the identification and analysis of potential environmental effects of proposed federal actions and alternatives before those actions take place. The NEPA review process is intended to help federal agencies make decisions that are based on an understanding of the action's environmental impacts and, if necessary, to take actions that protect, restore, and enhance the environment. NEPA also requires that federal agencies provide opportunities for public involvement in the decision-making process.

TVA is initiating the preparation of this SEIS to assess the environmental impacts of the proposed action and a reasonable range of alternatives. An EIS is the most intense level of NEPA review. A supplement is prepared to update a previous EIS; in this case the 2002 SEIS for BFN License Renewal. During the completion of this SEIS, the public and environmental and permitting agencies will have opportunities to provide input on the development of the environmental review. After considering input from the scoping period, TVA will develop and publish a Draft SEIS that will be provided to the public and intergovernmental agencies for additional comment. During the Draft SEIS public comment period, TVA plans to conduct a public meeting. TVA will consider all the comments received during the public review of the Draft SEIS, make revisions as appropriate, and publish a Final SEIS stating a preferred alternative. Subsequently, TVA will publish a Record of Decision documenting its final decision regarding the proposed action.

TVA estimates that the Draft SEIS will be published in Fall 2022, the Final SEIS would be published in Early 2023, and a final decision would be made in Spring 2023.

Public Outreach During Scoping Period

The purpose of the scoping period is to present TVA's project objectives and initial alternatives for input from the public and interested stakeholders.

On June 1, 2021, TVA published a Notice of Intent (NOI) in the Federal Register announcing plans to prepare a SEIS to address the potential environmental effects associated with extending the operation of BFN Units 1, 2, and 3 for an additional 20 years (see Appendix A). The NOI initiated a 30-day public scoping period, which concluded on July 1, 2021. In addition to the NOI in the Federal Register, TVA published notices regarding this effort in two local newspapers: The Decatur Daily which serves the Decatur and the Tennessee Valley in northern Alabama and the News Courier which serves Limestone County. TVA also issued a news release to media and posted the news release on the TVA Web site (See Appendix B).

To accommodate social distancing guidelines and public health recommendations related to the COVID-19 pandemic, TVA created a virtual meeting room that was available for the duration of the scoping period. The URL link to the virtual meeting room was included in the NOI and can be accessed through TVA's website (https://www.tva.com/environment/environmental-stewardship/environmental-reviews/nepa-detail/browns-ferry-nuclear-plant-subsequent-license-renewal) through the completion of the EIS process. The virtual scoping meeting room contains information on the NEPA process and the proposed action, as well as links to TVA and NRC websites related to the project. The virtual scoping meeting room also allows the public to submit a comment or feedback on the project during open comment periods (scoping and draft SEIS review). Posterboards and screenshots from the virtual scoping meeting room are included in Appendix C.

Summary of Public Scoping Feedback

TVA received a total of 23 comments regarding the SLR of BFN Units 1, 2, and 3 from five commenters. Of the five comment submissions, two were from federal entities (U.S. Environmental Protection Agency [USEPA] and U.S. Geological Survey [USGS]) and three were from members of the public. Nine of the 23 comments received were in regard to safety and aging infrastructure. The remaining comments received pertained to alternatives, general environmental concerns, air quality, water quality and stormwater, wetlands and streams, waste disposal, climate, and environmental justice. The comments related to TVA's proposed action are provided below. Original comment submissions are included in Appendix D.

Public Scoping Comments

Safety and Aging Infrastructure

Comment 1: There is no evidence these installations will remain safe for an additional 20 years. I ask that all systems be thoroughly inspected and investigated before these extensions are considered and the results made public. (Commenter: Steve Sondheim)

Comment 2: Commenters noted the collapse of the Surfside, Florida condo building as an example that older structures are vulnerable to a variety of aging factors. Aging, stressed components are more likely to fail the longer they are in service. A link to an article was included. (Commenters: Steven Sondheim and Don Safer)

Comment 3: The Supplemental Environmental Impact Statement should reevaluate fundamental assumptions of safety that have been used to justify previous SLRs of other nuclear power reactors in the US. (Commenter: Don Safer)

Comment 4: The SEIS should include the effects of a catastrophic accident and massive radiation release at one or more of these aging reactors that were designed to operate for 40 years. Extending operation to 80 years demands an exhaustive study of the aging management. The longer these reactors run, the greater the risk of a devastating accident. (Commenter: Don Safer)

Comment 5: The Browns Ferry reactors are Fukushima style GE Mark 1 reactors, a design that has a long, controversial history, with many questioning the lack of robustness in the containment system and foreshadowing the three reactor melt-downs, hydrogen explosions, resulting containment breeches, and release of massive amounts of radiation at Fukushima. Links to four articles were included to support this comment. (Commenter: Don Safer)

Comment 6: The Browns Ferry reactors have a history of mechanical problems and other issues resulting in six separate shut-downs of longer than a year including the longest shutdown of any US reactor (Unit 1 from 1985 to 2007) and the second and third longest shutdowns (Unit 3 from 1985 to 1995 and Unit 2 from 1984 to 1991). In 2011 they received one of only 4 “Red finding” safety warnings from the NRC for extended safety performance deficiencies. Safety concerns have plagued these reactors throughout their lives. Links to three articles were included to support this comment. (Commenter: Don Safer)

Comment 7: The BFN spent fuel pools locations are over 40 feet off the ground and with only sheet metal roofing overhead and these pools contain an enormous amount of deadly radiation. The SEIS should consider deficiencies in the BFN spent fuel pools and the environmental effects of a failure of one or more of these pools and the resulting release of radiation. Links to three articles were included to support this comment. (Commenter: Don Safer)

Comment 8: The commenter states that “reasonable assurance” of reactor safety during the proposed SLR period is far from certain. The safety of this license extension is wholly unproven. The NRC and the nuclear reactor operators have taken a “don’t look, don’t want to know” approach to verification of continued integrity of inner reactor critical components that are subject to the intense conditions in a nuclear reactor (heat, neutron bombardment, pressure, extreme temperature swings in SCRAM events, etc.). The commenter also provided a quote from former NRC Commissioner Victor Gilinsky and the link to the story from which the comment was taken, noting the absence of validity of the NRC’s SLR process. (Commenter: Don Safer)

Comment 9: The commenter stated that SEIS should consider the wide range of critical knowledge gaps in the age-related material degradation process in General Electric Mark 1 boiler water reactors and the management of that degradation over 60 or 80 years. The SEIS should also provide an evidence basis on materials safety and systems reliability to make informed, scientifically qualified decisions in regulatory review of longer license extensions of nuclear power plants. Harvesting and material testing of nuclear plant components and compiling an evidence basis to assess age-related degradation management are necessary for "reasonable assurance," which is an explicit NRC requirement for license extension. The commenter provided a link to a Department of Energy Pacific Northwest National Laboratory (PNNL) Technical Letter Report published in December 2017 in which PNNL was instructed to identify knowledge gaps and recommended harvestings and analysis of materials in decommissioning. He noted that a revised report (PNLL-27120, Rev. 1) was republished in April 2019 having removed scores of references to critical knowledge gaps and recommendations to require decommissioning harvesting and analysis for reasonable assurance in NRC safety and environmental review and approval process of license extension applications. Without scientifically founded "reasonable assurance," the NRC lacks a legal basis for granting Subsequent License Renewal. (Commenter: Don Safer)

Alternatives
Comment 10: Nuclear power is not needed if renewable energy is adequately deployed by 2035-40. (Commenter: Steven Sondheim)

Comment 11: The No Action Alternative (A) should be chosen, and a new process started that focuses on alternative (E): Replacement of BFN Generating Capacity with Renewable Energy Sources. TVA should bring on board renewables, energy efficiency and additional storage with urgency. Renewable energy is the fastest growing energy resource in the world and the United States. The commenter provide links to two articles. (Commenter Don Safer)

General Environmental Concerns
Comment 12: The SEIS should comprehensively cover all conceivable environmental impacts of continued operation of the BFN reactors. It should consider the fundamental environmental, health and environmental justice problems inherent in nuclear power at every step in the nuclear fuel chain: uranium mining, milling, fuel fabrication, operations, radioactive waste, and decommissioning. (Commenter: Don Safer)

Air Quality
Comment 13: Limestone County is in attainment with the Clean Air Act National Ambient Air Quality Standard. (Commenter: USEPA)

Water Quality and Stormwater
Comment 14: Based on NEPA, the proposed project may be located within a mile of an impaired stream Round Island Creek/Round Island Creek (Wheeler Lake). TVA should consider implementing best management practices during maintenance for areas greater than one acre per the Clean Water Act's (CWA) National Pollutant Discharge Elimination System Permit for stormwater, where applicable, to ensure that water quality impairments are not exacerbated. (Commenter: USEPA)

Wetlands and Streams
Comment 15: The EPA recommends that TVA collaborate with Alabama Department of Environmental Management (ADEM) and US Army Corps of Engineers (USACE) to determine any potential impacts from the hydraulic and hydrological design associated with thermal discharges to the Tennessee River that may impact terrestrial and/or aquatic species, including both flora and fauna. TVA in collaboration with USACE may wish to include CWA Section 404(b)(1) documents in the SEIS to support any wetland and stream mitigation decisions and to help ADEM evaluate potential stream impact requirements for the CWA Section 401 Water Quality permit. Providing adequate wetland and stream information within the NEPA process can help to streamline the final environmental review and permitting processes for these

resources. According to NEPAssist, there are five approved mitigation or conservations banks in the facility vicinity - Flint River Mitigation Bank Phase I (1042), Wheeler Pointe Mitigation Bank (1044). ADOT Town Creek (1198) and ADOT Crow Creek (1199) and Robinson Spring Mitigation Bank (930) should mitigation be required. (Commenter: USEPA)

Waste Disposal

Comment 16: The SEIS should indicate if there will be any changes in the generation of waste including low-level radioactive waste, mixed low-level radioactive waste, transuranic waste, and hazardous and Toxic Substance Control Act wastes over the life of the program. The SEIS should indicate where TVA will send the spent nuclear fuel and spent fuel debris for storage pending long-term disposal options. (Commenter: USEPA)

Climate

Comment 17: Climate change may impact the proposed project, posing threats to aging infrastructure, worker health and safety and the environment. We recommend that the SEIS include an evaluation of climate-related impacts including discussions of frequency and severity of major storm events, wildfires, or drought that could lead to power disruptions or increased cooling demands in summer months. Efforts that TVA is taking at BFNP to address and adapt to potential climate impacts should be discussed in the SEIS. (Commenter: USEPA)

Comment 18: [The SEIS] should consider the growing threats to nuclear power reactor operation and safety posed by the ever-growing effects of climate change. (Commenter: Don Safer)

Environmental Justice

Comment 19: The SEIS should include an analysis that is consistent with the Environmental Justice (EJ) Executive Order (EO) 12898. The analysis should indicate whether minority, low income or other overburdened populations reside within the vicinity of the proposed project area. If so, the EPA recommends that the communities with EJ concerns should be meaningfully involved throughout the decision-making process to help identify potential benefits and burdens associated with relicensing and permitting decisions. Adaptive and innovative approaches to both public outreach and community involvement regarding project issues should take place during the project planning. It would also be helpful to include a current map depicting the population demographics near the BFNP facility. EPA's EJSCREEN can be used a preliminary screen to help identify potential issues. (Commenter: USEPA)

General Comments

Comment 20: The USGS has no comment at this time. Thank you. (Commenter: USGS)

Comment 21: Renew the licenses. Keep the plant running. We need it. (Commenter: Jack Keeling)

Comment 22: I highly object to the extension of licenses to the Browns Ferry Nuclear Power reactors from 60-80 years which is 40 years beyond the original license. (Commenter: Steven Sondheim)

Comment 23: The subsequent license renewal (SLR) of the three Browns Ferry (BFN) Reactors should be rejected. (Commenter: Don Safer)

Appendix A: Federal Register Notice of Intent

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• 20 CFR 404.1740(b)(8) and 416.1540(b)(8)—This regulatory section requires representatives to disclose to SSA whether the representative is or has been disqualified from participating in or appearing before any Federal program or agency, including instances in which a Federal program or agency took administrative action to disqualify the representative in lieu of disciplinary proceedings. If the disqualification occurs after the appointment of the representative, the representative will immediately disclose the disqualification to SSA; and;

• 20 CFR 404.1740(b)(9) and 416.1540(b)(9)—This regulatory section requires representatives to disclose to SSA whether the representative has been removed from practice or suspended by a professional licensing authority for reasons that reflect on the representative's character, integrity, judgment, reliability, or fitness to serve as a fiduciary. If the removal or suspension occurs after the appointment of the representative, the representative will immediately disclose the removal or suspension to SSA.

A representative's obligation to report these events is ongoing, and SSA requires representatives to report any time one or more of these events occurs. We consider this information essential to ensure the integrity of our administrative process and to safeguard the rights of all claimants. SSA requires representatives to notify SSA in writing, but there is no prescribed format for these reports. The respondents are individuals appointed to represent claimants before SSA.

Type of Request: Extension of an OMB-approved information collection.

Regulation section	Number of respondents	Frequency of response	Average burden per response (minutes)	Estimated annual burden (hours)	Average theoretical hourly cost amount (dollars) *	Total annual opportunity cost (dollars) **
404.1740(b)(5)/416.1540(b)(5)	43,600	1	5	3,633	* $26.45	** $96,093
404.1740(b)(6)/416.1540(b)(6)	2	1	5	0	* 69.86	** 0
404.1740(b)(7)/416.1540(b)(7)	50	1	5	4	* 69.86	** 279
404.1740(b)(8)/416.1540(b)(8)	10	1	5	1	* 69.86	** 70
404.170(b)(9)/416.1540(b)(9)	10	1	5	1	* 69.86	** 70
Totals	43,672			3,639		96,512

* We based this figure on average hourly wages for paralegals/legal assistants and lawyers as posted by the U.S. Bureau of Labor Statistics (*https://www.bls.gov/oes/current/oes_nat.htm*).

** These figures do not represent actual costs that SSA is imposing on representatives to complete the required disclosures; rather, these are theoretical opportunity costs for the additional time representatives or their employees and associates will spend to complete the required disclosures. *There is no actual charge to representatives to complete the required disclosures.*

Dated: May 25, 2021.

Naomi Sipple,

Reports Clearance Officer, Social Security Administration.

[FR Doc. 2021–11421 Filed 5–28–21; 8:45 am]

BILLING CODE 4191–02–P

TENNESSEE VALLEY AUTHORITY

Supplemental Environmental Impact Statement—Browns Ferry Nuclear Site Subsequent License Renewal

AGENCY: Tennessee Valley Authority.

ACTION: Notice of intent.

SUMMARY: The Tennessee Valley Authority (TVA) intends to prepare a Supplemental Environmental Impact Statement (SEIS) to address the potential environmental effects associated with obtaining subsequent license renewals (SLR) for the Browns Ferry Nuclear Plant (BFN) Units 1, 2, and 3 located in Limestone County, Alabama. Renewal of the operating licenses would allow the plant to continue to operate for an additional 20 years beyond the current operating licenses expiration dates of 2033, 2034, and 2036 for Units 1, 2, and 3, respectively. TVA plans to evaluate a variety of alternatives including a no-action alternative. Public comments are invited to identify other potential alternatives, relevant information, and analysis related to the proposed action.

DATES: The public scoping period begins with the publication of this Notice in the **Federal Register** and comments on the scope of the SEIS must be received or postmarked by July 1, 2021. To accommodate social distancing guidelines and public health recommendations related to the COVID–19 pandemic, TVA will have a virtual meeting room available for the duration of the scoping period. Visit *https://www.tva.com/nepa* to obtain more information.

ADDRESSES: Comments may be submitted in writing to J. Taylor Cates, NEPA Specialist, 1101 Market Street, BR 2C–C, Chattanooga, TN 37402. Comments may also be submitted online at: *https://www.tva.com/nepa* or by email to *nepa@tva.gov.* Due to COVID–19 teleworking restrictions, electronic submission of comments is encouraged to ensure timely review and consideration.

FOR FURTHER INFORMATION CONTACT: Other related questions should be sent to Tennessee Valley Authority, J. Taylor Cates, NEPA Specialist, 1101 Market Street, BR 2C–C, Chattanooga, TN 37402, or 423–751–2732/*jtcates@tva.gov.*

SUPPLEMENTARY INFORMATION: This Notice is provided in accordance with the Council on Environmental Quality's (CEQ) regulations for implementing the National Environmental Policy Act (NEPA) at 40 CFR parts 1500–1508 and Section 106 of the National Historic Preservation Act (NHPA), and its implementing regulations (36 CFR part 800). The SEIS will be prepared consistent with the 2020 CEQ regulations for implementing NEPA at 40 CFR parts 1500–1508 (85 FR 43304–43376, Jul. 16, 2020). The regulations of the Nuclear Regulatory Commission (NRC) in 10 CFR part 54 set forth the applicable license extension requirements.

TVA Power System

TVA is a corporate agency and instrumentality of the United States, created by and existing pursuant to the TVA Act of 1933 (16 U.S.C. part 831), and created to, among other things, foster the social and economic welfare of the people of the Tennessee Valley region and promote the proper use and conservation of the Valley's natural resources. TVA generates and distributes electricity for business customers and local power distributors, serving more than 10 million people in parts of seven southeastern states. TVA is fully self-financed without Federal appropriations, and funds virtually all operations through electricity sales and power system bond financing. In addition to operating and investing its revenues in its electric system, TVA provides flood control, navigation and management for the Tennessee River system, and assists local power companies and state and local governments with economic development efforts.

Dependable electrical capacity on the TVA power system is about 33,000 Mega Watts Electric (MWe). TVA's current generating assets include one pumped-storage facility, one diesel generator site, three nuclear plants, five coal plants, nine combustion turbine plants, eight combined cycle plants, 14 solar energy sites, 29 hydroelectric dams, and several small renewable generating facilities. A portion of delivered power is obtained through long-term power purchase agreements. About 13 percent of TVA's annual generation is from hydro; 14 percent is from coal; 27 percent is from natural gas; 41 percent is from nuclear; and the remainder is from wind and solar. TVA also gains available capacity through its energy efficiency programs. TVA transmits electricity from these facilities over almost 16,000 miles of transmission lines. Like other utility systems, TVA has power interchange agreements with utilities surrounding the Tennessee Valley region, and routinely buys and sells power.

Background

TVA operates BFN Units 1, 2, and 3 in Limestone County, Alabama. BFN is located on an 840-acre tract on the north shore of Wheeler Reservoir at Tennessee River Mile (TRM) 294, approximately 10 miles northwest of Decatur, Alabama, and 10 miles southwest of Athens, Alabama. BFN consists of three General Electric boiling water reactors (BWRs) and associated turbine generators that collectively supply approximately 3,900 MWe of electric power to the TVA transmission and distribution system.

In March 2002 and June 2002, TVA issued a Final SEIS (FSEIS) and a Record of Decision (ROD) for the operating license renewal of BFN. TVA submitted a License Renewal Application (LRA) to the NRC in December 2003 for a 20-year renewal of the operating licenses for each BFN unit. The environmental conclusions of the NRC FSEIS did not differ from the TVA FSEIS conclusions, and the NRC issued Supplement 21 regarding Browns Ferry Nuclear Plant Units 1, 2, and 3, to the Generic EIS (GEIS) for License Renewal of Nuclear Plants (NUREG–1437) in June 2005. The NRC issued operating license renewals for Units 1, 2, and 3 in May 2006, allowing continued operation of the three BFN units until 2033, 2034, and 2036, respectively.

In September 2015, TVA submitted a license amendment request (LAR) for extended power uprate (EPU) of all three units. The NRC issued a draft Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) in the **Federal Register** on December 1, 2016 for public comment. On May 22, 2017 the NRC issued the Final EA and FONSI related to the EPU license amendment.

Project Purpose and Need

The purpose of the proposed action is to help provide continued generation of baseload power between 2033 and 2053 by obtaining license renewals to operate BFN Units 1, 2, and 3. BFN is considered baseload power because the plant generally runs at close to maximum output. BFN's current baseload generation supports future forecasted baseload power needs, as outlined in TVA's 2019 Integrated Resource Plan (IRP), by helping to maintain grid stability and generating capacity for TVA's generation portfolio mix. As an integral part of TVA's current generation portfolio, in 2020, BFN produced approximately 20 percent of TVA's average generation capacity. Renewal of the current operating licenses would allow BFN to continue supplying approximately 3,900 MWe capacity of baseload power.

TVA needs to generate sufficient electricity to supply the Tennessee Valley with increasingly clean, reliable, and affordable electricity for the foreseeable future for the region's homes and businesses, working with local power companies to keep service steady and reliable. By renewing the licenses, TVA would maximize use of existing assets to support TVA's goals of generating electricity at the lowest feasible cost for the people of the Tennessee Valley. BFN's carbon-free generating capacity supports TVA's goal of a net-zero carbon emissions generating system by 2050.

Preliminary Proposed Action and Alternatives

TVA proposes to submit a Subsequent LRA (SLRA) to the NRC requesting renewal of BFN operating licenses. Renewal of the current operating licenses would permit operation for an additional 20 years past the current operating license terms, which expire in 2033, 2034, and 2036 for Units 1, 2, and 3, respectively. This SEIS is being prepared to provide the public and TVA decision-makers an assessment of the environmental impacts of renewing BFN Unit 1, 2, and 3 operations, as well as provide the public an opportunity to participate in the SEIS process. License renewal does not require any new construction or modifications beyond normal maintenance and minor refurbishment. However, there are other proposed projects not directly related to SLR that are connected to, or could affect, license renewal.

The SEIS proposes to address a range of alternatives (A–D) including: (A) The No-Action Alternative; (B) BFN Subsequent License Renewal; (C) Use of Existing Generating Assets; and (D) Use of Existing and Construction of New Generating Assets. Two additional alternatives, (E) Replacement of BFN Generating Capacity Entirely with Renewable Energy Sources and (F) Replacement of BFN Generating Capacity Entirely with Purchase Power, were considered but eliminated.

Anticipated Environmental Impacts

The SEIS will include a detailed evaluation of the environmental, social, and economic impacts associated with implementation of the proposed action. Resource areas to be addressed in the SEIS include, but are not limited to: Air quality; aquatics; botany; climate change; cultural resources; emergency planning; floodplains; geology and groundwater; hydrothermal; land use; navigation; noise and vibration; radiological safety; soil erosion and surface water; socioeconomics and environmental justice; threatened and endangered species; transportation; visual; waste; water use; wetlands; and wildlife. Measures to avoid, minimize, and mitigate adverse effects will be identified and evaluated in the SEIS.

In preparing this SEIS, TVA will consider the analysis within the NRC's Generic Environmental Impact Statement (GEIS) for License Renewal of Nuclear Plants (NUREG–1437, Revision 1), where the NRC generically considered the environmental effects of renewing nuclear power plant operating licenses for a 20-year period (results are codified in 10 CFR part 51). The GEIS identified 78 environmental issues and reached generic conclusions on environmental impacts for 59 of those issues that apply to all plants or to plants with specific design or site characteristics. The GEIS' generic assessment is relevant to the assessment of impacts of the proposed action at BFN. Generic information from the NRC GEIS that is related to the current assessment would be incorporated by reference, generally following the tiering process described in 40 CFR 1501.11, with the SEIS providing a more narrow analysis relevant to the specific aspects of this proposed project. Additional plant-specific review would be conducted for impacts not covered by the GEIS and which are encompassed by the range of resource issue areas identified above.

Anticipated Permits and Other Authorizations

TVA anticipates consulting with the required authorities including, but not limited to: The Endangered Species Act; Bald and Golden Eagle Protection Act; Rare Species Protection and Conservation Act; National Historic Preservation Act; Clean Air Act; and Federal Clean Water Act.

TVA anticipates seeking required permits or authorizations as appropriate, from the following governmental entities: The Nuclear Regulatory Commission; US Army Corps of Engineers; US Coast Guard; US Environmental Protection Agency; Alabama Department of Environment and Conservation; US Fish and Wildlife Service; Alabama State Historic Preservation Officer; and Tribal Historic Preservation Officers. This is not an exhaustive list, other permits or authorizations may be sought as required or appropriate.

Public Participation and Scoping Process

TVA seeks comment and participation from all interested parties for the proposed action, including, but not limited to, assisting TVA in determining the scope of issues for analysis in the SEIS. Information about this project is available at *https://www.tva.com/nepa,* which includes a link to an online public comment page. TVA invites the public to identify other alternatives, and analysis relevant to the proposed action. Comments must be received or postmarked no later than July 1, 2021. Federal, state, local agencies, and Native American Tribes are also invited to provide comments.

Please note that any comments received, including names and addresses, will become part of the project administrative record and will be available for public inspection.

To accommodate social distancing guidelines and public health recommendations related to the COVID–19 pandemic, TVA will have a virtual meeting room available for the duration of the scoping period that includes a range of information on the proposed action. Visit *https://www.tva.com/nepa* to obtain more information about the virtual open house.

SEIS Preparation and Schedule

TVA will consider comments received during the scoping period and develop a scoping report which will be published at *https://www.tva.com/nepa.* The scoping report will summarize public and agency comments that were received and identify the projected schedule for completing the SEIS process. Following completion of the environmental analysis for SLR, TVA will post a Draft SEIS for public review and comment on the project web page. TVA anticipates holding a public open house, which may be virtual, after releasing the Draft SEIS. Open house details will be posted on TVA's website in conjunction with the Draft SEIS. TVA expects to release the Draft SEIS in mid-2022.

TVA will consider comments received on the Draft SEIS, as well as cost, engineering, risk and other applicable evaluations before selecting one or more alternatives as preferred in the Final SEIS. TVA projects completing a Final SEIS in early 2023. A final determination on proceeding with the preferred alternative will be documented in a ROD.

Authority: 40 CFR 1501.9.

Rebecca Tolene,

Vice President, Environment.

[FR Doc. 2021–11557 Filed 5–28–21; 8:45 am]

BILLING CODE 8120–08–P

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Notice of Intent To Release Certain Properties From All Terms, Conditions, Reservations and Restrictions of a Quitclaim Deed Agreement Between City of Tallahassee and the Federal Aviation Administration for the Tallahassee International Airport, Tallahassee, FL

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Request for public comment.

SUMMARY: The FAA hereby provides notice of intent to release certain airport properties 44.66 acres at the Tallahassee International Airport, Tallahassee, FL from the conditions, reservations, and restrictions as contained in a Quitclaim Deed agreement between the FAA and the City of Tallahassee, dated March 14, 1990. The release of property will allow the City of Tallahassee to dispose of the property for non-aeronautical purposes. The City of Tallahassee requests the release of a 44.66 acre tract located along Capital Circle SW in Tallahassee, Florida to facilitate the widening of State Road 263 for municipal development. This capital improvement project is funded by the Florida Department of Transportation. The parcel is currently designated as aeronautical property. The property will be released of its federal obligations given the land is no longer required by The City of Tallahassee. The Fair Market Value (FMV) of this parcel has been determined to be $2,020,050.00.

Documents reflecting the Sponsor's request are available, by appointment only, for inspection at the Tallahassee International Airport and the FAA Airports District Office.

SUPPLEMENTARY INFORMATION:

Section 125 of The Wendell H. Ford Aviation Investment and Reform Act for the 21st Century (AIR–21) requires the FAA to provide an opportunity for public notice and comment prior to the ''waiver'' or ''modification'' of a sponsor's Federal obligation to use certain airport land for non-aeronautical purposes.

DATES: Comments are due on or before July 1, 2021.

ADDRESSES: Documents are available for review at the Tallahassee International Airport, 3300 Capital Circle SW, Suite One, Tallahassee, FL 32310–8732 and the FAA Airports District Office, 8427 SouthPark Circle, Suite 524, Orlando, FL 32819–9058. Written comments on the Sponsor's request must be delivered or mailed to: Stephen Wilson, Program Manager, Orlando Airports District Office, 8427 South Park Circle, Suite 524, Orlando, FL 32819–9058.

In addition, a copy of any comments submitted to the FAA must be mailed or delivered to Mr. Eric Houge, Airport Engineer, Tallahassee International Airport, 3300 Capital Circle SW, Suite One, Tallahassee, FL 32310–8732.

FOR FURTHER INFORMATION CONTACT: Stephen Wilson, Program Manager, (407) 487–7229, Orlando Airports District Office, 8427 SouthPark Circle, Suite 524, Orlando, FL 32819–9058.

Issued in Orlando, FL on May 26, 2021.

Bartholomew Vernace,

Manager, Orlando Airports District Office, Southern Region.

Revision Date 11/22/00.

[FR Doc. 2021–11435 Filed 5–28–21; 8:45 am]

BILLING CODE 4910–13–P

Appendix B: Newspaper Advertisements and Media Release

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Free beer, other new incentives for Biden's 'vaccine sprint'

By Zeke Miller
The Associated Press


Biden

WASHINGTON Dangling everything from sports tickets to a free beer, President Joe Biden is looking for that extra something anything that will get people to roll up their sleeves for COVID 19 shots when the promise of a life saving vaccine by itself hasn't been enough.

Biden on Wednesday announced a "month of action" to urge more Americans to get vaccinated before the July 4 holiday, including an early summer sprint of incentives and a slew of new steps to ease barriers and make getting shots more appealing to those who haven't received them. He is closing in on his goal of getting 70% of adults at least partially vaccinated by Independence Day essential to his aim of returning the nation to something approaching a pre pandemic sense of normality this summer.

"The more people we get vaccinated, the more success we're going to have in the fight against this virus," Biden said from the White House. He predicted that with more vaccinations, America will soon experience "a summer of freedom, a summer of joy, a summer of get togethers and celebrations. An All American summer."

The Biden administration views June as "a critical month in our path to normal," Courtney Rowe, the director of strategic communications and engagement for the White House COVID 19 response team, told the AP.

Biden's plan will continue to use public and private sector partnerships, mirroring the "whole of government" effort he deployed to make vaccines more widely available after he took office. The president said he was "pulling out all the stops" to drive up the vaccination rate.

Among those efforts is a promotional giveaway announced Wednesday by Anheuser Busch, saying it will "buy Americans 21+ a round of beer" once Biden's 70% goal is met.

"Get a shot and have a beer," Biden said, advertising the promotion even though he himself refrains from drinking alcohol.

Additionally, the White House is partnering with early childhood centers such as KinderCare, Learning Care Group, Bright Horizons and more than 500 YMCAs to provide free childcare coverage for Americans looking for shots or needing assistance while recovering from side effects.

The administration is also launching a new partnership to bring vaccine education and even doses to more than a thousand Black owned barbershops and beauty salons, building on a successful pilot program in Maryland.

They're the latest vaccine sweeteners, building on other incentives like cash giveaways, sports tickets and paid leave, to keep up the pace of vaccinations.

"The fact remains that despite all the progress, those who are unvaccinated still remain at risk of getting seriously ill or dying or spreading the disease to others," said Rowe.

Aiming to make injections even more convenient, Biden is announcing that many pharmacies are extending their hours this month and thousands will remain open overnight on Fridays. The White House is also stepping up its efforts to help employers run on site vaccination clinics.

Biden will also announce that he is assigning Vice President Kamala Harris to lead a "We Can Do This" vaccination tour to encourage shots. It will include first lady Jill Biden, second gentleman Doug Emhoff and Cabinet officials. Harris' travel will be focused on the South, where vaccination rates are among the lowest in the country, while other officials will travel to areas of the Midwest with below average rates.

To date 62.9% of the adult U.S. population have received at least one dose of a COVID 19 vaccine and 133.9 million are fully vaccinated. The rate of new vaccinations has slowed to an average below 555,000 per day, down from more than 800,000 when incentives like lotteries were announced, and down from a peak of nearly 2 million per day in early April when demand for shots was much higher.

The lengths to which the U.S. is resorting to convince Americans to take a shot stands in contrast to much of the world, where vaccines are far less plentiful. Facing a mounting U.S. surplus, the Biden administration is planning to begin sharing 80 million doses with the world this month.

"All over the world people are desperate to get a shot that every American can get at their neighborhood drugstore," Biden said.

Thanks to the vaccinations, the rate of cases and deaths in the U.S. are at their lowest since the beginning of the pandemic last March, averaging under 16,000 new cases and under 400 deaths per day.

As part of the effort to drive Americans to get shots, the White House is borrowing some tools from political campaigns, including phone banks, door knocking and texting. The administration says more than 1,000 such events will be held this weekend alone. Additionally, it is organizing competitions between cities and colleges to drive up vaccination rates.

Other new incentives include a $2 million commitment from DoorDash to provide gift cards to community health centers to be used to drive people to get vaccinated. CVS launched a sweepstakes with prizes including free cruises and Super Bowl tickets. Major League Baseball will host on site vaccine clinics and ticket giveaways at games. And Kroger will give $1 million to a vaccinated person each week this month and dozens of people free groceries for the year.

The fine print on the Anheuser Busch promotion reveals the benefits to the sponsoring company, which will collect consumer data and photos through its website to register for the $5 giveaway. The company says it will hand out credits to however many people qualify.

COVID-19

From Page A1

appear effective against worrisome virus mutants, at least for now.

Scientists do not yet know what's called the correlate of protection, the level below which antibodies cannot fend off the coronavirus with out additional help.

Dr. Anthony Fauci, the U.S. government's leading infectious disease expert, told a Senate subcommittee last week that vaccine protection would not be infinite.

"I would imagine we will need, at some time, a booster," Fauci said. "What we're figuring out right now is what that interval is going to be."

To date, 62.8% of the adult U.S. population has received at least one dose of a COVID 19 vaccine and 133.6 million, or more than 40 percent, are full vaccinated. The rate of new vaccinations has slowed to an average below 600,000 per day, according to the Centers for Disease Control and Prevention. That's closing in on President Joe Biden's goal of 70% with at least one inoculation by July 4.

Infections and deaths continue to fall. The nation's seven day average for daily new cases fell to less than 17,300 on Tuesday, down from more than 31,000 two weeks ago. Daily deaths declined to 588, down from 605, according to data from Johns Hopkins University. In all, the virus has killed more than 595,000 people in the U.S.

So called long lived plasma cells are one of the body's backups. Immunologist Ali Ellebedy at Washington University in St. Louis found that nearly a year after people recovered from mild COVID 19, those plasma cells had migrated to the bone marrow where they were continuing to secrete


Cole Smith receives a Moderna variant vaccine shot from clinical research nurse Tigisty Girmay on March 31 at Emory University's Hope Clinic in Decatur, Ga. [AP PHOTO/BEN GRAY, FILE]

antibodies. That's why although antibodies do diminish with time, they have not disappeared.

Now Ellebedy is hunting for the same cells in vaccine recipients, and while the research isn't finished, he's finding hints that they're forming.

An even more important backup system comes in the form of memory B cells. If existing antibodies are not enough to stop the coronavirus, memory B cells are poised to churn out large numbers of new antibodies, Ellebedy explained. Numerous studies have found those memory cells after COVID 19 vaccination.

And if the virus makes it past those defenses, yet another immune branch the memory T cells jumps in to eliminate infected cells and prevent severe illness.

With different coronaviruses that cause common colds, people tend to get re infected every two to five years, Wherry noted.

Based on natural immunity against those related viruses, "we are sort of expecting our immunity may decline," he said. "But we don't know. For these mRNA vaccines, we may be doing better than nature, better than a natural infection."

So far, health authorities agree that the most common COVID 19 vaccines in the U.S. and Europe protect against the virus mutations that are currently circulating, though not as strongly as they guard against the original virus.

Why? The vaccines mimic the protein that covers the outer surface of the coronavirus, and only certain spots of that protein are mutating, said FDA vaccine chief Dr. Peter Marks. The mRNA vaccines in particular make antibody levels skyrocket after the second dose. Those levels are so high that they offer some protection even when the vaccine and the variant are not a perfect match.

With so many people still unvaccinated, opportunities abound for more mutations to occur. The biggest sign that a booster might be necessary would be a jump in COVID 19 cases in fully vaccinated people, especially severe illnesses and especially if the infections are caused by a new variant.

To get ready, people vaccinated a year ago as part of the first Pfizer and Moderna vaccine trials now are being enrolled in studies of additional shots either a third dose of the original or versions that have been updated to match a variant that first emerged in South Africa. Moderna says preliminary findings are promising. More results are due this summer.

The National Institutes of Health also just began testing a system in which patients are given a different brand of booster than their original vaccination, to see if it is effective.

Most of the world's population has yet to receive a first dose. With different countries using different kinds of vaccines, decisions on booster shots may vary widely. Already, the United Arab Emirates has offered a third dose to recipients of a Chinese made shot, the first formal introduction of any kind of booster.

If boosters eventually are called for, they will not be needed all at once because antibodies fade gradually rather than disappearing suddenly.

"Even if we require boosters or get to the point where we see immunity waning a little bit, we still are going to be far better off than we were a year ago," Wherry said.

LIMESTONE LEDGER

SATURDAY

Guided nature walk
Damien Simbeck will guide a free nature walk starting 8 a.m. Saturday, June 5, at Marbut Bend Walking Trail in West Limestone. Participants can learn about the area and the wildlife who live there. Binoculars, comfortable walking shoes, sun screen and insect repellent are appreciated. The trail is handicapped-accessible.

Coffee call
The Alabama Veterans Museum & Archives' Coffee Call, sponsored by Vietnam Veterans Chapter 511 and Lyle Sadler, will take place 8 a.m. Saturday, June 5, at the museum's new facility, 114 W. Pryor St., Athens.

Family fun day
TLC Pediatrics will host a family fun day from 9 a.m. until noon Saturday, June 5, to celebrate their one-year anniversary. All invited. Games, treats, prizes and more available.

Addiction Eviction Rally
The 3rd annual Addiction Eviction Rally is set for 10:30 a.m.–7 p.m. Saturday, June 5, at Swan Creek Park, 98 U.S. 31, Athens. Free meals, school supplies, hygiene bags and food boxes available. School supply and diaper donations accepted. Three scholarships will be awarded. More information: Lori Masonia, 256-374-3202

Earth Day & Outdoor EXPO
Keep Athens-Limestone Beautiful will host its annual Earth Day & Outdoor EXPO from 11 a.m. to 2 p.m. Saturday, June 5, in Big Spring Memorial Park. Vendors will be located throughout the park with activities for kids, earth-friendly products, information and more. Steve Trash will perform at 11:30 a.m., 12:30 p.m. and 1:30 p.m. More information: KALB 256-233-8000; KALBCares@gmail.com

TUESDAY

Cooking contest
The Alabama Farmers Federation Women's Committee will accept entries for the annual Heritage Cooking Contest 10 a.m. Tuesday, June 8, at the ALFA office, 524 U.S. 72 West, Athens (across from Hobbs Jewelry). The category is candy. Copy of recipe required with registration and entry. Cash prizes available. Must be an ALFA member to enter. More information: 256-233-0938

WEDNESDAY

Childcare class
Limestone County Kids and Kin will host a free child-rearing class from 10 a.m. until noon Wednesday, June 9, at The Haven, 810 N. Malone St., Athens. The class is designed for those raising a relative's child and will focus on "Tails and Tales, Part 1." More information: Tammie Hill, 256-724-2554

UPCOMING

Community appreciation day
Women Empowering Women of Alabama and FreshWind Church will host a community appreciation day 11 a.m.–3 p.m. Saturday, June 12, at 17200 Lucas Ferry Road, Athens. Food, clothing and door prizes will be given away. All ages welcome. More information: Janice Williams, 256-233-5995

Mitchell reunion
Descendants of the Cross Key community's Mitchell family are invited to a family reunion starting 11 a.m. Saturday, June 12, at Swan Creek Park Pavilion #3, U.S. 31 in Athens. Food will be served at noon. More information: Louis, 256-232-7783

Beans and rice
Beans and rice will be given away 9–11 a.m. Saturday, June 19, by volunteers at Saint Timothy's Episcopal Church, 207 E. Washington St., Athens. No names taken; no ID required. More information: 256-232-2567; sttimothy.athens@gmail.com

Juneteenth Festival
A Juneteenth Festival will be held 10 a.m.–7 p.m. Saturday, June 19, on The Square in Athens. Food, vendors, live music, art and more available. Free admission.

Childcare class
Limestone County Kids and Kin will host a free child-rearing class from 10 a.m. until noon Wednesday, June 23, at The Haven, 810 N. Malone St., Athens. The class is designed for those raising a relative's child and will focus on "Tails and Tales, Part 2." More information: Tammie Hill, 256-724-2554

Kiddie Carnival opening
The Athens Lions Club Kiddie Carnival will start the 2021 season 6:30–9:30 p.m. Thursday, June 24, at 309 E. Forrest St., Athens. The carnival will open at those hours Thursdays, Fridays and Saturdays through July 31. Rides, concessions and games available. Free admission to carnival. Ride tickets 50 cents each. More information: "Athens Lions Club Kiddie Carnival" on Facebook

Day of Caring
Limestone County Churches Involved will host a Day of Caring from 9 a.m.–noon Saturday, June 26, at the facility on Jefferson Street in Athens. LCCI will offer food and general assistance to Limestone County residents, including help with rent or utilities for those who qualify. More information: the Rev. Thom Porter, 256-262-0671

ONGOING

Summer feeding program
Women Empowering Women of Alabama, in partnership with FreshWind Church, is offering free meals for children 1-18 years old. Meals available 10 a.m.–1 p.m. Mondays through Fridays from Monday, June 7, until Friday, July 23.

Bill assistance
Community Action Partnership of Huntsville-Madison and Limestone County Inc.'s LIHEAP Cooling Season will begin June 1. Elderly and/or disabled residents and parents of children 18 or younger who meet the income qualifications can apply for assistance with their cooling bills. Call 256-907-1550 to schedule an appointment. More information: www.caa-htsval.org/services/utilities.html

Walk-in vaccine clinic
The Athens-Limestone Hospital COVID-19 vaccine clinic will accept walk-ins for the Pfizer COVID-19 vaccine on a first-come, first-serve basis for ages 12 and older. Clinic hours are 8 a.m.–3 p.m. Mondays through Fridays at Emmanuel Baptist Church, 1917 U.S. 72 West, Athens. More information: ALH COVID-19 hotline, 256-262-6188

New library hours
The Houston Memorial Library and Museum has extended its hours. Patrons can now visit 10 a.m.–4 p.m. Mondays, Wednesdays, Thursdays and Fridays; 10 a.m.–7 p.m. Tuesdays; and 10 a.m.–4 p.m. on the first Saturday of each month. Book sale room also now open. Additional changes may be announced later. Masks and social distancing requested. More information: 256-233-8770

Vaccine rides
The Limestone County NAACP is offering free rides at 12:30 and 3:30 p.m. Mondays through Fridays for those wishing to receive their COVID-19 vaccine at the Athens-Limestone Hospital clinic. More information: 256-227-8489; 256-216-5668

Food giveaway
Ebenezer Missionary Baptist Church's food pantry will be open 11 a.m.–1 p.m. on the third Saturday of each month at 1911 Hine St., Athens. Patrons must provide proof of at least one of the following: eligibility to receive supplemental food assistance (SNAP/food stamps); eligibility for Temporary Assistance to Needy Families; eligibility to receive Supplemental Security Income; income at or below 130% of the federal poverty level; or special circumstances (fire, flood, illness, injury, etc.). Eligibility forms provided at distribution site. Must have valid ID card or driver's license. Only one distribution per household while supplies last. Monetary and food donations accepted. More information: 256-424-5403

Used book sale
Friends of the Athens-Limestone Public Library host a used book sale from 10:15 a.m.–2:15 p.m. each Tuesday and first Saturday of each month at the library, 603 S. Jefferson St., Athens. More information: 256-232-1233

Virtual exercise class
Limestone County Council on Aging presents virtual exercise class 2–3 p.m. Mondays and Fridays via Zoom. The classes are called S.A.I.L., which stands for Stay Active and Independent for Life. More information: 256-233-6412

Corruption hotline
The Alabama Attorney General's Office and the Federal Bureau of Investigation are asking residents with knowledge of public corruption in Limestone County to email details to reportcorruption@ago.state.al.us or call the tip line at 844-404-TIPS

CHURCH EVENTS

Sermon series
Alabama Fork CPCA will host a two-part virtual sermon series titled "Thirsting for More" 9 a.m. Sunday, June 6, and Sunday, June 13. More information: 256-431-7926; sundaymorningseminary.org

Gospel singing
Berea Baptist Church will host a Southern gospel singing with the Hogan family starting 6 p.m. Sunday, June 13, at 16779 Lucas Ferry Road, Athens. Love offering will be received. More information: Gary Wilson, 256-497-9763

CEMETERY CLEANUP

Reunion Cemetery
Reunion Cemetery will host decoration day with a chicken and goat stew fundraiser Saturday, June 5. Attendees are asked to bring their own container. Donations made payable to the Reunion Cemetery Fund should be sent to Nicole Collins, 25172 Alabama 127, Elkmont, AL 35620.

New Garden Cemetery
New Garden Cemetery will host a cleanup day Saturday, June 5, with the annual decoration day held Sunday, June 6. Donations are needed for upkeep and can be made both days at the cemetery. Those who cannot attend in person can mail donations to Harold Atkinson, 20321 Sandlin Road, Elkmont, AL 35620; or to Harold Robinson, 14016 Robinson Lane, Elkmont, AL 35620

City cemeteries
The City of Athens reminds residents and families of the following regarding its cemeteries: No flowers or decorations allowed on the ground between April 1 and Oct. 31, unless following a funeral; flower placement acceptable year-round on monuments, at their base or at foot markers; fresh flowers will be removed one week after a funeral; silk flowers will be removed 21 days after a funeral; approval by cemetery superintendent required before planting flowers, shrubs, trees or sod; city personnel will remove all trees or shrubs deemed detrimental to adjacent lots or grave openings; and worn, tattered or damaged U.S. flags will be removed and disposed of properly.

MEETINGS

- **Legion.** American Legion Post 49 will meet 7 p.m. Thursday, June 3, at the Disabled American Veterans building, 25396 Airport Road, Athens. More information: Rod Huffman, 256-233-3023

Limestone Ledger is a community calendar in which nonprofit organizations can notify the public of events. Publication of donation requests or services offered should not be considered an endorsement by this newspaper. The News Courier encourages residents to research organizations before donating or accepting services. All items will run as space allows until the day of the event and should be submitted at least one week prior to the event for best results. Ongoing items run for up to one month but can be resubmitted regularly. Email submissions to newscouriersoundoff@gmail.com, fax to 256-233-7753 or bring to The News Courier, 410 W. Green St., Athens.

TVA

TVA MEDIA ADVISORY

TVA Requests Input on Browns Ferry Nuclear Subsequent License Renewal

ATHENS, Ala. – The Tennessee Valley Authority is asking for public comment on its Notice of Intent to prepare a Supplemental Environmental Impact Statement on proposed actions associated with obtaining U.S. Nuclear Regulatory Commission license renewals for the Browns Ferry Nuclear Plant Units 1, 2 and 3 in Limestone County, Alabama.

The NRC license renewals would authorize the Browns Ferry Nuclear Plant Units 1, 2, and 3 to continue operation for an additional 20 years beyond the current NRC operating licenses expiration dates of 2033, 2034, and 2036, respectively. TVA plans to evaluate a variety of alternatives including a no-action alternative.

TVA has a virtual meeting room available from June 1 through July 1, 2021. Access the virtual meeting and other details at https://www.tva.com/nepa under the section titled Open for Public Comment.

Comments must be received or postmarked by July 1, 2021, and may be submitted in writing to J. Taylor Cates, NEPA Specialist, 1101 Market Street, BR 2C-C, Chattanooga, TN 37402; online at https://www.tva.com/nepa; or by email to nepa@tva.gov. Due to COVID-19 teleworking restrictions, electronic submission of comments is encouraged to ensure timely review and consideration.

All comments received, including names and addresses, will become part of the administrative record and available for public inspection.

For more information about TVA and its 88-year mission of service to the Tennessee Valley, click here.

# # #

Media Contact: Malinda Hunter, Chattanooga, 423-718-9245
TVA Public Relations, Knoxville, 865-632-6000
http://www.tva.com/newsroom
Follow TVA news on Facebook, Twitter and Instagram

(Distributed: June 2, 2021)

TVA TENNESSEE VALLEY AUTHORITY

TVA Requests Input on Browns Ferry Nuclear Subsequent License Renewal

Jun 2, 2021

ATHENS, Ala. – The Tennessee Valley Authority is asking for public comment on its Notice of Intent to prepare a Supplemental Environmental Impact Statement on proposed actions associated with obtaining U.S. Nuclear Regulatory Commission license renewals for the Browns Ferry Nuclear Plant Units 1, 2 and 3 in Limestone County, Alabama.

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All comments received, including names and addresses, will become part of the administrative record and available for public inspection.

Contact

Malinda Hunter
Public Relations
mhunter@tva.gov
423-718-9245

TVA Media Line

Our media staff is available 24 hours a day. If you cannot reach the contact above, please call our media line at 865-632-6000.

TVA TENNESSEE VALLEY AUTHORITY

Browns Ferry Nuclear Plant Subsequent License Renewal

Virtual Public Meeting

Enter the virtual meeting room

Notice of Intent to Prepare a Supplemental Environmental Impact Statement

On June 1, 2021, TVA published a Notice of Intent (NOI) to prepare a Supplemental Environmental Impact Statement (SEIS) to address the potential environmental effects associated with obtaining US Nuclear Regulatory Commission (NRC) subsequent license renewals (SLR) for the Browns Ferry Nuclear Plant (BFN) Units 1, 2, and 3 located in Limestone County, Alabama. Renewal of the current operating licenses would permit operations for an additional 20 years past the current operating license terms, which expire in 2033, 2034, and 2036 for Units 1, 2, and 3, respectively. The SEIS is being prepared to provide the public and TVA decision-makers with an assessment of the environmental impacts related to the aforementioned NRC license renewal, as well as provide the public an opportunity to participate in the SEIS process. The NRC license renewal would not require any new construction or modifications beyond normal maintenance and minor refurbishment. However, there are other proposed projects not directly related to the NRC SLR that are connected to, or could affect, license renewal.

BFN is considered baseload power because the plant generally runs at close to maximum output. BFN's current baseload generation supports future forecasted baseload power needs, as outlined in TVA's 2019 Integrated Resource Plan (IRP), by helping to maintain grid stability and generating capacity for TVA's generation portfolio mix. As an integral part of TVA's current generation portfolio, in 2020, BFN produced approximately 20 percent of TVA's average generation capacity. Renewal of the current operating licenses would allow BFN to continue supplying approximately 3,900 MWe capacity of baseload power.

TVA needs to generate sufficient electricity to supply the Tennessee Valley with increasingly clean, reliable, and affordable electricity for the foreseeable future for the region's homes and businesses, working with local power companies to keep service steady and reliable. By renewing the licenses, TVA would maximize use of existing assets to support TVA's goals of generating electricity at the lowest feasible cost for the people of the Tennessee Valley. BFN's carbon-free generating capacity supports TVA's goal of a net-zero carbon emissions generating system by 2050.

The SEIS proposes to address a range of alternatives (A-D) including: (A) the No-Action Alternative; (B) BFN Subsequent License Renewal; (C) Use of Existing Generating Assets; and (D) Use of Existing and Construction of New Generating Assets. Two additional alternatives, (E) Replacement of BFN Generating Capacity Entirely with Renewable Energy Sources and (F) Replacement of BFN Generating Capacity Entirely with Purchase Power, were considered but eliminated.

The NOI is provided in accordance with the Council on Environmental Quality's (CEQ) regulations for implementing the National Environmental Policy Act (NEPA) at 40 CFR parts 1500-1508 and Section 106 of the National Historic Preservation Act (NHPA), and its implementing regulations (36 CFR Part 800). The PEIS will be prepared consistent with the 2020 CEQ regulations for implementing NEPA at 40 CFR parts 1500-1508 (85 FR 43304-43376, Jul. 16, 2020).

Public Involvement

Public scoping was open from June 1, 2021 – July 1, 2021.

TVA is interested in an open process and wants input from the community. The public was invited to submit comments on the scope of this SEIS, alternatives being considered, and environmental issues.

Related Documents:

Notice of Intent

Contact

More information on this environmental review can be obtained from:

TENNESSEE VALLEY AUTHORITY

423-751-2732
1101 Market Street, 2C-C
Chattanooga, TN 37402

CONTACT

400 WEST SUMMIT HILL DRIVE

KNOXVILLE, TN 37902

(865) 632-2101

TVAINFO@TVA.COM

ISSUES / SUGGESTIONS

INFORMATION QUALITY

WEBSITE FEEDBACK

TOOLS AND RESOURCES

DOING BUSINESS WITH TVA

EMPLOYEES AND RETIREES

INSPECTOR GENERAL

SAFETY

TVA KIDS

TVA POLICE

TVA STEM

POLICIES

ACCESSIBILITY INFORMATION

EQUAL EMPLOYMENT OPPORTUNITY POLICY

FREEDOM OF INFORMATION ACT

LEGAL NOTICES

NO FEAR ACT DATA

PRIVACY POLICY

REASONABLE ACCOMMODATION

VULNERABILITY DISCLOSURE POLICY

Appendix C: Virtual Scoping Meeting Room Materials

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Virtual Scoping Meeting Room Posterboards

TVA TENNESSEE VALLEY AUTHORITY

Welcome
to the

BFN SLR SEIS Virtual Scoping Open House

June 1 – July 1, 2021

The National Environmental Policy Act (NEPA) and Scoping

NEPA requires the identification and analysis of potential environmental effects of major proposed federal actions and alternatives before those actions take place. NEPA's intent is to protect, restore, or enhance the environment through well-informed federal decisions. Public involvement is integral to the federal decision-making process and is required by NEPA.

The purpose of this virtual open house is to inform the public of TVA's intent to prepare a Supplemental Environmental Impact Statement (SEIS) pursuant to NEPA to assess the environmental impacts associated with obtaining subsequent license renewals (SLR) for the Browns Ferry Nuclear Plant (BFN) Units 1, 2, and 3. Additionally, TVA invites early input from the public regarding the development of the scope, alternatives being considered, and environmental issues related to the proposed action.

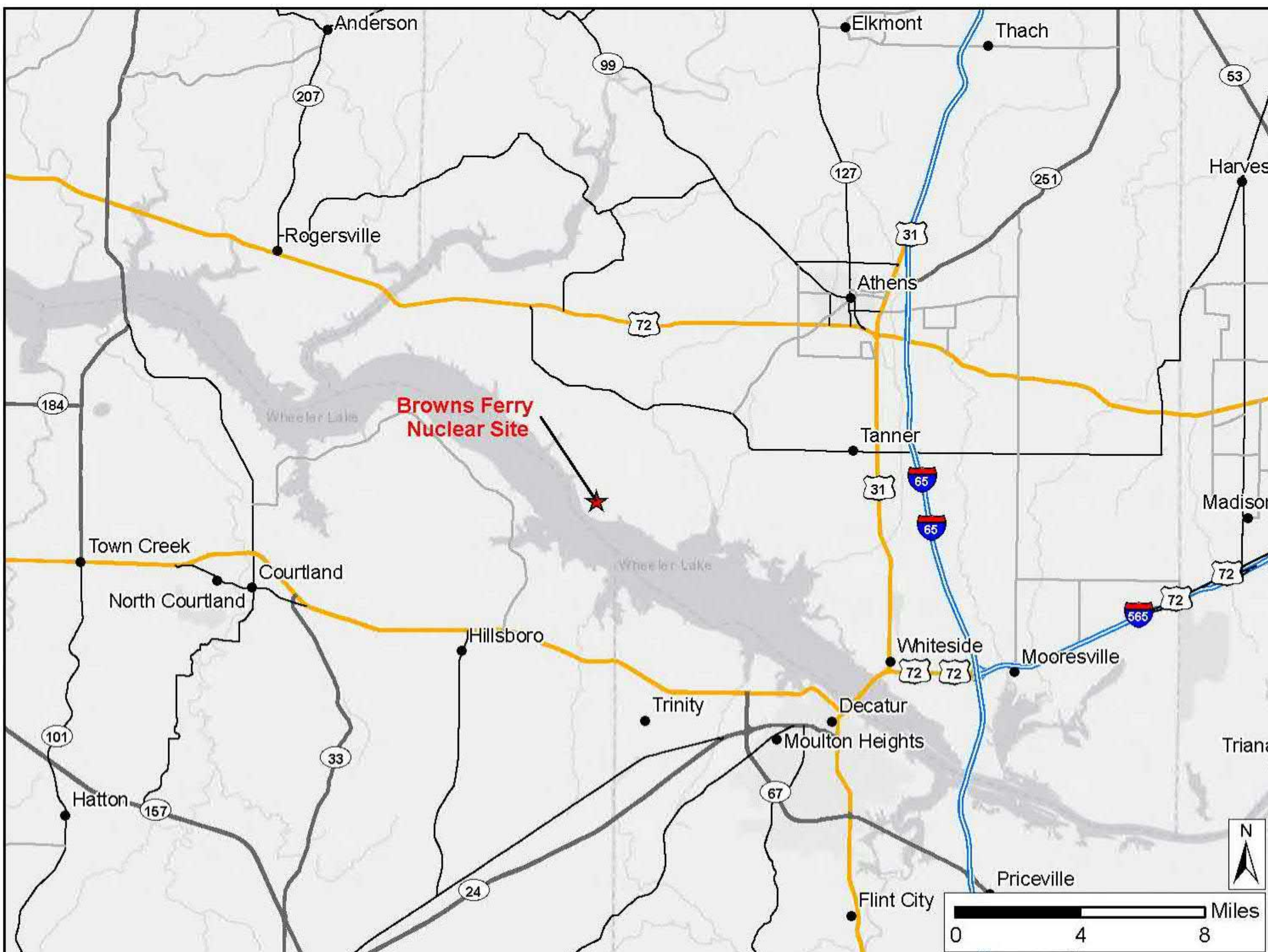
Questions to consider:

- What environmental resources should the SEIS consider?
- What potential impacts should be evaluated?
- Are there any additional alternatives that should be considered?
- Can you recommend any additional sources of information?
- What organizations should TVA be coordinating with?

TVA TENNESSEE VALLEY AUTHORITY

Project Location

The Tennessee Valley Authority's (TVA) Browns Ferry Nuclear Plant (BFN) is located on an 840-acre tract on the north shore of Wheeler Reservoir at Tennessee River Mile (TRM) 294, approximately 10 miles northwest of Decatur, Alabama, and 10 miles southwest of Athens, Alabama.



TVA TENNESSEE VALLEY AUTHORITY

Background

TVA operates BFN Units 1, 2, and 3 consistent with its mission as charged under the TVA Act of 1933. BFN consists of three General Electric boiling water reactors (BWRs) and associated turbine generators that collectively supply approximately 3900 Megawatts electric (Mwe) of electric power to the TVA transmission and distribution system.

In March 2002, TVA issued a Final SEIS (FSEIS) followed by a Record of Decision (ROD) in June 2002 for the operating license renewal of BFN. TVA submitted a License Renewal Application (LRA) to the Nuclear Regulatory Commission (NRC) in December 2003 for a 20-year extension of the operating licenses for each BFN unit. The environmental conclusions the NRC FSEIS did not differ from the TVA FSEIS conclusions and the NRC issued Supplement 21 regarding Browns Ferry Nuclear Plant Units 1, 2, and 3, to the Generic EIS (GEIS) for License Renewal of Nuclear Plants (NUREG-1437) in June 2005. The NRC issued operating license renewals for Units 1, 2, and 3 in May 2006, allowing continued operation of the three BFN units until 2033, 2034, and 2036, respectively.

TVA submitted a license amendment request (LAR) for extended power uprate (EPU) of approximately 15% for all three units in September 2015. The NRC issued a draft Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) in the Federal Register in December 2016 for public comment. In May 2017, the NRC issued the Final EA and FONSI related to the EPU license amendment. The NRC issued the license amendment in August 2017.

TVA TENNESSEE VALLEY AUTHORITY

Project Purpose and Need

The purpose of the proposed action is to help provide continued generation of baseload power between 2033 and 2053 by obtaining US Nuclear Regulatory Commission (NRC) license renewals to operate BFN Units 1, 2, and 3. BFN's current generation supports future forecasted baseload power needs, as outlined in TVA's 2019 Integrated Resource Plan (IRP), by helping to maintain grid stability and generating capacity for TVA's generation portfolio mix. As an integral part of TVA's current generation portfolio, in 2020, BFN produced approximately 20 percent of TVA's average generation. Renewal of the current NRC operating licenses would authorize BFN to continue supplying approximately 3,900 MWe of safe, clean, reliable, and cost-effective baseload power for the foreseeable future for the Tennessee Valley region's homes and businesses, working with local power companies to keep service steady and reliable.

By renewing the NRC licenses, TVA would maximize use of existing assets to support TVA's goals of generating electricity at the lowest feasible cost for the people of the Tennessee Valley. BFN's carbon-free generating capacity supports TVA's goal of a net-zero carbon emissions generating system by 2050.

TVA TENNESSEE VALLEY AUTHORITY

Preliminary Proposed Action

TVA proposes to submit a Subsequent License Renewal Application to the NRC requesting renewal of the BFN operating licenses.

- Renewal of the NRC operating licenses will authorize the plant to continue to operate for an additional 20 years beyond the current 20-year renewed operating licenses expiration dates of 2033, 2034, and 2036 for Units 1, 2, and 3, respectively.

- Subsequent NRC license renewal for the operating BFN facilities does not involve new major construction or modifications beyond normal maintenance and refurbishment.

- There are other proposed projects not directly related to NRC license renewal that are connected to, or could affect, license renewal.

TVA TENNESSEE VALLEY AUTHORITY

Alternatives

The SEIS proposes to address a range of alternatives including:

- Alternative A: No-Action Alternative
- Alternative B: BFN NRC Subsequent License Renewal
- Alternative C: Use of Existing Generating Assets
- Alternative D: Use of Existing and Construction of New Generating Assets

Two additional alternatives were considered but eliminated:

- Alternative E: Replacement of BFN Generating Capacity Entirely with Renewable Energy Sources
- Alternative F: Replacement of BFN Generating Capacity Entirely with Purchase Power

Anticipated Environmental Impacts

The SEIS will include a detailed evaluation of the environmental, social, and economic impacts associated with implementation of the proposed action and alternatives. Measures to avoid, minimize, and mitigate potential adverse effects will also be identified and evaluated in the SEIS.

Resource areas to be addressed in the SEIS include, but are not limited to:

- Air Quality
- Aquatics
- Botany
- Climate Change
- Cultural Resources
- Emergency Planning
- Floodplains
- Geology and Groundwater
- Hydrothermal
- Land Use
- Navigation
- Noise and Vibration
- Radiological Safety
- Soil Erosion and Surface Water
- Socioeconomics and Environmental Justice
- Threatened and Endangered Species
- Transportation
- Visual Resources
- Waste
- Water Use
- Wetlands
- Wildlife

TVA TENNESSEE VALLEY AUTHORITY

SEIS and GEIS

In preparing this SEIS, TVA will review the GEIS for License Renewal of Nuclear Plants, NUREG-1437, in which the NRC considered the environmental effects of renewing nuclear power plant operating licenses for a 20-year period (codified in 10 CFR Part 51).

The GEIS identified 78 environmental issues and reached generic conclusions on environmental impacts for 59 of those issues that apply to all plants or to plants with specific design or site characteristics.

The GEIS' generic assessment is relevant to the assessment of impacts of the proposed action at BFN. Generic information from the NRC GEIS that is related to the current assessment would be incorporated by reference, generally following the tiering process described in 40 CFR 1501.11, with the SEIS providing a more narrow analysis relevant to the specific aspects of this proposed project.

Additional plant-specific review would be conducted for impacts not covered by the GEIS and which are encompassed by the range of resource issue areas identified on the Anticipated Environmental Impacts poster.

TVA TENNESSEE VALLEY AUTHORITY

Anticipated Permits and Other Authorizations

TVA anticipates consulting with the required authorities including, but not limited to:

- Endangered Species Act
- Bald and Golden Eagle Protection Act
- Rare Species Protection and Conservation Act
- National Historic Preservation Act
- Clean Air Act
- Federal Clean Water Act

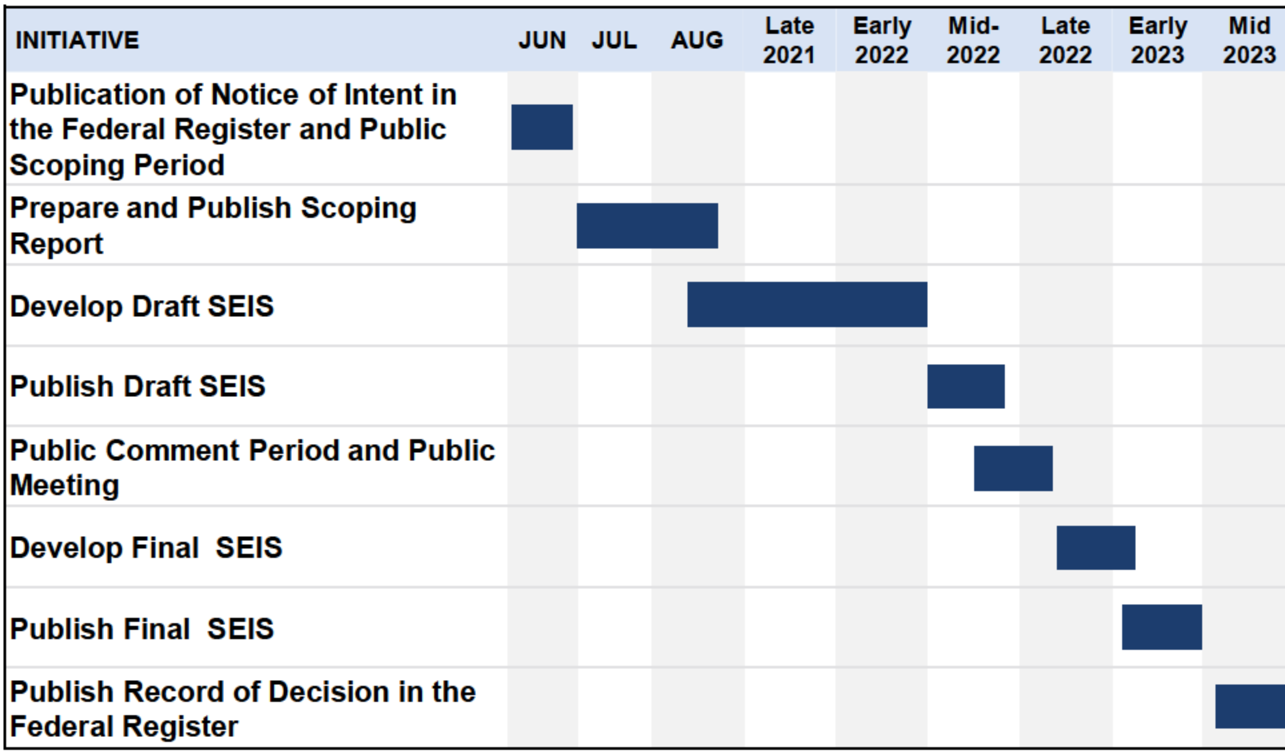
TVA anticipates seeking or renewing required permits or authorizations, from the following governmental entities:

- Nuclear Regulatory Commission
- US Army Corps of Engineers
- US Coast Guard
- US Environmental Protection Agency
- Alabama Department of Environment and Conservation
- US Fish and Wildlife Service
- Alabama State Historic Preservation Officer
- Tribal Historic Preservation Officers

Other permits or authorizations may be sought as required or appropriate.

SEIS Preparation and Schedule

TVA will consider comments received during the scoping period and develop a scoping report which will be published at https://www.tva.com/nepa. The scoping report will summarize public and agency comments that were received and identify the projected schedule for completing the SEIS process.



Following completion of the SLR environmental analysis, TVA will post a Draft SEIS for public review and comment on the project web page. TVA anticipates holding a public open house, which may be virtual, after releasing the Draft SEIS. Open house details will be posted on TVA's website in conjunction with the Draft SEIS. TVA expects to release the Draft SEIS in mid-2022.

TVA will consider comments received on the Draft SEIS, as well as cost, engineering, risk and other applicable evaluations before selecting one or more alternatives as preferred in the Final SEIS. TVA projects completing a Final SEIS in early 2023. A final determination on proceeding with the preferred alternative will be documented in a Record of Decision.

TVA TENNESSEE VALLEY AUTHORITY

How to Submit Comments

TVA invites the public to submit comments on the scope of this SEIS, alternatives being considered, and analysis relevant to the proposed action. Federal, state, local agencies, and Native American Tribes are also invited to provide comments.

Comments are encouraged and must be received or postmarked no later than July 1, 2021.

Due to COVID-19 teleworking, TVA recommends that the public submit comments electronically to ensure their timely review and consideration.

Please note that any comments received, including names and addresses, will become part of the project administrative record and will be available for public inspection.

Comments can be provided by:

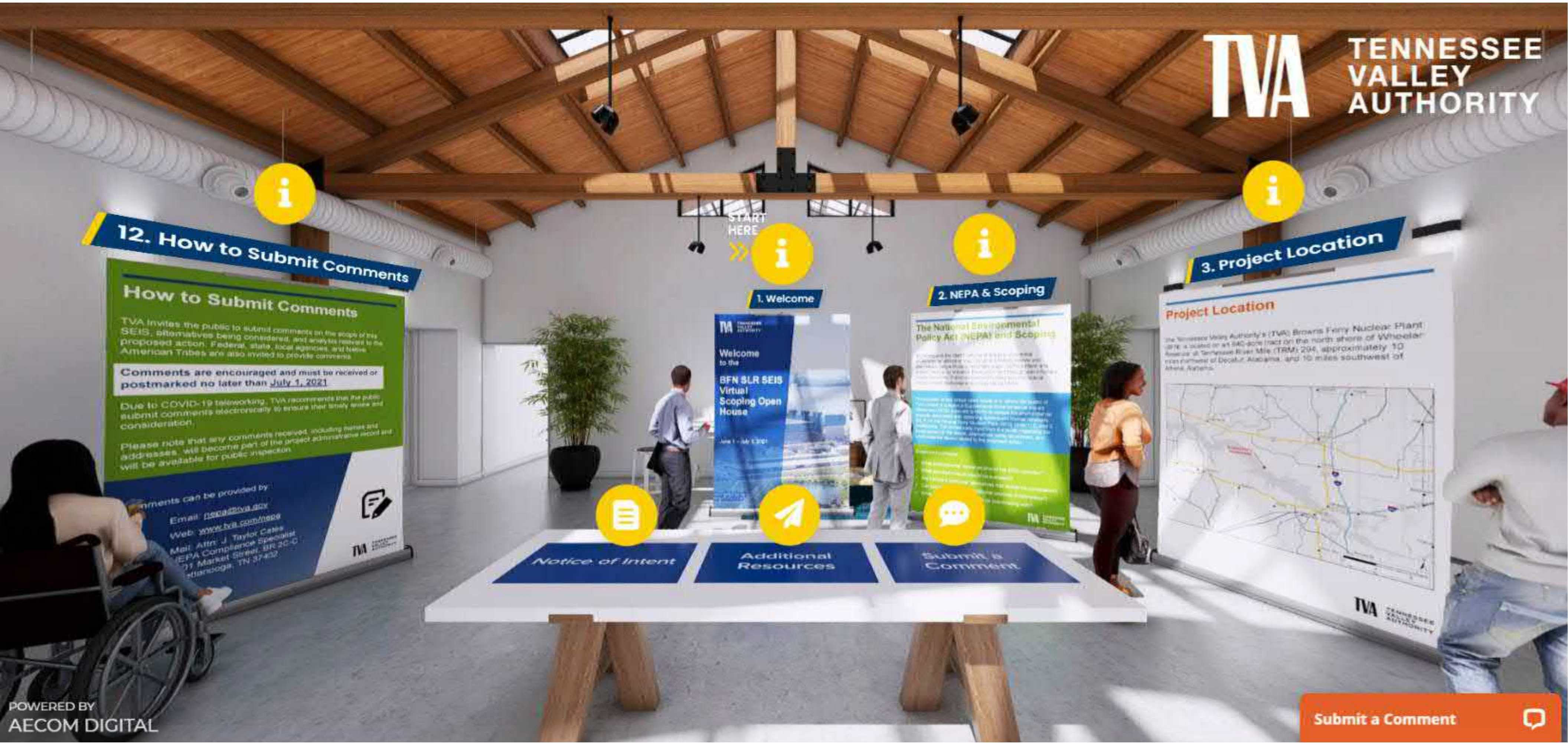
Email: nepa@tva.gov

Web: www.tva.com/nepa

Mail: Attn: J. Taylor Cates
NEPA Compliance Specialist
1101 Market Street, BR 2C-C
Chattanooga, TN 37402

TVA TENNESSEE VALLEY AUTHORITY

Virtual Scoping Meeting Room Screenshots


TVA TENNESSEE VALLEY AUTHORITY
START HERE
1. Welcome
Welcome to the BFN SLR SEIS Virtual Scoping Open House
2. NEPA & Scoping
3. Project Location
Project Location
12. How to Submit Comments
How to Submit Comments
Comments are encouraged and must be received or postmarked no later than July 1, 2021
Notice of Intent
Additional Resources
Submit a Comment
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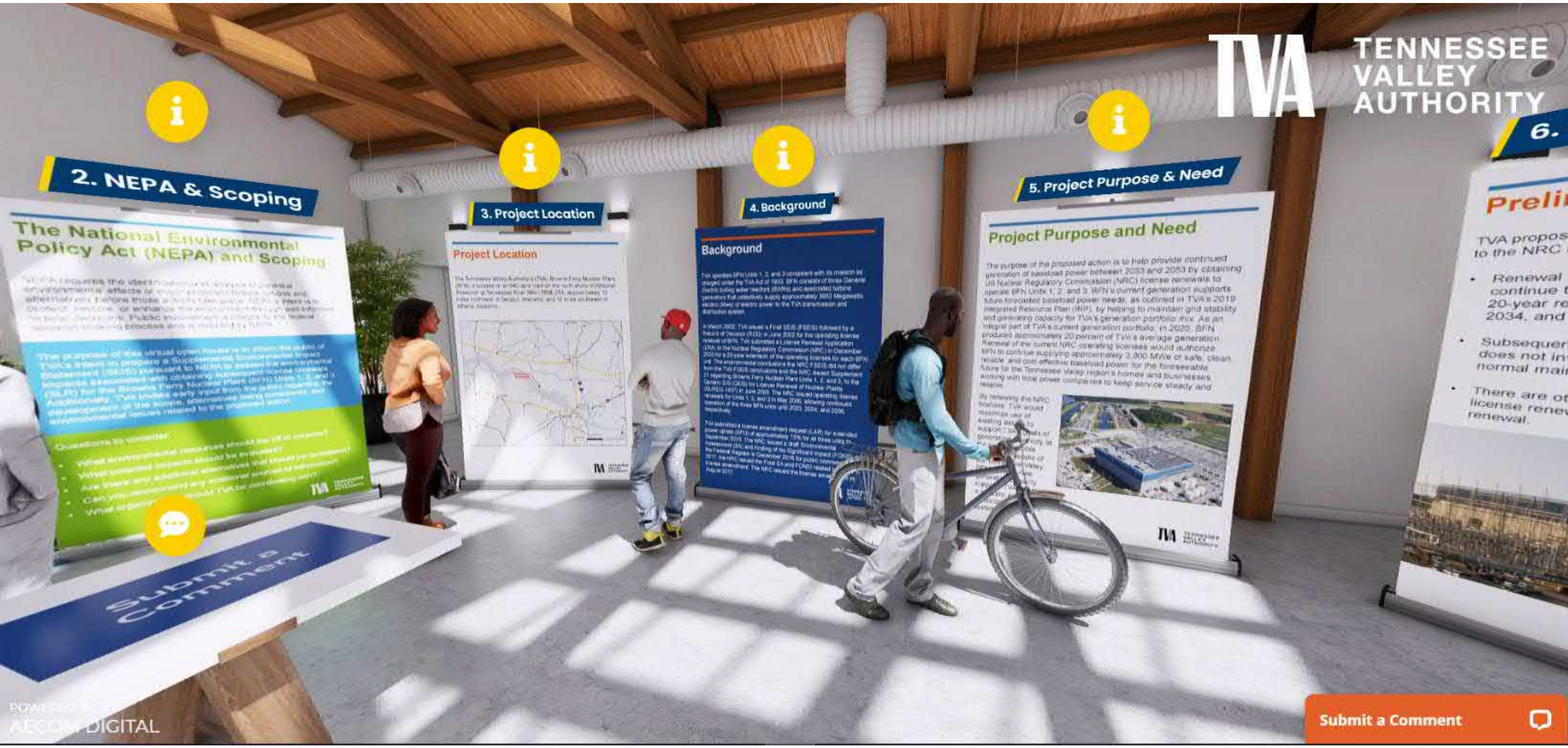
Submit a Comment



TVA
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2. NEPA & Scoping
The National Environmental Policy Act (NEPA) and Scoping
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5. Project Purpose & Need
Project Purpose and Need
Submit a Comment
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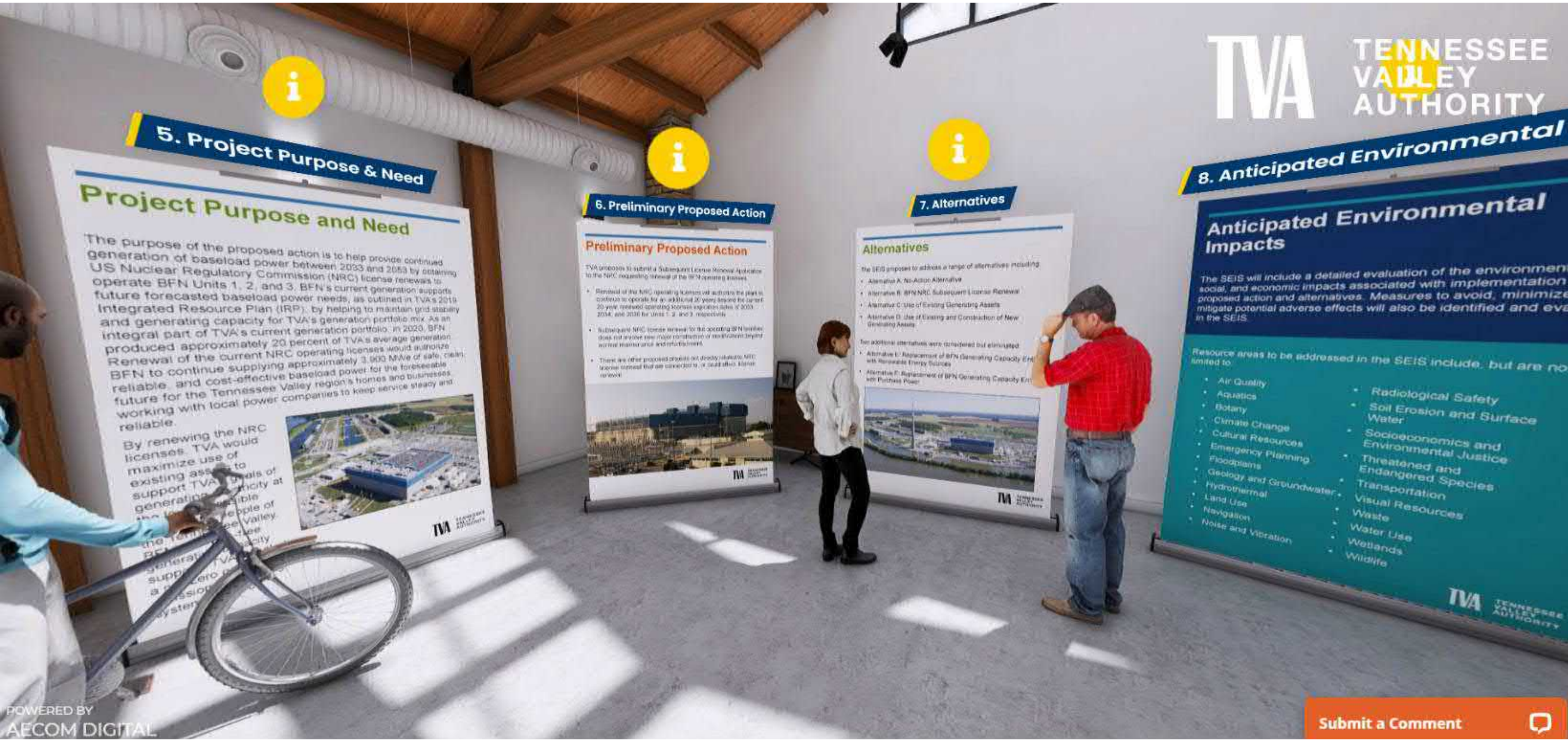

TVA TENNESSEE VALLEY AUTHORITY
5. Project Purpose & Need
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6. Preliminary Proposed Action
Preliminary Proposed Action
7. Alternatives
Alternatives
8. Anticipated Environmental
Anticipated Environmental Impacts
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Radiological Safety
Soil Erosion and Surface Water
Socioeconomics and Environmental Justice
Threatened and Endangered Species
Transportation
Visual Resources
Waste
Water Use
Wetlands
Wildlife
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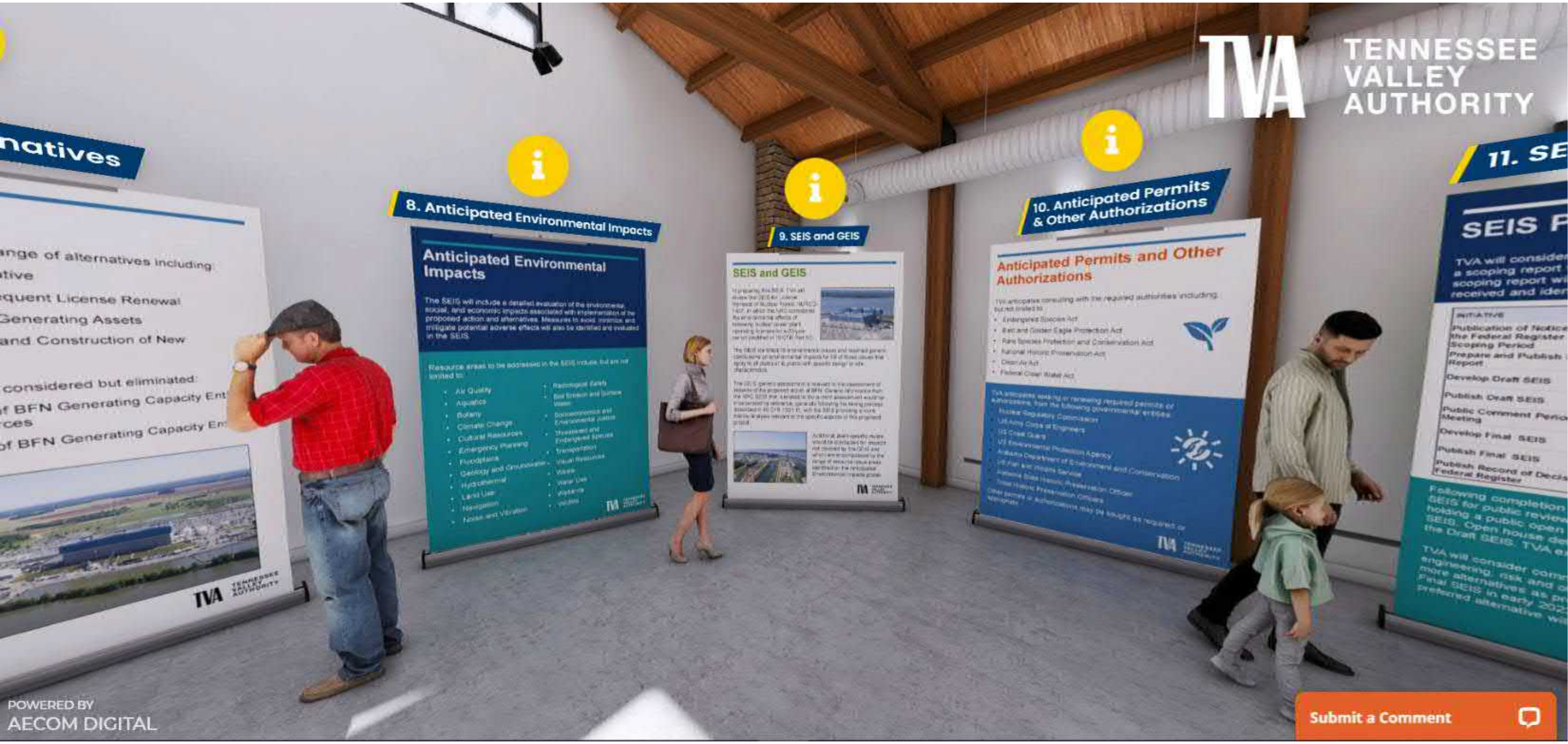

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10. Anticipated Permits & Other Authorizations
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10. Anticipated Permits & Other Authorizations
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Bald and Golden Eagle Protection Act
Rare Species Protection and Conservation Act
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June 1 – July 1, 2021
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Additional Resources
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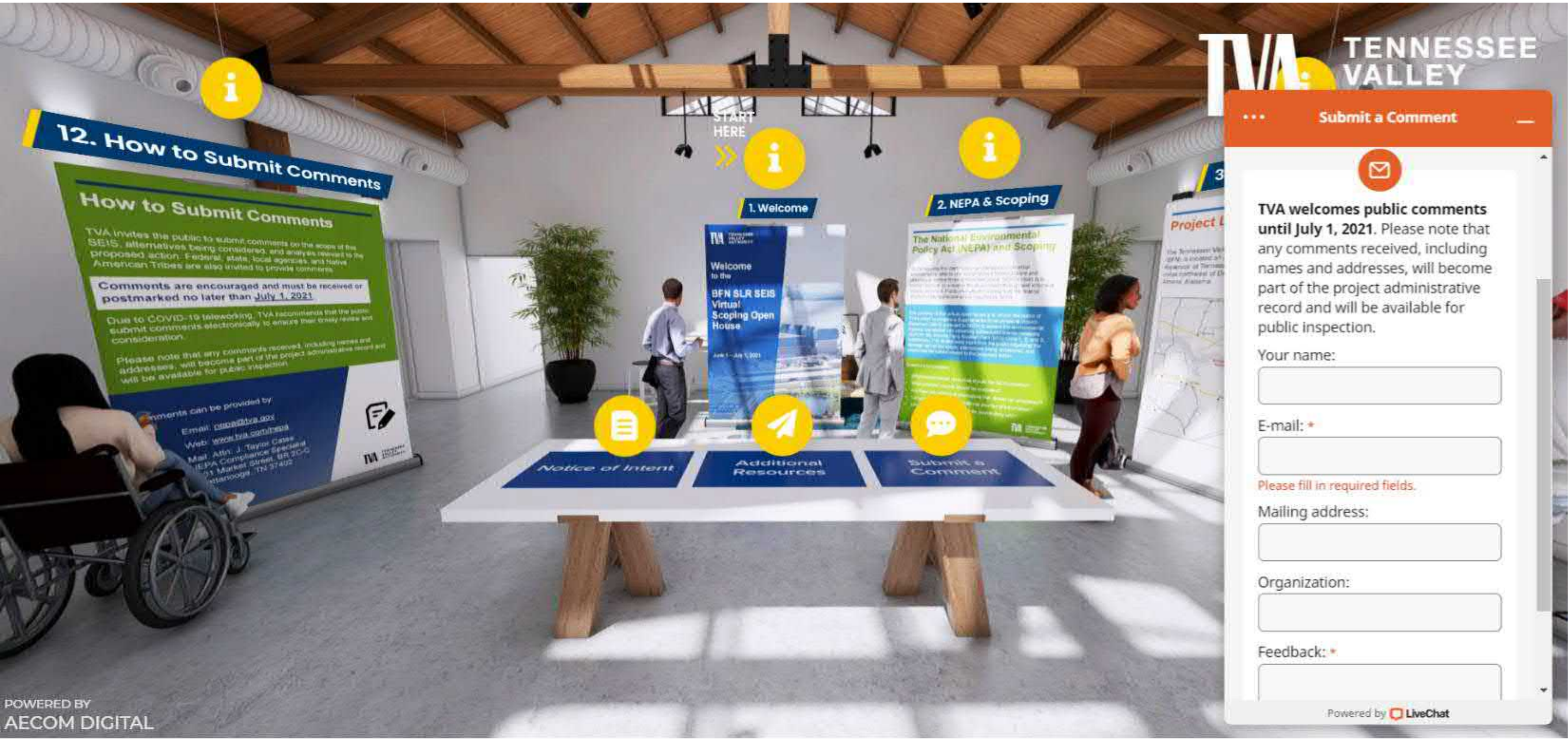
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The National Environmental Policy Act (NEPA) and Scoping
Notice of Intent
Additional Resources
Submit a Comment
TENNESSEE VALLEY
Submit a Comment
TVA welcomes public comments until July 1, 2021. Please note that any comments received, including names and addresses, will become part of the project administrative record and will be available for public inspection.
Your name:
E-mail: *
Please fill in required fields.
Mailing address:
Organization:
Feedback: *
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Appendix D: Public and Agency Comments

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From:	Long, Larry
To:	Cates, J. Taylor
Cc:	Kajumba, Ntale
Subject:	Browns Ferry NOI comments
Date:	Friday, June 25, 2021 1:45:09 PM

J. Taylor Cates
Tennessee Valley Authority
NEPA Specialist
1101 Market Street, BR 2C-C
Chattanooga, TN 37402

RE: Notice of Intent to prepare a Supplemental Environmental Impact Statement for the subsequent license renewal for Browns Ferry Nuclear Plant Units 1, 2, and 3.

Dear Mr. Cates:

The U.S. Environmental Protection Agency (EPA) has reviewed Tennessee Valley Authority's (TVA) Notice of Intent (NOI) to prepare a Supplemental Environmental Impact Statement (SEIS) that addresses the environmental effects associated with obtaining relicense renewals (SLR) for the Browns Ferry Nuclear Plant (BFNP) Units 1, 2, and 3 in Limestone County, Alabama. Renewal of the operating licenses would allow the plant to continue to operate for an additional 20-years beyond the current operating licenses of 2033, 2034, and 2036 for the three units. The BFNP Units 1, 2, and 3 are located on 840-acres tract on the north shore of Wheeler Reservoir. The TVA plant consists of three General Electric boiling water reactors and associated turbine generators.

According to the NOI, TVA indicates that the SLR would not require any new construction or modifications beyond normal maintenance and minor refurbishment. However, there are other proposed projects that are connected to or could affect license renewal. We recommend that TVA evaluate the effects of the other proposed projects and describe efforts to address potential impacts in the SEIS.

Air Quality. Limestone County is in attainment with the Clean Air Act National Ambient Air Quality Standard.

Water Quality/Stormwater -Based on NEPA, the proposed project may be located within a mile of an impaired stream Round Island Creek/Round Island Creek (Wheeler Lake). TVA should consider implementing best management practices during maintenance for areas greater than one acre per the CWA's National Pollutant Discharge Elimination System Permit for stormwater, where applicable, to ensure that water quality impairments are not exacerbated

Wetlands and Streams - The EPA recommends that TVA collaborate with Alabama

Department of Environmental Management (ADEM) and US Army Corps of Engineers (USACE) to determine any potential impacts from the hydraulic and hydrological design associated with thermal discharges to the Tennessee River that may impact terrestrial and/or aquatic species, including both flora and fauna. TVA in collaboration with USACE may wish to include Clean Water Act (CWA) Section 404(b)(1) documents in the SEIS to support any wetland and stream mitigation decisions and to help ADEM evaluate potential stream impact requirements for the CWA Section 401 Water Quality permit. Providing adequate wetland and stream information within the NEPA process can help to streamline the final environmental review and permitting processes for these resources. According to NEPAssist, there are five approved mitigation or conservations banks in the facility vicinity - Flint River Mitigation Bank Phase I (1042), Wheeler Pointe Mitigation Bank (1044). ADOT Town Creek (1198) and ADOT Crow Creek (1199) and Robinson Spring Mitigation Bank (930) should mitigation be required.

Waste Disposal - The SEIS should indicate if there will be any changes in the generation of waste including low-level radioactive waste, mixed low-level radioactive waste, transuranic waste, and hazardous and Toxic Substance Control Act wastes over the life of the program. The SEIS should indicate where TVA will send the spent nuclear fuel and spent fuel debris for storage pending long-term disposal options.

Climate - Climate change may impact the proposed project, posing threats to aging infrastructure, worker health and safety and the environment. We recommend that the SEIS include an evaluation of climate-related impacts including discussions of frequency and severity of major storm events, wildfires, or drought that could lead to power disruptions or increased cooling demands in summer months. Efforts that TVA is taking at BFNP to address and adapt to potential climate impacts should be discussed in the SEIS.

Environmental Justice - The SEIS should include an analysis that is consistent with the Environmental Justice (EJ) Executive Order (EO) 12898. The analysis should indicate whether minority, low income or other overburdened populations reside within the vicinity of the proposed project area. If so, the EPA recommends that the communities with EJ concerns should be meaningfully involved throughout the decision-making process to help identify potential benefits and burdens associated with relicensing and permitting decisions. Adaptive and innovative approaches to both public outreach and community involvement regarding project issues should take place during the project planning. It would also be helpful to include a current map depicting the population demographics near the BFNP facility. EPA's EJSCREEN can be used a preliminary screen to help identify potential issues.

Thank you for the opportunity to review the proposed project. If you have any questions, feel free to contact Mr. Larry Long, of the NEPA Section, at (404) 562-9460, or by e-mail at long.larry@epa.gov.

Larry Long
Regional Mining Expert
Physical Scientist/Sr. Principle Reviewer
NEPA Section/Strategic Programs Office
Office of the Regional Administrator
61 Forsyth Street, SW

Atlanta, GA 30303
404-562-9460
404-562-9598(FAX)
long.larry@epa.gov

Intelligence does not always define wisdom, but adaptability to change does

From: Kopec, Brett A
To: nepa
Cc: Janowicz, Jon A
Subject: Fw: ENVIRONMENTAL REVIEW (ER) NEW POSTING NOTIFICATION: ER21/0210 - NOI TVA to Prepare Supplemental Environmental Impact Statement (SEIS) for the Browns Ferry Nuclear Site Subsequent License Renewal, Units 1, 2, and 3 located in Limestone County, Ala...
Date: Monday, June 7, 2021 8:29:35 AM

Brett Kopec
USGS
Administrative Operations Assistant

From: Gordon, Alison D <agordon@usgs.gov>
Sent: Friday, June 4, 2021 5:00 PM
To: Kopec, Brett A <bkopec@usgs.gov>
Cc: Janowicz, Jon A <jjanowicz@usgs.gov>
Subject: Fw: ENVIRONMENTAL REVIEW (ER) NEW POSTING NOTIFICATION: ER21/0210 - NOI TVA to Prepare Supplemental Environmental Impact Statement (SEIS) for the Browns Ferry Nuclear Site Subsequent License Renewal, Units 1, 2, and 3 located in Limestone County, Ala...

The USGS has no comment at this time. Thank you.

From: oepchq@ios.doi.gov <oepchq@ios.doi.gov>
Sent: Tuesday, June 1, 2021 7:33 AM
To: Reddick, Virginia <Virginia_Reddick@ios.doi.gov>; Treichel, Lisa C <Lisa_Treichel@ios.doi.gov>; Alam, Shawn K <Shawn_Alam@ios.doi.gov>; Braegelmann, Carol <carol_braegelmann@ios.doi.gov>; Kelly, Cheryl L <cheryl_kelly@ios.doi.gov>; ERs, FWS HQ <FWS_HQ_ERs@fws.gov>; Runkel, Roxanne <Roxanne_Runkel@nps.gov>; Stedeford, Melissa <Melissa_Stedeford@nps.gov>; Hamlett, Stephanie R <shamlett@osmre.gov>; Janowicz, Jon A <jjanowicz@usgs.gov>; Gordon, Alison D <agordon@usgs.gov>; oepchq@ios.doi.gov <oepchq@ios.doi.gov>; Stanley, Joyce A <Joyce_Stanley@ios.doi.gov>
Subject: ENVIRONMENTAL REVIEW (ER) NEW POSTING NOTIFICATION: ER21/0210 - NOI TVA to Prepare Supplemental Environmental Impact Statement (SEIS) for the Browns Ferry Nuclear Site Subsequent License Renewal, Units 1, 2, and 3 located in Limestone County, Alabama

This e-mail alerts you to a Environmental Review (ER) request from the Office of Environmental Policy and Compliance (OEPC). This ER can be accessed here.
To access electronic ERs visit the Environmental Assignments website: https://ecl.doi.gov/ERs.cfm. For assistance, please contact the Environmental Review Team at 202-208-5464.
Comments due to Agency by: 07/01/21

From: Wufoo
To: nepa
Subject: NEPA Comments - Browns Ferry Nuclear Plant [#1]
Date: Wednesday, June 2, 2021 11:29:16 AM

Name	Jack Keeling
City	CHATTANOOGA
State	Tennessee
Organization	None
Email	[redacted]
Phone Number	[redacted]
Please provide your comments by uploading a file or by entering them below. *	Renew the licenses. Keep the plant running. We need it.

From: [redacted]
To: Cates, J. Taylor
Subject: Comments on extending licenses
Date: Thursday, July 1, 2021 7:12:59 PM

This is an EXTERNAL EMAIL from outside TVA. THINK BEFORE you CLICK links or OPEN attachments. If suspicious, please click the "Report Phishing" button located on the Outlook Toolbar at the top of your screen.

July 1 was the deadline. Today is July 1. Please submit these comments on my behalf. And please let me know if the comments will be submitted.

Steven Sondheim
[redacted]
Memphis 38117

I highly object to the extension of licenses to
The Browns Ferry Nuclear Power Reactors from 60-80 years which is 40 years beyond the original license.

Besides this power not being needed if renewable energy is adequately deployed by 2035-40, there is no evidence these installations will remain safe for an additional 20 years.

I ask that all systems be thoroughly inspected and investigated before these extensions are considered and the results made public. As the following article points out, older structures are vulnerable to a variety of aging factors.

https://readersupportednews.org/opinion2/277-75/70146-rsn-collapsed-florida-condo-sends-a-giant-nuke-warning

Sent from my iPhone


A man prays Friday near where search and rescue operations are ongoing at the partially collapsed 12-story Champlain Towers South condo building in Surfside, Fla. (photo: Joe Raedle/Getty Images)

Collapsed Florida Condo Sends a Giant Nuke Warning

By Harvey Wasserman, Reader Supported News
28 June 21

The horrifying collapse of a south Florida condo should alarm us all about the next reactor catastrophe.

The owners of that 13-story condo were warned years ago that it could implode. They were apparently getting ready for repairs, but in the interim did nothing.

The owners of America's 93 licensed reactors have been warned for decades that they could both implode and explode. They have also done nothing.

More than 150 people may have died in this avoidable Florida disaster. The death toll from the next avoidable reactor disaster could stretch into the millions, with property damage in the trillions, a blow from which our economy and ecosystems might never recover.

South Florida authorities have now ordered inspections of large buildings over forty years old. Nearly all US reactors – including four on the ocean in South Florida – are also now around forty years old.

They all must be immediately shut for rigorous inspection. To wait is to invite a radioactive version of what just happened to that condo.

The argument is not about nuclear power. It's about basic sanity.

The industry is currently pushing "new" designs based on fusion, thorium, breeder technologies, molten salt, small modular, and more. None have been proven safe or effective in fighting climate chaos. Nor can they compete with renewables. None have a reasonable prospect of coming online before being completely left in the radioactive dust by accelerating advances in wind, solar, batteries, and LED efficiency.

All are certain to consume huge quantities of public money, pouring into private pockets (like those of Bill Gates) before failing utterly.

But they pale in importance alongside the 93 US reactors (there are some 430 worldwide) now plummeting toward certain catastrophe.

None of these reactors can get private liability insurance against an apocalyptic disaster. Most were designed in the pre-digital 1950s and '60s. Many were built with inferior materials and understanding.

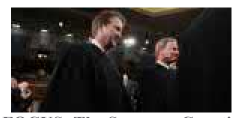
Critical welds at California's Diablo Canyon, for example, contain metal components long since banned. But Unit One continues to operate.

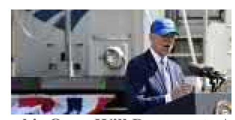
Critical concrete at New Hampshire's Seabrook and Ohio's Davis-Besse is crumbling. Fort Calhoun in Nebraska was flooded. Intake pipes at South Texas froze. Reactors in Ohio and Virginia have been damaged by earthquakes. Diablo is surrounded by earthquake faults set to deliver seismic shocks which a Nuclear Regulatory Commission resident inspector has said it can't withstand. The owners of San Onofre want to bury their high-level wastes ONE HUNDRED FEET from the tide line. Meaningful evacuation planning is nonexistent at sites where nearby population centers have exploded since the original siting approval.

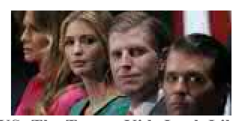
All these old reactors contribute to climate chaos with emissions of heat, radiation, and carbon. They suck up billions of gallons of precious water, then dump it or evaporate it with chemical, radioactive, and thermal pollution. In every case, our planet would benefit from their shutdown.

Virtually all US reactors are almost certainly embrittled, meaning emergency cooling water poured into the core to quell a meltdown would shatter critical components, resulting in apocalyptic hydrogen and possibly fission explosions, as at Chernobyl and Fukushima.


FOCUS: Ex-Dam CEO And West Point Grad Convicted In Murder Of Berta Cáceres
Democracy Now!
06 July 2021

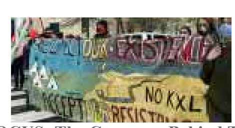

FOCUS: The Supreme Court's Conservatives Have Laid The Groundwork For The Devastation To Come
Dahlia Lithwick and Mark Joseph Stern, Slate
06 July 2021

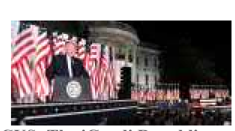

Break's Over. Will Democrats Act?
Katrina vanden Heuvel, The Washington Post
06 July 2021


FOCUS: The Trump Kids Look Likely To Turn On Their Dad – And I Suspect Ivanka Will Go First
Arwa Mahdawi, Guardian UK
07 July 2021


Republicans' Effort To Deny The Capitol Attack Is Working - And It's Dangerous
David Smith, Guardian UK
06 July 2021


Meet The Consulting Firm That's Staffing The Biden Administration
Jonathan Guyer and Ryan Grim, The Intercept
07 July 2021


FOCUS: The Company Behind The Keystone XL Pipeline Would Like $15 Billion Of Your Money, Please
Charles Pierce, Esquire
07 July 2021


FOCUS: The 'Good' Republicans Are Bad, And The Bad Ones Are Batshit
Molly Jong-Fast, The Daily Beast
08 July 2021

To put it most simply: no embrittled reactor has a workable set of brakes. Yet states like California, and the NRC itself, refuse to conduct relatively cheap and simple open inspections.

Thus embrittlement, pipe cracking, component degradation, technical obsolescence, an aging workforce, rampant incompetence, and worse define the reality of virtually every operating atomic reactor, here and around the planet.

So when we look in horror at that collapsed south Florida condo, with all those innocent souls buried in the rubble, we must remember that later today, parallel pictures could show a mega-hot runaway reactor spewing Chernobyl/Fukushima levels of radiation throughout the ecosphere.

Thankfully, the Solartopian realities of fast-accelerating wind, solar, battery, and efficiency technologies give us the leeway to shut them all NOW.

Let's do it before it's too late!!

Harvey Wasserman co-convenes the weekly Election Protection 2024 ZOOM. His People's Spiral of US History *is at www.solartopia.org.*

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Comments

We are concerned about a recent drift towards vitriol in the RSN Reader comments section. There is a fine line between moderation and censorship. No one likes a harsh or confrontational forum atmosphere. At the same time everyone wants to be able to express themselves freely. We'll start by encouraging good judgment. If that doesn't work we'll have to ramp up the moderation.

General guidelines: Avoid personal attacks on other forum members; Avoid remarks that are ethnically derogatory; Do not advocate violence, or any illegal activity.

Remember that making the world better begins with responsible action.

- The RSN Team

Steppen-Wolf 2021-06-28 14:42 -8
Face it, people, we live in an evil, mass-insane world run by people who care more about money and profit(s) than lives. Contrary to their claims that such is supposedly not the case, they don't care if masses of people die. Their lord and master is Satan, who hates humanity and wants us all dead. What else besides evil explains the level of greed at the expense of lives and the well-being of the entire planet? I'll tell you the answer: Nothing. So, if you don't want to believe in evil, especially evil at the level(s) that it exist(s) today, too bad, because it clearly exists, and the massively-evil people who run things clearly exist as well. Many of them even (falsely) claim to be "Christians", and/or part of other "benevolent" religions.

What does facing all of this point to? It makes it abundantly-clear that our only hope is God through Jesus the Christ (John 14:6). The evil and insane people who run things aren't going to stop endangering and mass-murdering us for profit(s), including those of them who are religious people. Please don't depend on such people to save the day, even the minority of them who claim to mean well. Against the juggernaut that is the majority of such people, they stand little or no chance. Laws may be passed that make it appear we will be protected, but when the crap hits the fan to a completely-overwhelming extent, we will be left high and dry by them. We can only depend on God to save us, not the whims of evil people.

davehaze 2021-06-29 15:54 +6
I dont know Steppen, depending on God has had mixed results. Depending on Christians has been disastrous. Let's make humans without excuses responsible. Try that.

mbrenman 2021-06-28 17:37 -13
Bizarre comparison, and shameful to use this tragedy for political ax grinding.

laborequalswealth 2021-06-29 12:16 +9
"None of these reactors can get private liability insurance against an apocalyptic disaster."

THAT tells you ALL you need to know. GD right it's POLITICAL. What's wrong with YOU?

Texas Aggie 2021-06-29 13:59 +11
Not bizarre at all. Both examples are structures made of concrete that deteriorates over time and are located in places where their failure will cause damage to life and property.

davehaze 2021-06-29 14:39 +5
mb

That's the way the concrete crumbles-- without thought or concern of consequence, people crushed or nuclear core melted.

johnescher 2021-06-29 16:49 +1
Why, Wulfie, does Satan want everybody dead? Wouldn't He prefer people to stay alive the better to roast slowly as the globe warms?

elizabethblock 2021-06-28 18:39 +16
Bob Bossin, Canadian musician, said a long time ago that building a nuclear reactor without a safe way to dispose of nuclear waste is like building an outhouse without digging a hole first.
And in seventy years, we have not figured out a safe way to dispose of nuclear waste. I don't think we ever will.

NAVYVET 2021-06-28 19:55 +14

Browns Ferry Nuclear Subsequent License Renewal Scoping Comments for SEIS

The subsequent license renewal (SLR) of the three Browns Ferry (BFN) Reactors should be rejected: the collapse of the Champlain Towers South condo in Surfside, Florida reminded us of the vulnerability of aging infrastructure. Aging, stressed components are more likely to fail the longer they are in service. The No-Action Alternative (A) should be chosen, and a new process started that focuses on alternative (E): Replacement of BFN Generating Capacity with Renewable Energy Sources. TVA should bring on board renewables, energy efficiency and additional storage with urgency. Renewable energy is the fastest growing energy resource in the world: https://www.npr.org/2021/05/11/995849954/renewable-energy-capacity-jumped-45-worldwide-in-2020-iea-sees-new-normal. Renewable energy is the fastest growing in the US as well: https://www.c2es.org/content/renewable-energy/.

The Supplemental Environmental Impact Statement should reevaluate fundamental assumptions of safety that have been used to justify previous SLRs of other nuclear power reactors in the US.

The SEIS should comprehensively cover all conceivable environmental impacts of continued operation of the BFN reactors. It should consider the fundamental environmental, health and environmental justice problems inherent in nuclear power at every step in the nuclear fuel chain: uranium mining, milling, fuel fabrication, operations, radioactive waste, and decommissioning. It should consider the growing threats to nuclear power reactor operation and safety posed by the ever-growing effects of climate change.

The SEIS should include the effects of a catastrophic accident and massive radiation release at one or more of these aging reactors that were designed to operate for 40 years. Extending operation to 80 years demands an exhaustive study of the aging management. The longer these reactors run, the greater the risk of a devastating accident.

The Browns Ferry reactors are Fukushima style GE Mark 1 reactors, a design that has a long, controversial history, with many questioning the lack of robustness in the containment system and foreshadowing the three reactor melt-downs, hydrogen explosions, resulting containment breeches, and release of massive amounts of radiation at Fukushima. Please include the articles at these and all links in the SEIS scoping process: https://www.environews.tv/091117-ges-mark-1-nuclear-reactor-recalled-worldwide-like-faulty-unsafe-auto-pt-5/; https://www.nytimes.com/2011/03/16/world/asia/16contain.html;

https://abcnews.go.com/Blotter/fukushima-mark-nuclear-reactor-design-caused-ge-scientist/story?id=13141287; https://www.nirs.org/boiling-water-reactors/.

The Browns Ferry reactors have a history of mechanical problems and other issues resulting in six separate shut-downs of longer than a year including the longest shutdown of any US reactor (Unit 1 from 1985 to 2007) and the second and third longest shutdowns (Unit 3 from 1985 to 1995 and Unit 2 from 1984 to 1991). In 2011 they received one of only 4 "Red finding" safety warnings from the NRC for extended safety performance deficiencies. Safety concerns have plagued these reactors throughout their lives: https://www.nirs.org/wp-content/uploads/factsheets/brownsferryfactsheet.pdf. A whistleblower's story illuminates these concerns:
https://www.al.com/wire/2013/07/browns_ferry.html ;
https://www.al.com/wire/2013/07/browns_ferry_engineer_never_ex.html .

This 2013 study highlights more issues: https://www.bredl.org/pdf4/AL_BFN_Report_2013-final-digit.pdf including the spent fuel pools locations over 40 feet off the ground and with only sheet metal roofing overhead. Safety concerns: https://allthingsnuclear.org/dlochbaum/susquehanna-spent-fuel-pool-concerns-and-how-i-ended/ . These pools contain an enormous amount of deadly radiation. The SEIS should consider deficiencies in the BFN spent fuel pools and the environmental effects of a failure of one or more of these pools and the resulting release of radiation:
https://nautilus.org/uncategorized/risks-of-densely-packed-spent-fuel-pools/ .

The "reasonable assurance" of reactor safety during the proposed SLR period is far from certain. The safety of this license extension is wholly unproven. The NRC and the nuclear reactor operators have taken a "don't look, don't want to know" approach to verification of continued integrity of inner reactor critical components that are subject to the intense conditions in a nuclear reactor (heat, neutron bombardment, pressure, extreme temperature swings in SCRAM events, etc).

The SEIS should consider the wide range of critical knowledge gaps in the age-related material degradation process in GE Mark 1 BWRs and the management of that degradation over 60 or 80 years. It is therefore critical that the scoping process fill those gaps and provide an evidence basis on materials safety and systems reliability to make informed, scientifically qualified decisions in regulatory review of longer license extensions of civilian NPPs. Critical reactor systems, structures, and components must be strategically harvested from decommissioning similar design nuclear power plants and studied in labs by materials scientists, rather than disposing of them as is done now. This would include and not be limited to harvesting and analysis of base metals and weld materials from irreplaceable reactor pressure vessels, concrete from reactor containment structures and spent fuel pools, reactor internal components, and sections of electrical cable. These components provide a unique opportunity for real-world analysis of the effects of NPPs' harsh operational environment and the outcomes of licensees' age management programs. Essentially the only way to access, extract and study these materials is in the decommissioning process.

The DOE's Pacific Northwest National Laboratory, under contract with NRC Office of Research, published a Technical Letter Report in December 2017 entitled "Criteria and Planning Guidance for Ex-Plant Harvesting to Support Subsequent License Renewal" (PNNL-27120). The contract explicitly instructed PNNL to identify the "knowledge gaps" and make recommendations. PNNL recommended harvesting and analysis of these materials in decommissioning. The report can be found here: http://static1.1.sqspcdn.com/static/f/356082/28026831/1542303608657/autopsy_PNNL-27120_harvesting_Dec2017.pdf?token=m0Gx1ULrrWdHLvN%2BE3yET8AfdLw%3D

The report was publicly posted for nine months on the government websites of PNNL, DOE Office of Scientific and Technical Information (OSTI) and the IAEA International Nuclear Information System (INIS), before the NRC Office of Nuclear Reactor Regulation removed it from government websites in September 2018. It was republished (only on the NRC website) as PNNL-27120 Rev.1 in April 2019. The revised version removed scores of references to critical "knowledge gaps" and recommendations to "require" decommissioning harvesting/analysis as necessary for reasonable assurance in NRC safety and environmental review and approval process of license extension applications. Without scientifically founded "reasonable assurance," the NRC lacks a legal basis for granting Subsequent License Renewal.

PNNL's recommendations from December 2017 remain well founded. Harvesting and material testing of nuclear plant components and compiling an evidence basis to assess age-related degradation management are necessary for "reasonable assurance" (which is an explicit NRC requirement for license extension). They are therefore prerequisites for approving long license extensions and are critical to fulfilling the NRC's mission of protecting public safety and the environment.

Former NRC Commissioner Victor Gilinsky has noted the absence of validity of the NRC's SLR process: "The so-called license extension safety review is a scandal. Although the whole thing is bureaucratically elaborate, and a bonanza for industry consultants and lawyers, the only question the NRC safety reviewers address is whether the plant owners have a plan for dealing with aging equipment so that the plant can meet its current “licensing basis”. The NRC reviewers are specifically forbidden by regulation from questioning that licensing basis, that is, the basis on which safety depends, even though it was set many decades ago when less was known about, say, for example, seismic events, and in the light of current information may well be out of date.” From a comment sent to the Bulletin of Atomic Scientists on the story at this link: https://thebulletin.org/2020/09/with-climate-change-aging-nuclear-plants-need-closer-scrutiny-turkey-point-shows-why/ . Please include that entire article in these comments.

Submitted by,

Don Safer

[redacted]

Nashville, TN 37205

July 1, 2021

ENERGY

Renewable Energy Growth Rate Up 45% Worldwide In 2020; IEA Sees 'New Normal'

May 11, 2021 · 11:51 AM ET

BILL CHAPPELL

Workers next to solar panels in an integrated power station in Yancheng, China, in October. An unprecedented amount of renewable power came online in the fourth quarter of 2020, according to a new report from the International Energy Agency. China alone added more than 92 gigawatts of capacity, more than triple the amount it added in the fourth quarter of 2019.

Hector Retamal / AFP

Despite the pandemic, the growth rate in the world's renewable energy capacity jumped 45% in 2020, part of "an unprecedented boom" in wind and solar energy, according to a new report from the International Energy Agency. It's the largest annual rate of increase since 1999.

"An exceptional 90% rise in global wind capacity additions led the expansion," the report states. It also cites a 23% expansion in new solar power installations.

In 2020, renewable power was "the only energy source for which demand increased ... while consumption of all other fuels declined," says the IEA, whose mission is to make the world's energy supply more reliable, affordable and sustainable.

The IEA predicts large capacity gains in renewable energy will become the "new normal" in 2021 and 2022, with increases similar to 2020's record total.

An unprecedented amount of renewable power came online in the fourth quarter of 2020, the report states. China alone added more than 92 gigawatts of capacity – more than triple the amount it added in the fourth quarter of 2019. The U.S. added 19 gigawatts, a sharp gain over the 13.7 it added in the same quarter of the previous year.

Despite the gains in renewable energy, experts warn that a "substantial gap" persists between emissions from continued fossil fuel use and the lower levels needed to meet temperature limits in the Paris Agreement on climate change by the end of the decade.

"A massive expansion of clean electricity is crucial to enable the world to reach its net zero goals," IEA head Fatih Birol said on Tuesday, calling on governments to build on the momentum of the past year to invest more in solar, wind and other renewables, along with bolstering their electrical grid infrastructures.

Global coal consumption of coal, a key source of greenhouse gas emissions that contribute to global climate change, fell by 4% in 2020 – the biggest drop since World War II, the IEA said earlier this year. But demand has been building anew since late last year, driven by Asia's economies that were among the first to start bouncing back from the COVID-19 pandemic.

Another factor: even as China invests in "green" energy, the country has also continued to build new coal power plants. China is responsible for about a third of the world's annual coal consumption – and it's expected to hit a new record high in 2021, the IEA said in April.

The U.S. relies on coal-fired power plants for about 20% of its electricity generating capacity, according to the federal Energy Information Administration, citing figures from the end of 2020. The largest share of the country's power comes from natural gas-fired plants, which account for 43% of U.S. capacity, the agency says.

The IEA says it revised its U.S. renewable energy forecast after Congress extended federal tax credits for solar and wind projects, as part of the spending bill lawmakers approved in late 2020.

The sector could rise further if Congress passes legislation that is based on President Biden's infrastructure plan, the Paris-based agency says.

The U.S. approved a large offshore wind project on Tuesday, advancing a plan to build a turbine installation some 12 nautical miles offshore from Martha's Vineyard, Mass. This photo shows the first offshore wind project in America: the Block Island Wind Farm, off the shores of Block Island, R.I., as seen in 2016.

Don Emmert/AFP via Getty Images

The U.S. approved a large offshore wind project on Tuesday, advancing a plan to build a turbine installation some 12 nautical miles offshore from Martha's Vineyard, Mass. The 800-megawatt project would produce enough electricity to power 400,000 homes and businesses, the Biden administration says.

The IEA's Renewable Energy Market Update identifies several countries as driving the phenomenal growth in renewable energy last year, including China, the U.S. and Vietnam. All three countries were facing policy deadlines that spurred renewable energy projects to completion.

For the first time, China accounted for 50% of the world's growth in renewable energy capacity, the report says. The country is expected to add slightly less renewable power capacity in 2021, as it phases out some subsidies for wind and solar projects.

Despite those changes, solar energy development "will continue to break records," the IEA says, predicting that annual capacity additions will hit 162 gigawatts by the end of next year – almost 50% higher than the solar capacity gains in the pre-pandemic era of 2019.

Renewable energy sources "are expected to account for 90% of total global power capacity increases" this year and next, according to the agency, citing support from government policies and investments.

The Paris-based IEA was founded during the energy crisis of the early 1970s. It has 30 members, including the U.S., along with eight "association countries," such as China and India.

Correction

May 13, 2021

The original version of this story incorrectly said global renewable energy capacity increased 45% in 2020. The 45% increase was in the annual rate of increase of global renewable energy capacity.

renewable energy

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Renewable Energy

At-a-glance

- Renewable energy is the fastest-growing energy source in the United States, increasing 100 percent from 2000 to 2018.
- Renewables made up more than 17 percent of net U.S. electricity generation in 2018, with the bulk coming from hydropower (7.0 percent) and wind power (6.6 percent).
- Solar generation (including distributed) is projected to climb from 11 percent of total U.S. renewable generation in 2017 to 48 percent by 2050, making it the fastest-growing electricity source.
- Globally, renewables made up 24 percent of electricity generation in 2016, much of it from hydropower (16 percent).
- Renewable ethanol and biodiesel transportation fuels made up over 12 percent of total U.S. renewable energy consumption in 2018, up from 7 percent in 2006.

Renewable Supply and Demand

Renewable energy is the fastest-growing energy source globally and in the United States.

Globally:

- Eighteen percent of the energy consumed globally for heating, power, and transportation was from renewable sources in 2017 (see figure below). Nearly 60 percent came from modern renewables (i.e., biomass, geothermal, solar, hydro, wind, and biofuels) and the remainder from traditional biomass (used in residential heating and cooking in developing countries).
- Renewables made up 26.2 percent of global electricity generation in 2018. That's expected to rise to 45 percent by 2040. Most of the increase will likely come from solar, wind, and hydropower.

The International Energy Agency notes that the development and deployment of renewable energy technologies will depend heavily on government policies and financial support to make renewable energy cost-competitive.

Estimated Global Renewable Energy Share of Total Final Energy Consumption (2017)

SOURCE

Renewable Energy Policy Network for the 21st Century, p. 31. (2019)

In the United States:

- Eleven percent of the energy consumed across sectors in the United States was from renewable sources in 2018 (11.5 quadrillion Btu out of a total of 101.1 quadrillion Btu). U.S. consumption of renewables is expected to grow over the next 30 years at an average annual rate of 1.8 percent, higher than the overall growth rate in energy consumption (0.2 percent per year) under a business-as-usual scenario.
- Renewables made up 17.1 percent of electricity generation in 2018, with hydro, wind, and biomass making up the majority. That's expected to rise to 24 percent by 2030. Most of the increase is expected to come from wind and solar. Non-hydro renewables have increased their share of electric power generation from less than 1 percent in 2005 to nearly 10.1 percent at the end of 2018 while demand for electricity has remained relatively stable.

In the transportation sector, renewable fuels, such as ethanol and biodiesel, have increased significantly during the past decade. E85 (ethanol transportation fuel) is expected to be the fastest growing renewable energy type, growing at an average annual rate of 9.7 percent over the next 30 years, although it starts from a very low base.

In the industrial sector, biomass makes up 98 percent of the renewable energy use with nearly 60 percent derivec ass wood, 32 percent from biofuels, and nearly 7 percent from biomass waste.

Uncertainty about federal tax credits, fuel prices, and economic growth will influence the pace of U.S. renewable energy source development.

Renewable Energy Drivers

Factors affecting renewable energy deployment include market conditions (e.g., cost, diversity, proximity to demand or transmission, and resource availability), policy decisions, (e.g., tax credits, feed-in tariffs, and renewable portfolio standards) as well as specific regulations. Nearly all countries had renewable energy policy targets in place at the end of 2018.

Businesses with sustainability goals are also driving renewable energy development by building their own facilities (e.g., solar roofs and wind farms), procuring renewable electricity through power purchase agreements, and purchasing renewable energy certificates (RECs).

Policy Drivers

Two federal tax credits have encouraged renewable energy in the United States:

- The production tax credit (PTC), first enacted in 1992 and subsequently amended, was a corporate tax credit available to a wide range of renewable technologies including wind, landfill gas, geothermal, and small hydroelectric. For eligible technologies, the utility received a 2.2 ¢/kWh ($22/MWh) credit for all electricity generated during the first 10 years of operation. The PTC is currently being phased out; facilities beginning construction after December 31, 2019 will no longer be able to claim this credit.
- The investment tax credit (ITC) is earned when qualifying equipment, including solar hot water, photovoltaics, and small wind turbines, is placed into service. The credit reduces installation costs and shortens the payback time of these technologies. The Consolidated Appropriations Act (2016) extended the ITC for three years. It will phase down to 10 percent in 2022 (from 30 percent in 2019).

States offer added incentives, making renewables even easier to implement from a cost perspective.

A renewable portfolio standard requires electric utilities to deliver a certain amount of electricity from renewable or alternative energy sources by a given date. State standards range from modest to ambitious, and qualifying energy sources vary. Some states also include "carve-outs" (requirements that a certain percentage of the portfolio be generated from a specific energy source, such as solar power) or other incentives to encourage the development of particular resources. Although climate change may not be the prime motivation behind these standards, they can deliver significant greenhouse gas reductions and other benefits, including job creation, energy security, and cleaner air. Most states allow utilities to comply with the renewable portfolio standard through tradeable credits that utilities can sell for additional revenue.

In states with a renewable portfolio standard, utilities consider cost, intermittency and resource availability in choosing technologies that satisfy this requirement.

In the U.S. transportation sector, The Energy Policy Act of 2005 created a Renewable Fuel Standard that required 2.78 percent of gasoline consumed in the United States in 2006 to be renewable fuel.

The Energy Independence and Security Act of 2007 created a new Renewable Fuel Standard, which increased the required volumes of to 36 billion gallons by 2022, or about 7 percent of expected annual gasoline and diesel consumption above a business-as-usual scenario.

Types of Renewable Energy

Renewable energy comes from sources that can be regenerated or naturally replenished. The main sources are:

- Water (hydropower and hydrokinetic)
- Wind
- Solar (power and hot water)
- Biomass (biofuel and biopower)
- Geothermal (power and heating)

All sources of renewable energy are used to generate electric power. In addition, geothermal steam is used directly for heating and cooking. Biomass and solar sources are also used for space and water heating. Ethanol and biodiesel (and to a lesser extent, gaseous biomethane) are used for transportation.

Renewable energy sources are considered to be zero (wind, solar, and water), low (geothermal) or neutral (biomass) with regard to greenhouse gas emissions during their operation. A neutral source has emissions that are balanced by the amount of carbon dioxide absorbed during the growing process. However, each source's overall environmental impact depends on its overall lifecycle emissions, including manufacturing of equipment and materials, installation as well as land-use impacts.

Water

Large conventional hydropower projects currently provide the majority of renewable electric power generation. With about 1,132 gigawatts (GW) of global capacity, hydropower produced an estimated 4,210 terawatt hours (TWh) of the 26,700 TWh total global electricity in 2018.

The United States is the fourth-largest producer of hydropower after China, Brazil, and Canada. In 2011, a much wetter than average year in the U.S. Northwest, the United States generated 7.9 percent of its total electricity from hydropower. The Department of Energy has found that the untapped generation potential at existing U.S. dams designed for purposes other than power production (i.e., water supply, flood control, and inland navigation) represents 12 GW, roughly 15 percent of current hydropower capacity.

Hydropower operational costs are relatively low, and hydropower generates little to no greenhouse gas emissions. The main environmental impact is that a dam to create a reservoir or divert water to a hydropower plant changes the ecosystem and physical characteristic of the river.

Waterpower captures the energy of flowing water in rivers, streams, and waves to generate electricity. Conventional hydropower plants can be built in rivers with no water storage (known as "run-of-the-river" units) or in conjunction with reservoirs that store water, which can be used on an as-needed basis. As water travels downstream, it is channeled down through a pipe or other intake structure in a dam (penstock). The flowing water turns the blades , generating electricity in the powerhouse, located at the base of the dam.

Other Hydroelectric Power Generation

Small hydropower projects, generally less than 10 megawatts (MW), and micro-hydropower (less than 1 MW) are less costly to develop and have a lower environmental impact than large conventional hydropower projects. In 2016, the total amount of small hydro installed worldwide was 78 GW. China had the largest share at 51 percent.

China, Italy, Japan, Norway and the United States are the top five small hydro countries by installed capacity. Many countries have renewable energy targets that include the development of small hydro projects.

Hydrokinetic electric power, including wave and tidal power, is a form of unconventional hydropower that captures energy from waves or currents and does not require dam construction. These technologies are in various stages of research, development, and deployment. In 2011, a 254 MW tidal power plant in South Korea began operation, doubling the global capacity to 527 MW. By the end of 2018, global capacity was about 532 MW.

Low-head hydro is a commercially available source of hydrokinetic electric power that has been used in farming areas for more than 100 years. Generally, the capacity of these devices is small, ranging from 1kW to 250kW.

Pumped storage hydropower plants use inexpensive electricity (typically overnight during periods of low demand) to pump water from a lower-lying storage reservoir to a storage reservoir located above the power house for later use during periods of peak electricity demand. Although economically viable, this strategy is not considered renewable since it uses more electricity than it generates.

Hydroelectric Power Generation

SOURCE

Environment Canada, 2012

Wind

Wind was the second largest renewable energy source (after hydropower) for power generation. Wind power produced more than 5 percent of global electricity in 2018 with 591 GW of global capacity (568.4 GW is onshore). Capacity is indicative of the maximum amount of electricity that can be generated when the wind is blowing at sufficient levels for a turbine. Because the wind is not always blowing, wind farms do not always produce as much as their capacity. With around 210 MW, China had the largest installed capacity of wind generation in 2018. The United States, with 96.5 GW, had the second-largest capacity; Texas, Oklahoma, Iowa, and Kansas provide more than half of U.S. wind generation.

Although people have harnessed the energy generated by the movement of air for hundreds of years, modern turbines reflect significant technological advances over early windmills and even over turbines from just 10 years ago. Generating electric power using wind turbines creates no greenhouse gases, but since a wind farm includes dozens or more turbines, widely-spaced, it requires thousands of acres of land. For example, Lone Star is a 200 MW wind farm on approximately 36,000 acres in Texas.

Average turbine size has been steadily increasing over the past 30 years. Today, new onshore turbines are typically in the range of 2 – 5 MW. The largest production models, designed for off-shore use can generate 12 MW; some innovative turbine models under development are expected to generate more than 14 MW in offshore projects in the coming years. Due to higher costs and technology constraints, off-shore capacity, approximately 22.6 GW in 2018, is only a small share (about 4 percent) of total installed wind generation capacity.

Wind Turbine Sizes

SOURCE

GE, Vox, 2019

Solar

Solar energy resources are massive and widespread, and they can be harnessed anywhere that receives sunlight. [illegible] of solar radiation, also known as insolation, reaching the Earth's surface every hour is more than all the energy currently consumed by all human activities each [illegible] umber of factors, including geographic location, time of day, and weather conditions, all affect the amount of energy that can be harnessed for electricity production or heating purposes.

Solar photovoltaics are the fastest growing electricity source. In 2018, around 100 GW of global capacity was added, bringing the total to about 505 GW and producing a bit more than 2 percent of the world's electricity.

Solar energy can be captured for electricity production using:

- A solar or photovoltaic cell, which converts sunlight into electricity using the photoelectric effect. Typically, photovoltaics are found on the roofs of residential and commercial buildings. Additionally, utilities have constructed large (greater than 100 MW) photovoltaic facilities that require anywhere from 5 to 13 acres per MW, depending on the technologies used.
- Concentrating solar power, which uses lenses or mirrors to concentrate sunlight into a narrow beam that heats a fluid, producing steam to drive a turbine that generates electricity. Concentrating solar power projects are larger-scale than residential or commercial PV and are often owned and operated by electric utilities.

Solar hot water heaters, typically found on the roofs of homes and apartments, provide residential hot water by using a solar collector, which absorbs solar energy, that in turn heats a conductive fluid, and transfers the heat to a water tank. Modern collectors are designed to be functional even in cold climates and on overcast days.

Electricity generated from solar energy emits no greenhouse gases. The main environmental impacts of solar energy come from the use of some hazardous materials (arsenic and cadmium) in the manufacturing of PV and the large amount of land required, hundreds of acres, for a utility-scale solar project.

Concentrating Solar Power

NOTES

Solar collectors (i.e., parabolic troughs) capture and concentrate sunlight to heat a synthetic oil called therminol, which then heats water to create steam. The steam is piped to an onsite turbine-generator to produce electricity, which is then transmitted over power lines. On cloudy days, the plant has a supplementary natural gas boiler.

SOURCE

U.S. Department of Energy, 2019

Biomass

Biomass energy sources are used to generate electricity and provide direct heating, and can be converted into biofuels as a direct substitute for fossil fuels used in transportation. Unlike intermittent wind and solar energy, biomass can be used continuously or according to a schedule. Biomass is derived from wood, waste, landfill gas, crops and alcohol fuels. Traditional biomass, including waste wood, charcoal and manure, has been a source of energy for domestic cooking and heating throughout human history. In rural areas of the developing world, it remains the dominant fuel source. Globally in 2017, traditional biomass accounted for about 7.5 percent of total energy consumption. The growing use of biomass has resulted in increasing international trade in biomass fuels in recent years; wood pellets, biodiesel, and ethanol are the main fuels traded internationally.

In 2018, global biomass electric power capacity stood at 130 GW. In 2018, the United States had 16 GW of installed biomass-fueled electric generation capacity. In the United States, most of the electricity from wood biomass is generated at lumber and paper mills using their own wood waste; in addition, wood waste is used to generate the heat for drying wood products and other manufacturing processes. Biomass waste is mostly municipal solid waste, i.e., garbage, which is burned as a fuel to run power plants. On average, a ton of garbage generates 550 to 750 kWh of electricity. Landfill gas contains methane that can be captured, processed and used to fuel power plants, manufacturing facilities, vehicles and homes. In the United States, there is currently more than 2 GW of installed landfill gas-fired generation capacity at more than 600 projects.

In addition to landfill gas, biofuels can be synthesized from dedicated crops, trees and grasses, agricultural waste and algae feedstock; these include renewable forms of diesel, ethanol, butanol, methane and other hydrocarbons. Corn ethanol is the most widely used biofuel in the United States. Roughly 38 percent of the U.S. corn crop was diverted to the production of ethanol for gasoline in 2018, up from 20 percent in 2006. Gasoline with up to 10 percent ethanol (E10) can be used in most vehicles without further modification, while special flexible fuel vehicles can use a gasoline-ethanol blend that has up to 85 percent ethanol (E85).

Closed-loop biomass, where power is generated using feedstocks grown specifically for the purpose of energy production, is generally considered to be carbon dioxide neutral because the carbon dioxide emitted during combustion of the fuel was previously captured during the growth of the feedstock. While biomass can avoid the use of fossil fuels, the net effect of biopower and biofuels on greenhouse gas emissions will depend on full lifecycle emissions for the biomass source, how it is used, and indirect land-use effects. Overall, however, biomass energy can have varying impacts on the environment. Wood biomass, for example, contains sulfur and nitrogen, which yield air pollutants sulfur dioxide and nitrogen oxides, though in much lower quantities than coal combustion.

Geothermal

Geothermal provided an estimated 175 TWh globally in 2018, one half in the form of electricity (with an estimated 13.3 GW of capacity) and the remaining half in the form of heat. (Total global electricity generation in 2018 was 26,700 TWh).

In the United States, 16 billion kWh of geothermal electricity was generated in 2018, making up about 4 percent of non-hydroelectric renewable electricity generation, but only 0.4 percent of total electricity generation. Seven states generated electricity from geothermal energy: California, Hawaii, Idaho, Nevada, New Mexico, Oregon and Utah. Of these, California accounted for 80 percent of this generation.

Traditional geothermal energy exploits naturally occurring high temperatures, located relatively close to the Earth' [illegible] some areas, to generate electric power and for direct uses such as heating and cooking. Geothermal areas are generally located near tectonic plate boundari[illegible]ere there are earthquakes and volcanoes. In some places, hot springs and geysers have been used for bathing, cooking and heating for centuries

Generating geothermal electric power typically involves drilling a well, perhaps a mile or two in depth, in search of rock temperatures in the range of 300 to 700°F. Water is pumped down this well, where it is reheated by hot rocks. It travels through natural fissures and rises up a second well as steam, which can be used to spin a turbine and generate electricity or be used for heating or other purposes. Several wells may have to be drilled before a suitable one is in place and the size of the resource cannot be confirmed until after drilling. Additionally, some water is lost to evaporation in this process, so new water is added to maintain the continuous flow of steam. Like biopower and unlike intermittent wind and solar power, geothermal electricity can be used continuously. Very small quantities of carbon dioxide trapped below the Earth's surface are released during this process.

Enhanced geothermal systems use advanced, often experimental, drilling and fluid injection techniques to augment and expand the availability of geothermal resources.

Geothermal Power Station

SOURCE

BBC Science

Renewable Energy Indicators, 2018

SOURCE

Renewable Energy Policy Network for the 21st Century (REN21), 2019

U.S. Renewable Resource Availability

The following maps from the DOE National Renewable Energy Laboratory depict the relative availability of renewable energy resources throughout the United States.

- Wind resources are abundant in the Great Plains, Iowa, Minnesota, along the spine of Appalachian Mountains, in the Western Mountains and many off-shore locations.
- Solar photovoltaic and concentrating solar power resources are the highest in the desert Southwest and diminish in intensity in a northward direction.
- The best biomass resources are in the upper central plains (corn) and forests of the Pacific Northwest.
- Traditional geothermal resources are concentrated in the Western United States.

U.S. Wind Resource Map

SOURCE

U.S. National Renewable Energy Laboratories

U.S. Photovoltaic Solar Resources

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Should GE's Mark 1 Nuclear Reactor Be Recalled Worldwide Like a Faulty Unsafe Automobile? (Pt. 5)

bureau EnviroNews DC News Bureau | by Josh Cunnings | on September 11, 2017 | 1 Comment

(EnviroNews DC Bureau) — **Editor's Note:** *The following news piece represents the fifth in a 15-part mini-series titled,* Nuclear Power in Our World Today, *featuring nuclear authority, engineer and whistleblower Arnie Gundersen. The EnviroNews USA special encompasses a wide span of topics, ranging from Manhattan-era madness to the continuously-unfolding crisis on the ground at Fukushima Daiichi in eastern Japan. The transcript is as follows:*

Josh Cunnings (Narrator): Good evening and thanks for joining us at the *EnviroNews USA* news desk for the fifth segment in our 15-part mini series, *Nuclear Power in Our World Today*. In our previous episodes, we explored several Manhattan-era messes in the United States, but tonight, we begin by discussing the troublesome situation on the ground at the Fukushima Daiichi power plant on Japan's eastern coast.

Now, if you trace Japan's troubles back far enough, then once again, you're going to find yourself right back here in the good old U S of A – in the state of California – during the 1970s – with General Electric at the helm.

The project that we're referring to was the development of the Mark 1 boiling water nuclear reactor – the very same model which melted entirely in units 1, 2 and 3 at Fukushima.

Now, when it comes to people who are qualified to talk about the many issues and problems surrounding the Mark 1, few could be more capable than former nuclear reactor operator and engineer Arnie Gundersen. As a matter of fact, the distinguished expert is all too familiar with the ins and outs of the design.

So, without further ado, here's another excerpt from this simply fantastic interview with Arnie Gundersen by *EnviroNews USA* Editor-in-Chief Emerson Urry. Take a listen.

Urry: And so speaking about these reactors and the technical components – you were actually involved with the Mark 1. And I remember reading that some of the engineers that worked on that project had resigned way back then in 1972, yet General Electric was still apparently willing to pimp this reactor out essentially, all over the planet. What can you tell us about the Mark 1 reactor, and your understanding of what happened back then with these engineers, and how General Electric has been able to spread this reactor to all corners of the globe, with really no consequence. We saw Greenpeace had started a petition to make General Electric and Hitachi, and maybe a couple others of the service providers, actually pay for the damage there, but has there been any culpability? **[Editor's Note: Urry intended to say "1976" not "1972" in this passage]**

Gundersen: Fukushima Daiichi has four units – one, two, three, four — and they're all Mark 1 designs. In addition, there's another 35 in the world, including 23 here in America, that are the same design. A group of three engineers quit General Electric in 1976 because they realized the design was not safe. Two of the three are still alive and living here in California, and they are my personal heroes. They understood before any of us did how seriously we really didn't understand what it was that the engineers were doing.

Excerpt From Greenpeace Video With Dale Bridenbaugh

> **Bridenbaugh:** My boss said to me, that if we have to shut down all of these Mark 1 plants, it will probably mean the end of GE's nuclear business forever.
>
> I started with GE immediately after I got out of college as a mechanical engineer, and I started out as a field engineer responsible for supervising the construction and startup of power plant equipment across the United States.
>
> In the first ten or fifteen plants that GE sold of the large-scale commercial boiling water reactors, they did so on what's called a "turnkey" basis. They built the whole thing, get it operating, and then they turn the key over to the utility, and the utility then is theoretically capable of operating it to produce electricity.
>
> Fukushima 1 was basically a turnkey plant provided to TEPCO by GE. In 1975 the problem developed that became known at the Mark 1 plants – the some 24 Mark 1 units in the United States, and also those overseas, including the Fukushima units – had not taken into account all of the pressures and forces that are called hydrodynamic loads that could be experienced by the pressure suppression units as a result of a major accident. We didn't really know if the containments would be able to contain the event that they were supposedly designed to contain.
>
> Not only were there the containment problems that existed with the Mark 1s, which I was very familiar with, but there were a

number of other problems with the GE boiling water reactors and with the nuclear program in general. And I got disillusioned with the speed with which these problems were being addressed, and then in the middle of the night I called my boss at GE and I said, "My recommendation is that we tell the U.S. utilities that GE cannot support the continued operation of these plants." And my boss said to me, "Well, it can't be that bad Dale, and keep in mind that if we have to shut down all of these Mark 1 plants it will probably mean the end of GE's nuclear business forever." That conversation occurred at about midnight on January 26, and that clinched my decision on resignation on February 2.

The accident that occurred in Fukushima, it's some two years later now, and we don't really know the condition of the reactor core; we don't really know the condition of the containment. The radiation levels are so high inside the containment that it's very difficult to get in there. It will be years before that plant site is cleaned up.

The damage that has been experienced at Fukushima is so great and so extensive that I don't think any one utility, certainly TEPCO, has the capability to be able to pay for all of that. So, it becomes a national issue. I think it would be a good idea to not have reliance on nuclear units. They're very risky enterprises. And I would like to see a world that is provided with electricity by alternative energy supplies.

Gundersen: When Maggie [Gundersen] and I were walking one day in February [a month] before the [Fukushima] accident, she said to me, "Where is the next accident going to be?" And I said, "I don't know where, but I know it's going to be in a Mark 1 reactor." And, I'm not alone. It's not like I was clairvoyant. The Nuclear Regulatory Commission had a report that they published in 1982, and they said there was an 85 percent chance, if there was a meltdown in a Mark 1 reactor, that the containment would explode. The writing was on the wall.

Urry: How many of these things are still out there in operation today?

Gundersen: In the U.S., all 23 continue to run, and as a matter of fact, the staff of the Nuclear Regulatory Commission recommended some pretty substantial improvements, and the politically appointed commissioners, who have no nuclear background, overrode the staff and said, "no, we're not going to do those changes." So, the Commission has been actively involved in thwarting the safety improvements that everybody knows are needed.

Script for General Electric Television Commercial

> "
> **Voice of Child Narrator:** My mom, she makes underwater fans that are powered by the moon. My mom makes airplane engines that can talk. My mom makes hospitals you can hold in your hand. My mom can print amazing things, right from her computer. My mom makes trains that are friends with trees. My mom works at GE.

Cunnings: If GE, a company that successfully weaseled its way out of paying any taxes whatsoever in the U.S. wants to boast night and day on the mainstream media airwaves the same mainstream media which it once nearly monopolized — that it "brings good th to life" and makes "underwater fans that are powered by the moon" and locomotives tha "talk to trees" perhaps the company should also bother to mention its own manufacture and sales of faulty nuclear power reactors that quite frankly, bring good things to an early death.

Oh, and by the way, the company not only builds the reactors that breed uranium into plutonium for bombs, oh no, its role goes much deeper. In fact, GE is in the business of manufacturing the actual bombs too. "We bring good things to life." Seriously? Let's get real.

Documentary Film Trailer for *Deadly Deception: General Electric, Nuclear Weapons and Our Environment*

> **Narrator:** The Hanford Nuclear Reservation, a massive 570-square-mile facility, where General Electric made plutonium for the U.S. military.
>
> **Subject #1:** I began loosing my hair, which I had long naturally curly hair.
>
> **Narrator:** [Of] 28 families who lived in a small area near Hanford, 27 of them had suffered severe health problems.
>
> **Subject #1:** … and the physician said that I had the most severe case of hypothyroidism he'd ever seen in his career…
>
> **Narrator:** … all of which are associated with exposure to high doses of radiation.
>
> **Subject #2:** We took twice the amount that the Children of Chernobyl took. There was absolutely no warning. They came and said, "You're safe."
>
> **Narrator:** According to the business press, General Electric is the most powerful company in the United States, and GE is rapidly expanding its control of markets worldwide.
>
> **Subject #3:** I'd like to wake Jack Welch up in the middle of his atomic power lab; let him explain why their husbands died of cancer related to the asbestos.
>
> **Subject #4:** I find their ads disgusting. I find that ad disgusting.
>
> **Narrator:** Four million individuals and 450 organizations in the U.S., Canada and around the world, have decided to join the GE boycott.
>
> **Subject #4:** Are you asking us to clean up your toxic waste again!?
>
> **Subject #5:** What GE does is not bring good things to life. They mislead the American public.
>
> **Subject #6:** General Electric is in this business of building weapons for profit – not for patriotism, not for the country, not for the flag, but for profit.
>
> **Ronald Reagan:** Until next week then, good night for General Electric.

Excerpt from Fairewinds Associates Video, Featuring Arnie Gundersen on the GE Mark 1 Reactor

“

Gundersen: This picture of a boiling water reactor containment is taken in the early 70s. It was taken at Browns Ferry [Nuclear Plant], but it’s identical to the Fukushima reactors. Now, let me walk you through that as I talk about it.

There are two pieces to the containment, the top looks like an upside down light bulb, and that’s called a “drywell.” Inside there is where the nuclear reactor is. Down below is this thing that looks like a doughnut, and that’s called the “torus,” and that’s filled almost all the way with water. The theory is that if the reactor breaks, steam will shoot out through the light bulb into the doughnut, creating lots of bubbles, which will reduce the pressure. Well, this thing’s called a “pressure suppression containment.” Now, at the bottom of that picture is the lid for the containment. When it’s fully assembled, that lid sits on top. The containment’s about an inch thick. Inside it is the nuclear reactor that’s about eight inches thick, and we’ll get to that in a minute.

Well, this reactor containment was designed in the early 70s, late 60s, and by 1972 a lot of people had concerns with the containment. So, in the early 70s, the Nuclear Regulatory Commission recognized this containment design was flawed. In the mid-70s, they realized the forces were in the wrong direction; instead of down, they were up, and large straps were put into place.

Well, then in the 80s, there was another problem that developed. After Three Mile Island engineers began to realize that this containment could explode from a hydrogen buildup. That hadn’t been factored into the design in the 70s either. Well, what they came up with for this particular containment was a vent in the side of it.

Now, a vent is designed to let the pressure out, and a containment is designed to keep the pressure in. So, rather than contain this radioactivity, engineers realized that if the containment were to survive an explosion they’d have to open a hole in the side of it called a “containment vent.”

Well, these vents were added in the late 1980s. And they weren’t added because the Nuclear Regulatory Commission demanded it. What the industry did to avoid that was create an initiative and they put them in voluntarily. Now, that sounds really proactive, but in fact, it wasn’t. If the Nuclear Regulatory Commission required it, it would have opened up the license on these plants to citizens and scientists who had concerns. Well, by having the industry voluntarily put these vents in it did two things: One, it did not allow any public participation in the process to see if they were safe. And the second thing is that it didn’t allow the Nuclear Regulatory Commission to look at these vents and say they were safety related. In fact, it sidetracked the process entirely.

Well, these vents were never tested until Fukushima. This containment was never tested until Fukushima. And it failed three times out of three tries. In retrospect, we shouldn't be surprised.

Looking at the procedures for opening these vents, in the event electricity fails, requires someone fully clad in radiation gear to go down to an enormous valve in the bowels of the plant and turn the crank 200 times to open it. Now, can you imagine, in the middle of a nuclear accident, with steam and explosions and radiation, expecting an employee to go into the plant and turn a valve 200 times to open it?

So, that was the second Band-Aid fix that failed, on a containment that 40 years earlier, was designed too small.

Well, with all this in mind, I think we really need to ask the question: should the Mark 1 containment even be allowed to continue to operate? The NRC's position is: well, we can make the vents stronger. I don't think that's a good idea.

Now, all those issues that I just talked about are related to the Mark 1 containment. The next thing I'd like to talk about is the reactor that sits inside that containment. So, that light bulb and that doughnut are the containment structure; inside that is where the nuclear reactor is.

Now, on a boiling water reactor, the nuclear control rods come in at the bottom; on a pressurized water reactor they come in from the top. All of the reactors at Fukushima, and 35 in the world in this design, have control rods that come in from the bottom. Now, that poses a unique problem and an important difference that the NRC is not looking at right now.

If the core melts in a pressurized water reactor, there's no holes in the bottom of the nuclear reactor, and it's a very thick eight to 10-inch piece of metal that the nuclear reactor core would have to melt through. But that didn't happen at Fukushima.

Fukushima was a boiling water reactor; it's got holes in the bottom. Now, when the nuclear core lies on the bottom of a boiling water reactor like Fukushima, or the ones in the U.S., or others in Japan, it's easier for the core to melt through because of those 60 holes in the bottom of the reactor. It doesn't have to melt through eight inches of steel. It just has to melt through a very thin-walled pipe and scoot out the hole in the bottom of the nuclear reactor. I'm not the only one to recognize that holes at the bottom of a boiling water reactor are a problem.

Last week an email came out that was written by the Nuclear Regulatory Commission right after the Fukushima accident, where they recognize that if there's a core meltdown, and it's now lying as a blob on the bottom of the nuclear reactor, these holes in the bottom of the reactor form channels, through which the hot molten fuel can get out a lot easier and a lot quicker than the thi pressurized water reactor design. Now, this is a flaw in any boilir water reactor, and the Nuclear Regulatory Commission is not recognizing that the likelihood of melting through a boiling water reactor like Fukushima, is a lot more significant than the likelihood of melting through a pressurized water reactor.

The third area is an area we've discussed in-depth in a previous video, and that's that the explosion at Unit 3 was a detonation, not a deflagration. It has to do with the speed of the shockwave. The shockwave at Unit 3 traveled faster than the speed of sound, and that's an important distinction that the Nuclear Regulatory Commission, and the entire nuclear industry, is not looking at.

A containment can't withstand a shockwave that travels faster than the speed of sound. Yet, all containments are designed assuming that doesn't happen. At Fukushima 3 it did happen, and we need to understand how it happened and mitigate against it in the future on all reactors.

Now, I measured that. I scaled the size of the building versus the speed at which the explosion occurred, and I can determine that that shockwave traveled at around 1,000 feet per second. The speed of sound is around 600 feet per second. So, it traveled at supersonic speeds that can cause dramatic damage to a containment. They're not designed to handle it. Yet, the NRC is not looking at that. **[Editor's Note: Gundersen intended to say "miles per hour," not "feet per second" in this video.]**

So, we've got three key areas where the NRC, and the nuclear industry, don't want people to look, and that's: 1) should this Mark 1 containment even be allowed to continue to operate?

Cunnings: In America, when a vehicle, or even a part in a vehicle, is deemed unsafe for the population at large, the government forces automakers into costly and multi-billion dollar recalls – and the mainstream media does its part by shaming those culprit companies, relentlessly beating them to a bloody pulp for their negligence and their reckless endangerment of innocent American citizens.

The Mark 1 nuclear reactor is an extremely outdated model with obvious design flaws. Apparently, it has so many problems, that as Mr. Gundersen pointed out, three of the engineers who originally designed it ended up resigning because they knew it wasn't safe – and that was well before Three Mile Island or Chernobyl ever happened – long before the public had experienced the fright, and health consequences of a full-scale nuclear meltdown.

Surely, after the triple meltdowns at Fukushima, Japan, it appears the Mark 1 is far from safe, yet here in the U.S., the government continues to let operators drive this faulty nuclear vehicle down the road – knowing full well that it could fall apart and crash, harming, or even killing innocent Americans at any time.

Perhaps the government should consider holding nuke-plant manufacturers, like GE, to the same standards it demands from automakers, and punish them with shameful recalls when they market a piece of faulty equipment that poses any danger to the public.

So, just what would a recall of the Mark 1 nuclear reactor look like, and who would issue enforce it? The Nuclear Regulatory Commission? And how could enough political will ev be mustered for such a massive undertaking? It would surely cost more than any auto recall ever has, but frankly, who should give a damn (except for General Electric's shareholders of course)? I mean, if it ain't safe, then it just ain't safe mate. Besides, after paying zero taxes, GE's pockets should be plenty deep enough to handle such an event — right? The concept of an all-out recall on the antiquated General Electric Mark 1 reactor is one that we will continue to explore. As a matter of fact, in tomorrow's show, we'll discuss the problems with the Mark 1 a little further.

Tune in then for episode six in our series of short films, *Nuclear Power in Our World Today*, with esteemed expert and whistleblower Arnie Gundersen.

Signing off for now – Josh Cunnings – *EnviroNews USA*.

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Josh Cunnings - *Anchor, Narrator*
The Editors - *Author*
Emerson Urry - *Interviewer, Research Journalist, Producer, Video Editor, Sound Editor, 3D Animator, Director of Photography (News Desk), Lighting, Transcript*
Louis Ekrem - *Director of Photography (Gundersen Interview), A Cam, B Cam, C Cam, Lighting (Interview)*
Dakota Otero - *Production Assistant*

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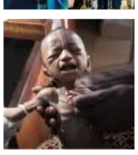
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By Tom Zeller Jr.

March 15, 2011

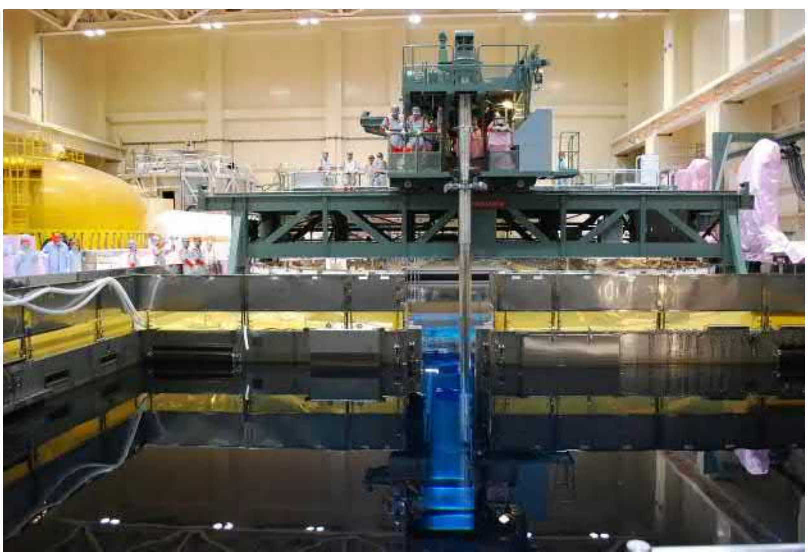
The warnings were stark and issued repeatedly as far back as 1972: If the cooling systems ever failed at a "Mark 1" nuclear reactor, the primary containment vessel surrounding the reactor would probably burst as the fuel rods inside overheated. Dangerous radiation would spew into the environment.

Now, with one Mark 1 containment vessel damaged at the embattled Fukushima Daiichi nuclear plant and other vessels there under severe strain, the weaknesses of the design — developed in the 1960s by General Electric — could be contributing to the unfolding catastrophe.

When the ability to cool a reactor is compromised, the containment vessel is the last line of defense. Typically made of steel and concrete, it is designed to prevent — for a time — melting fuel rods from spewing radiation into the environment if cooling efforts completely fail.

In some reactors, known as pressurized water reactors, the system is sealed inside a thick steel-and-cement tomb. Most nuclear reactors around the world are of this type.

But the type of containment vessel and pressure suppression system used in the failing reactors at Japan's Fukushima Daiichi plant is physically less robust, and it has long been thought to be more susceptible to failure in an emergency than competing designs. In the United States, 23 reactors at 16 locations use the Mark 1 design, including the Oyster Creek plant in central New Jersey, the Dresden plant near Chicago and the Monticello plant near Minneapolis.



A fuel storage pool in the Fukushima plant reactor building. Surrounding this and reactors like it is a containment vessel, the last line of defense if cooling fails. Jiji Press/Agence France-Presse — Getty Images

G.E. began making the Mark 1 boiling-water reactors in the 1960s, marketing them as cheaper and easier to build — in part because they used a comparatively smaller and less expensive containment structure.

American regulators began identifying weaknesses very early on.

In 1972, Stephen H. Hanauer, then a safety official with the Atomic Energy Commission, recommended that the Mark 1 system be discontinued because it presented unacceptable safety risks. Among the concerns cited was the smaller containment design, which was more susceptible to explosion and rupture from a buildup in hydrogen — a situation that may have unfolded at the Fukushima Daiichi plant. Later that same year, Joseph Hendrie, who would later become chairman of the Nuclear Regulatory Commission, a successor agency to the atomic commission, said the idea of a ban on such systems was attractive. But the technology had been so widely accepted by the industry and regulatory officials, he said, that “reversal of this hallowed policy, particularly at this time, could well be the end of nuclear power.”

In an e-mail on Tuesday, David Lochbaum, director of the Nuclear Safety Program at the Union for Concerned Scientists, said those words seemed ironic now, given the potential global ripples from the Japanese accident.

“Not banning them might be the end of nuclear power,” said Mr. Lochbaum, a nuclear engineer who spent 17 years working in nuclear facilities, including three that used the G.E. design.

Questions about the design escalated in the mid-1980s, when Harold Denton, an official with the Nuclear Regulatory Commission, asserted that Mark 1 reactors had a 90 percent probability of bursting should the fuel rods overheat and melt in an accident.

Industry officials disputed that assessment, saying the chance of failure was only about 10 percent.

Michael Tetuan, a spokesman for G.E.’s water and power division, staunchly defended the technology this week, calling it “the industry’s workhorse with a proven track record of safety and reliability for more than 40 years.”

Mr. Tetuan said there are currently 32 Mark 1 boiling-water reactors operating safely around the globe. “There has never been a breach of a Mark 1 containment system,” he said.

Several utilities and plant operators also threatened to sue G.E. in the late 1980s after the disclosure of internal company documents dating back to 1975 that suggested that the containment vessel designs were either insufficiently tested or had flaws that could compromise safety.

The Mark 1 reactors in the United States have undergone a variety of modifications since the initial concerns were raised. Among these, according to Mr. Lochbaum, were changes to the torus — a water-filled vessel encircling the primary containment vessel that is used to reduce pressure in the reactor. In early iterations, steam rushing from the primary vessel into the torus under high pressure could cause the vessel to jump off the floor.

In the late 1980s, all Mark 1 reactors in the United States were also retrofitted with venting systems to help reduce pressure in an overheating situation.

It is not clear precisely what modifications were made to the Japanese boiling-water reactors now failing, but James Klapproth, the chief nuclear engineer for General Electric Hitachi, said a venting system was in place at the Fukushima plants to help relieve pressure.

The specific role of the G.E. design in the Fukushima crisis is likely to be a matter of debate, and it is possible that any reactor design could succumb to the one-two punch of an earthquake and tsunami like those that occurred last week in Japan.

Although G.E.’s liability would seem limited in Japan — largely because the regulatory system in that country places most liability on the plant operator — the company’s stock fell 31 cents to $19.61 in trading Tuesday.

Fukushima: Mark 1 Nuclear Reactor Design Caused GE Scientist To Quit In Protest

Damaged Japanese nuclear plant has five Mark 1 reactors.

By MATTHEW MOSK
March 15, 2011, 2:34 PM • 4 min read

Preventing a Nuclear Meltdown

his colleagues at General Electric resigned from their jobs after becoming increasingly convinced that the nuclear reactor design they were reviewing -- the Mark 1 -- was so flawed it could lead to a devastating accident.

Questions persisted for decades about the ability of the Mark 1 to handle the immense pressures that would result if the reactor lost cooling power, and today that design is being put to the ultimate test in Japan. Five of the six reactors at the Fukushima Daiichi plant, which has been wracked since Friday's earthquake with explosions and radiation leaks, are Mark 1s.

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"The problems we identified in 1975 were that, in doing the design of the containment, they did not take into account the dynamic loads that could be experienced with a loss of coolant," Bridenbaugh told ABC News in an interview. "The impact loads the containment would receive by this very rapid release of energy could tear the containment apart and create an uncontrolled release."

The situation on the ground at the Fukushima Daiichi plant is so fluid, and the details of what is unfolding are so murky, that it may be days or even weeks before anyone knows how the Mark 1 containment system performed in the face of a devastating combination of natural disasters.

But the ability of the containment to withstand the events that have cascaded from what nuclear experts call a "station blackout" -- where the loss of power has crippled the reactor's cooling system -- will be a crucial question as policy makers re-examine the safety issues that surround nuclear power, and specifically the continued use of what is now one of the oldest types of nuclear reactors still operating.

GE told ABC News the reactors have "a proven track record of performing reliably and safely for more than 40 years" and "performed as designed," even after the shock of a 9.0 earthquake.

Still, concerns about the Mark 1 design have resurfaced occasionally in the years since Bridenbaugh came forward. In 1986, for instance, Harold Denton, then the director of NRC's Office of Nuclear Reactor Regulation, spoke critically about the design during an industry conference.

"I don't have the same warm feeling about GE containment that I do about the larger dry containments," he said, according to a report at the time that was referenced Tuesday in The Washington Post.

"There is a wide spectrum of ability to cope with severe accidents at GE plants," Denton said. "And I urge you to think seriously about the ability to cope with such an event if it occurred at your plant."

Bridenbaugh Believes Design Flaws Were Addressed At Fukushima Plant

Bridenbaugh told ABC News that he believes the design flaws that prompted his resignation from GE were eventually addressed at the Fukushima Daiichi plant. Bridenbaugh said GE agreed to a series of retrofits at Mark 1 reactors around the globe. He compared the retooling to the bolstering of highway bridges in California to better withstand earthquakes.

"Like with seismic refitting, they went back and re-analyzed the loads the structures might receive and beefed up the ability of the containment to handle greater loads," he said.

When asked if that was sufficient, he paused. "What I would say is, the Mark 1 is still a little more susceptible to an accident that would result in a loss of containment."

ABC News asked GE for more detail about how the company responded to critiques of its Mark 1 design. GE spokesman Michael Tetuan said in an email that, over the past 40 years, the company has made several modifications to its Mark 1 reactors in the U.S., including installing "quenchers" and fortifying the steel structures "to accommodate the loads that were generated." He said that GE's responses to modifications ordered by the Nuclear Regulatory Commission were also shared with the Japanese nuclear industry.

Bridenbaugh told ABC News that he is watching the events in Japan with a mix of anxiety and deep reflection. Many years have passed since he and fellow GE colleagues Gregory C Minor and Richard B. Hubbard publicly resigned, joined the anti-nuclear movement, and became known as the "GE Three."

Undoubtedly, he said, the containment structures at that Fukushima Daiichi plant are facing significant amounts of pressure -- and testing the very questions he was studying on paper more than three decades earlier. While he knew then that the Mark 1 had design limits, he said, no one knows now whether those limits will be surpassed.

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Comments (1)

HAZARDS OF BOILING WATER REACTORS IN THE UNITED STATES

March 1, 1996

BACKGROUND

Of the 104 operational nuclear power reactors in the United States, thirty-five are boiling water reactors (BWR). General Electric is the sole designer and manufacturer of BWRs in the United States. The BWR's distinguishing feature is that the reactor vessel serves as the boiler for the nuclear steam supply system. The steam is generated in the reactor vessel by the controlled fissioning of enriched uranium fuel which passes directly to the turbogenerator to generate electricity.

LACK OF CONTAINMENT INTEGRITY DURING A NUCLEAR ACCIDENT

The purpose of a reactor containment system is to create a barrier against the release of radioactivity generated during nuclear power operations from certain "design basis" accidents, such as increased pressure from a single pipe break. It is important to understand that nuclear power plants are not required by the Nuclear Regulatory Commission (NRC) to remain intact as a barrier to all possible accidents or "non-design basis" accidents, such as the melting of reactor fuel. All nuclear reactors can have accidents which can exceed the design basis of their containment.

But even basic questions about the the GE containment design remain unanswered and its integrity in serious doubt. For example, 23 of these BWRs use a smaller GE Mark I pressure suppression containment conceived as a cost-saving alternative to the larger reinforced concrete containments marketed by competitors. A large inverted light-bulb-shaped steel structure called "the drywell" is constructed of a steel liner and a concrete drywell shield wall enclosing the reactor vessel–this is considered the "primary" containment.. The atmosphere of the drywell is connected through large diameter pipes to a large hollow doughnut-shaped pressure suppression pool called "the torus", or wetwell, which is half-filled with water. In the event of a loss-of-coolant-accident (LOCA), steam would be released into the drywell and directed underwater in the torus where it is supposed to condense, thus suppressing a pressure buildup in the containment.

The outer concrete building is the "secondary" containment and is smaller and less robust (and thus cheaper to build) than the containment buildings used at most reactors.

As early as 1972, Dr. Stephen Hanauer, an Atomic Energy Commission safety official, recommended that the pressure suppression system be discontinued and any further designs not be accepted for construction permits. Hanauer's boss, Joseph Hendrie (later an NRC Commissioner) essentially agreed with Hanauer, but denied the recommendation on the grounds that it could end the nuclear power industry in the U.S.

Here are copies of the three original AEC memos, including Hendrie's:

November 11, 1971: outlines problems with the design and pressure suppression system containment.

September 20, 1972: memo from Steven Hanauer recommends that U.S. stop licensing reactors using pressure suppression system

September 25, 1972: memo from Joseph Hendrie (top safety official at AEC) agrees with recommendation but rejects it saying it "could well mean the end of nuclear power…"

In 1976, three General Electric nuclear engineers publicly resigned their prestigious positions citing dangerous shortcomings in the GE design.

An NRC analysis of the potential failure of the Mark I under accident conditions concluded in a 1985 report that Mark I failure within the first few hours following core melt would appear rather likely."

In 1986, Harold Denton, then the NRC's top safety official, told an industry trade group that the "Mark I containment, especially being smaller with lower design pressure, in spite of the suppression pool, if you look at the WASH 1400 safety study, you'll find something like a 90% probability of that containment failing." In order to protect the Mark I containment from a total rupture it was determined necessary to vent any high pressure buildup. As a result, an industry workgroup designed and installed the "direct torus vent system" at all Mark I reactors. Operated from the control room, the vent is a reinforced pipe installed in the torus and designed to release radioactive high pressure steam generated in a severe accident by allowing the unfiltered release directly to the atmosphere through the 300 foot vent stack. Reactor operators now have the option by direct action to expose the public and the environment to unknown amounts of harmful radiation in order to "save containment." As a result of GE's design deficiency, the original idea for a passive containment system has been dangerously compromised and given over to human control with all its associated risks of error and technical failure.

As we have now seen at Fukushima, Japan, in March 2011, this containment design failed catastrophically when hydrogen built up in the outer containment buildings until three of them exploded. The outer containment building was neither large enough nor strong enough to withstand these explosions.

VULNERABILITY OF IRRADIATED FUEL POOLS

The irradiated (sometimes called "spent") fuel pools in GE Mark I reactors are above the reactor core and outside the primary containment system. This design was chosen for efficiency, not safety–the fuel rods in the reactor are lifted by crane and simply moved over to the fuel pool. The explosions at Fukushima that caused severe damage to the containment buildings (as can be seen in the above satellite photo taken March 18, 2011) also exposed and compromised the fuel pools providing a direct pathway for release of radioactivity into the air. While there was substantial amounts of fuel in the Fukushima pools, in the U.S. pools are typically packed even more densely, meaning even higher potential radiation risks if they are compromised.

DETERIORATION OF BWR SYSTEMS AND COMPONENTS

It is becoming increasingly clear that the aging of reactor components poses serious economic and safety risks at BWRs. A report by NRC published in 1993 confirmed that age-related degradation in BWRs will damage or destroy many vital safety-related components inside the reactor vessel before the forty year license expires. The NRC report states "Failure of internals could create conditions that may challenge the integrity the reactor primary containment systems." The study looked at major components in the reactor vessel and found that safety-related parts were vulnerable to failure as the result of the deterioration of susceptible materials (Type 304 stainless steel) due to chronic radiation exposure, heat, fatigue, and corrosive chemistry. One such safety-related component is the core shroud and it is also an indicator of cracking in other vital components through the reactor made of the same material.

Core Shroud Cracking

The core shroud is a large stainless steel cylinder of circumferentially welded plates surrounding the reactor fuel core. The shroud provides for the core geometry of the fuel bundles. It is integral to providing a refloodable compartment in the event of a loss-of-coolant-accident. Extensive cracking of circumferential welds on the core shroud has been discovered in a growing number of U.S. and foreign BWRs. A lateral shift along circumferential cracks at the welds by as little as 1/8 inch can result in the misalignment of the fuel and the inability to insert the control rods coupled with loss of fuel core cooling capability. This scenario can result in a core melt accident. A German utility operating a GE BWR where extensive core shroud cracking was identified estimated the cost of replacement at $65 million dollars. The Wuergassen reactor, Germany's oldest boiling water reactor, was closed in 1995 after wary German nuclear regulators rejected a plan to repair rather than replace the reactor's cracked core shroud.

Rather than address the central issue of age related deterioration, U.S. BWR operators now opt for a dangerous piecemeal approach of patching cracking parts at least cost but increased risk.

Paul Gunter, NIRS, March, 1996, updated by Michael Mariotte, NIRS, March 2011

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WISE-International

P.O. Box 59636, 1040 LC
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T: 31-20-6126368
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SAFETY DEFICIENCIES AT BROWNS FERRY NUCLEAR POWER COMPLEX

The Tennessee Valley Authority's (TVA) Browns Ferry nuclear power complex is composed of three aging reactors of obsolete design replete with safety deficiencies. Despite having spent $1.8 Billion to restart the long-shuttered Browns Ferry-1 reactor in 2007, TVA could not address the fundamental design problems with these reactors.

Perhaps even worse, TVA did not address the safety deficiencies it could have addressed: namely the ability to meet fire protection regulations promulgated by the Nuclear Regulatory Commission (NRC) in 1981 because of a near-catastrophic fire in 1975 at the same Browns Ferry-1. Inexplicably, the NRC did not require Browns Ferry-1 to meet its legal obligations to comply with the fire protection regulations before allowing it to restart. Indeed, a critical document demonstrating this NRC negligence was not released to the public until it was discovered by NIRS after the restart had been approved.

FIRE PROTECTION

Fire risk and fire code violations were overlooked by NRC in its approval of the restart of Browns Ferry-1, which was site of the original March 22, 1975 fire--the same fire that was responsible for promulgation of the safe shutdown fire code (10 CFR 50.48 and 10 CFR 50 Appendix R, section iii.g.2)

A prescriptive fire code was put in place for U.S. nuclear power stations following the fire at Alabama's Browns Ferry nuclear power station on March 22, 1975 to provide the best assurance that no single fire can destroy the reactor control room's ability to safely shutdown the reactor following a significant fire.

The Browns Ferry fire was started by an employee using a candle flame to check for air leaks along electrical cable trays under the reactor control room, initially igniting polyurethane foam insulating material around electrical cable used for control, power and instrumentation equipment to shut down the reactor from the control room, the preferred method for controlling the reactor. The fire quickly spread from the cable spreading room into the reactor building. The fire burned out of control for seven and half hours destroying over 1600 electrical cables including 628 safety-related cable systems.

The fire demonstrated that a high number of electrical circuit failures can occur in a relatively short period of time--in this case within 15 minutes from the ignition of the foam material. It further demonstrated that the federal government's hands-off approach for enforcement policy contributed to the non-regulation of fire protection requirements at nuclear power stations and was a principle contributing factor to the seriousness and near catastrophe of the fire. Station nuclear engineers privately confided a catastrophic release of radiation was avoided only by "sheer luck."

NRC began promulgating stricter fire protection codes as result of the Browns Ferry fire and, in a rulemaking highly contested by the nuclear industry, codified detailed and prescriptive fire protection requirements in 1981. The new rule, among other requirements, specifically required passive fire protection features (qualified and rated fire barriers, minimum separation requirements and automated fire suppression and detection) to limit fire damage done to electrical circuits for equipment so that capability to shut down the plant safely from the control room is ensured.

By 1992, well after Browns Ferry-1's shutdown in 1985, the industry was in widespread non-compliance with the fire code because of bogus fire barriers materials that did not meet requirements and failure to incorporate the minimum separation requirement.

NRC's permission to restart Unit I was based on "enforcement discretion" of these fire protection violations. Instead of protecting the safe shutdown electrical cable with qualified fire barriers, smoke detectors and automated sprinkler systems or minimum separation requirements between redundant electrical circuits when they appear in the same fire zone, NRC is allowing TVA (and other reactor operators) to proceed in violation of fire code by substituting largely unreviewed and unapproved compensatory actions that would allow the operator to conduct "operator manual actions." These allow circuits to burn in a fire with subsequent loss of control room operation and instead send plant employees throughout the reactor complex to those end pieces of safe shutdown equipment to manually pull switches, circuit breakers, open or close valves. These operators could encounter and even be delayed or halted by smoke, fire, radiation, even bad guys in case of sabotage, which make completion of their tasks uncertain and not an appropriate substitute for preferred control room operation preserved through qualified passive design.

A document not released by the NRC prior to restart indicates that NRC staff notes that TVA mischaracterized fire zones where redundant electrical circuits appear in the same fire zone. The document states "Manual actions are also permitted when using alternate shutdown in accordance with III.G.3." This corresponds to federal fire protection law for nuclear power stations 10 CFR 50 Appendix R III.G.2 and III.G.3) III.G.2 requires and prioritizes that when electric circuits for redundant safe shutdown equipment appear in the same fire zone of a nuclear power station, one train is required to be protected by one of three passive fire protection features 1) a qualified three-hour rated fire barrier; 2) a qualified 1-hour rated fire barrier used in conjunction with smoke detectors and automated suppression or; 3) a minimum separation of 20-ft between redundant circuitry with no intervening combustible used in conjunction with automated suppression and smoke detectors.

This is to assure that no single fire will knock out control room operations for the safe shutdown of the reactor as occurred during the Browns Ferry fire on March 23, 1975.

The operator can provide NRC with an alternate shutdown strategy through the formalized exemption process for a safety evaluation. TVA did not submit the proposed operator manual actions to the exemption and safety review process as required by law.

Section 3.1.5 of this document states "Section 3 of the licensee FPR (fire protection report) proposes to use the same safe shutdown methods used in Units 2 and 3." It goes on to say later in that paragraph that Unit 1 relies on OMA (operator manual actions) to accomplish post fire safe shutdown. In other words, TVA has abandoned bringing the unit into compliance with fire code as required. They did not apply for the exemption and receive the staff scrutiny for safety and ability to pull off these operator manual actions successfully.

As a result, NRC allowed them to restart under "enforcement discretion" as has already been applied to Browns Ferry Units 2 and 3. However, these unapproved and largely unreviewed operator manual actions are illegal.

THE BROWNS FERRY DESIGN IS DANGEROUSLY ANTIQUATED

All three Browns Ferry units use a General Electric Mark 1 containment design that has long been controversial. In 1976, three top GE engineers publicly resigned from the company and testified before Congress that the GE BWR was "dangerous" and not a "quality product."

http://www.time.com/time/magazine/article/0,9171,918045,00.html

The GE BWR Mark I containment was mistakenly designed and constructed to be undersized. As a result if there is an accident the containment system is very likely to fail and rupture. This could very easily be compared as "America's Chernobyl" design. According to NRC's then Director of Nuclear Reactor Regulation Harold Denton in 1985, there is something like a 90% chance of containment failure of this containment under accident conditions. The chances were high enough that NRC advised and industry back-fitted the Mark I with a vent system to deliberately defeat containment from the control room in order to save it. In the event that Browns Ferry has an over-pressurization accident, operators are faced with the decision to deliberately vent the containment structure through the Direct Torus Vent System (DTVS) which bypasses the radiation filtration system and sends radiation directly to the atmosphere through a "controlled release." They then preserve the option to close the controlled release rather than blow the roof off.

The Atomic Energy Commission (now the NRC) abandoned licensing the Mark I in 1972.

VULNERABLE ELEVATED NUCLEAR WASTE STORAGE POOL

In the GE Mark I design, the irradiated fuel pool, containing billions of curies of high-level atomic waste, sits atop the reactor building, outside primary containment and vulnerable to attack according to both NRC documents (2001) and the National Academy of Sciences (2005).

The NRC paper documents that there are no significant structures that would prevent an aircraft from penetrating the high-level nuclear waste storage pool for the Mark I and Mark II BWR. The consequences of draining down the fuel pool would be a catastrophic nuclear waste fire outside containment spreading a radioactive pall out hundreds of miles and inducing tens of thousands of fatal cancers.

A coalition of groups petitioned the NRC in 2005 requesting emergency enforcement action on the vulnerability of the Mark I and II elevated nuclear waste storage pool. The coalition's petition to the NRC was denied. *–June 2007*

Nuclear Information and Resource Service
6930 Carroll Avenue, #340, Takoma Park, MD 20912
301-270-6477; www.nirs.org; nirsnet@nirs.org

Browns Ferry: Shrinking the safety margin at Alabama's largest nuclear plant

Updated Mar 07, 2019; Posted Jul 07, 2013

By **Challen Stephens | cstephens@al.com**

aerial.JPG

Browns Ferry Nuclear Plant on the north shore of Wheeler Reservoir in Limestone County. Browns Ferry was TVA's first nuclear plant and was the largest in the world when it commenced operations in 1974. (submitted file photo)

By Challen Stephens and Brian Lawson

ATHENS, Alabama – For more than two years, the largest nuclear plant in Alabama operated without a fully functioning failsafe system.

A massive cooling pump didn't work. Bearings were installed backwards. Emergency cooling lines sat blocked and unnoticed for years. The last was a safety lapse so dire **Browns Ferry Nuclear Plant in Athens** received the federal notice of a "red finding" – the final warning before being forced to shut down.

Now a TVA engineer tells *The Huntsville Times/AL.com* that both the mechanical and managerial shortcomings were worse than what has been reported by federal regulators. Joni Johnson, a 52-year-old who's been a TVA engineer for half her life, contends that a worst-case scenario – overlapping failures of a broken line and a rapid loss of coolant in Unit 1 – could have led to a meltdown.

What federal regulators have said in recent years:

• Browns Ferry received a red finding, the federal government's most serious warning before shutdown.

• Browns Ferry failed to notice a blocked low-pressure cooling line.

• Inspectors discovered wider problems with safety culture at Browns Ferry.

• The backup low-pressure line also malfunctioned.

• The high-pressure core spray was installed incorrectly.

• The Unit 1 reactor operated for years with overlapping, malfunctioning emergency cooling systems.

What a whistleblower alleges, and paperwork supports:

• TVA ignored or obscured failing safety tests for malfunctioning equipment.

• TVA hurried to install equipment based on managerial bonuses.

What TVA acknowledges in their own paperwork:

• The plant operated for years with a bias toward power production over safety.

The Federal Emergency Management Agency says the danger from a nuclear accident is public exposure to radiation caused by the release of radioactive material from the plant.

Johnson points to managerial bonuses for rapid installation of equipment. She also blames an emphasis on continuous running of three boiling water reactors, which need to be shut down to allow for major repairs. But Browns Ferry generates about $1 billion a year, or about 10 percent of TVA's annual revenue, and maintenance shutdowns cost money.

For the past two months, a 23-member Nuclear Regulatory Commission (NRC) inspection team has been poring over records at Browns Ferry. Federal scrutiny in 2011 over one blocked failsafe line soon led to concerns about TVA's broader safety culture, prompting the NRC to expand its investigation from Unit 1 to all three reactors at the Athens plant.

TVA, in preparing for federal inspections, acknowledged shortcomings.

Nuclear, perhaps more than any other industry, is built around a vocabulary of safety. Yet, in a recent newsletter preparing employees for the NRC visit, Keith Polson, site vice president at Browns Ferry, is quoted in large bold letters saying Browns Ferry had slipped.

"Our performance declined," Polson said. "Employee morale was low and because we were so wrapped in a production-first mentality, we didn't realize just how bad things had gotten. Even when outside experts told us we needed to get better, we really didn't listen."

Whistleblower

Johnson, who is trained to conduct a "root cause analysis" of plant malfunctions, said she's speaking out now to restore the focus on safety. She said initial concerns voiced at the plant drew retaliation, that she was labeled a "man-hater," pulled from assignments and given poor performance reviews.

She has since engaged in a failed mediation with TVA. She alleges she was discriminated against for raising safety concerns. Regulators with the NRC wrote her a letter in October saying her case met the standards for a federal investigation. Johnson said she has met with NRC investigators on multiple occasions.

Browns Ferry (Huntsville Times file)

TVA and the NRC won't discuss legal matters or an ongoing investigation.

Johnson said the basis for her complaints was that TVA officials attempted to manipulate her team's findings related to equipment failures and how those findings pointed to organizational failures. A report by TVA's own inspector general backs up Johnson's equipment concerns about overlapping failures in the emergency cooling system.

The discrimination investigation remains open.

"You retaliate enough and people aren't going to come forward, and that's the real safety significance," said Johnson, who declined to be photographed for this report.

Slot machine

It's not that Browns Ferry experienced an accident, explains David Lochbaum, a nuclear engineer with the Union of Concerned Scientists. It's that Browns Ferry had reduced the odds the plant could avoid an accident.

Imagine a slot machine, he says. You sit down to find that three cherries are already up. Five cherries win a million. You pull the arm.

With that head start, you get to watch just two dials spin.

That was Browns Ferry for three years, running with faults in three of five emergency cooling systems.

Worst-case scenario

The top floor of the reactor building at Browns Ferry Nuclear Plant shows the cover of Unit 1 and the spent fuel storage tank where 29 feet of water covers the rods. (Michael Mercier/ The Huntsville Times)

In 2007, TVA restarted Unit 1 at Browns Ferry. It was a massive undertaking. The reactor had gone online in the early 1970s, but had sat dormant since the mid-1980s after being shut down for safety reasons.

The five-year restart cost $1.9 billion and was completed in May 2007. President George W. Bush visited Browns Ferry in June 2007 to mark the recovery. But problems surfaced almost immediately, and the plant had five emergency shutdowns in six months in 2007.

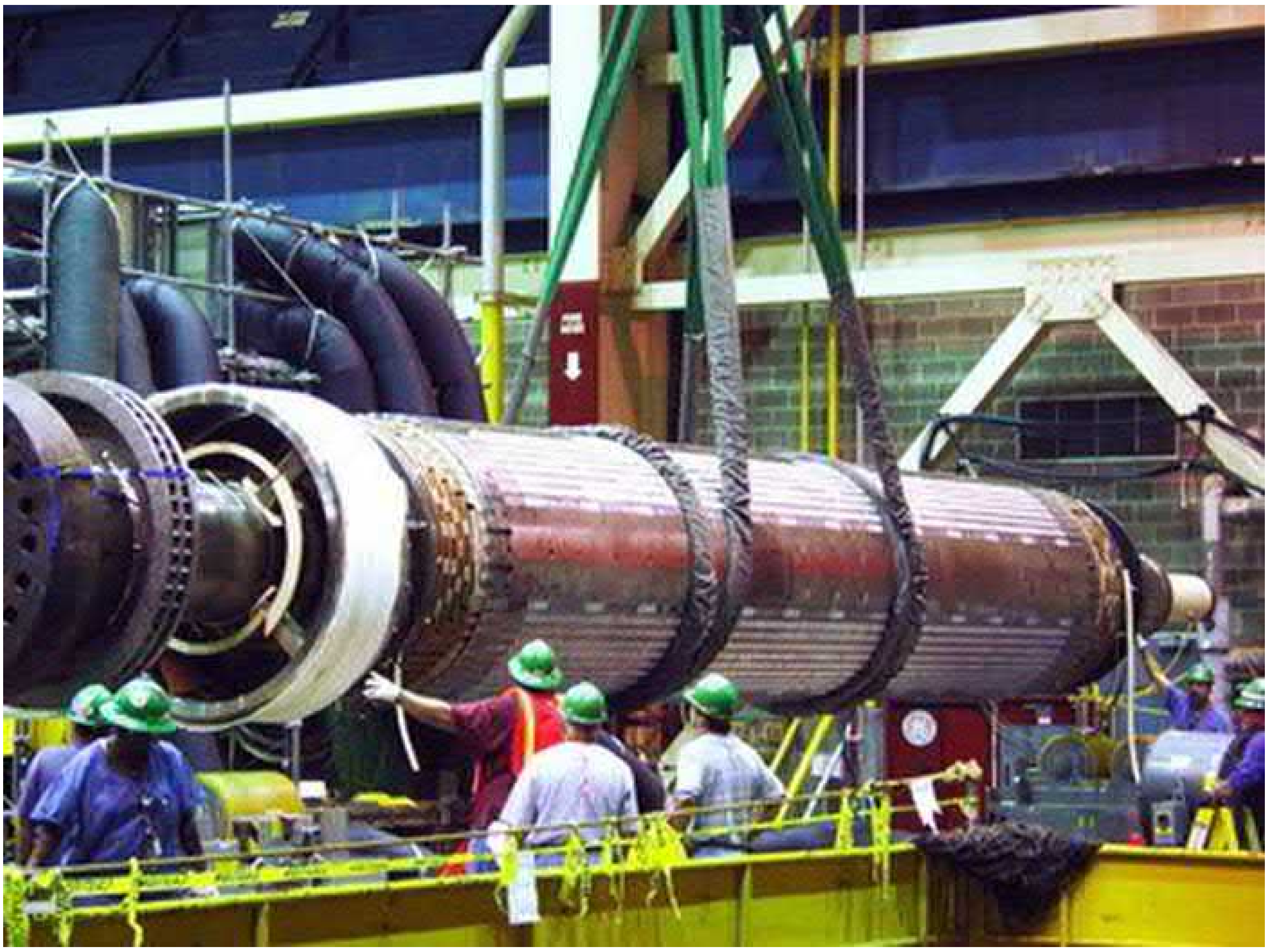
Three years later, a blocked cooling line would result in the costly federal probe and bring to light other equipment failures.

During a shutdown cooling in October of 2010, a 600-pound steel angle-wedge valve in Loop Two failed to open. Water could not reach the core. But safety calls for redundancy. Operators turned to the back-up low-pressure system, Loop One.

The NRC report in February of 2011 states that the residual heat removal pump in Loop One "had been in service for shutdown cooling for approximately 94 hours prior to experiencing a catastrophic failure of the motor on October 27" of 2010.

Redundant malfunctions

Johnson was on a team that studied the pump failure in the backup loop. She wrote the root cause analysis report.



Workers at Browns Ferry in 2004 move the Unit 1 main generator rotor from the generator on the turbine floor to the turbine access hatch. The 207-ton rotor was lowered through the access hatch to the main floor about three stories below. The restart of Unit 1 cost $1.9 billion. (Submitted photo)

TVA and NRC have said the second system was considered to have been functional up until the pump died.

But Johnson's team found the pump could never have cooled the core for its mission time of 30 days, that the van-sized motor had been installed hurriedly and incorrectly. The rotor was rubbing against a stationary part of the motor.

Again, nuclear safety relies on redundancy. There are two massive pumps in each loop. When the first one burned up, that left just one working pump in one back-up loop.

Polson at first said one pump would work. It was enough to complete shutdown. But one pump could not move enough water to control temperatures in a worst-case scenario.

Both pumps in a system must operate for containment cooling, according to Emergency Core Cooling specifications for Browns Ferry. Some of the worst scenarios, such as recirculation suction breaks, call for four working pumps.

Polson later acknowledged he was not talking about a worst-case scenario when commenting on the adequacy of one pump.

Backwards bearings

In addition to the low-pressure loops, there is also a high-pressure system, which can inject water into the core while it is under pressure. But during the restart, the bearings had been installed backwards in a turbine.

TVA officials say the high-pressure system would have worked. Polson said the high-pressure spray met its mission time of 14 hours after the April 27, 2011, tornado severed external power lines and forced the plant into shutdown. But Johnson said mission-time cooling is not as long as required for emergency cooling and the spray wouldn't have lasted long enough in a worst-case scenario.

Keith Polson, TVA Site VP for Browns Ferry Nuclear Plant, during an interview in 2012. (Huntsville Times file)

Polson said the plant has since stripped the high-pressure system and replaced all parts.

"Safety is the number-one priority," he said on the phone last month. Polson, who started at Browns Ferry in 2009, said perhaps TVA underestimated the extra work necessary to restart Unit 1, that the recovery took "a big toll on the trust of the people."

"I think the trust has been improved," he said, alluding to internal surveys that show improvements in morale last year. "Are we perfect? No, we're not perfect."

Catastrophe is just that, a plane crash, an earthquake, an EF-5 tornado like the one that just barely missed the Athens plant in 2011. A tsunami. The plant loses external power. Fire burns up control cables. The largest coolant pipe to the reactor breaks, requiring continuous operation of the low-pressure loops.

Nuclear plants are designed around such scenarios.

"It's not one broken pipe or one power outage away from disaster. It takes a lot of steps," said Lochbaum with the Union of Concerned Scientists.

Catastrophe assumes failure of the normal cooling system. Beyond the three problematic failsafe systems at Unit 1, there is also a pressure relief system, basically a steam release system. There is also a last-ditch, smaller core spray system.

But malfunctions in the high-pressure and both low-pressure failsafe systems represent an alarming drop in what the industry calls "safety margins." That's the three cherries up. And that invites federal scrutiny.

Winning performance

The inspector general for TVA, in a report requested by *The Times/AL.com*, backs up Johnson's mechanical concerns, as well as finding the same "unrealistic timetables" for installation.

A TVA worker in 2011 comes out of the reactor vessel while carrying out refueling operations on the Unit 2 reactor. (Michael Mercier/ The Huntsville Times)

The inspector general wrote that the pump in Loop One was installed in 2005 just one week before the deadline for a "winning performance" bonus. That was despite "dangerously high" readings on vibration tests, Johnson said. And that was despite the fact the pump wasn't needed for nearly two more years.

"Some personnel involved did not agree with the direction or findings of the root-cause analysis team," noted the TVA inspector general of Johnson's work, finding that Browns Ferry in general quickly reacts to broken equipment but "fails to perform the causal analysis necessary to understand why the problem occurred and how to prevent it."

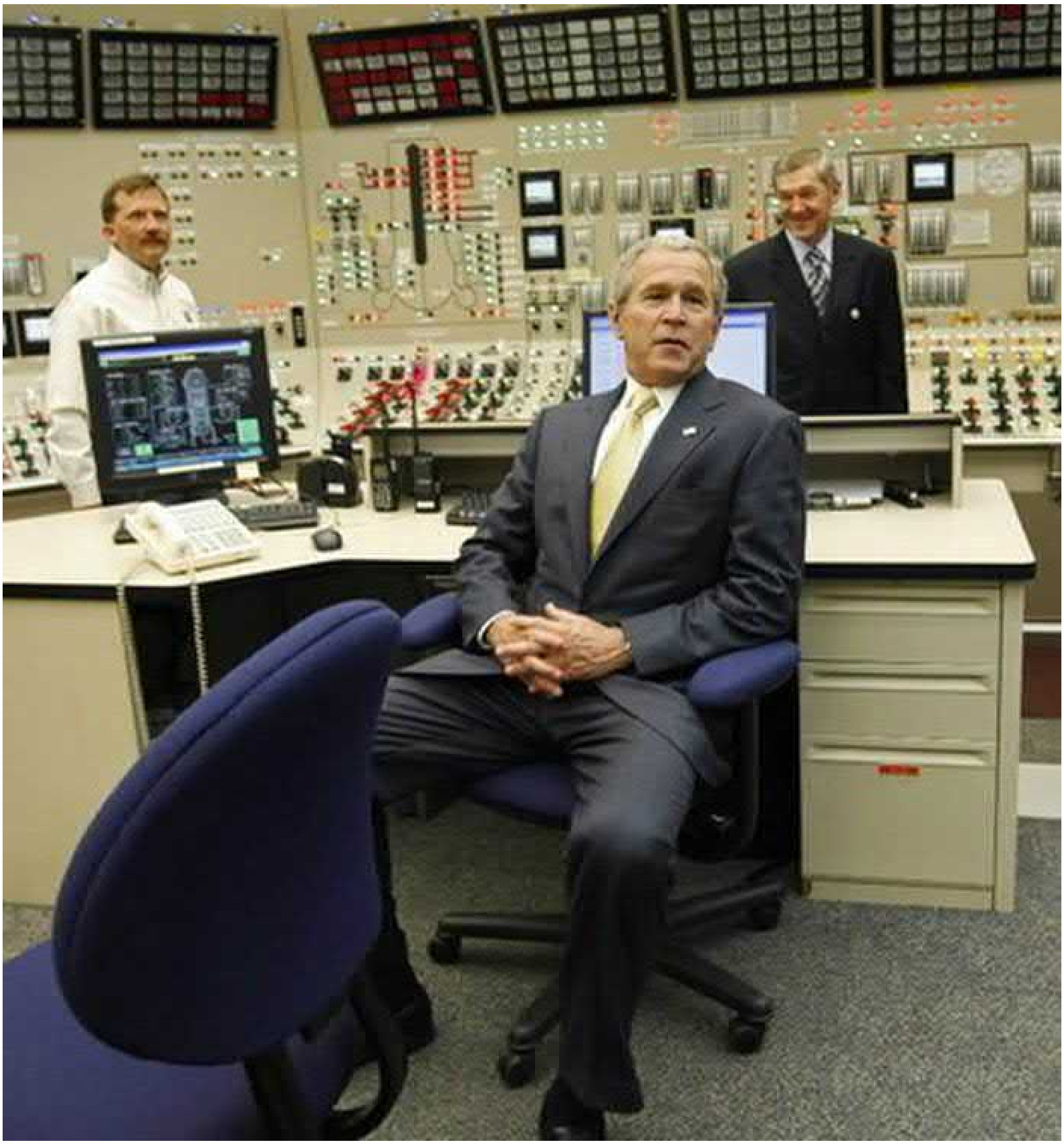
NRC inspectors last month told reporters that the pump failure in Loop One is not considered overlapping with the original blockage in Loop Two.

But NRC in its own lengthy 2011 inspection paperwork writes that the pump was required to be able to run for 720 hours to fulfill its safety role, and that the pump "had been incapable of meeting its required mission time, and thereby considered inoperable, since at least November 2007."

But that's not why the plant was given the costly red finding.

Bad bet

In the event of a fire or some unforeseen disaster, NRC inspectors say, TVA planned to kill power to other systems and flood the core using Loop Two. That means Browns Ferry would have, at least during crucial early steps, bet everything on a failsafe system that was blocked. That's why the red finding.



President George W. Bush sits in the control room at the Browns Ferry Nuclear Plant in Athens, Ala. Thursday June 21, 2007. His visit marked the restart of Unit 1. (AP Photo/Gerald Herbert)

TVA at first said the valve had separated from its stem due to poorly manufactured metal threads and undersized welds. TVA argued it couldn't be held accountable for a manufacturing defect. It also argued that, when needed, vibrations from massive amounts of water would have forced the valve to become unstuck.

NRC didn't buy any of what it labeled TVA's poor methodology and "unvalidated assumptions and calculations." Instead, NRC in a "final significance determination" in May of 2011 said TVA was at fault for inadequate testing of its own equipment. It also concluded the valve would never have opened. Johnson said it took two men with a jack hammer two days to free the valve.

Bill Baker, manager of the Browns Ferry Integrated Improvement Plan, spoke at length in the same employee newsletter ahead of the current NRC visit. The article says that, as Baker delved into historical data around the undetected valve failure, he came to a realization. "He needed to stop justifying continued operation and start putting nuclear safety first," reads the employee newsletter.

On April 27, 2011, a deadly EF-5 tornado crushed Independence Tube across the river from Browns Ferry. The tornado also flattened dozens of transmission towers, forcing a shutdown of the nuclear plant. (The Huntsville Times/ Michael Mercier)

Polson said eliminating "production bias" has been a priority in reshaping TVA's culture, and "that's changed 100 percent now."

But in April 2012, TVA seemed to remain focused on production, announcing that all three units at Browns Ferry had set records for continuous running without an outage.

With Unit 1 operating for 114 days, Unit 2 for 302 days and Unit 3 for 188 days, the site's record for continuous operation of all three units was three days longer than the previous best set in 2011, TVA said in a news release last year. Polson said at the time that the record reflected the overall health of the plant.

"Browns Ferry is a big plant. We account for about 10 percent of all TVA revenue," Polson told reporters last month. According to SEC filings, TVA grossed about $11.1 billion from selling power in 2012.

"They call it the cash cow," said Johnson of Browns Ferry.

As for the blocked line, Johnson said they didn't find it sooner because plant managers didn't do adequate testing. When testing the pump motor, according to the TVA inspector general, the vibration and oil tests didn't match expectations. "So they reset the set points," said Johnson.

Other equipment tests were not conducted, Johnson said. "You are encouraged to make it look better than it is," she said. "It's institutional bullying."

Selling power

On May 15, the NRC spoke to the press at Browns Ferry. It was not a flattering account. They said TVA initially challenged the findings related to the faulty angle-wedge valve.

NRC Engineering Area Assistant Lead Inspector Atif Shaikh examines pipes in May, 2013, at the Browns Ferry plant. (Photo courtesy NRC)

Federal regulators began to probe "overall issues," said Bill Jones with NRC, and those "were broader than we originally put down." NRC expanded its investigation from Unit 1 to the entire plant. "The more we looked, the more type of problems that were revealed."

Browns Ferry remains in Column 4 on the federal watch list. "Column 4 is as far to the right as you can get without being shut down," said Joey Ledford with NRC.

However, Jones appeared to disagree with Johnson's warnings, even though her charges are supported by some of the NRC paperwork. "Everything else was working. It was just that one valve," Jones said. "But that valve was important."

NRC representatives Joey Ledford, left, and Bill Jones (Brian Lawson /blawson@al.com)

Jones also acknowledged that the high-pressure system was malfunctioning due to backwards bearings.

"They are in business to sell power. It's not here for us," reminded Jones of the plant. He said it's the duty of NRC to ask cultural questions: "Do you run the plant even though it's compromised? What kind of tone does management set?"

In the end, despite the red finding and poor testing of failsafe equipment, Jones said: "Bottom line is even

een are

NRC is expected to release the results of its inspection during a public meeting on July 11.

For Johnson, speaking out has had consequences, as she said she ran up substantial legal bills without expectation of a resolution with TVA. But she became more concerned about the costs of not speaking out.

"I found myself in the position of becoming a whistleblower when TVA management altered root cause reports I authored to subdue their findings," she said last week. "I hope that bringing this story to public light will force TVA to address the safety significance of altering the findings of teams of engineers and experts for the sake of protecting production and their own bonuses."

Browns Ferry engineer never expected to be nuclear plant whistleblower

Updated Mar 07, 2019; Posted Jul 07, 2013

Nuclear Regulatory Commission inspectors during a May intensive inspection of the Browns Ferry Nuclear Plant in Athens. (NRC photo)

By **Brian Lawson**

By Brian Lawson and Challen Stephens

ATHENS, Alabama -- TVA engineer Joni Johnson is reluctant to talk about herself, and says she never expected to become a federal whistleblower.

Johnson's world changed when she ran into what she described as a flawed safety culture at the plant.

Johnson, 52, was used to going to work at the Browns Ferry Nuclear Plant where she's served since 1987.

She is a married mother of two sons, with an engineering degree from the University of Alabama in Huntsville.

Johnson worked full-time while finishing school, sometimes logging 60-hour work weeks while pursuing an electrical engineering degree. Her work at TVA has been recognized by colleagues and managers. She provided good performance reviews, internal awards and plenty of notes from co-workers thanking her for dedication and quality work.

Performance reviews note that Johnson "always accepts ownership," has strong technical knowledge, is detail-oriented and "provides excellent guidance."

Raised in a large family in Connecticut, Johnson is the daughter of an Army veteran of World War II and the Korean War. Her mom was born and raised in Carbon Hill. Her father worked on nuclear-related projects for the Army in Maryland and New Mexico late in his career and found the work fascinating, Johnson said.

Though engineering was not a booming career field for women in the 1970s, her father encouraged her to pursue technical work and she did. But in a male-dominated culture, it wasn't always easy.

"When you work so hard at something, achieve things nobody thinks you should be doing, it does a lot for your self-worth," Johnson said. "Being a field type person -- I don't like staying behind a desk, - that's when you get to the relationships especially with male engineers. I gained their respect. They saw I do know what I'm doing."

Johnson has been certified as a root cause analyst, charged with figuring out what went wrong with a system, a piece of equipment or process.

It was through work on a root cause analysis for a failed cooling system motor at Browns Ferry that Johnson first encountered what she said was troubling resistance to getting to the bottom of a problem and identifying what went wrong.

"It's a very detailed and scientific process," she said. "Your conclusions are based in fact and data. You accumulate them based on fact and data. There can be no unvalidated assumptions allowed in the root cause process."

Johnson said the completion of the root cause report and the issues it cited led to strong pushback from some managers, accusations against her and eventually poor performance reviews. She said a second root cause report she wrote on software problems affecting industrial safety led to similar responses, and her career suffered.

Nuclear Regulatory Commission investigators met with her last fall and agreed to look into her allegation that she was retaliated against by TVA for speaking out about safety concerns.

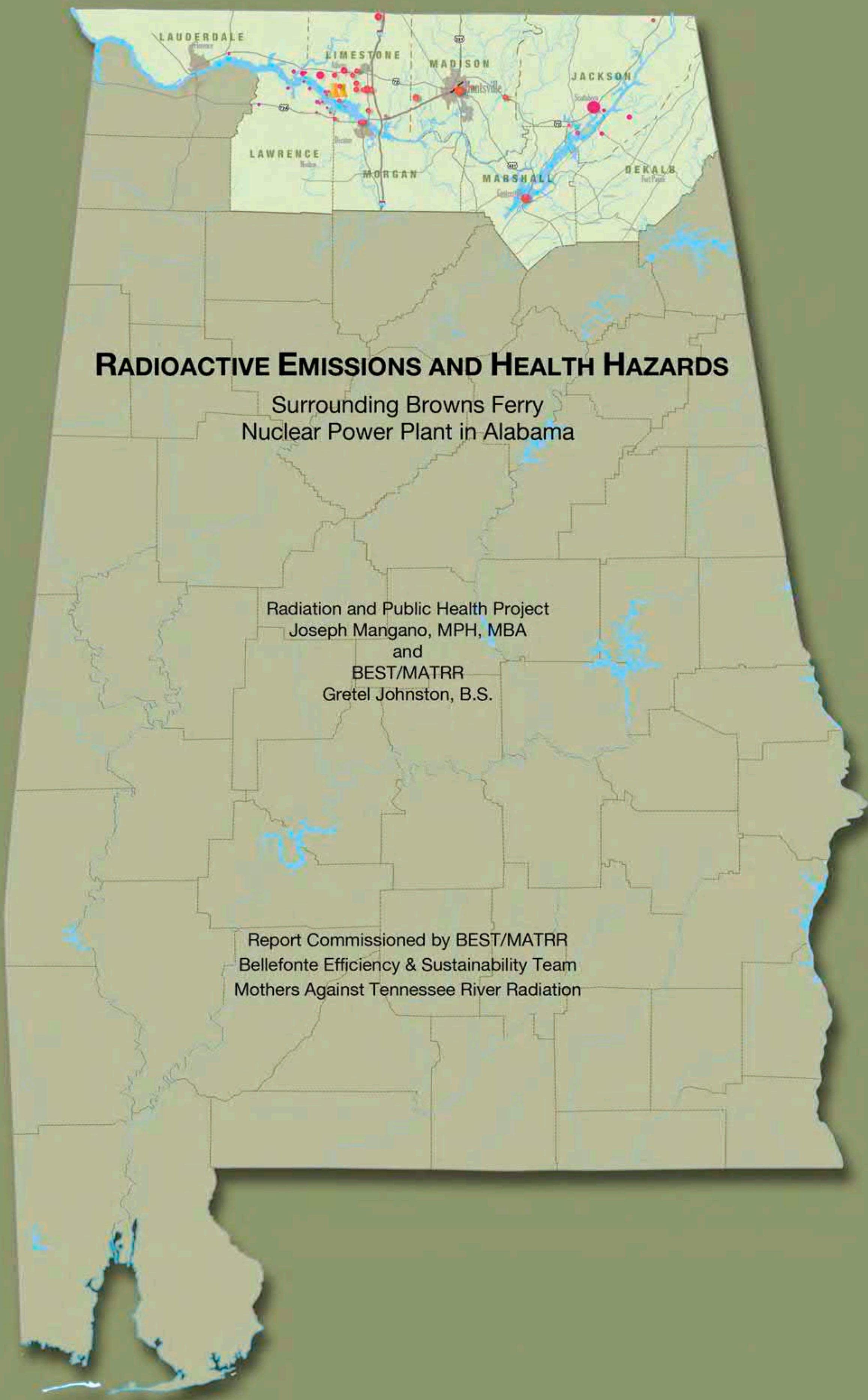
Officials with TVA and NRC would not discuss an ongoing investigation.

TVA has embarked on a substantial corrective action plan at Browns Ferry and said it has seen a major turnaround in the improvement of its safety culture.

Johnson hired an attorney to address her claims of discrimination. They pursued an unsuccessful mediation

Johnson said she remains "pro nuclear power."

"What we do is very important," she said. "We control the strongest form of energy on planet earth. I'm raising a family here. I don't take shortcuts when it comes to nuclear power. I'm sorry to have been around others that do."



Radioactive Emissions and Health Hazards

Surrounding Browns Ferry Nuclear Power Plant in Alabama

Radiation and Public Health Project
Joseph Mangano, MPH, MBA
and
BEST/MATRR
Gretel Johnston, B.S.

Report Commissioned by BEST/MATRR
Bellefonte Efficiency & Sustainability Team
Mothers Against Tennessee River Radiation

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JUNE 4, 2013

REPORT COMMISSIONED BY BEST/MATRR
A CHAPTER OF THE BLUE RIDGE ENVIRONMENTAL DEFENSE LEAGUE

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List of Acronyms

BEST	Bellefonte Efficiency & Sustainability Team
BREDL	Blue Ridge Environmental Defense League
BWR	Boiling Water Reactor
CRB	Control Rod Blades
GE	General Electric
MATRR	Mothers Against Tennessee River Radiation
NCI	National Cancer Institute
NPP	Nuclear Power Plant
NRC	U.S. Nuclear Regulatory Commission
PWR	Pressurized Water Reactor
RPHP	Radiation and Public Health Project
TVA	Tennessee Valley Authority

Gratitude

We are grateful to BEST/MATRR members and donors who have made this report possible, and especially to the Blue Ridge Environmental Defense League and the organizers of the Know Nukes Ya'll Summit, who generously donated legacy funds from the Summit to help support our local efforts. And special thanks go to our BEST Radiation Monitoring Project Manager, Garry Morgan, who called for local citizen radiation monitoring for many years, then with Lou Zeller's assistance, Garry equipped, organized and implemented systematic monitoring of areas near and downwind of Browns Ferry, creating videos and a graphic users manual to help empower other communities to monitor as well. The Tennessee Valley is fortunate to have Garry Morgan's concern, expertise and energy working for its citizens.

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EXECUTIVE SUMMARY

The Browns Ferry Nuclear Plant in northern Alabama runs three of the five operating nuclear reactors in the state. Nearly 1 million persons live within 50 miles of the plant.

Potential harm to local residents from Browns Ferry can be expressed in various ways:

1. Browns Ferry stores massive amounts of high-level radioactive waste, mostly in pools of water that must be constantly cooled to avoid a meltdown. **Browns Ferry has the 2nd largest waste storage of 71 U.S. nuclear power plants**.

2. Browns Ferry reactors have been closed for more than one year on six separate occasions due to mechanical problems, more than any U.S. nuclear plant. **The longest shutdown in the U.S. occurred at Browns Ferry 1, from 1985 to 2007.**

3. The 1975 near-miss accident at Reactor Unit 1 is considered the worst mishap at a U.S. nuclear power reactor, aside from the Three Mile Island meltdown; yet, Browns Ferry still does not comply with the fire safety regulations created after its 1975 fire.

4. **A 1982 federal estimate of 60,000 radiation poisoning cases and 3,800 cancer deaths per meltdown to a reactor core would be greater today**, due to higher population and effects beyond the 1982 study's geographic limits.

5. Amounts of tritium and beta-emitting radiation in drinking water near Browns Ferry are substantially greater than in Montgomery, which is far from nuclear plants.

6. Citizen-based monitoring has found higher levels of radioactivity (air, water, and land) close to, downwind, and downriver from Browns Ferry, and highest after rain events.

7. **Infant mortality in the seven closest downwind counties from Browns Ferry is 22.3% above U.S. rate, a steady increase from the early 1990s**, when it was below U.S. rate. The excess is 40.3% for Hispanics and 32.6% for whites.

8. **Since Browns Ferry's startup in the mid-1970s, the local mortality rate (all causes) steadily rose from 1.7% to 20.5% above U.S. rate.** Significant excesses exist for both genders, all ages, whites, and nearly all major causes.

Data presented in this report suggests a possible link between Browns Ferry emissions and elevated health risks. This finding is particularly important at this time, as the plant's three reactors approach 40 years in operation. Aging reactors have corroding parts, which can increase the risk of a meltdown and of larger routine releases. Officials and the public should understand patterns of radioactive contamination near the plant, along with local health trends, to ensure that decisions are made that best protect public health.

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I. INTRODUCTION

A. BRIEF HISTORY OF NUCLEAR POWER IN ALABAMA

The discovery of nuclear fission, or creation of high energy by splitting uranium atoms, was first used for military purposes, i.e. the atomic bombs in Japan during World War II. Soon after, other uses of the fission process were introduced. One of these was the creation of electric power from the heat generated by fission. The "Atoms for Peace" speech given at the United Nations by President Dwight Eisenhower in 1953 opened the door for the development of reactors that would produce electricity, and the first reactor began operating at Shippingport, near Pittsburgh, PA in 1957.

Hundreds of reactors were proposed by electric utilities, who were interested based on the potential to produce clean and cheap energy. In 1974, the U.S. Atomic Energy Commission predicted that the nation would have 1,200 reactors by the turn of the century. In Alabama, formal applications were made by utility companies for 13 reactors in the state. Five (5) of these are in operation; all others were cancelled, except for Bellefonte 1, which is still being planned (Table 1).

TABLE 1

NUCLEAR POWER REACTORS IN ALABAMA

Reactor	City/Town	Announced	**Startup**
Browns Ferry 1	Decatur	6/17/66	8/17/73
Browns Ferry 2	Decatur	6/17/66	7/20/74
Browns Ferry 3	Decatur	6/22/67	8/ 8/76
Joseph M. Farley 1	Dothan	5/13/69	8/ 9/77
Joseph M. Farley 2	Dothan	6/30/70	5/ 8/81
Barton 1	Clanton	1/ 1/72	
Barton 2	Clanton	1/ 1/72	
Barton 3	Clanton	1/ 1/74	
Barton 4	Clanton	1/ 1/74	
Bellefonte 1	Scottsboro	1/ 1/70	
Bellefonte 2	Scottsboro	1/ 1/70	
Bellefonte 3	Scottsboro	9/ 1/05	
Bellefonte 4	Scottsboro	9/ 1/05	

Source: U.S. Nuclear Regulatory Commission, www.nrc.gov

The U.S. Nuclear Regulatory Commission (NRC) has never refused a license extension request and has granted 20-year license extensions, after the initial 40-year licenses expire, for 75 of the 104 U.S. reactors, including the five reactors in Alabama. Nuclear power in Alabama has been producing over 25% of the state's electricity in recent years.
(Source: U.S. Nuclear Regulatory Commission, Information Digest, various years, www.nrc.gov.)

B. RADIOACTIVE WASTE STORED AT NUCLEAR PLANTS

To produce electricity, nuclear power reactors split uranium-235 atoms, generating high energy that is transformed into electrical power. This splitting process, known as fission, also produces over 100 chemicals not found in nature. These chemicals are the same as those found in the large clouds of fallout after above-ground atomic bomb tests.

Fission products, which take the form of gases and particles, include Cesium-137, Iodine-131, and Strontium-90. They are highly unstable atoms which emit alpha particles, beta particles, or gamma rays. When they enter the body, they affect various organs. Cesium seeks out the muscles (including the heart and reproductive organs), iodine attacks the thyroid gland, and strontium attaches to bone. Each causes cancer after breaking cell membranes and damages cell DNA creating mutations, and is especially harmful to the fetus, infant, and child. Some decay quickly (Iodine-131 has a half life of 8.05 days), while others remain for long periods (Strontium-90 has a half life of 28.7 years and Cesium-137 of 30 years, meaning it remains radioactive for over 300 years).

Most of the radioactivity produced in reactors is contained within the reactor building and stored as high-level waste in deep pools of water that must be constantly cooled. At Browns Ferry and other aging plants, the pools are becoming full and have no dedicated backup power. Only about 20% of the waste nationally has been transferred to safer above-ground outdoor casks. **As of the end of 2010, Browns Ferry maintained 1,932 metric tons of waste on site, the second largest of 71 U.S. nuclear plants.** The amount of radioactivity at the plant (**314,140,400 curies**), the 5th highest in the U.S., is equivalent to several times more than that released by the 1986 Chernobyl meltdown, and hundreds of times more than releases from atomic bombs at Hiroshima and Nagasaki in 1945. The list of U.S. nuclear plants with the largest amounts of high-level waste is given in Table 2:

TABLE 2

U.S. Nuclear Power Plants (Total = 71)
With Largest Amounts of High-Level Nuclear Waste, As of December 2010

Plant	State	Metric Tons	Curies
1. Dresden	IL	2,146	350,380,400
2. Browns Ferry	**AL**	**1,932**	**314,140,400**
3. Nine Mile Point	NY	1,865	355,269,600
4. Millstone	CT	1,709	445,230,400
5. Palo Verde	AZ	1,674	360,032,400
6. Salem/Hope Creek	NJ	1,659	216,050,800
7. Peach Bottom	PA	1,554	254,072,600
8. Edwin I. Hatch	GA	1,446	237,432,400
9. D.C. Cook	IL	1,433	286,914,600
10. San Onofre	CA	1,423	315,932,400

Source: Alvarez, Robert *Spent Nuclear Fuel Pools in the U.S.: Reducing the Deadly Risks of Storage*, Institute for Policy Studies, May 2011.

In 2002, after decades of investigation and debate, the federal government designated Yucca Mountain in Nevada as a permanent waste site, despite considerable opposition. In 2010, the Obama administration stopped all expenditures for building the inadequate site, and assembled a panel to further consider options for long term waste storage. Some experts believe a permanent repository will never open, leaving existing nuclear plants like Browns Ferry to maintain the waste indefinitely.

C. MARK I REACTOR DESIGN FAULTS

The Browns Ferry GE Mark I Boiling Water Reactors, the same model as Fukushima, had serious enough design flaws that three General Electric (GE) nuclear engineers working on the system publicly resigned their positions in 1976, citing dangerous shortcomings in the GE Mark I design. In 1986, top Nuclear Regulatory Commission (NRC) safety official, Harold Denton, stated that the WASH 1400 Safety Study revealed a 90% probability of the Mark I containment failing in the case of a significant malfunction, resulting in retrofit torus vent pipe installations for all Mark I's allowing the control operator to release unfiltered radiation into the atmosphere to save containment. (Source: Gunter, Paul; "Hazards of Boiling Water Reactors in the United States," NIRS, 1996 and 2011.)

D. BROWNS FERRY AGING ISSUES

During their first 10 to 15 years of operation, all three Browns Ferry Reactors had poor operational records with high numbers of SCRAMs (emergency nuclear reactor shutdowns), which thermally shock reactor containment structures, causing weakening, premature aging and metal fatigue of the reactor pressure vessels. Altogether, the three reactors have suffered over 270 emergency SCRAMs. The reactors are now reaching their 40 design-basis life span, but NRC extended their operating license for 20 more years – despite a 1993 NRC report which confirmed "age-related degradation in Boiling Water Reactors will damage or destroy vital safety related components inside the reactor vessel before the forty year license expires." It was determined that the reactor vessel cracks were the result of the deterioration of Type 304 Stainless Steel due to exposure to chronic radiation, heat, corrosive chemistry, and fatigue.

After 20 year over design-basis license extensions were granted by the NRC, GE issued warnings about control rods cracking, then inspected Browns Ferry and found cracking of the rods necessary for shutting down the reactor for SCRAMs or refueling. In addition, according to an Associated Press Investigative Report in 2011, "The AP found proof that aging reactors have been allowed to run less safely to prolong operations. As equipment has approached or violated safety limits, regulators and reactor operators have loosened or bent the rules."; and, "Last year, the NRC weakened the safety margin for acceptable radiation damage to reactor vessels — for a second time. The standard is based on a measurement known as a reactor vessel's "reference temperature," which predicts when it will become dangerously brittle and vulnerable to failure." (Source: AP report by Jeff Donn, "Safety Rules Loosened for Aging Nuclear Reactors," June 20, 2011, http://www.nbcnews.com/id/43455859/ns/us_news-environment/t/safety-rules-loosened-aging-nuclear-reactors/#.UYp50JVs3S8; and, NRC, Licensee Event Reports search of BFN SCRAMSs; https://lersearch.inl.gov/Entry.aspx.)

E. <u>BROWNS FERRY LONG-TERM SHUT DOWNS</u>

A 2006 Union of Concerned Scientists Report listed 51 instances when a U.S. nuclear reactor closed for over one year before restart. **Six year-long (or more) outages occurred at Browns Ferry – the largest number of any U.S. nuclear plant** (Table 3). Three shutdowns of over one year occurred at Peach Bottom PA and Sequoyah TN. The 22-year shut down at Browns Ferry 1, from 1975 to 2007, was by far the longest in the U.S., while the plant also has the 2nd and 3rd longest shut downs ever.

TABLE 3

BROWNS FERRY SHUT DOWNS OF ONE YEAR OR LONGER

REACTOR	DATE SHUT	DATE OPEN	
Browns Ferry 1	3/22/75	9/24/76	
Browns Ferry 1	3/19/85	6/ 2/07	**1st Longest in U.S.**
Browns Ferry 2	3/22/75	9/10/76	
Browns Ferry 2	9/15/84	5/24/91	**3rd Longest in U.S.**
Browns Ferry 3	9/ 7/83	11/28/84	
Browns Ferry 3	3/ 9/85	11/19/95	**2nd Longest in U.S.**

Source: Union of Concerned Scientists, *Unlearned Lessons of Year-plus Reactor Outages*, 2006

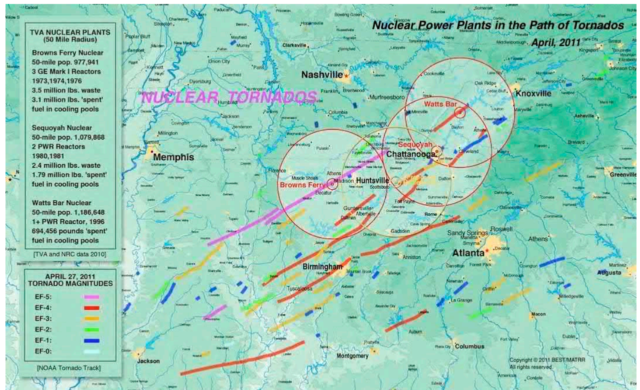
F. <u>BROWNS FEERY I FIRE - 1975</u>

On March 22, 1975, a fire broke out at Browns Ferry Unit 1 when a worker set a cable seal on fire with a candle. The fire caused significant damage to the cable room, burning about 1600 cables, and threatened the entire reactor unit, almost resulting in a core boiloff/meltdown accident, before it was extinguished seven hours later. The U.S. Nuclear Regulatory Commission made multiple changes to its fire prevention regulations after the incident, but Browns Ferry is still not in compliance (37 years later) with the regulations its own fire was responsible for creating, and the NRC has allowed the negligence. **The 1975 incident at Browns Ferry 1 is considered by many to be the most serious accident of any U.S. nuclear power reactor, with the exception of the Three Mile Island partial core meltdown in 1979.**

It seems worthy of note that David Dinsmore Comey (on whom the U.S, Environmental Protection Agency (EPA) bestowed its First Annual Environmental Quality Award in 1974 "for services that have immeasurably improved the design and safety review of nuclear reactors") writing in 1976 about the Browns Ferry fire said, "Every nuclear plant in the country uses a cable spreader room below its control room. Despite requirements for separation and redundancy of reactor protection and control systems, every reactor has been permitted to go into operation with this sort of configuration which lends itself to a single failure's wiping out all redundant systems." Source: David Dinsmore Comey, "The Fire at Brown's Ferry Nuclear Power Station," in *Not Man Apart*, Friends of the Earth, California, 1976, http://www.ccnr.org/browns_ferry.html

G. TORNADO EVENTS OF 2011

The Tennessee Valley is in what locals call a tornado corridor, since the area periodically suffers the destruction of major tornados and they seem to return along familiar pathways. On April 27, 2011, fifteen EF-4 and EF-5 tornados crossed the southeastern U.S. (see Appendix 2) and one Category EF-5, the strongest tornado known to man, destroyed a row of incoming power towers right next to Browns Ferry Nuclear Power Plant, cutting power to the plant for seven days. Given over three million pounds (with over 314 million curies) of highly radioactive fuel is stored in pools requiring constant power for coolant circulation and raised 40 feet in the air with only sheet metal roofing overhead, this was a serious near-miss event. All but one line of incoming power was lost to the plant, and despite TVA reports to the public that all emergency systems performed as designed, numerous incidents occurred that were serious enough to require Event Reports (Nos. 46793, 46801, 46805) to the Nuclear Regulatory Commission (NRC). What they revealed was worthy of note:



Nuclear and Tornados Map (see Appendix 2)

1.) Only 12 of the required 100 off-site Emergency Sirens were functional on April 27.

2.) Two of eight Emergency Diesel Generators failed that day, one for the fire pump and one for the security station and sirens. A third generator was shutdown the next day – totaling a 37.5% failure rate for emergency backup power.

3.) On that day, a Main Steam Isolation Valve indicator failed on Unit 3 – so operators could not tell if the valve had closed as it should during the reactor emergency shutdown.

4.) On that day, April 27, hours after Unit 1 automatically shut down due to loss of the electrical grid, it received a second automatic shut down signal due to a low water level inside the reactor vessel. TVA later explained the operating crew was "distracted," allowing the water level to boil down too low for safe reactor cooling.

5.) On April 28, an electrical part failure on Unit 1 initiated an automatic closer of Shutdown Cooling emergency valves. Power was restored after 47 minutes.

6.) On May 2, Unit 1 received an 'A' Emergency Generator output breaker trip, resulting in loss of Shutdown Cooling. Power was restored after 57 minutes.

H. 'RED FINDING' FOR BROWNS FERRY NUCLEAR PLANT

Nuclear Regulatory Commission inspectors were on-site reviewing existing safety issues when the tornados hit in 2011, and NRC issued Browns Ferry a rare 'Red Finding' (only four have ever been issued in nuclear history) for unrelated problems just eleven days after the tornados hit, a finding that still stands two years later. A 'Red Finding' is NRC's worst rating, the most severe rating possible before a plant is shut down and forced into its decommissioning stage. The 'Red Finding' was given because of extended safety performance deficiencies and missed testing opportunities for a significantly degraded coolant injection valve, which meant an entire system could not be counted on to cool the reactor core, potentially leading to core damage. The faulty reactor cooling valve was found to have been inoperable for 18 months before the problem was discovered, and a jerry-rigged work-around was initially attempted to address the problem. A Professional Reactor Operator Society article also noted: "TVA provided incomplete and inaccurate information in a letter to the NRC. . . [which] referenced 18 valves. . . a Severity Level III violation." Source: Bob Meyer, "Most Significant NRC findings of 2012," Professional Reactor Operator Society, Feb.3, 2013, http://nucpros.com/content/most-significant-nrc-findings-2012

I. CONTROL ROOM FIRE - 2012

In January of 2012, Unit 3 control room operators noticed smoke and a flame under an annunciator panel. According to the Professional Reactor Operator Society, "The cause of the event was a failed power supply. An overcurrent was caused by an aged capacitor that had not received preventative maintenance to address its service life." The signifcance of this fire is that there had been three similar warning events of power failure in an annuciator panel – twice in 2008 and again in 2009, but the aged equipment was not monitored by the TVA or the NRC. Source: Professional Nuclear Reactor Operator Society "Browns Ferry Nuclear Plant, Unit 3 LER: Annunciator Panel Power Supply Fire in Unit 3 Control Room," July 9, 2012, http://www.nucpros.com/content/browns-ferry-nuclear-plant-unit-3-ler-annunciator-panel-power-supply-fire-unit-3-control-roo

J. ONGOING RADIOACTIVE LEAKS AND RELEASES

There have been sixteen reportable radioactive leaks at Browns Ferry Nuclear Power Plant (see Appendix 3), in addition to the routine radioactive releases. In 2010, a worker discovered an open test valve at Condensate Storage Tank 5, where 1,000 gallons of radioactively contaminated water had leaked, at concentrations of 2 million picocuries per liter which is 100 times the EPA drinking water contamination limit. So far, TVA reports drinking water test sites have not exceeded EPA limits. Sources: Jeff Donn, "Radioactive tritium leaks found at 48 US nuke sites," AP, June 21, 2011,http://www.nbcnews.com/id/43475479/ns/us_news-environment/t/radioactive-tritium-leaks-found-us-nuke-sites/#.UX7Aa5Vs3S8; and Union of Concerned Scientists, "Groundwater Events Sorted by Location," September 29, 2010, http://www.ucsusa.org/assets/documents/nuclear_power/Groundwater-Events-Sorted-by-Location.pdf (See Appendix 3)

II. HEALTH HAZARDS POSED BY REACTOR MELTDOWNS

A. DESCRIPTION

Much of the health concern posed by nuclear reactors focuses on major meltdowns. The radioactivity in a reactor core and waste pools must be constantly cooled by water, or the fuel will heat uncontrollably, causing a huge release of radioactivity. This release can be caused by mechanical failure (like at Chernobyl in 1986, when safeguard redundancy was deliberately shut off during testing), by an act of nature (like the earthquake/tsunami at Fukushima in 2011), or by an act of sabotage.

The experience at Hiroshima and Nagasaki demonstrated how exposure to high levels of radioactivity can harm humans. Those closest to the bombs were vaporized, literally melting from the intense heat. But many other victims who survived the initial blast developed acute radiation poisoning, marked by symptoms such as nausea, vomiting, diarrhea, skin burns, weakness, dehydration, bleeding, hair loss, ulcerations, bloody stool, and skin sloughing (falling off), according to the *Medical Encyclopedia of the National Library of Medicine* (Radiation Sickness, http://www.nlm.nih.gov/medlineplus/ency/article/000026.htm). In addition, a large number of bomb survivors in the two cities developed cancers over the next several decades; thyroid and breast cancer had the greatest excesses. (Source: Thompson DE et al. Cancer Incidence in Atomic Bomb Survivors. Part II: Solid Tumors, 1958-1987. Radiation Effects Research Foundation, Hiroshima Japan, 1994).

B. ESTIMATES OF CASUALTIES

If a meltdown resulting in large scale releases of radioactivity from the reactor core or the waste pools occurred at Browns Ferry, there would be no vaporizing of humans. However, many would suffer from acute radiation poisoning (in the short term) and cancer (in the long term). In 1982, the Sandia National Laboratories submitted estimates to Congress for each U.S. nuclear plant in the case of core meltdown. Estimates for Browns Ferry are given in Table 4.

TABLE 4

Estimated Deaths/Cases of Acute Radiation Poisoning and Cancer Deaths Near Browns Ferry, Following a Core Meltdown [1982]

Type of Effect	Unit 1	Unit 2	Unit 3
Deaths, Acute Radiation Poisoning	18,000	18,000	18,000
Cases, Acute Radiation Poisoning	42,000	42,000	42,000
Cancer Deaths	3,800	3,800	3,800

Note: Acute radiation poisoning cases and deaths calculated for a radius of 20 miles from the plant, cancer deaths calculated for radius 30 miles from the plant. Source: Sandia National Laboratories, *Calculation of Reactor Accident Consequences (CRAC-2) for U.S. Nuclear Power Plants*. Prepared for U.S. Congress, Subcommittee on Oversight and Investigations, Committee on Interior and Insular Affairs. November 1, 1982. Published in New York Times and Washington Post the following day.

The Sandia figures are known as CRAC-2 (Calculation of Reactor Accident Consequences). **CRAC-2 estimated casualties for a core meltdown per Browns Ferry Units 1, 2, or 3 are 60,000 cases of acute radiation poisoning (18,000 fatal) and 3,800 cancer deaths**. Estimates would be much larger today, since the local population has grown since 1982 when the calculations were made, and people beyond a 20 mile radius from the plant will also suffer adverse health consequences. Estimated costs from a meltdown after each unit ($67.3 billion, $69.1 billion, and $73.0 billion in 1980 dollars) would also be far greater today due to inflation. In the seven north Alabama counties immediately downwind of Browns Ferry (DeKalb, Jackson, Lawrence, Limestone, Madison, Marshall, and Morgan), the population grew 47.7%, from 534,059 to 788,777 from 1980 to 2010.

Concerns about meltdowns near Browns Ferry are well founded. According to the 2010 Census, there are nearly 1 million residents living within 50 miles of Browns Ferry – up 11.0% from a decade earlier (Table 5):

TABLE 5

2010 Population and Change from 2000
By Distance from Browns Ferry

Distance	2010 Population	% Ch. From 2000
10 miles	39,930	+12.3%
20 miles	196,318	+14.8%
50 miles	977,941	+11.0%

Source: Bill Dedman, NBC News. "Nuclear Neighbors: Population Rises Near US Reactors", April 4, 2011

Despite the 1975 fire accident just two years after the plant began operating, Browns Ferry reactors may have become more vulnerable to a meltdown from mechanical failure in recent years because of their aging parts, and are decidedly more vulnerable to a meltdown from a terrorist attack. Finally, the March 2011 meltdown at four reactors in Fukushima, Japan is a reminder that these disasters can also occur from an act of nature.

III. RADIOACTIVITY RELEASED FROM BROWNS FERRY

A. OFFICIAL RADIOACTIVE RELEASES INTO THE ENVIRONMENT

Radionuclides created by fission disintegrate, releasing energy as they try to regain stability, and a curie is a unit of radioactivity corresponding to 3.7×10^{10} disintegrations per second. Utilities operating nuclear power plants are required to submit annual reports on radioactive releases to the federal government. From 1970-1993, the Brookhaven National Laboratories collected and disseminated data for each nuclear plant on airborne emissions of "Iodine-131 and effluents," or those radioactive chemicals with a half life of at least eight days, and most likely to enter the food chain and the body.

In this period, the three Browns Ferry reactors emitted 1.70 curies of Iodine-131, which is relatively typical of U.S. reactors. This total represents about 15% of the 14.20 official total from the 1979 Three Mile Island partial core meltdown. Comparisons of all U.S. plants were halted after 1993 by the U.S. government. (Source: Brookhaven National Laboratory *Radioactive Materials Released from Nuclear Power Plants*, NUREG/CR-2907, annual reports)

More recent data on radioactive emissions into the environment include the years 2000 through 2009, by quarter, for most U.S. reactors. The information is available online, but it is very resource-intensive to rank reactors and plants, since one must analyze each reactor's data. The data, posted by federal regulators, includes several types of airborne emissions, including fission and activation gases, iodine-131, particulates (half life over eight days), and tritium. The web site, operated by the U.S. Nuclear Regulatory Commission, also provides quarterly measurements of several types of liquid emissions, including dissolved/entrained gases, fission/activation products, and tritium. (Source: U.S. Nuclear Regulatory Commission, Effluent Database for Nuclear Power Plants, www.reirs.com/effluent).

An examination of the quarterly emission levels database, reveals a number of omissions and limitations in the data that make helpful analyses difficult, namely:

1. For the 10-year period, liquid releases are given only for 2005, 2007, 2008, and 2009

2. For the 10-year period, airborne releases are not given for 2006

3. For airborne releases of fission and activation gases, almost all of the quarterly measurements after 2003 are given as "N/D" (not detectable)

4. For liquid releases of fission/activation products, the number of curies from 2008 to 2009 jumped from 0.0114 to 34.8200, a 3054 times higher jump (which seems not likely)

5. Also for liquid releases of fission/activation products, the number of curies in the last three quarters of 2009 was 10.1, 10.1, and 10.1, respectively; the chance of these three being exactly equal is almost zero, and suggests these data are rough estimates

6. In 2008, while Browns Ferry emitted its highest amount of airborne tritium in the decade, it emitted its lowest amount of liquid tritium

TVA Photographs of Browns Ferry, Fair usage for Non-profit science and health report.

Without any further explanation from the Tennessee Valley Authority (TVA), which operates the plant and makes measurements, and the U.S. Nuclear Regulatory Commission (NRC), which regulates the TVA and publishes measurements, these unusual results have no obvious explanation. Because of these and other limits, precaution should be taken when analyzing these data for patterns and trends. Perhaps the most complete and most reliable type of radiation measure data is the airborne levels of tritium, a gas found in much greater amounts than many chemicals in reactors, and thus easier to measure.

Table 6. provides the quarterly and annual environmental releases of tritium from Browns Ferry 1, 2, and 3. All figures are given in curies.

TABLE 6

Quarterly Airborne Releases of Tritium, 2000-2009
From Browns Ferry Nuclear Plant, in Curies

Year	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	TOTAL
2000	8.25	12.00	16.40	11.90	**48.55**
2001	19.50	9.22	14.80	15.30	**58.82**
2002	31.00	13.20	10.60	63.80	**121.70**
2003	25.80	38.30	22.90	22.90	**109.90**
2004	23.60	10.30	12.00	8.61	**54.51**
2005	13.20	14.90	10.10	5.57	**43.77**
2006	No data	No data	No data	No data	-----
2007	1.90	14.30	11.30	7.13	**34.63**
2008	21.40	56.00	76.30	30.20	**183.90**
2009	39.10	19.20	19.50	17.70	**95.50**

Source: U.S. Nuclear Regulatory Commission, Effluent Database for Nuclear Power Plants, www.reirs.com/effluent.

In the decade, there are periods of increase and decline, from an annual low of 34.63 curies (in 2007) to a high of 183.90 curies (in 2008). There are even "hot" and "cold" quarters that sometimes follow one another. For example, there was a large increase from 10.60 to 63.80 curies from 3rd to 4th quarter 2002, before a decline back to 25.80 in 1st quarter 2003.

While acknowledging the limits of the data, Browns Ferry can be ranked among the 65 operating nuclear power plants in the U.S. In 2008, the year of its highest recorded airborne tritium emissions, Browns Ferry had the 8th highest amount in the nation:

TABLE 7

U.S. Nuclear Power Plants (Total = 65 operational)
With Largest Airborne Tritium Released, 2008

Plant	State	Curies
1. Palo Verde	AZ	1715.1
2. Brunswick	NC	296.2
3. Salem	NJ	278.9
4. Harris	NC	259.7
5. Catawba	SC	258.7
6. D. C. Cook	MI	242.7
7. McGuire	NC	226.4
8. Browns Ferry	**AL**	**183.9**

Source: U.S. Nuclear Regulatory Commission, Effluent Database for Nuclear Power Plants, www.reirs.com/effluent.

Curies of Tritium Released in Liquid Effluents		
Statistical Summary for 2003	PWR	BWR
Total	40,600	665
Minimum	0.1	0
Maximum	2,080	174
Average	725	27.7
Number of Data	56	24

An NRC example of typical annual liquid releases from nuclear power plants. Source: U.S. Nuclear Regulatory Commission, FAQs About Liquid Radioactive Releases, http://www.nrc.gov/reactors/operating/ops-experience/tritium/faqs.html#affect (Note: The EPA allows 20,000 picocuries per liter in drinking water, and one picocurie equals 0.000000000001 curie or one trillionth of one curie.)

B. Official Radioactivity Levels in the Environment

Nuclear power plants release tritium into the environment via routine and accidental releases into the air and water. The U.S. Environmental Protection Agency makes levels of environmental radioactivity at various sites in the U.S. publicly available. Measurements in air, water, and milk are included. The web site is called "Envirofacts," can be accessed at http://iaspub.epa.gov/enviro/erams_query_v2.simple_query, and covers measurements taken since 1978.

There are nine Alabama locations in the EPA web site. Two are relatively close to Browns Ferry. One is Muscle Shoals in Colbert County, about 20 miles west of the plant, and the other is Scottsboro, about 70 miles east of the plant, in Jackson County. Each of these locations contains periodic measurements of various types of radioactivity in drinking water, beginning in 1978.

Unfortunately, many measurements for some types of radioactivity are given as negative numbers. A single measurement has an error range, meaning that there is a 95% chance that the true concentration of radioactivity is within that range. Sometimes, when levels are relatively low, the number falls below zero, although the true number is a low, but positive value. Analyzing data with many negative numbers is not helpful; types of radioactivity in drinking water with many values below zero include Iodine-131 and gross alpha (sum of all radioactive chemicals emitting alpha particles).

However, measurements of other types of radioactivity show most or all positive values. Table 8 summarizes the results for (annual) gross beta and (quarterly) tritium in drinking water, for Muscle Shoals, Scottsboro, and also Montgomery (a "control" location, far from any reactor). Gross beta is given for the period 1978-2013, while tritium is given for 1996-2013 (from 1978-1995, only measurements to the nearest hundred were reported for tritium).

TABLE 8

Tritium and Gross Beta in Drinking Water, in Picocuries per Liter
Muscle Shoals, Scottsboro, and Montgomery AL, 1978-2013

Indicator	Muscle Shoals	Scottsboro	Montgomery
Tritium (quarterly), 1996-2013			
Measurements	66	66	60
Average	**88.52**	**78.53**	**11.08**
High Measurement	574	295	151
Number < Zero	9	10	25
Average (assume negative numbers equal zero)	**90.97**	**84.53**	**25.42**
Gross Beta (annual), 1978-2013			
Measurements	34	33	34
Average	**1.94**	**1.73**	**1.63**
High Measurement	2.67	2.99	3.07
Number < Zero	0	0	0

Note: EPA allows 20,000 picocuries in our drinking water. One picocurie is one trillionth of a curie. Source: U.S. Environmental Protection Agency. Radnet: Envirofacts, http://iaspub.epa.gov/enviro/erams_query_v2.simple_query.

The tritium data in drinking water show both Muscle Shoals and Scottsboro have much greater levels than Montgomery (3-4 times more, or 7-8 times more, depending on whether negative numbers are counted as negative or zero). There were 66 measurements at both Muscle Shoals and Scottsboro, and 60 in Montgomery. The Muscle Shoals average is slightly above Scottsboro (+12.7%, or 88.52 vs. 78.53). **The highest single concentration of tritium in drinking water since 1996 was 574 picocuries per liter, in Muscle Shoals on October 11, 2012.**

The gross beta readings also show Muscle Shoals has a higher 1978-2013 average than Scottsboro and Montgomery. Muscle Shoals is the highest, or 19.0% above Montgomery (1.94 vs. 1.63 picocuries per liter). None of the 101 measurements in the three locations were less than zero.

While these data show relatively higher environmental levels closer to Browns Ferry, they are quite limited. Both tritium and gross beta are present in natural background radiation, and are not just produced by nuclear reactors; however, tritium is produced by and routinely released from nuclear power plants – and then there are the accidental releases (see Appendix 3). Identifying levels of individual anthropogenic (man made) radioactive chemicals only produced in reactors or atomic bombs, by using spectrographs or radiation spectral analyzers, would be much more helpful to understand the additional radioactivity that Browns Ferry adds to the environment.

In addition, testing at more sites, especially those closer than 20 miles from the plant, would also provide more useful information. Finally, more frequent tests could better identify patterns; for example, **readings such as the very high October 11, 2012 tritium in Muscle Shoals drinking water (574 pCi/l) might be identified if more than quarterly measurements were made.**

C. RADIOACTIVITY IN THE ENVIRONMENT MEASURED BY CITIZENS

Because of the limitations of official measurements of environmental radioactivity, interested local citizens near Browns Ferry embarked on a program of measurements in October 2012. The group, Bellefonte Efficiency and Sustainability Team (BEST), a chapter of the larger Blue Ridge Environmental Defense League (BREDL). The group's mission includes empowering communities through environmental education in the Tennessee River Valley, encompassing the Browns Ferry, Sequoyah, and Watts Bar nuclear reactors.

Lou Zeller, BREDL's Executive Director and the project's Quality Assurance Officer, began the group's training using EPA standards; and BEST Monitoring Project Manager, Garry Morgan (retired U.S. Army Medical Department), expanded protocol to include Homeland Security standards and created the *BEST Radiation Monitoring Manual*.

BEST project methods are based on models developed in 2005 by Russian scientist Sergey Pashenko and American scientist Norm Buske and published in *A Citizen's Guide to Radiation Monitoring*; and also the BREDL/Shell Bluff Draft QAPP of July 3, 2012. BEST purchased a Geiger counter (Inspector™, manufactured by Southeast International) to measure the total of alpha, beta, gamma, and X-ray radiation in the air, water, and land.

Background levels were always established first, since a portion of environmental radioactivity is from natural sources (spectrographs are needed to identify radionuclides). Background levels, in Counts Per Minute (CPM), were 26 in water and 36 to 40 on land.

Although these are preliminary, several findings became clear in the first few months of BEST project operations that were not identified by measurements posted by NRC and EPA regulators on their websites.

1. ELEVATED LEVELS CLOSE TO PLANT Higher than background levels were generally found in locations close to Browns Ferry, i.e. those 1 to 10 miles from the plant's outer boundary. The high counts at these locations were about 125 CPMs, or 3-4 times above the background level of 36 to 40.

2. ELEVATED LEVELS DOWNWIND OF PLANT Higher levels of airborne and land-based radioactivity were documented at locations downwind (east) of Browns Ferry. Measurements upwind (west) showed minor difference with background levels.

3. ELEVATED LEVELS DOWNRIVER OF PLANT Measurements taken in the Tennessee River downriver from the plant were roughly 2 times greater than those taken from upriver locations.

4. <u>HIGHEST LEVELS AFTER RAIN EVENT</u> The highest levels of radioactivity occurred just after precipitation brought particles to earth. The highest readings observed by BEST members occurred in Scottsboro AL, 70 miles east of Browns Ferry. The team wiped droplets of precipitation from the hood of a car with a paper towel; the droplets were observed to be black. It is possible that radioactive particles, which are invisible, might be trapped in blackened soot particles. The team made minute-by-minute tests for one hour holding the Inspector™ counter just above the sample, and observed a high reading of 1602 CPM at twelve minutes (at least 40 times above background levels); also performing simple paper and aluminum tests confirming beta and gamma radiation.

5. <u>HIGHEST LEVELS FOUND FAR FROM PLANT</u> The fact that the highest levels detected thus far were from Scottsboro, 70 miles downwind of Browns Ferry, indicates a possibility that dispersion of radioactive emissions from nuclear plants may be an inconsistent result of wind and precipitation patterns, and may travel relatively long distances from a plant; however, the source can not be pin-pointed without spectrometers.

BEST has made their users manual available online at RadiationMonitors.blogspot.com and many of their field test operations can be viewed through a series of internet-based videos at RadiationVideos.blogspot.com. (Also see Appendix 5.)

D. <u>RADIOACTIVITY LEVELS IN THE BODY</u>

In the 1950s and 1960s, Washington University and the Greater St. Louis Committee for Nuclear Information collected 320,000 baby teeth, and tested them for levels of radioactive Strontium-90, one of dozens of radioactive chemicals found only in atomic bomb tests and nuclear reactor emissions. It is chemically similar to calcium, seeking out bone and teeth, and resides in the body for many years (half-life of 28.7 years), making it possible to test in-body levels. Sr-90 impairs and kills cells in the bone and bone marrow (in which the immune system defenses are built) making it a risk factor for all cancers.

The St. Louis study found that for children born in 1964, just after above-ground bomb testing ended, the average Sr-90 level was **50 times greater** than for those born in 1950, just before testing began. After above-ground atom bomb tests were banned, Sr-90 averages declined sharply (about 50% from 1964-1969) until the federal government discontinued the study in 1970. (Source: Rosenthal HL. Accumulation of Environmental 90Sr in Teeth of Children. Hanford Radiobiological Symposium, Richland WA, May 1969, 163-171).

From 1961-1982, the U.S. Atomic Energy Commission (later the U.S. Department of Energy or DOE) operated a program measuring annual Sr-90 concentrations in the vertebrae of 100 healthy adults in San Francisco and New York City who had died in accidents. From 1965-74, after the Partial Test Ban Treaty reduced levels of fallout in diet, the average concentration of Sr-90 declined by 50% and at a lesser rate thereafter.

(Source: Klusek CS, Strontum-90 in Human Bone in the U.S., 1982. New York: Department of Energy Environmental Measurements Laboratory, 1982.)

The DOE terminated its program in 1982. Since then, the U.S. has been without a systematic government program of testing humans for radioactivity levels in their bodies.

From 1996 to 2006, the Radiation and Public Health Project (RPHP) research group conducted a baby tooth study measuring Sr-90 levels, known as the Tooth Fairy Project. The study is patterned on the St. Louis effort, which provides historical data on Sr-90 levels in the U.S. **The RPHP tooth project represents the only study in the U.S. of in-body radioactivity for persons living near nuclear reactors.**

RPHP collected and tested nearly 5000 teeth, mostly from California, Connecticut, Florida, New Jersey, New York, and Pennsylvania. It found a consistent pattern of elevated Sr-90 (30 to 50% higher) in baby teeth living in counties closest to reactors, and a 49% rise in Sr-90 for children born in the late 1990s vs. the late 1980s. (Source: Mangano JJ et al. An unexpected rise in strontium-90 in US deciduous teeth in the 1990s. The Science of the Total Environment 2003;317:37-51). Very few teeth from Alabama were collected and tested.

IV. HEALTH RISKS OF BROWNS FERRY

A. INTRODUCTION

Since the atomic era began in the 1940s, scientists have studied effects of exposures to man-made radioactivity. Elevated levels of illness and death are attributed to the Hiroshima and Nagasaki bombs; bomb tests in Nevada, the South Pacific, and the former Soviet Union; and the 1986 accident at the Chernobyl nuclear power plant. Each of these involved relatively high levels of exposure to radioactivity.

In addition, researchers have addressed effects of relatively low doses of radioactivity. The first to document hazards of low-dose exposures was British physician Alice Stewart. In the 1950s, Stewart showed that a pelvic X-ray to a pregnant woman nearly doubled the chance the baby would die of cancer before age 10. (Source: Stewart AM, Webb J, and Hewitt D. A Survey of Childhood Malignancies. British Medical Journal, 1958;i:1495-1508).

Studies of low-dose exposures have addressed many diseases, but often focus on cancer in children. Radioactive chemicals are known to be more harmful to the young, particularly the developing fetus and infant. Body growth and cell division is most rapid early in life, and thus a damaged cell is most likely to cause harm. **There are at least 19 medical journal articles that identify elevated child cancer rates near different nuclear plants**, mostly power plants (see Appendix 1).

B. DEFINING AREAS CLOSEST TO BROWNS FERRY

Defining which areas are most likely to be harmed by toxic emissions from Browns Ferry is an inexact process. The most affected are a result of proximity and downwind location, along with the source of food and water. The prevailing wind direction in the area is, similar to most of the continental U.S., from west to east (usually from the northwest in colder months and from the southwest in warmer months).

The seven Alabama counties closest to and downwind of Browns Ferry will be used for most analyses. These counties have a combined 2010 population of 788,867, including DeKalb (71,109), Jackson (53,227), Lawrence (34,339), Limestone (82,782), Madison (334,811), Marshall (93,109). The city of Huntsville is in Madison County. These counties are used because BEST citizens found the highest environmental radiation levels were detected in Scottsboro, 70 miles downwind. The map below shows monitored sites.

Map shows Browns Ferry and BEST radiation test sites. by Roy Simmons for BEST/MATRR

C. BREAST CANCER MORTALITY NEAR BROWNS FERRY

RPHP's Jay Gould performed research on breast cancer near nuclear reactors. In his 1996 book *The Enemy Within*, Gould used National Center for Health Statistics data to show that women living within 100 miles of nuclear reactors are at the greatest risk of dying of breast cancer. (Source: Gould JM et al. The Enemy Within: The High Cost of Living Near Nuclear Reactors. New York: Four Walls Eight Windows, 1996).

Gould found that for most counties closest to Browns Ferry, the breast cancer death rate for white women rose substantially from the early 1950s to the late 1980s (Table 8). These include Limestone (+15%), Madison (+74%), and Morgan (+4%). The exception is Lawrence County (-37%). By contrast, rates for the U.S. only rose 1%.

TABLE 9

Breast Cancer Mortality Rates, White Females and All Ages
Alabama Counties Closest to Browns Ferry Nuclear Plant, 1950-54 and 1985-89

	Rate/100,000 (Deaths)		
County	1950-54	1985-89	% Change
Lawrence	20.4 (8)	12.9 (10)	- 37%
Limestone	18.8 (11)	21.7 (27)	+15%
Madison	15.9 (20)	27.6 (149)	+74%
Morgan	16.6 (17)	17.3 (50)	+ 4%
U.S.	24.4 (91932)	24.6 (178868)	+ 1%

Source: National Center for Health Statistics, in *The Enemy Within*, Gould JM et al. New York: Four Walls Eight Windows, 1996. Rates age adjusted to 1950 U.S. Standard.

D. THYROID CANCER INCIDENCE

Exposure to radioactive fission products constitutes a risk factor for all cancers. However, some cancers are considered more radiosensitive than others. One is childhood cancer, for reasons already explained. Another is thyroid cancer. One of the radioactive chemicals not found in nature, but produced only in atom bomb tests and nuclear reactor operations is radioisotopic iodine, which seeks out the thyroid gland when it enters the body, impairing and killing cells. Experts have not identified any true cause of thyroid cancer other than exposure to radioactive iodine; other risk factors, such as presence of another thyroid disorder, are not considered causes of the disease.

Thyroid cancer, of which radioactive iodine produced by nuclear power or bombs is the only known cause, is the fastest-rising type of cancer in the U.S., its rate having more than tripled from 1980 to 2009. The annual number of Americans diagnosed with the disorder has risen from 12,000 to 56,000 since 1991. While some contend that better diagnosis over time accounts for this increase, numerous researchers assert that there are other, still unknown factors. (Source: National Cancer Incidence, Surveillance, Epidemiology, and End Results program, http://www.seer.cancer.gov).

Because thyroid cancer is often treatable, and 97% of victims live more than five years after diagnosis, incidence is a much more useful measure of thyroid cancer than mortality. Table 10 lists the 10 Alabama counties (with at least 15 cases) with the highest 2005-2009 thyroid cancer incidence rates in the state:

TABLE 10

Highest Thyroid Cancer Incidence
Alabama Counties, 2005-2009

County	Rate/100,000	(Cases)
1. Winston	15.6	(20)
2. Walker	12.4	(45)
3. Lauderdale	11.7	(55)
4. Marshall	**11.4**	**(55)**
5. Escambia	10.7	(20)
6. Jackson	**10.3**	**(30)**
7. Etowah	9.7	(55)
8. Madison	**9.3**	**(150)**
9. Limestone	**9.2**	**(35)**
10. Tuscaloosa	9.1	(75)

Black spot denotes Browns Ferry

U.S. Census Bureau
www.census.gov

Source: National Cancer Institute, State Cancer Profiles.
www.statecancerprofiles.cancer.gov. Age Adjusted to 2000 U.S. Standard Population

Of the 10 Alabama counties with the highest thyroid cancer rates, four (4) are among the seven proximate/downwind counties in this analysis. Among the four is Madison, with nearly one-half of the residents in the area. It appears that thyroid cancer in the area is higher than most Alabama counties.

E. Federal Studies of Cancer Near U.S. Nuclear Plants

The federal government conducts no systematic tracking of disease and death rates among persons living near nuclear plants. The only large-scale federal study on cancer near nuclear reactors was a 1990 effort prepared by the National Cancer Institute (NCI), after Senator Edward M. Kennedy wrote to the National Institutes of Health director James Wyngaarden about an article on elevated leukemia rates near the Pilgrim plant in Massachusetts. NCI concluded there was no link between cancer risk and proximity to reactors, even though study methods have received criticism.

Browns Ferry was one of the 62 nuclear plants included in the NCI's 1990 study. The project analyzed cancer mortality in five-year periods before and after reactor startup in the period 1950 to 1984. It used the Standard Mortality Ratio (SMR), or the county rate divided by the U.S. rate, as a measure of mortality. The only cancer incidence (as opposed to mortality) data in the report was near reactors in Connecticut and Iowa, which were the only states with operating and reliable cancer registries before 1984.

The NCI selected Lawrence and Limestone counties as the "study" counties most proximate to Browns Ferry. Table 11 shows the change in SMR for all cancers before (1950-1973) and after (1974-1984) the startup of Browns Ferry.

TABLE 11

Standard Mortality Ratio, All Cancers Combined
Lawrence and Limestone Counties, 1950-1973 and 1974-1984

Type of Cancer	Std. Mortality Ratio (Deaths) 1950-73	1974-84	% Change
All+	0.78 (1497)	0.91 (1230)	+17**
Leukemia	0.98 (91)	1.00 (55)	+ 2
Hodgkins Disease	0.79 (18)	1.17 (9)	+48
Non-Hodgkins Lymphoma	0.46 (24)	0.75 (31)	+63
Multiple Myeloma	0.56 (13)	0.66 (15)	+ 9
Stomach	0.89 (132)	0.58 (30)	- 35*
Colorectal	0.58 (162)	0.75 (135)	+29**
Liver	0.84 (56)	1.54 (31)	+83*
Trachea, Bronchus, Lung	0.61 (189)	1.00 (343)	+64*
Female Breast	0.75 (131)	0.79 (96)	+ 5
Thyroid	0.71 (5)	0.30 (1)	- 58
Bone and Joint	1.37 (20)	1.20 (6)	- 12
Bladder	0.76 (42)	0.76 (25)	0
Brain/Other Nervous Sys.	0.97 (46)	1.04 (36)	+ 7
Benign/unspecified neoplasms	1.13 (7)	1.40 (15)	+24

+Excluding Leukemia, * Significant at p<.05, ** Significant at p<.001
Source: Jablon S. et al. Cancer in Populations Living Near Nuclear Facilities. Washington DC: U.S. Government Printing Office, 1990.

Of the 15 types of cancer, the Standard Mortality Ratio (SMR) increased in 11; decreased in 3; and was unchanged in 1. The SMR increase for all cancers of 0.78 to 0.91, or from -22% to -9% below the U.S. rate, was highly significant at p<.001. Increases were also significant for colorectal, liver, and lung cancer.

In May 2009, the U.S. Nuclear Regulatory Commission published a notice in the Federal Register, announcing it was pursuing another study of cancer near nuclear plants. After dropping its initial choice of subcontractor (Oak Ridge Associated Universities), the NRC selected the National Academy of Sciences to conduct the study. The NAS has convened a panel to judge the feasibility of such a study, and to conduct and present it. There will be no public release of the study, whether or not it is completed, until at least 2015.

F. INFANT MORTALITY

In 2000 and 2002, this author, Joseph Mangano, published articles for the Radiation Public Health Project showing that when nuclear power plants shut down, deaths of infants under one year and cancer cases of children under five years in local downwind counties decline rapidly immediately after shutdown. Sources: Mangano JJ. Improvements in local infant health after nuclear power reactor closing. Environmental Epidemiology and Toxicology 2000;2(1):32-36. Mangano JJ et al. Infant death and childhood cancer reductions after nuclear plant closings in the United States. Archives of Environmental Health 2002;57(1):23-32.

Because the developing fetus and infant are especially sensitive to harmful biological effects of radiation exposure, any change in health status from adding or removing environmental radioactivity will first be observed in the youngest.

Table 12 shows the change in the infant death rate in the seven Alabama counties closest to and downwind from Browns Ferry, from the two-year period 1973-1974 (as the plant was running at limited power) to the two year period 1975-1976 (as the plant was operating at full power).

TABLE 12

Change in Local Infant Mortality, Age 0-1
Two Years Before 1973-74 and Two Years After 1975-76 Browns Ferry Startup

	Infant Deaths		Live Births		Deaths/1000		
Area	Before	After	Before	After	Before	After	% Ch
7 Counties	287	271	15213	14604	18.87	18.56	**- 1.6**
United States	108357	98790	6296923	6311986	17.21	15.65	**- 9.5**

Source: U.S. Centers for Disease Control and Prevention, http://wonder.cdc.gov. Compares periods 1973-1974 and 1975-1976. Includes DeKalb, Jackson, Lawrence, Limestone, Madison, Marshall, and Morgan Counties.

The change in the death rate under one year in the seven counties closest to Browns Ferry was -1.6%, much less than the reduction in the United States (-9.5%). Even though the difference was not statistically significant, the change in local infant mortality supports studies showing the fetus and infant are more susceptible to radiation doses than adults. (See Appendix 1)

Another opportunity to evaluate changes after reactor startup was the re-start of Browns Ferry Unit 1 in June 2007, after 22 years of the reactor being offline (since 1985). The change in infant mortality in the two years after the Unit 1 reactor operated at full power (2008-2009) was also compared with the prior two years, for the same seven downwind counties: Lawrence, Limestone, Morgan, Madison, Marshall, Jackson, and DeKalb.

The local infant death rate fell just -0.4% after Browns Ferry Unit 1 re-start in 2007, compared to a nationwide decline of -4.9%. The Unit 1 restart infant mortality difference fell short of statistical significance. However, this followed the same pattern that was indicated when the plant began operating in the mid-1970s (Table 12).

With 43 years of infant mortality data available, it is possible to evaluate trends in local rates, compared to the U.S., over a long period of time. Table 13 shows the change in mortality among infants younger than one year for five-year periods, from 1968 to 2010. (The six-year period 1968-1973 is used to illustrate the period before Browns Ferry began operating; the two-year period 2009-2010 is used because it is the most current data available on the CDC web site as of spring 2013).

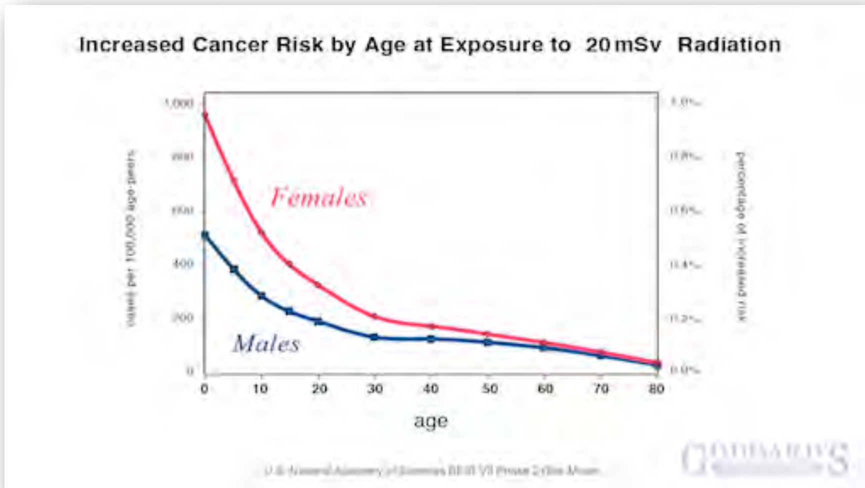
TABLE 13

Infant Mortality, Age 0-1
Seven-County Area in Northern Alabama vs. U.S.
Five Year Periods, 1968-2010

	Deaths/1000			
Period	Local	U.S.	Local Deaths	**% Local vs. U.S.**
1968-1973	20.99	19.71	1,084	**+ 6.5**
1974-1978	16.99	15.16	639	**+12.1**
1979-1983	12.73	12.05	501	**+ 5.7**
1984-1988	10.06	10.36	411	**- 2.8**
1989-1993	8.39	8.98	390	**- 6.5**
1994-1998	7.54	7.47	346	**+ 0.8**
1999-2003	7.76	7.14	352	**+ 8.7**
2004-2008	8.56	6.99	419	**+22.6**
2009-2010	7.80	6.42	154	**+21.6**

Source: U.S. Centers for Disease Control and Prevention, http://wonder.cdc.gov. Includes DeKalb, Jackson, Lawrence, Limestone, Madison, Marshall, and Morgan Counties.

After an initial jump in local vs. national infant mortality in the late 1970s, when Browns Ferry first began operating, the following years saw the local rate decline more rapidly, until it was below the U.S. But since the early 1990s, a steady increase has occurred in the local vs. national rate **(-6.5%, +0.8%, +8.7%, +22.6%, and +21.6%** for the latest two years available). With about 80 local infants dying each year in the seven counties, the numbers are large enough to merit further examination into potential reasons for this unexpected change, including exposure to emissions from Browns Ferry.



Source: National Academy of Sciences, *Biological Effects of Ionizing Radiation BEIR VII Phase 2 Report: Health Risks from Exposure to Low Levels of Ionizing Radiation*, National Academies Press, 2006, http://www.nap.edu/catalog/11340.html, (pg. 311), adjusted 100 mSv to 20 mSv by Ian Goddard according to BEIR instructions.

One way to further examine recent infant death rates is by race. Since 1999, the CDC web site classifies deaths into white non-Hispanics, black non-Hispanics, and white Hispanics, which make up nearly 100% of all deaths in the seven counties downwind of Browns Ferry. Table 14 shows local rates compared to the U.S. for each of these three racial/ethnic groups for the years 2004-2010, when local infant mortality was more than 20% greater than the U.S.

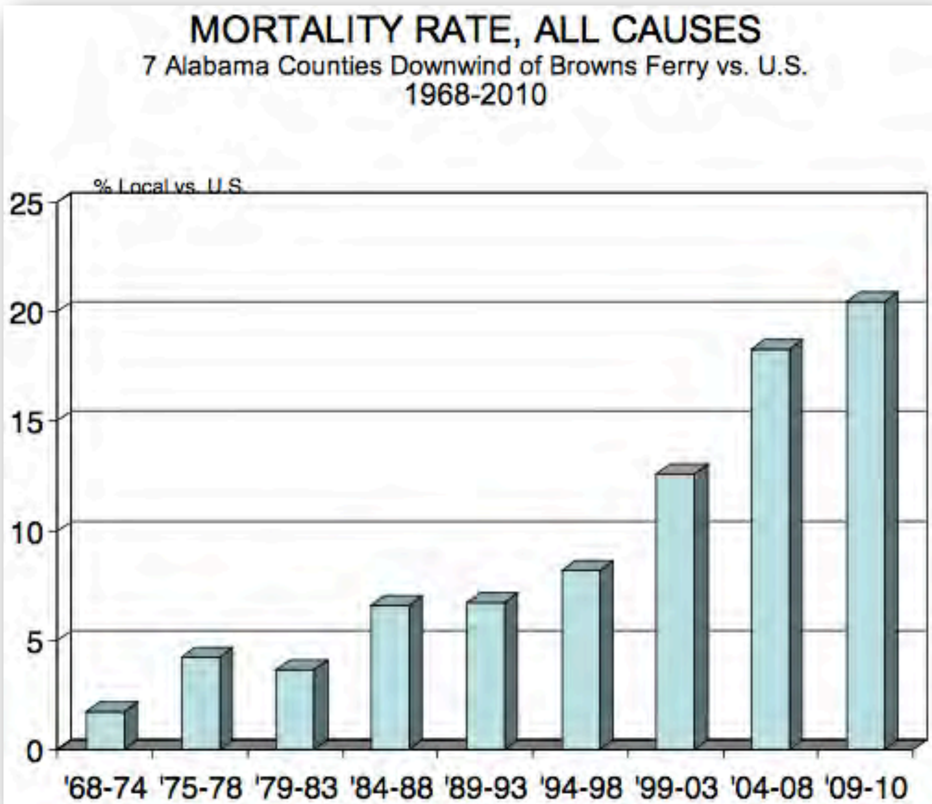
TABLE 14

Infant Mortality, Age 0-1, By Race, 2004-2010
Seven-County Area in Northern Alabama vs. U.S.

	Deaths/1000			
Group	Local	U.S.	Local Deaths	% Local vs. U.S.
White Hispanic	8.21	5.85	77	**+40.3**
White non-Hispanic	7.59	5.72	352	**+32.6**
Black non-Hispanic	12.71	13.46	135	**- 5.6**

Source: U.S. Centers for Disease Control and Prevention, http://wonder.cdc.gov. Includes DeKalb, Jackson, Lawrence, Limestone, Madison, Marshall, and Morgan Counties.

Local 2004-2010 infant mortality rates for whites greatly exceeded the U.S., both for Hispanics (+40.3%) and non-Hispanics (+32.6%). Both are statistically significant. The local rate for black non-Hispanics was actually 5.6% less than the nation, a non-significant difference.



G. LOCAL MORTALITY RATE FROM ALL CAUSES

Another way to examine any potential health hazards from Browns Ferry radioactive emissions is to examine mortality. As mentioned, the U.S. Centers for Disease Control and Prevention maintains a data base on its web site of all deaths in the U.S. from 1968 to 2010, and adds the latest year's data annually.

Table 15 shows the local age-adjusted mortality rate compared to the U.S. rate for each five-year period beginning in 1968. The first period (1968-1974) is six years, as it represents the period before large-scale operations began at Browns Ferry, and the last period (2009-2010) is only two years pending the addition of future years. The table uses the seven closest counties located downwind (east) of the plant.

TABLE 15

Mortality, All Causes Combined, All Ages
Seven-County Area in Northern Alabama vs. U.S.
Five Year Periods, 1968-2010

Period	Deaths/100,000 Local	Deaths/100,000 U.S.	Local Deaths	**% vs. US**	Expected	**Excess**
1968-1974	1244.0	1222.8	26,426	+ **1.7**	-	-
1975-1978	1113.1	1067.8	15,834	+ **4.2**	15,438	396
1979-1983	1042.5	1005.9	21,079	+ **3.6**	20,678	401
1984-1988	1043.4	978.5	23,883	+ **6.6**	22,713	1170
1989-1993	990.6	927.9	25,836	+ **6.7**	24,544	1292
1994-1998	965.4	892.5	28,650	+ **8.2**	26,788	1862
1999-2003	968.6	860.3	31,515	**+12.6**	28,080	3435
2004-2008	939.0	793.7	34,234	**+18.3**	28,551	5683
2009-2010	901.9	748.3	14,405	**+20.5**	11,452	2953
Total 1975-2010	**(36 years)**		**195,436**		**178,244**	**17,192** (**8.8%**)

Source: U.S. Centers for Disease Control and Prevention, http://wonder.cdc.gov. Rates age adjusted to 2000 U.S. Standard Population. Includes DeKalb, Jackson, Lawrence, Limestone, Madison, Marshall, and Morgan Counties.

In 1968-1974, largely before operations at Browns Ferry began, the local mortality rate was just 1.7% above the U.S. Thereafter, the gap steadily increased, until by 2009-2010, the local rate was 20.5% greater – the largest elevation in at least 43 years.

Because the annual number of deaths in the seven counties is now over 7,000, this trend is highly significant. There is no obvious demographic change, such as race, ethnicity, age, or gender that explains such a dramatic difference. But while there are many potential factors that could contribute to this steady increase, exposure to emissions from Browns Ferry should be considered as one.

It is notable that a similar trend in local infant deaths occurred for all deaths, and that currently, local rates for both are more than 20% above the U.S. rate.

In 1999-2010, the most recent 12-year period, in which the greatest local-national gap in mortality rates was observed, it would be informative to examine the patterns for various demographic groups. Table 16 provides these data for four age groups, for racial/ethnic groups, and for each gender.

TABLE 16

Mortality, All Causes Combined, All Ages
Seven-County Area in Northern Alabama vs. U.S.
By Race/Ethnicity, Gender, and Age Group, 1999-2010

Group	Deaths/100,000 Local	Deaths/100,000 U.S.	Local Deaths	% Local vs. U.S.
All Persons	943.0	811.7	80,154	**+16.2**
Race/Ethnicity				
White non-Hispanic	951.0	808.0	71,039	**+17.7**
Black non-Hispanic	1006.0	1042.5	8,198	**- 3.5**
Gender				
Males	1128.9	971.1	40,132	**+16.2**
Females	799.9	687.9	40,022	**+16.3**
Age at Death				
0-24	88.0	69.1	2,595	**+27.4**
25-44	192.0	152.7	4,745	**+25.7**
45-64	728.8	613.9	16,677	**+18.7**
65+	5482.0	4790.5	56,137	**+14.4**

Source: U.S. Centers for Disease Control and Prevention, http://wonder.cdc.gov. Rates age adjusted to 2000 U.S. Standard Population.. Includes DeKalb, Jackson, Lawrence, Limestone, Madison, Marshall, and Morgan Counties.

In the 12-year period, the local age-adjusted mortality rate for all deaths was 16.2% above the U.S., based on 80,154 deaths. Local rates exceeded the nation for each age group, males and females, and white non-Hispanics. All local-national differences were statistically significant. The only demographic group in which the local rate was less than the U.S. was for black non-Hispanics (-3.5% lower). This group accounted for 10% of the deaths in the seven counties from 1999-2010. The low rate for all deaths for black non-Hispanics was similar to the low rate for infant deaths in this racial/ethnic group.

Local death rates were especially high for young persons. The rates for persons who died at age 0-24 and 25-44 were 27.4% and 25.7% above the U.S., respectively.

Another way to examine mortality patterns in the seven closest counties downwind from Browns Ferry is by cause of death. Table 17 compares local and national 1999-2010 age-adjusted mortality rates for the 11 most common causes, which account for 98% of deaths, plus all others combined.

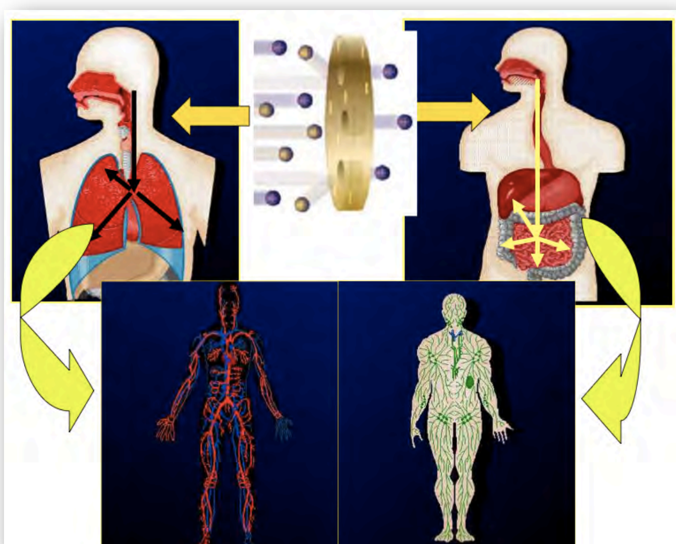
TABLE 17

Mortality, Most Common Causes, All Ages
Seven-County Area in Northern Alabama vs. U.S., 1999-2010

Cause	Deaths/100,000 Local	U.S.	Local Deaths	% Local vs. U.S.
All Persons	943.0	811.7	80,154	**+ 16.2**
Circulatory System	354.0	289.0	29,511	**+ 22.5**
Neoplasms	199.7	190.5	17,865	**+ 4.8**
Respiratory System	95.8	78.4	8,079	**+ 22.3**
Homicide, Suicide, Accidents	68.2	57.6	5,922	**+ 18.4**
Nervous System	43.5	38.5	3,512	**+ 13.0**
Endocrine, Nutr., Metabolic	36.8	32.8	3,155	**+ 12.4**
Digestive System	31.6	29.0	2,778	**+ 9.1**
Genitourinary System	30.3	20.3	2,477	**+ 49.5**
Infectious/Parasitic Diseases	21.9	21.7	1,887	**+ 0.9**
Mental/Behavioral Diseases	23.3	25.1	1,817	**- 7.0**
Signs and Symptoms	19.7	11.1	1,625	**+ 77.9**
All Other	18.2	17.9	1,526	**+ 1.6**

Source: U.S. Centers for Disease Control and Prevention, http://wonder.cdc.gov. Rates age adjusted to 2000 U.S. Standard Population.. Includes DeKalb, Jackson, Lawrence, Limestone, Madison, Marshall, and Morgan Counties.

The seven county mortality rate exceeded the U.S. rate for 11 of the above 12 categories. Of the 11 categories with excesses, 9 were statistically significant. The greatest excesses include signs and symptoms (+77.9%), genitourinary system disorders (+49.5%), circulatory system disorders (+22.5%), and respiratory system disorders (+22.3%).



Graphic Source: Antonietta M. Gatti et al, "Nanopathology: The Role of Micro and Nanoparticles in Biomaterial-induced Pathology", The European Commission, Project QLRT-2002-J47 (2002-2005), http://inchesnetwork.net/Fetal%20and%20embryological%20origin%20of%20diseases_Gatti.pdf

Analysts often point out that there may be limitations in geographic comparisons by cause of death. Categories are defined by the primary cause of death; in many cases, a decedent suffers from multiple disorders (such as heart disease and cancer). There are rules to define which cause is the primary cause, but they can be subject to interpretation by physicians completing death certificates and coders assigning a code to the primary cause of death. In other cases, a vague symptom might be assigned as the primary cause of death instead of a known disease entity; the seven-county death rate from signs and symptoms is nearly double that of the U.S. (19.7 vs. 11.1 deaths per 100,000 persons).

The local mortality rate from neoplasms, or cancers, is just 4.8% above the U.S. However, there is a possibility that a greater proportion of those local decedents who had cancer were assigned to another disease category than in the nation as a whole.

It is clear that the consistently high local death rates across various causes of death show an unusual pattern worthy of greater investigation, especially since the 1968-1974 local death rate was just 1.7% above the U.S, compared to the 2010 rate of 20.5%.

H. CHILD CANCER INCIDENCE

Another health condition sensitive to radiation is childhood cancer. As mentioned, a dose of radiation causes much more genetic and cellular damage to the fetus, infant, and young child than the same exposure does to an adult. However, it is not possible to examine long-term trends in cancer incidence in Alabama, since the state cancer registry only began in 1996, and the latest available data are for cases diagnosed in 2009.

In the most recent available period (2005-2009), cancer incidence among children age 0-19 for each Alabama county with at least 15 cases in the five year period is provided on the internet. Rates for two of the four counties closest to Browns Ferry exceeded the Alabama rate of 15.2 cases per 100,000 per year; Limestone County (21.8) and Morgan County (16.7). Madison County's rate (12.4) was below the state; and no figures are calculated for all 50 states combined. Given limited data, a precise cause and effect relationship between Browns Ferry and local childhood cancer cannot be made or rejected. Nevertheless, there are 26 children a year who contract cancer in Browns Ferry's Limestone County and 42 kids a year who get cancer in downwind Madison County for yet unknown reasons. Source: National Cancer Institute, State Cancer Profiles. www.statecancerprofiles.cancer.gov and census.gov.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

This report has addressed patterns of radioactive emissions from the Browns Ferry Nuclear Power Plant, and potential links with adverse health effects among those living near or downwind of the plant. The plant has three of the five operating nuclear power reactors in Alabama. Nearly 1 million persons live within 50 miles of Browns Ferry.

The potential health consequences posed by Browns Ferry are massive. The plant contains 1,932 metric tons (containing 314,140,400 curies) of high-level radioactive waste, the highest of all U.S. nuclear plants except for Dresden IL. Most of this radioactivity is stored in deep pools of constantly-cooled water; loss of cooling water would result in a disastrous meltdown, which would poison many thousands of persons. A 1982 U.S. government panel estimated casualties from a core meltdown near all U.S. nuclear plants, and calculated 60,000 acute radiation poisoning and 3,800 cancer deaths per reactor near Browns Ferry. The numbers would be higher today because of increased population and additional casualties beyond the 20- and 30-mile limits of the study.

Browns Ferry has had a checkered safety record. The six shutdowns of at least one year is the highest number at any U.S. nuclear plant. The source of one of these shutdowns, the 1975 fire at Browns Ferry unit 1, is regarded by many as the most serious accident at a U.S. nuclear power plant other than the Three Mile Island partial meltdown. In addition, the 22-year outage at Browns Ferry 1 from 1985 to 2007 is easily the longest 'temporary' shutdown of any U.S. nuclear reactor.

The design of the Mark I reactor cooling pools at Browns Ferry are vulnerable to attacks by tornados as well as terrorists, since they are raised four stories in the air with no hardened overhead containment of these pools holding millions of pounds of highly enriched radioactive fuel in addition to nearly a million gallons of radioactive water. Browns Ferry is also one of the four nuclear power plant sites in history to receive a 'Red Finding' (the most severe short of plant shutdown) from the Nuclear Regulatory Commission in May, 2011 – a finding which still stands today.

While official measurements of radioactive emissions and environmental levels are often limited, some findings suggest that Browns Ferry is adding harmful radioactivity to the environment and food chain. For example, quarterly tritium levels taken since 1996 in drinking water at Muscle Shoals and Scottsboro were 3-4 times and 7-8 times greater than those in Montgomery, a control site far from any nuclear power plant.

Citizen-based monitoring, while only in operation for seven months, shows preliminary patterns indicating that Browns Ferry may be adding to environmental radioactivity levels, especially at downwind and downriver sites, and after rain events; however, spectrographic analyses of the offending radionuclides is required to determine specific identification of the radiation sources. BEST monitoring has recorded radiation levels from double to 40 times greater than background levels downwind and downriver from Browns Ferry, with only near background readings upwind and upriver. Since the highest levels recorded were found 70 miles downwind, early datum suggest the possibility that radioactivity from Browns Ferry may travel long distances before returning to earth.

The report also examined patterns of disease and death rates near Browns Ferry. For this purpose, the seven-county area immediately downwind (east) of the plant, with a population of about 800,000, was compared with the U.S. averages. Findings included:

1. Infant deaths changed little in the first two years after Browns Ferry startup in the 1970s, and the first two years after restart of Browns Ferry 1 in 2007.

2. The local infant death rate was below the U.S. in the late 1980s and early 1990s. However, the local rate has diverged steadily from the nation in the last decade (latest records are for 2010), until it has currently reached a level 22.3% above the U.S. These elevated infant death rates are even greater for whites (32.6%) and Hispanics (40.3%).

3. The mortality rate for all causes combined in the seven counties rose steadily from +1.7% above the U.S. in the early 1970s to +20.5% in the latest period (2009-2010). Elevated rates were observed for both genders, all age groups, whites (not blacks), and all major causes of death except for mental disorders.

4. Some of the highest current thyroid cancer rates in Alabama occurred in the seven-county area.

B. Recommendations

This report has provided information about the potential adverse health consequences that the Browns Ferry nuclear facility poses to many thousands of local residents. Some questions have been raised, especially the steadily rising mortality rate in the closest downwind counties.

While these data should be taken seriously, they also need to be followed up with additional studies. Continued citizen-based monitoring of environmental radioactivity levels should be encouraged, and results should be considered by EPA, TVA and NRC officials, who are responsible for the health and safety surrounding nuclear power facilities, and therefore must consider and implement improvements in current methods of measuring emissions and environmental radioactivity emanating from Browns Ferry.

The unusual and steady rise in local death rates should be taken seriously by health officials, who need to conduct their own studies to examine potential causes – among them, toxic releases from Browns Ferry.

Continued operations of the Browns Ferry reactors, which are aging and are now reaching their original design-basis age limit of 40 years, should include a “report card” of emissions performance, for which that they have not been held accountable in the past, so that sound decisions can be made to best protect the public health.

APPENDIX 1: JOURNAL ARTICLES (19) THAT IDENTIFY ELEVATED LEVELS OF CHILDHOOD CANCER NEAR NUCLEAR PLANTS

Sharp L, McKinney PA, Black RJ. Incidence of childhood brain and other non-haematopoietic neoplasms near nuclear sites in Scotland, 1975-94. *Occupational and Environmental Medicine,* 1999; 56(5): 308-314.

Busby C, Cato MS. Death rates from leukaemia are higher than expected in areas around nuclear sites in Berkshire and Oxfordshire. *British Medical Journal,* BMJ 1997; 315(7103): 309.

Black RJ, Sharp L, Harkness EF, McKinney PA. Leukaemia and non-Hodgkin's lymphoma: incidence in children and young adults resident in the Dounreay area of Carthness, Scotland in 1968-91. *Journal of Epidemiology and Community Health,* 1994; 48(3): 232-236.

Draper GJ, Stiller CA, Cartwright RA, Craft AW, Vincent TJ. Cancer in Cumbria and in the vicinity of the Sellafield nuclear installation, 1963-90. *British Medical Journal,* BMJ 1993; 306(6870): 89-94.43.

Goldsmith JR. Nuclear installations and childhood cancer in the UK: mortality and incidence for 0-9 year-old children, 1971-1980. *The Science of the Total Environment* 1992; 127(1-2): 13-35.

Kinlen LJ, Hudson CM, Stiller CA. Contacts between adults as evidence for an infective origin of childhood leukaemia: an explanation for the excess near nuclear establishments in west Berkshire? *British Journal of Cancer* 1991; 64(3): 549-554.

Ewings PD, Bowie C, Phillips MJ, Johnson SA. Incidence of leukemia in young people in the vicinity of Hinkley Point nuclear power station, 1959-86. *British Medical Journal,* BMJ 1989; 299(6694): 289-293.

Cook-Mozaffari PJ, Darby SC, Doll R, Forman D, Herman C, Pike MC, Vincent T. Geographical variation in mortality from leukemia and other cancers in England and Wales in relation to proximity to nuclear installations, 1969-78. *British Journal of Cancer* 1989; 59(3): 476-485.

Roman E, Beral V, Carpenter L, Watson A, Barton C, Ryder H, Aston DL. Childhood leukaemia in the West Berkshire and Basingstoke and North Hampshire District Health Authorities in relation to nuclear establishments in the vicinity. *British Medical Journal,* BMJ (Clinical Research Edition) 1987; 294(6572): 597-602.

Appendix 1

Forman D, Cook-Mozaffari P, Darby S, Davey G, Stratton I, Doll R, Pike M. Cancer near nuclear installations. *Nature* 1987; 329(6139): 499-505.

Heasman MA, Kemp IW, Urquhart JD, Black R. Childhood leukemia in northern Scotland. *Lancet* 1986; 1(8475): 266.

Gunay U, Meral A, Sevinir B. Pediatric malignancies in Bursa, Turkey. *Journal of Environmental Pathology, Toxicology, and Oncology* 1996; 15(2-4): 263-265.

McLaughlin JR, Clarke EA, Nishri ED, Anderson TW. Childhood leukemia in the vicinity of Canadian nuclear facilities. *Cancer Causes and Control* 1993; 4(1): 51-58.

Viel JF, Pobel D, Carre A. Incidence of leukaemia in young people around the La Hague nuclear waste reprocessing plant: a sensitivity analysis. *Statistical Medicine* 1995; 14(21-22): 2459-2472.

Hoffmann W, Dieckmann H, Schmitz-Feuerhake I. A cluster of childhood leukemia near a nuclear reactor in northern Germany. *Archives of Environmental Health* 1997; 52(4): 275-280.

Zaridze DG, Li N, Men T, Duffy SW. Childhood cancer incidence in relation to distance from the former nuclear testing site in Semipalatinsk, Kazakhstan. *International Journal of Cancer* 1994; 59(4): 471-475.

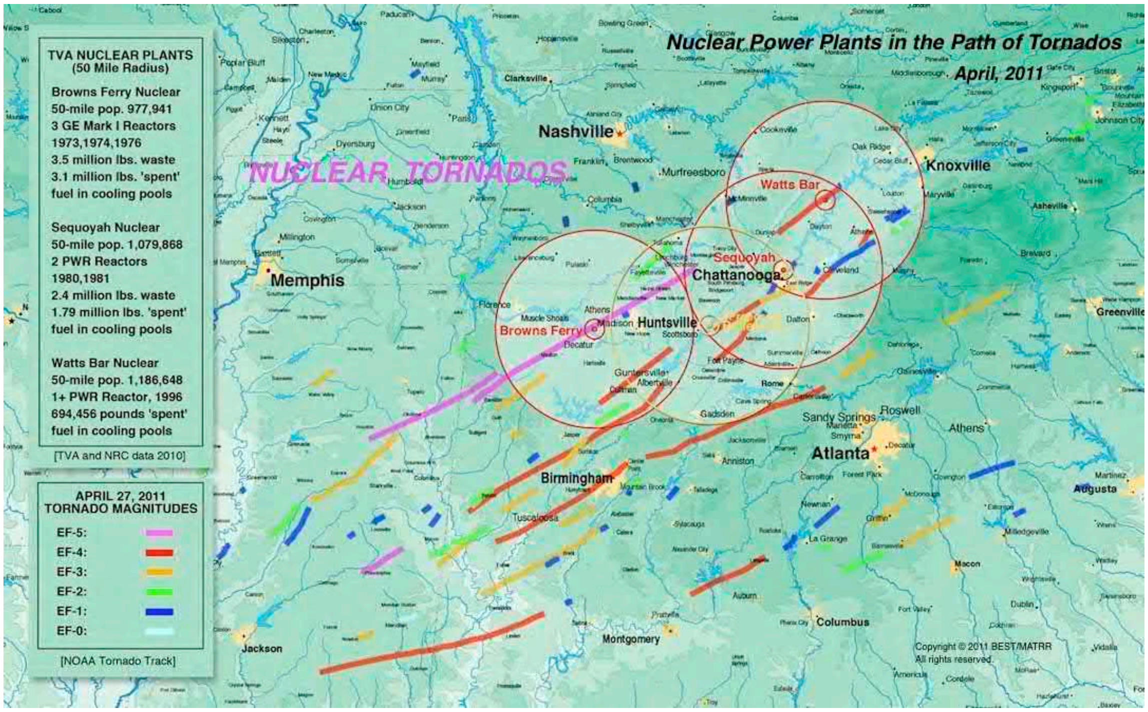
Mangano JJ, Sherman J, Chang C, Dave A, Feinberg E, Frimer M. Elevated childhood cancer incidence proximate to U.S. nuclear power plants. *Archives of Environmental Health* 2003; 58(2): 74-82.

Spix C, Schmiedel S, Kaatsch P, Schultze-Rath R, Blettner M. Case-control study on childhood cancer in the vicinity of nuclear power plants in Germany 1980-2003. *European Journal of Cancer* 2008; 44(2); 275-284.

Sermage-Faure C, Laurier D, Goujon-Bellec S, Chartier M, Guyot-Goubin A, Rudant J, et al. Childhood leukemia around French nuclear power plants – the Geocap study, 2002-2007. *International Journal of Cancer* 2012; 131(5): E769-E780.

Appendix 2: Nuclear Power Plants in the Path of Tornados April 27, 2011

50 Mile Radii of Nuclear Power Plants in the Tennessee Valley and 2011 Tornado Tracks



Sources: NOAA Tornado Tracks http://www.srh.noaa.gov/srh/ssd/mapping/; Bill Dedman, NBC News, "Nuclear Neighbors: Interactive Map," http://www.srh.noaa.gov/srh/ssd/mapping/; Pam Sohn, "Nuclear Waste Piling Up in Region," http://www.timesfreepress.com/news/2010/mar/22/nuclear-waste-piling-up-in-region/ Nuclear Tornados map created by Roy Simmons for BEST/MATRR, May 2011.

Appendix 3: Radioactive Leaks at Browns Ferry Nuclear Plant

Record of leaks and spills at TVA's Browns Ferry Nuclear Power Plant near Decatur, AL.

In chronological order, 1973 - 2010

Sources: Union of Concerned Scientists (UCS), "Groundwater Events Sorted by Location," September 29, 2010, http://www.ucsusa.org/assets/documents/nuclear_power/Groundwater-Events-Sorted-by-Location.pdf

1. 1973, October 19

Browns Ferry Unit 1 About 1,400 gallons of liquid radwaste of unknown, unanalyzed concentration was inadvertently discharge to the river due to personnel error. The liquid radwaste tank was intended to be placed in recirculation mode but was mistakenly placed in discharge mode.

2. 1977, January 4

Browns Ferry Unit 1 A leak in a residual heat removal heat exchanger allowed radioactive water to be released to the river at levels exceeding technical specification limits.

3. 1978, July 15

Browns Ferry Unit 1 After the unit was shut down for maintenance, the residual heat removal system was placed in operation to assist shut down cooling of the reactor vessel water. Workers determined that a residual heat removal heat exchanger had a tube leak and that radioactively contaminated water was being discharged to the Tennessee River "at a rate above permissible limits."

4. 1983, January 16

Browns Ferry Unit 3 A leaking tube in a residual heat removal heat exchanger allowed radioactive water from the reactor coolant system to be released to the river at levels exceeding technical specification limits.

5. 2001, January 00

Browns Ferry Unit 3 Tritium levels greater than baseline values were detected in an onsite monitoring well west of the Unit 3 condenser circulating water conduit in the radwaste loading area.

6. 2005, March 00

Browns Ferry Unit 1 A leak in a pipe elbow on the east side of the cooling tower and an overflow of the cooling tower basin caused by malfunction of the system level indicators resulted in radioactive contamination of the concrete pad and ground around the tower.

7. 2005, March 00

Browns Ferry Unit 2 A leak in a pipe elbow on the east side of the cooling tower and an overflow of the cooling tower basin caused by malfunction of the system level indicators resulted in radioactive contamination of the concrete pad and ground around the tower.

8. 2005, March 00

Browns Ferry Unit 3 A leak in a pipe elbow on the east side of the cooling tower and an overflow of the cooling tower basin caused by malfunction of the system level indicators resulted in radioactive contamination of the concrete pad and ground around the tower.

9. 2005, November 00

Browns Ferry Unit 1 Tritium levels greater than baseline values were detected in an underground cable tunnel between the intake structure and the turbine building. Samples taken in January 2006 identified gamma emitters in addition to tritium (beta emitter).

10. 2005, November 00

Browns Ferry Unit 2 Tritium levels greater than baseline values were detected in an underground cable tunnel between the intake structure and the turbine building. Samples taken in January 2006 identified gamma emitters in addition to tritium (beta emitter).

11. 2005, November 00

Browns Ferry Unit 3 Tritium levels greater than baseline values were detected in an underground cable tunnel between the intake structure and the turbine building. Samples taken in January 2006 identified gamma emitters in addition to tritium (beta emitter).

12. 2006, February 00

Browns Ferry Unit 1 A soil sample taken from underneath the radwaste ball joint vault (located outside the radwaste doors) indicated trace levels of cobalt-60 and cesium-137.

13. 2006, February 00

Browns Ferry Unit 2 A soil sample taken from underneath the radwaste ball joint vault (located outside the radwaste doors) indicated trace levels of cobalt-60 and cesium-137.

14. 2006, February 00

Browns Ferry Unit 3 A soil sample taken from underneath the radwaste ball joint vault (located outside the radwaste doors) indicated trace levels of cobalt-60 and cesium-137.

15. 2008, January 05

Browns Ferry Unit 3 The condensate storage tank overflowed due to failed tank level instrumentation. The spilled water flowed into the sump in the condensate piping tunnel, triggering a high level alarm that prompted workers to initiate the search that discovered the overflow condition. Some of the spilled water may have permeated through the pipe tunnel into the ground.

16. 2010, April 07

Browns Ferry Unit 3 Approximately 1,000 gallons of radioactively contaminated water leaked from Condensate Storage Tank No. 5 as workers were transferring water between condensate storage tanks. A worker conducting routine rounds observed water leaking from an open test valve near the top of CST No. 5.

APPENDIX 4: REQUEST TO SUSPEND BROWNS FERRY OPERATING LICENSE

Blue Ridge Environmental Defense League
www.BREDL.org PO Box 88 Glendale Springs, North Carolina 28629 BREDL@skybest.com (336) 982-2691

October 7, 2011

Siva P. Lingam, Project Manager
Plant Licensing Branch 11-2
Division of Operating Reactor Licensing
U.S. Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, MD 20852

RE: § 2.206 Request for Action to Suspend GE Mark I Boiling Water Reactors Operating Licenses due to Flawed Primary Containment and Unreliable Back-up Electric Power Systems for Cooling Spent Fuel Pools

Pursuant to 10 CFR § 2.206, the Blue Ridge Environmental Defense League ("BREDL" or "Petitioner") hereby submits written testimony regarding our June 7, 2011 joint petition request to the Nuclear Regulatory Commission for emergency enforcement action. The purpose of this request is to have NRC protect public health and safety through the prompt and thorough evaluation of safety problems at the Browns Ferry Nuclear Plant operated by the Tennessee Valley Authority near Athens, Alabama. BREDL is one of the co-petitioners ("Petitioners") to the Beyond Nuclear petition ("Petition") submitted on April 13, 2011. These remarks identify the enforcement action requested and the facts that BREDL believes are sufficient grounds for NRC to take enforcement action at Browns Ferry.

The Petitioners request that the NRC immediately suspend the operating licenses of General Electric (GE) boiling-water reactor (BWR) Mark I units to ensure that public health and safety is not unduly jeopardized. The Petition focuses on the unreliability of the GE BWR Mark I containment system to mitigate a severe accident and the lack of emergency power systems to cool high density storage pools and radioactive reactor fuel assemblies.

Esse quam videre

Two items recommended by the NRC for further review; specifically, the possible overheating of radioactive fuel pools during an emergency and the loss of power such as the recent tornado-caused black outs. The GE Mark I irradiated fuel pools are located at the top of the reactor building and currently do not have backup power if offsite and onsite electrical power were lost simultaneously. Other petition items accepted by the NRC for review are: 1) the failure of the Mark I to prevent radioactive contamination of the atmosphere and ocean, 2) failure of the hardened vent system to cope with a severe accident and 3) the threats posed by rising river water at reactors located in flood plains.

Background

On April 13, 2011, Beyond Nuclear filed a petition for an enforcement action under 10 CFR 2.206. On April 19, 2011, the Petition Review Board denied the request for immediate action only. On or about June 7 BREDL and others submitted copetitioners requests. The PRB held a public meeting June 8. Over 3,000 co-petitioner requests were received by the NRC following the June 8 public meeting. On August 16, 2011, the Petitioners were informed of the Petition Review Board's decision to accept in part the petition for review.

Enforcement action requested

The Petition seeks to suspend the operation of the General Electric Mark I Boiling Water Reactors, which are almost identical to the Fukushima reactors that melted down in Japan. Petitioners ask that the Mark I reactors cease operations until several emergency actions are taken including: 1) that the NRC revoke the 1989 prior approval for all GE Mark I operators to voluntarily install the same experimental hardened vent systems on flawed containment structures that the Fukushima catastrophe demonstrates to

have a 100% failure rate and; 2) that the agency immediately issue Orders requiring all U.S. Mark I operators to promptly install dedicated emergency back-up electrical power to ensure reliable cooling systems for the densely packed spent fuel pools. The GE BWR fuel pools are located at the top of the reactor building and currently do not have backup power if offsite and on-site electrical power were lost simultaneously.

Further, BREDL seeks the following specific actions: 1) NRC should order TVA to evaluate pressure suppression containment venting to determine whether the Browns Ferry Nuclear Plant should be allowed to continue operation. 2) NRC should issue an order to TVA to inspect control rod blades at Browns Ferry and not merely rely on the suggestion in an Information Notice; and 3) The NRC should order TVA to eliminate the existing unsafe irradiated fuel storage system at Browns Ferry and move the fuel to hardened storage in concrete structures.

In accordance with 10 CFR 2.202(e)(1), these orders would involve the modification of a part 50 license and are backfits; therefore, the requirements of § 50.109(a)(5) are to be followed; i.e., "The Commission shall always require the backfitting of a facility if it determines that such regulatory action is necessary to ensure that the facility provides adequate protection to the health and safety of the public and is in accord with the common defense and security." TVA is subject to the Commission's jurisdiction.

Facts Supporting Enforcement Action

- ***Reactor Containment***

The GE Mark I reactor was badly designed. To correct a fundamental flaw, pressure suppression containments systems were added to these plants in order to prevent high

pressures inside the reactor containment building during an accident. To do this, the direct torus vent system was designed to release steam—unfiltered and radioactive—directly to the atmosphere. Banning such dangerous pressure suppression methods and substituting safer dry containments was proposed by a few principled nuclear engineers, but their advice fell on deaf ears because it would, "[M]ake unlicensable the GE and Westinghouse plants now in review."[1] Today, some principled engineers persist in this quest to turn the NRC back from the dark side of promoting nuclear power to regulating it. This year, Arnold Gundersen stated the case most eloquently to the Advisory Committee on Reactor Safeguards:

Everyone sitting on the ACRS today knows that the pressure suppression

> containments on General Electric BWR's were inadequate when they were first designed. As a result of that design inadequacy, boiling water reactor containment vents were added in 1989 to prevent containment overpressurization. Currently there are 23 Mark 1 containment systems in operation. All 23 Mark 1's have vents that were added as a Band-Aid fix. It is time for the ACRS to evaluate containment venting to determine whether or not it any of these reactors be allowed to continue operation. [2]

The nuclear disaster at Fukushima Dai-ichi lends an urgency to the immediate question: What will it take to convince the NRC to prevents a similar disaster in the United States? Germany, when faced with the issue of providing energy with adequate protection to the health and safety of the public and in accord with the common defense and security said *no* to the nuclear power program in its entirety.

Further, it is just plain wrong to posit, as the NRC does, that no radioactive leaks are associated with the GE Mark I reactor pressure suppression containments systems. To avoid exceeding the primary containment pressure limit, that is what they are designed to

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1 Note from Joseph M. Hendrie to John F. O'Leary, September 25, 1972.

2 Statement of Arnold Gundersen, Advisory Committee on Reactor Safeguards Subcommittee on Fukushima, Official Transcript of meeting of May 26, 2011, NRC HQ, Rockville, MD, ADAMS Accession No. ML11147A075

do in an accident. Based on his post-Fukushima findings, Gundersen served up crow to the committee:

> In December of 2010 I wrote to you again notifying you of a significant amount of additional information about containment failures and flaws because at the October 2010 ACRS meeting, the NRC staff informed the ACRS that the NRC's calculations assume that there is zero leakage in the Mark 1 design. Each time I have contacted you, the containment integrity data has been rebuffed and ignored. The accidents at the Fukushima Mark 1 BWR reactors have confirmed my belief that leakage of a nuclear containment cannot be based upon the assumption of a leakage rate of zero used by the NRC. This week, Tokyo Electric Power Company (TEPCO) has finally acknowledged that all three of the Fukushima Mark 1 containment systems are leaking significant radiation into the environment, and at least Units 1 and 2 began leaking on the first day of the accident. Unfortunately, the possibility of such containment failures, to which I have alerted you for the past six years, have been proven correct.[3]

If indeed United States were unable to license nuclear plants without pressure suppression containment Band-Aids, then perhaps Germany's example is correct. The NRC should order TVA to evaluate pressure suppression containment venting to determine whether the Browns Ferry Nuclear Plant should be allowed to continue operation.

- ***Control Rod Cracks***

Plant inspections done by the manufacturer indicate that the Browns Ferry Nuclear Plant suffers from cracking of the control rods necessary for shutting down the reactor. Based on this information, the manufacturer predicts that the control rods will fail sooner. An NRC Information Notice (IN) issued in June 2011 states:

> The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to inform addressees that GE Hitachi Nuclear Energy (GEH) has discovered severe cracking in Marathon control rod blades (CRBs) near the end of their nuclear lifetime limits in an international BWR/6. As a result of investigations into the cracking, GEH has determined that the design life of

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3 Statement of Arnold Gundersen, Advisory Committee on Reactor Safeguards Subcommittee on Fukushima, Official Transcript of meeting of May 26, 2011, NRC HQ, Rockville, MD, ADAMS Accession No. ML11147A075

> certain Marathon CRBs may be less than previously stated and is revising the end-of-life depletion limits of these CRBs. The NRC expects that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems.[4]

Not only did 100% of the control rods inspected suffer from cracking, the damage was more widespread and more serious than previously known. The Information Notice continued:

> In August 2010, GEH, as part of its surveillance program to monitor Marathon CRB performance, visually inspected four discharged CRBs at an international BWR/6 and found cracks on all four CRBs. The cracks were much more numerous and had more material distortion than those observed in previous inspections of Marathon CRBs. The cracks were also more severe in that they

> resulted in missing boron-carbide capsule tube fragments from two of the inspected CRBs.[5]

The list of suspect plants includes Browns Ferry 1, 2 and 3 and sixteen more GE Mark I BWRs: Cooper, Dresden 2 and 3, Duane Arnold, Fitzpatrick, Hatch 1 and 2, Monticello, Nine Mile Point 1, Oyster Creek, Peach Bottom 2 and 3, Pilgrim, Quad Cities 1 and 2, and Vermont Yankee.[6] Based on this evidence, 83% of the GE Mark I reactors in the United States are likely operating with cracked control rod blades.

Analysis of the missing fragments found in two of the four control rods inspected uncovered no negative effects on plant performance; however, to make this finding at Browns Ferry or the other affected plants would require individual reactor testing.

Browns Ferry was TVA's first nuclear power plant. The initial design life-span of nuclear plants is 30 to 40 years. All three Browns Ferry units are approaching the forty-year mark: Unit 1 began commercial operation on August 1, 1974, Unit 2 on March 1, 1975 and Unit 3 on March 1, 1977. NRC renewed the operating licenses for all three

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4 NRC Information Notice 2011-13: Control Rod Blade Cracking Resulting in Reduced Design Lifetime, June 29, 2011, ADAMS Accession No. ML111380019
5 *Id.*
6 The other four listed in the IN are Clinton, Grand Gulf, Perry and River Bend.

Browns Ferry reactors in May 2006, allowing TVA to continue operating them until 2033, 2034, and 2036, respectively. The new information regarding control rod cracks came after the renewal.

Control rod mismanagement was involved in at least two major nuclear accidents, at the Argonne Low Power Reactor and Chernobyl. The history of Chernobyl is familiar; less well known are events at Argonne, where the improper withdrawal of the control rod mechanism at the Army's experimental reactor in Idaho caused an explosion which killed three operators and released 1100 curies of fission products into the atmosphere.[7] In four milliseconds this small reactor went from 200 kilowatts power to 20 million kilowatts.[8] Although the NRC Information Notice includes no specific enforcement, it does point to the NRC's expectation that plant operators will act to avoid control rod problems caused by these flaws. NRC should issue an order to TVA to check these components and not merely rely on the IN suggestion.

- ***Irradiated Fuel Pool Danger***

TVA stores Browns Ferry's radioactive fuel rods in pools on upper levels of the plant. Over 1,415 metric tons of irradiated fuel in three pools is covered by a heavy metal sheet buildings on a concrete pad above the plant. As with most plants, water in the fuel pools is circulated by electric pumps. If the plant is scrammed and off-site power and electric back-ups fail, the fuel would heat the water, turning it to steam.

The area above the spent fuel pool is not designed to withstand high winds from tornadoes and hurricanes. As stated by an NRC spokesman, "The design of the Browns

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7 Horan, J. R., and J. B. Braun, 1993, *Occupational Radiation Exposure History of Idaho Field Office Operations at the INEL*, EGG-CS-11143, EG&G Idaho, Inc., October, Idaho Falls, Idaho (retrieved 10/6/11 from Wikipedia).
8 Steve Wander (editor) (February 2007) "Supercritical" *System Failure Case Studies* (NASA) **1** (4). http://pbma.nasa.gov/docs/public/pbma/general/sl1_sfcs.pdf (retrieved 10/6/11 from Wikipedia)

Ferry spent fuel pool has blowout panels. In case of a tornado where you have differential pressure across the wall, the panels would blow off and minimize any damage."[9]

On April 27, 2011 tornadoes knocked out TVA's electric power transmission lines in Mississippi and northern Alabama, causing an emergency and automatic cold shutdown of the Browns Ferry Nuclear Plant. The plant was forced to rely on diesel backup power for seven days.

> One NRC inspector told the audience that those containments were upgraded for assaults such as that on the heels of the Sept. 11, 2001, terrorist attacks. But David Lochbaum, a former TVA nuclear engineer and a former NRC training instructor, took that answer to task. "That's not accurate," said Lochbaum, a Chattanoogan who now works for the Union of Concerned Scientists. "It may be reassuring, but it's not accurate." The 9/11 changes "were only about airplanes," not multiple problems such as what the tornadoes caused or could

have caused if one had made a direct hit on the plant, he said. [10]

The NRC should order TVA to eliminate the existing unsafe irradiated fuel storage system and move the fuel to hardened storage in concrete structures.

- ***Need for Action Indicated by Record of Violations***

During the last few years, TVA has compiled an unenviable record of compliance at Browns Ferry.

On May 9, 2011, the NRC issued to TVA a violation (EA-11-018) for failure to implement an In-Service Training program for its engineers at Browns Ferry. More than a training exercise, this management failure led to an operational failure in which the RHR loop II subsystem was unable to fulfill its safety function due to a failure of LPCI

9 NRC Region II Administrator Victor McCee, "Tornado Concerns Raised At Browns Ferry Nuclear Plant" WHNT-TV, Huntsville, AL, May 31, 2011, retrieved 10/6/11 from http://www.whnt.com/news/whnttornado- concerns-raised-at-browns-ferry...
10 "Regulators say TVA's Browns Ferry Nuclear Plant safe to operate" *Times-Free Press* October 4th, 2011

Outboard Injection Valve. The malfunctioning valve was not discovered for a year and a half. The violation was of Red Significance. The system is necessary for reactor core cooling during accidents and the valve failure left that system inoperable, potentially leading to core damage had an accident involving a certain series of events occurred.

On April 19, 2010, NRC issued Notice of Violations (EA-09-307) to TVA at Browns Ferry for failure to meet the requirements of 10 CFR 50, Appendix R, III.G, fire protection of safe shutdown capability. The violations were of Yellow and White Significance. There were multiple examples of TVA not providing fire protection capable of limiting damage to the plant. In 1974 a worker using a candle to check for air leaks started a fire that disabled safety systems at Browns Ferry Nuclear Plant.

On May 12, 2004, NRC issued to TVA a Notice of Violation (EA-04-063) for Severity Level III violations at Browns Ferry. Numerous problems in the Long-Term Torus Integrity Program were cited for failures to perform numerous weld repairs; omission of welds requiring repair; and failure to verify the location of repaired welds.

APPENDIX 4

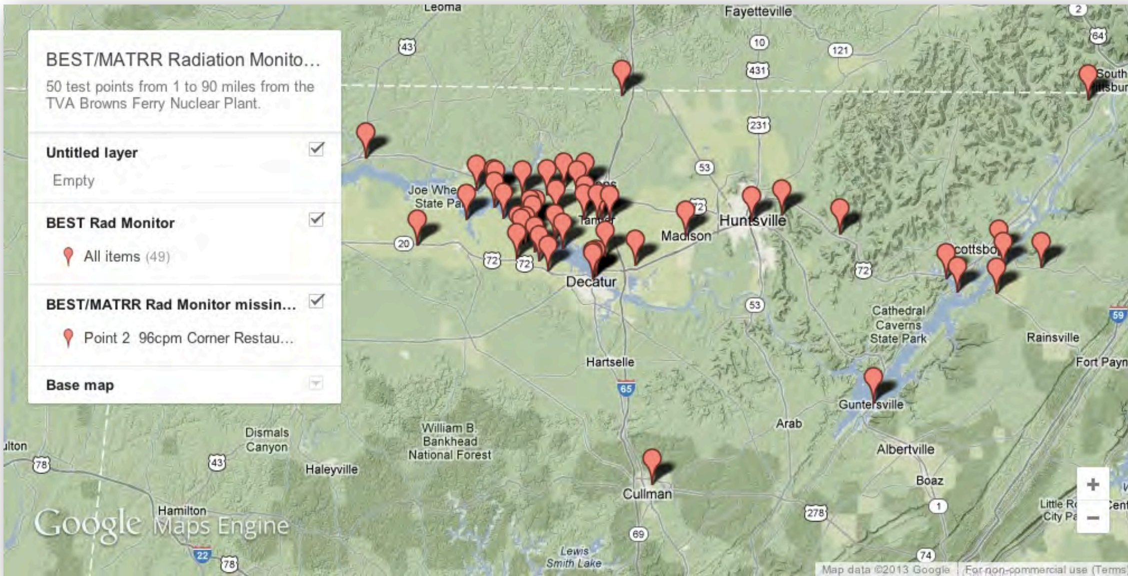
These violations support our request that regulatory action by the NRC is necessary to ensure that operations at Browns Ferry provide adequate protection to the health and safety of the public and are in accord with the common defense and security.

Respectfully submitted,

Louis A. Zeller
Blue Ridge Environmental Defense League
PO Box 88
Glendale Springs, NC 28629
bredl@skybest.org
www.BREDL.org

Esse quam videre

APPENDIX 5: BEST RADIATION MONITORING TEST SITES



As of publication, June 2013, the BEST/MATRR Radiation Monitoring Project had established 50 field test sites around Browns Ferry Nuclear Power Plant, and had recorded readings of radiation counts per minute (CPM) at each of the sites, some multiple times and under varying weather conditions. Test sites circled the plant and worked outward to determine plume paths. The distances range from under one mile to over 90 miles from the plant, and the readings on the Inspector™ geiger counter ranged from backgrounds of 32 to over 1600 CPM.

BEST/MATRR is a chapter of the Blue Ridge Environmental Defense League (BREDL), whose Executive Director, Lou Zeller, began group project training using EPA protocols and is BEST monitoring project Quality Assurance Officer. The Project Manager, Garry Morgan, is retired from the Army Medical Department with experience and training in Radiation Protection, Nuclear, Biological and Chemical Decontamination and Emergency Response in military and civilian medical care settings. Mr. Morgan expanded the training and procedures to include Department of Defense, Department of Homeland Security and State of Alabama Department of Health Radiation Control protocols.

BEST/MATRR Radiation Monitoring Project information and downloadable copies of *A Citizen's Guide to Monitor Radioactivity,* and our intended companion manual, *BEST Radiation Monitoring Manual* are available online at http://RadiationMonitors.blogspot.com. In addition, BEST project director, Garry Morgan, recorded several videos of field tests which are also available online at http://RadiationVideos.blogspot.com. The above map of BEST Radiation Monitoring Test Sites, also created by Morgan, may be viewed online using an interactive Google map showing CPM readings at https://mapsengine.google.com/map/edit?mid=zUriF2xNKAQ4.kc_DIj9TCDyM

BIBLIOGRAPHY

Alvarez, Robert *Spent Nuclear Fuel Pools in the U.S.: Reducing the Deadly Risks of Storage*, Institute for Policy Studies, May 2011; http://www.ips-dc.org/reports/spent_nuclear_fuel_pools_in_the_us_reducing_the_deadly_risks_of_storage

Brookhaven National Laboratory *Radioactive Materials Released from Nuclear Power Plants*, NUREG/CR-2907; http://pbadupws.nrc.gov/docs/ML0414/ML041450170.pdf

Centers for Disease Control and Prevention, http://wonder.cdc.gov.

Comey, David Dinsmore "The Fire at Brown's Ferry Nuclear Power Station," in *Not Man Apart*, Friends of the Earth, California, 1976, http://www.ccnr.org/browns_ferry.html

Donn, Jeff "Radioactive tritium leaks found at 48 US nuke sites," AP, June 21, 2011,http://www.nbcnews.com/id/43475479/ns/us_news-environment/t/radioactive-tritium-leaks-found-us-nuke-sites/#.UX7Aa5Vs3S8

Donn, Jeff "Safety Rules Loosened for Aging Nuclear Reactors," June 20, 2011; http://www.nbcnews.com/id/43455859/ns/us_news-environment/t/safety-rules-loosened-aging-nuclear-reactors/#.UYp50JVs3S8

Dedman, Bill "Nuclear Neighbors: Population Rises Near US Reactors", NBC News, April 4, 2011; http://www.nbcnews.com/id/42555888/ns/us_news-life/t/nuclear-neighbors-population-rises-near-us-reactors/?ns=us_news-life

Environmental Protection Agency, Radnet Search "Envirofacts," covers measurements taken since 1978, http://iaspub.epa.gov/enviro/erams_query_v2.simple_query

Gatti, Antonietta M. et al, "Nanopathology: The Role of Micro and Nanoparticles in Biomaterial-induced Pathology", The European Commission, Project QLRT-2002-J47 (2002-2005), http://inchesnetwork.net/Fetal%20and%20embryological%20origin%20of%20diseases_Gatti.pdf

Gould JM et al. *The Enemy Within: The High Cost of Living Near Nuclear Reactors*, New York: Four Walls Eight Windows, 1996.

Gunter, Paul "Hazards of Boiling Water Reactors in the United States," Nuclear Information Research Service (NIRS) March, 1996, updated by Michael Mariotte, NIRS.org, March 2011; http://www.nirs.org/factsheets/bwrfact.htm.

Jablon S. et al. Cancer in Populations Living Near Nuclear Facilities. Washington DC: U.S. Government Printing Office, 1990.

Klusek CS, Strontum-90 in Human Bone in the U.S., 1982. New York: Department of Energy Environmental Measurements Laboratory, 1982.

Lochbaum, David "Groundwater Events Sorted by Location," Union of Concerned Scientists, September 29, 2010, http://www.ucsusa.org/assets/documents/nuclear_power/Groundwater-Events-Sorted-by-Location.pdf

Lochbaum, David *Walking a Nuclear Tightrope: Unlearned Lessons of Year-plus Reactor Outages,* Union of Concerned Scientists, September 2006; http://www.ucsusa.org/nuclear_power/nuclear_power_risk/safety/walking-a-nuclear-tightrope.html

Mangano JJ et al. An unexpected rise in strontium-90 in US deciduous teeth in the 1990s. The Science of the Total Environment 2003;317:37-51

Mangano JJ. Improvements in local infant health after nuclear power reactor closing. Environmental Epidemiology and Toxicology 2000;2(1):32-36.

Mangano JJ et al. Infant death and childhood cancer reductions after nuclear plant closings in the United States. Archives of Environmental Health 2002;57(1):23-32.

Medical Encyclopedia of the National Library of Medicine, Medline Plus, "Radiation sickness," U.S. National Library of Medicine, National Institutes of Health, http://www.nlm.nih.gov/medlineplus/ency/article/000026.htm

Meyer, Bob "Most Significant NRC findings of 2012," Professional Reactor Operator Society, Feb.3, 2013, http://nucpros.com/content/most-significant-nrc-findings-2012

National Academy of Sciences, *Biological Effects of Ionizing Radiation BEIR VII Phase 2 Report: Health Risks from Exposure to Low Levels of Ionizing Radiation*, National Academies Press, 2006, http://www.nap.edu/catalog/11340.html

National Cancer Institute, Incidence, Surveillance, Epidemiology, and End Results program, National Institutes of Health, http://www.seer.cancer.gov

National Cancer Institute, State Cancer Profiles, National Institutes of Health, www.statecancerprofiles.cancer.gov.

Nuclear Regulatory Commission, Effluent Database for Nuclear Power Plants, www.reirs.com/effluent

Nuclear Regulatory Commission, FAQs About Liquid Radioactive Releases, http://www.nrc.gov/reactors/operating/ops-experience/tritium/faqs.html#affect

Nuclear Regulatory Commission, Information Digest, various years; www.nrc.gov.

Nuclear Regulatory Commission, Licensee Event Reports Search of BFN SCRAMSs; https://lersearch.inl.gov/Entry.aspx

Pashenko, Sergey and Buske, Norm *A Citizen's Guide to Radiation Monitoring,* ISAR: Resources for Environmental Activists, May 2005, http://www.radioactivist.org/ISAR%20final%20guide.pdf

Professional Nuclear Reactor Operator Society "Browns Ferry Nuclear Plant, Unit 3 LER: Annunciator Panel Power Supply Fire in Unit 3 Control Room," July 9, 2012, http://www.nucpros.com/content/browns-ferry-nuclear-plant-unit-3-ler-annunciator-panel-power-supply-fire-unit-3-control-roo

Rosenthal HL. Accumulation of Environmental 90Sr in Teeth of Children. Hanford Radiobiological Symposium, Richland WA, May 1969, 163-171.

Sandia National Laboratories, *Calculation of Reactor Accident Consequences (CRAC-2) for U.S. Nuclear Power Plants*. Prepared for U.S. Congress, Subcommittee on Oversight and Investigations, Committee on Interior and Insular Affairs. November 1, 1982.

Stewart AM, Webb J, and Hewitt D. A Survey of Childhood Malignancies. British Medical Journal, 1958;i:1495-1508.

Thompson DE et al. Cancer Incidence in Atomic Bomb Survivors. Part II: Solid Tumors, 1958-1987. Radiation Effects Research Foundation, Hiroshima Japan, 1994, http://www.ncbi.nlm.nih.gov/pubmed/8127952

U.S. Census Bureau, Alabama Counties Map, www.census.gov

Zeller, Lou "§ 2.206 Request for Action to Suspend GE Mark I Boiling Water Reactors Operating Licenses due to Flawed Primary Containment and Unreliable Back-up Electric Power Systems for Cooling Spent Fuel Pools," Letter to Licensing Branch 11-2, NRC, Oct. 7, 2011.

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Susquehanna Spent Fuel Pool Concerns, and How I Ended Up at UCS

April 21, 2011

Dave Lochbaum
Former contributor

In November 1992, Don Prevatte and I submitted a report to the NRC regarding our concerns with spent fuel pools at boiling water reactors (BWRs), of which 35 are operating in the US. We had been consultants working on a team to evaluate the proposed increase in the maximum power level of the two BWRs at the Susquehanna nuclear plant in Pennsylvania. My assignments included the spent fuel pool cooling and cleanup system while Don's assignments included the reactor building ventilation system. While reviewing each other's work, we uncovered a problem.

system was designed to cool rooms and areas in event of an accident to protect emergency equipment from damage caused by high air temperatures.

The design calculation for the reactor building ventilation system considered heat emitted by operating motors, heat emanating from piping filled with hot water, and heat given off by incandescent light bulbs. Collectively, these heat sources amounted to 5.2 million BTUs per hour (a British Thermal Unit, or BTU, is defined as the amount of heat needed to increase the temperature of one pound of water by one degree Fahrenheit).

The cooling system for the reactor building ventilation system was sized to accommodate this amount of heat removal, thus ensuring that emergency equipment would not overheat and fail.

But the design heat load from irradiated fuel stored in the spent fuel pool was 12.6 million BTUs per hour, meaning the spent fuel could emit up to that much heat. Under normal operation, that heat would be carried out of the building by the cooling system. However, safety analyses assume the spent fuel pool cooling system will not be operating during a reactor accident. In that case there would be no heat added to the reactor building from the spent fuel pool pump motors and piping, but without cooling the spent fuel pool water would heat up, boil, and release heat into the reactor building air. A lot of heat—considerably more heat than that present in the reactor building from all other sources, and far more than the cooling system could handle.

The water boiling off the spent fuel pool would condense and drain down into the basement of the building where it would submerge and disable emergency equipment—at least the emergency equipment that had not already been disabled accident would prevent workers from entering to open the manual valves that supply makeup water to the spent fuel pool.

Hence, a reactor accident would lead to a spent fuel pool accident. And the boiling spent fuel pool would create conditions inside the reactor building that would disable the emergency equipment needed to cool the reactor core.

As Don and I investigated further, more problems surfaced. Susquehanna's owner initially justified the situation by saying that the non-safety-related spent fuel pool cooling system would remove the heat, even though it was not credited as doing so in the safety studies. Indeed, we found that emergency procedures directed the operators to open two electrical breakers within an hour of an accident to shut down all non-emergency systems inside the reactor building.

We also found that the standby gas-treatment system—a ventilation system located inside the reactor building that processes air discharged to the atmosphere to reduce its radiation levels by a factor of 100—would shut down if the spent fuel pool water approached boiling because the warm vapor evaporating from the pool would trick sensors into thinking there was a fire, causing inlet dampers to close. And we found that if the spent fuel pool cooling system was not operating, the operators would have no indications of the level or temperature of the water in the spent fuel pool.

The NRC failed to take our report seriously. They didn't even read it. We had attached all the relevant correspondence between us and the plant's owner to the report. I made two-sided copies of many of the 35 attachments to save postage costs. But when I took the original report to a copy shop, they mistakenly made single-sided copies and left out every other page. The NRC dismissed our concerns at

Don and I wrote letters summarizing the spent fuel pool problems to the governors and US senators in the states with BWRs like Susquehanna. We also sent letters to the three congressional committees that oversee the NRC. Congressmen Phil Sharp wrote several letters to the NRC about our concerns, as did several governors and US senators. The NRC granted our request for a public meeting for us to communicate our concerns to the agency. About 15 minutes into that meeting on October 1, 1993, the NRC project manager for Susquehanna was sound asleep and snoring in the first row.

The issues were resolved at Susquehanna by the owners' commitment to always operate with the spent fuel pools connected to each other. In case of an accident involving the Unit 1 reactor core, the systems on Unit 2 could be used to cool both spent fuel pools without adversely affecting conditions inside the Unit 1 reactor building, and vice-versa. The owner also took steps to install additional instrumentation to enable operators to monitor spent fuel pool water levels and temperatures and resolve the standby gas treatment system design issues.

However, little to nothing has been done to address the spent fuel pool vulnerabilities at other BWRs in this country.

Following this incident, I authored *Nuclear Waste Disposal Crisis*, a book about spent fuel storage issues. It was released by PennWell Publishing in January 1996. Chapter 8 outlined spent fuel pool safety issues. Chapter 9 detailed our spent fuel pool concerns at Susquehanna. And Appendix A summarized actual spent fuel pool problems that occurred at U.S. nuclear power reactors.

The tragedy at Fukushima Dai-Ichi involved many of the same concerns Don and I raised at Susquehanna. It appears

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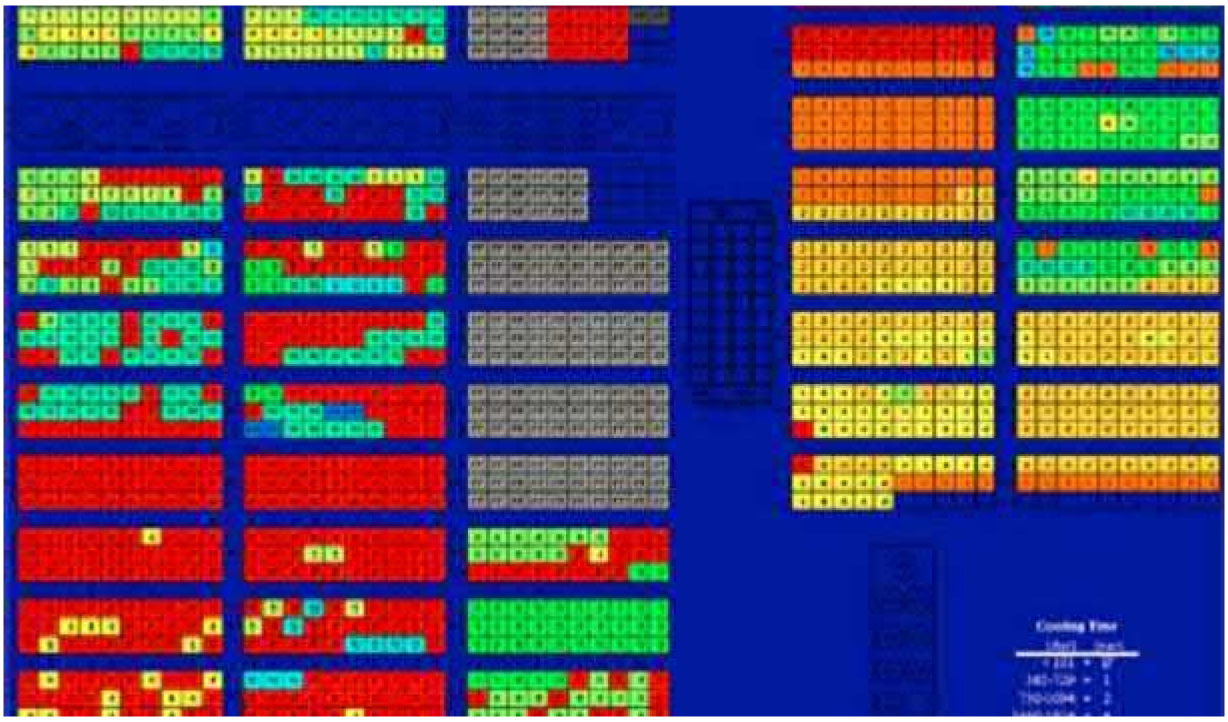
RISKS OF DENSELY PACKED SPENT FUEL POOLS



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by Allison Macfarlane
May 19, 2017

I. INTRODUCTION

This essay by Allison Macfarlane argues that “the back end of the fuel cycle, especially at reactors, has not received the attention to safety and management it needs. Management of spent fuel after discharge from the reactor requires careful thought and safety analysis. Surprisingly, regulators in some countries have taken a laissez-faire attitude to the back end of the fuel cycle at reactors.”

Allison Macfarlane is Professor of Science and Technology Policy at George Washington University and Director of the Center for International Science and Technology Policy at the University’s Elliott School of International Affairs. She was Chairman of the U.S. Nuclear Regulatory Commission from July, 2012 until December, 2014.

This Special Report was prepared for the *Project on Reducing Risk of Nuclear Terrorism and Spent Fuel Vulnerability In East Asia*. It was presented at a Nautilus Institute Workshop at International House, Tokyo, September 14-15, 2015, funded by The Macarthur Foundation.

The views expressed in this report do not necessarily reflect the official policy or position of the Nautilus Institute. Readers should note that Nautilus seeks a diversity of views and opinions on significant topics in order to identify common ground.

Banner Image Credit: Decay Heat of Fuel Inventory Fukushima Spent Fuel Pool 4, from Nuclear Energy Agency, 2015, Status on Spent Fuel Pools under Loss-of-Colling and Loss-of-Coolant Accident Conditions, Nuclear Safety NEA/CSNI/R(2010)2, May 2015, OECD, p.72, here.

II. SPECIAL REPORT BY ALLISON MACFARLANE

RISKS OF DENSELY PACKED SPENT FUEL POOLS
May 19, 2017

Introduction

Nuclear reactors need spent fuel pools to safely store spent nuclear fuel after discharge from a reactor core. Once discharged, the spent fuel is both thermally and radioactively hot and needs the cooling, shielding, and criticality protection provided by the pool.

The pools themselves are similar to very deep swimming pools. In fact, in some reactors divers "swim" in the pools to perform maintenance on them. In some countries, once spent fuel has cooled at least 5 years, it can be transferred to dry casks for passive cooling. Until then, the spent fuel needs the active cooling provided by the circulation of cool water in the pool. As a result, spent fuel pools are necessary equipment at nuclear power reactors.

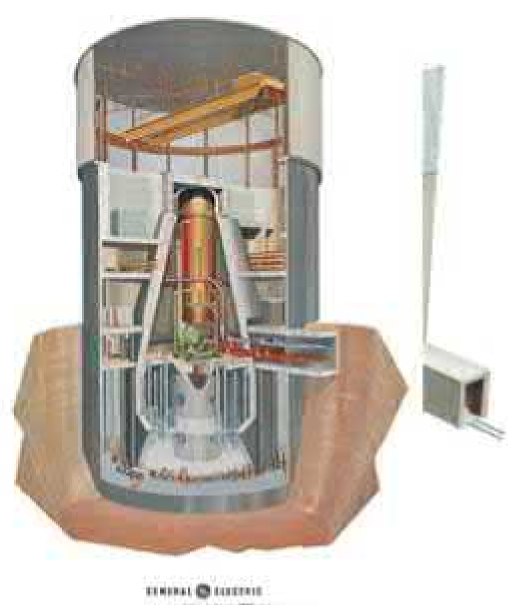
At the same time, in a number of countries, spent fuel management practices over time have pushed the envelope of pool performance, packing in more and more spent fuel into the same small volume in an effort to deal with large quantities of used fuel. No country has yet developed and operationalized a "final solution" for its high-level nuclear waste, but experts agree that some kind of deep geologic repository will be the solution. Sweden and Finland are furthest along the path to building and eventually opening a mined geologic repository. In the meantime, spent fuel continues to pile up at reactor sites around the world. Some countries largely keep spent fuel in pools at reactors, such as the U.S., some move spent fuel into dry storage, like the U.S. and Germany, some operate away-from-reactor centralized storage sites such as Germany and Sweden, and a few send spent fuel to reprocessing facilities like the U.K. and France.

As spent fuel pools are central to the operation of a nuclear power plant, as large quantities of spent fuel have accumulated in these pools, and given recent safety and security concerns, it is reasonable to address the safety of these facilities. The question addressed here is to what degree and in which circumstances spent fuel pools pose potential threats. I will place this issue in the larger issue of spent fuel management practices in general and discuss spent fuel management practices in a variety of countries.

Technical Background

Spent Fuel Pools

Spent fuel pools in light water reactors are usually located outside of containment, the thick concrete and steel reinforced structure that provides an additional line of defense in preventing radioactive contamination from a reactor accident (Figures 1-4). This is true for all designs except Russian VVER-1000's, AREVA's EPR, and the German KONVOI or pre-KONVOI designs, in which the pool is located within the containment (Nuclear Energy Agency, 2015). As a result, for most operational power reactors, in the event of a spent fuel pool accident, radioactivity would be more likely to reach the surrounding environment than with a reactor accident.[1] Additionally, many spent fuel pools are located at or above grade at the site. In the case of General Electric Boiling water reactors of the Mark I and Mark II designs, pools are located at the top floor of the reactor building, often 4 or 5 stories in the air (Figures 1-2).



Figures 1 and 2: GE Boiling water reactors. Figure 1 on left is Mark I design, Figure 2 on right is Mark II design. In Mark I, spent fuel pool into upper right of reactor vessel; in Mark II, spent fuel pool is to the upper left of the reactor. Containment in both is the flask-shaped area outside of the red/orange reactor vessel. From NRC, undated.

Figure 3: GE Boiling water reactor, Mark III design. Spent fuel pool is to the right of the reactor, number 20, outside the main containment. From NRC, undated.

Figure 4: Pressurized water reactor and pool. Pool is to the right in the cartoon – outside the containment. From http://www.nucleartourist.com/images/refuel-bldg.gif.

Pools are made from thick reinforced concrete and have stainless steel liners to prevent leaks. Pool size varies widely between and among reactor designs. In some cases two or more reactors share a single pool. Some reactor sites have more than one storage pool on site. Pool depth is in the 12 m range and fuel is loaded in racks in the lower portion of the pool and has about 7 m of water above it (Nuclear Energy Agency, 2015). Boiling water reactors (BWRs) and pressurized water reactors (PWRs) differ in types of pool racks and method of radiation or reactivity control.

Racks in both PWR and BWR spent fuel pools can be open or closed designs (Figures 5-6). The open frame racks (often the original design) depend on water flow and distance between fuel assemblies in part for criticality control.[2] As space to store more spent fuel was required over the reactor's lifetime, racks were converted to higher and higher density designs. In PWRs, for instance, they went from a 41-53 cm spacing between the centers of two fuel assemblies in a open frame rack to a 26 cm spacing in a high density rack (Nuclear Energy Agency, 2015). In the high-density PWR and BWR racks, criticality control is done by borated absorber (a metal plate impregnated with boron, an element that captures stray neutrons) between or within the stainless steel rack wall. These high-density racks do not allow for lateral or cross-flow of water between fuel assemblies. Water flow is vertical, convective within each separate fuel assembly cell. PWR pools use borated water in the pools while BWR pools use demineralized water. And unlike PWRs, BWR assemblies are gathered in a metal sheath that directs the water up the channel and provides support to the assemblies and the associated control rods (NRC, undated) (Figure 7).

Figure 5: High density storage racks for PWRs. From NEA, 2015.

Figure 6: Storage racks for BWRs. From NEA, 2015.

Figure 7: BWR fuel assemblies, showing the metal sheath surrounding the assemblies. From NRC, undated.

Most spent fuel pools are actively cooled with a system of heat exchangers and pumps. The water lines into the pools tend to enter the pools near the top to avoid the potential to inadvertently drain the pool (Nuclear Energy Agency, 2015). These systems are usually attached to backup diesel generators in the case of offsite power loss. Moreover, additional pumps and heat exchangers may be located on site in the case of emergency.

Spent fuel pools usually have instruments that measure water level and temperature and feed this information to the control room operators. Usually, the maximum allowable temperature in spent fuel pools during operation (and especially refueling outages) is 60 °C (Nuclear Energy Agency, 2015). As a result of the Fukushima accident, the US Nuclear Regulatory Commission (NRC) now requires all spent fuel pools in the US to have independent water level controls that can provide water level measurements under station blackout conditions.

Spent Fuel Loading

Spent fuel is loaded into pools after use in the reactor via use of overhead cranes. Fresh fuel is often also stored in pools, awaiting use in reactors. BWRs, VVERs, and German PWRs use transfer canals to move spent fuel from the reactor to the pool, allowing fuel to be moved in a vertical manner. If water is lost from the transfer canal, this can directly affect water level in the pool itself. For PWRs, fuel is transferred horizontally using a transfer tube (Figure 4), which uses a much smaller volume of water and as a result, leaks from the transfer tube won't affect the spent fuel pool water level very much (Nuclear Energy Agency, 2015).

Many reactor pools maintain space to offload the entire contents of the reactor core (or in the case that one pool is shared by two or more reactors, two or more full cores) in the case of emergency or necessity. The US NRC does not require this of their licensees, and a handful of reactors in the U.S. do not have this capability.

Spent fuel loading patterns may directly affect the potential for an accident in the case of a loss of cooling or coolant accident.

Emplacing newly discharged spent fuel assemblies next to each other in one portion of the pool can concentrate heat and pool heat load is highest just after a full core is loaded into the pool, but sometimes it is easier and cheaper to place spent fuel in one location in the pool (in the place where the fresh fuel was stored, for instance).

Some plants, such as the Koeberg nuclear power facility in South Africa use special reinforced racks for freshly discharged spent fuel. Others disperse newly discharged spent fuel into 1 x 4 or 1 x 8 patterns, in which a hot, newly discharged assembly is surrounded by 4 or 8 old cold assemblies (Figure 8). The US NRC, in a recent modeling study, showed the benefits of 1 x 4 and 1 x 8 dispersal patterns over other patterns (NRC, 2014a). The study showed that in the case of the Peach Bottom reactor in Pennsylvania, dispersing hot fuel into a 1 x 8 pattern provided the best pool heat management over surrounding the hot assembly with only 4 cold assemblies or even no assemblies or open rack space. The cold fuel surrounding the hot assembly provides a cold sink for the heat, dissipating the heat in the pool. The 1 x 8 pattern does not decrease time needed in the pool, which is controlled by the decay of short-lived radionuclides.

Figure 8: Alternative spent fuel loading patterns for pools. From NEA, 2015.

In the US, for instance, reactors are encouraged to achieve a 1 x 4 pattern, but are not required to do so. US reactors will tend to disperse permanently discharged fuel into at least a 1 x 4 pattern, though this information is not actually tracked by the US NRC. On the other hand, many U.S. PWRs, when discharging a full core, do not do so into a dispersed pattern, opting instead to discharge into a single area of the pool. They will keep the full core in the same location in the pool for the duration of the outage (NRC, 2014b).

Pool Management Practices

Spent fuel pool management practices vary by country. I include a few countries here to illustrate the variety of ways to manage spent fuel in the nuclear fuel cycle.

Canada: Unlike all other countries listed, Canada operates CANDU reactors that use heavy water as a coolant and moderator. As a result, spent fuel cannot go critical in spent fuel pools filled with "light" water, so the spent fuel pool's function is to maintain thermal and radiation control only. Spent fuel bundles are discharged to spent fuel pools and cooled there for 7-10 years, then transferred to dry storage facilities at reactor sites. In response to the Fukushima accident, Canadian operators have added equipment to reactor sites that can be transported to the pools to add water if needed. They have also installed hydrogen removal equipment to pools that can operate without external electrical power (Canadian Nuclear Safety Commission, 2015).

France: France reprocesses its spent fuel. As a result, it transfers its spent fuel from reactor sites within a few years after discharge to the La Hague reprocessing facility via train. At La Hague, the spent fuel is stored in large cooling pools for another few years before it is reprocessed. Spent MOX spent fuel is also transported back to La Hague after a longer period of cooling in reactor pools, but this fuel is not currently reprocessed (IPFM, 2011).

Germany: Germany reprocessed much of its spent fuel in the facilities in France and the UK until 2005. Since then, it has stored spent fuel at reactor sites and in centralized storage facilities. Most spent fuel is in dry storage at reactor sites (GAO, 2012).

Japan: Japan has managed spent fuel by a variety of methods. Much spent fuel is stored at reactor sites in spent fuel pools, centralized pools at reactors, and in a modest amount of dry storage. Some spent fuel has been shipped to Japan's Rokkasho reprocessing plant, whose pool is almost at capacity. Other spent fuel was shipped to reprocessing facilities in the United Kingdom and France for reprocessing.

Sweden: Sweden has an off-site interim storage facility, the CLAB facility located in Oskarshamn. CLAB is an underground storage pool facility, 50 m deep, with 2 large storage pools. Spent fuel is transferred to CLAB about 18 months after discharge from reactors. As a result, reactor pools do not maintain large inventories of spent fuel.

United States: Spent fuel remains at reactor sites in the United States. As a result, all spent fuel pools have high-density racks, many of which are almost full. There is no requirement to discharge into a dispersed pattern, although, according to an incomplete survey done by the US NRC, many licensees do use such a pattern.

Past Accidents

Though there have been no major accidents in which spent fuel pools feature, a few smaller-scale accidents or near misses provide interesting benchmarks to understand how such a spent fuel pool accident might progress. The most notable recent near miss was the Fukushima accident that began March 11, 2011, at the Fukushima Dai'ichi plant in Japan. Three boiling water reactor cores eventually melted down, but much concern focused on the condition of unit 4's spent fuel pool.

Unit 4's entire core was moved into its spent fuel pool for maintenance work during a routine shutdown in November 2010. At that time, the pool water temperature was 27 °C (Wang et al., 2012). When the accident occurred on March 11, the facility lost all power and entered a state of "station blackout." At this time unit 4's spent fuel pool lost active cooling. After a hydrogen explosion in unit 4's reactor building on March 15, 2011, concerns arose that the spent fuel in the pool had become so hot that the fuel cladding had reacted with steam to form hydrogen. In fact, the source of the hydrogen was unit 3's reactor, piped in via connections between the two closely spaced buildings. At the time though, many thought unit 4's spent fuel pool had lost significant water and efforts became focused on adding water to the pool. Since the reactor pool was at the top of the building, now under debris from the explosion, and radiation levels were extremely high, it was inaccessible to humans. So, alternative methods were conceived to add water to the pool. This was done most dramatically by helicopter, which flew over the unit and attempted to drop water into the pool (little of this water actually reached its target). On March 20, cranes to the pool lifted hoses from Japanese Defense Forces fire trucks and water was sprayed into the pool. By June 16, water was added to the pool with a temporary injection facility, providing a more stable form of water addition (Wang et al. 2012).

The fuel in unit 4's pool was loaded into high-density racks and the fuel discharged from the entire core was inserted into positions adjacent to each other. Measured temperatures show a marked increase after the accident – to 84 °C on March 14 to 90°C on April 12 (30 °C over the desired maximum pool temperature). By mid June, water temperatures had dropped to about 70 °C (Wang et al., 2012). No water level readings were available until mid April, when measurements show water levels of 1.8 – 2.0 m above the top of the spent fuel (Wang et al., 2012). If water level were to drop below the top of spent fuel, it could ignite and catch fire, releasing radioactivity. Modeling done by Wang and others (2012) suggests that water levels began to drop in the pool beginning around March 13 and dropped about 0.7 m/day, based on local meteorological conditions and estimated evaporation rates. If water addition had not begun by March 20, at that predicted rate of decrease, the fuel would have been uncovered by March 23, just under two weeks from loss of active cooling. This suggests that loss of cooling events at spent fuel pools are not dire emergencies that need to be addressed within hours, but slower-moving events that do require backup systems and a variety of alternative approaches to resolve.

Another spent fuel pool accident sheds light on how fuel can be damaged in a pool. The Paks nuclear power plant in Hungary experienced an INES level 3 accident on April 10, 2003 in the spent fuel pool of the unit 2 reactor. The Paks reactors are VVER-440 designs, and the fuel develops magnetite corrosion during use. The corrosion – called crud – is removed from the fuel assemblies, 30 at a time, in a tank placed at the bottom of the spent fuel pool (Figure 9). On April 10, 2003, after the assemblies were cleaned, they were not removed from the tank because the crane used to lift them was being used elsewhere. As a result, they stayed in the cleaning tank. The fuel was cooled by a pump with a low flow rate, which allowed the fuel to heat up and form steam. The steam pushed most of the water out of the cleaning tank and the fuel assemblies then, over a matter of hours, heated to over 1000 °C and were severely damaged (IAEA, 2009). The spent fuel heated so quickly in part because the tank it was kept in was small, and the water, once turned to steam, was forced out of the tank. Once the tank was discovered, it was opened, and cool pool water rushed in, quenching the overheated fuel rods, fracturing them, and releasing noble gases (the non-reactive gases like helium, neon, argon, krypton, xenon, radon) into the atmosphere around the plant. Volatile and non-volatile radionuclides, like cesium-137, were retained in the pool water and collected on filters in the pool (Hozer et al, 2009). Fission product noble gases released were xenon-133 (10^{13} Bq released per 10 min.), krypton-85 (10^{12} Bq released per 10 min.), and iodine-131 (10^{9} Bq released per 10 min.) with 99% of the total release occurring in the first 24 hours of the accident (Hozer, 2009). These products didn't stay in the pool because of their low solubility in water, but instead went out of the stack and into the surrounding atmosphere (Hozer, 2009).

Figure 9: Diagram of the Paks 2 spent fuel storage and treatment systems. From Hozer, 2009.

The Paks 2 accident suggests that even in the event of a loss of cooling or coolant accident in which spent fuel is not uncovered but damaged, some amount of radioactive release can occur. Since many spent fuel pools contain hundreds of assemblies, this release of noble gases could be significant.

Threats

Spent fuel pools must be designed to defend against three main potential threats: criticality accidents, loss of cooling accidents, and loss of coolant accidents. As explained above, criticality mitigation has become more of an issue with the rise of high-density racks. Open frame racks load fuel assemblies far enough apart so that criticality is not an issue. High density racks place fuel assemblies close enough so that neutron absorbers must be added to the rack material to prevent criticality. Some neutron absorbing materials used previously in the U.S., such as boraflex, have degraded in the spent fuel pools due to radiation damage and have caused concern about the ability to maintain reactivity control in spent fuel pools. Some pools use borated water to aid in controlling criticality. In the case of a loss of boron input and circulation in the pool, criticality may also be compromised.

Loss of cooling accidents, in which the *cooling function is lost*, and loss of coolant accidents, in which pool *water or coolant is lost* through leakage or sloshing both can pose significant problems. Spent fuel pools at "mature" power reactors pose a potential threat because of the possibility of radionuclide contamination in the event of a loss of cooling or coolant accident that involves a self-propagating zirconium cladding fire. Pools contain much higher "source terms" than reactor cores simply because, at plants that have been operating for many years, they can contain many reactor cores' worth of spent fuel. The source term for a high density pool like that of the Peach Bottom reactor in the U.S. ranges from 40 to 140 million curies of cesium-137. For perspective, the amount released by the Fukushima accident was between 0.2 to 0.8 million curies of cesium-137 (Macfarlane, 2014). The US NRC's recent modeling of a fire at the Peach Bottom pool suggested that in a high density configuration with no mitigation, the accident would affect 9,400 square miles of land, displacing over 4 million people, and result in a collective dose of 350,000 person-sieverts (NRC, 2014a).

Most studies, including the ones mentioned in this report, analyze a total loss of coolant. Few studies examine a partial loss of coolant in which there is a slow leak and the fuel becomes uncovered but the pool does not drain. In this case, fuel assemblies may not be able to take advantage of convective cooling up the cells in the high-density racks. An open-frame rack may provide cooling of fuel through convection in the case of partial drain down (Alvarez et al, 2003).

Loss of coolant accidents can result from a few scenarios: massive earthquake, cask drop, accidental plane crash, or terrorism. When analyzed by the US NRC, all events precursor events were found to have a very low probability of occurrence (see for example, NRC 2001, 2014a), even though the consequences of an accident would be high. Spent fuel pools are built robustly, and in seismically active areas, are reinforced to withstand shaking from earthquakes. Of course, they are only built to withstand the expected earthquakes and have additional margin added, and sometimes, as happened in Fukushima in 2011, at the North Anna plant in Virginia, US in 2011, and at the Kashiwaszaki-Kariwa plant in Japan in 2007, seismic building standards are exceeded by Mother Nature.

Loss of coolant accidents from cask drops need some explanation. Spent fuel is often transferred via a canister or small cask out of the pool for either dry storage or storage elsewhere (for instance, at a reprocessing facility). This is done by loading the spent fuel into a cask under water in the pool. Water is later drained and the cask removed from the pool via crane. Damage to the pool's integrity may result were the cask to drop into the pool while suspended by the crane. Casks can be heavy and if dropped from a height may exert significant force on the pool bottom or walls.

Inadvertent or deliberate plane crash could also damage spent fuel pools. Most spent fuel pools lie outside of containment and do not have the additional protection provided by such a structure. The US NRC performed a classified study of plane crashes into spent fuel pools after the attacks of September 11, 2001. They also completed classified studies of terrorist attack with high-energy weapons or explosive charges. The National Academy of Sciences (2006) reviewed these studies and, "Concluded that there are some scenarios that could lead to the partial failure of the spent fuel pool wall, thereby resulting in the partial or complete loss of pool coolant. A zirconium cladding fire could result if timely mitigative actions to cool the fuel were not taken." (National Research Council, 2006, p. 49). A recent National Academies report (National Academy of Sciences, 2016) reviewed these previous findings and noted that there are additional threats such as unmanned aerial vehicles and cyberattacks that could provide additional pathways to an accident scenario.

Security at nuclear power plants is not governed by any international standards, unlike safety, for which the International Atomic

Energy Agency, among others, sets example standards for countries to consider. In the U.S., security at nuclear power plants is governed by regulations set by the NRC, which has responsibility for ensuring safety and security at reactors. As a result, nuclear power plants are well-guarded facilities[3] that have considered and practiced scenarios of terrorist attack that affects the operation of the reactor and associated safety systems. In other countries, security is provided by the local police force. Recently, a number of plant breaches by anti-nuclear activists in Sweden and France have made clear some vulnerabilities at these plants.

Loss of cooling accidents can result from loss of offsite electric power and backup diesel generators, a situation referred to as station blackout, similar to what Fukushima Dai'ichi suffered during the March 2011 accident. Cooling loss can also occur when a pump fails or is inadequate, so coolant is no longer circulated, as happened in the Paks 2 accident.

Loss of cooling can also occur from lack of heat removal – especially in the case of higher heat loads in the pool. Higher heat loads might result from higher fuel burnup or the presence of spent MOX fuel. Burnup refers to the number of atoms that have fissioned in the fuel or the energy released by the fuel and is expressed in mega (or giga-) watt – days per metric tonne heavy metal. In the 1970s and 1980s, a typical burnup for light water reactors were in the 33-40 MWd/MTHM range. Now burnup averages 50 MWd/MTHM (Xu et al., 2005). Some in the nuclear industry are pushing to use even higher burnup, in the 70 MWd/MTHM range in the near future. Higher burnup results in less spent fuel to manage and squeezes more energy out of a single fuel rod, potentially allowing reactor operators to extend times between outages and therefore run a leaner operation. Higher burnup requires higher enrichment of fresh fuel in uranium-235. To achieve a burnup of 50 MWd/MTHM, enrichments of 4.5% U-235 are needed; to achieve a burnup of 70 MWd/MTHM, enrichments of 6.3 % are needed (Xu et al, 2005).

Higher burnup fuel generates spent fuels that produce more heat. For instance, according to models of PWR spent fuel discharged 10 days previously, a burnup of 35 GWd/MTHM generates 5.5×10^4 W/MTHM versus 9×10^4 W/MTHM for a burnup of 50 GWd/MTHM (ORNL, 2011). As a result, as more high-burnup spent fuel assemblies are added to a pool, overall heat loads will increase in the pool and will decrease more slowly over time. These increased heat loads may be accompanied by a reduction in the absolute number of spent fuel assemblies, but this benefit has yet to be realized.

MOX or mixed oxide fuel poses a similar problem. MOX is formed by mixing plutonium oxide with uranium oxide to fuel reactors. Currently, France, Germany, Switzerland, and Japan are among the countries using MOX fuel as well as uranium oxide fuel. MOX spent fuel, because of its initial plutonium content, has higher decay heat than its uranium dioxide equivalent. For instance, for models of PWR spent fuel with a 35 GWd/MTHM burnup, 10,000 days after discharge, uranium oxide fuel produces 8×10^2 W/MTHM versus 2.4×10^3 W/MTHM for MOX spent fuel, almost 50% more heat (ORNL, 2011). Spent fuel pools have to be able to manage this additional heat and have necessary backup equipment to handle the load in case of accident.

Mitigation

A number of measures can be taken to avoid or mitigate potential accidents. First, though, it is important to understand which factors heighten the potential for loss of cooling or coolant accidents. The amount of spent fuel in the pool, the time since discharge of that spent fuel, the type of racks in the pool, and the loading pattern of spent fuel in the pool are all factors that can affect the potential for accident in the case of loss of cooling or coolant. A number of these factors are interrelated.

Reducing the amount of spent fuel in cooling pools, in particular moving all fuel older than 5 years from discharge into dry storage, suggested by Alvarez and others (2003) as a strategy to deal with the potential for accidents, would reduce the source term by a factor of four and would reduce the heat load in the pool. Reducing the amount of spent fuel in the pool would also allow for the use of open frame racks, which, in the case of loss of coolant, allow for air cooling of spent fuel rods. The high-density racks in use today in many pools are closed-cell racks that allow for little air access and depend largely on vertical water circulation to provide cooling.

Transfer of spent fuel from the pool to dry storage is not without costs. Transfer capability must exist[4] and casks and cask storage areas – either concrete pads or buildings – must be available as well. Transferring large quantities of spent fuel will increase the potential for cask drop – a possible initiating event for a loss of coolant accident. Moreover, workers transferring the spent fuel would be exposed to more radiation (GAO, 2012). Finally, of course, are the actual costs of dry storage – the facilities, the casks, and the security and monitoring required once it is in place.

The period of highest vulnerability during the operation of a spent fuel pool is shortly after spent fuel is discharged into the pool. The recent NRC models (NRC, 2014a) suggest that for the first 3-4 months after discharge from the reactor, spent fuel can ignite within 72 hours, if the fuel is uncovered and no mitigative measures are taken. Over the 20-year life of a reactor, these 3-4 month blocks add up to a significant period of time – between one and five years (Macfarlane, 2014). This period of vulnerability is exacerbated if recently discharged spent fuel is placed adjacent cells, instead of using a loading pattern that can absorb some heat, like the 1 x 4 or better, the 1 x 8 pattern. Therefore, it is important to require nuclear power plant operators to discharge spent fuel – and especially full cores – into a dispersed loading pattern in the pool, such as the 1 x 4 or 1 x 8 patterns.

Other mitigative measures include ensuring the ability to add water in the case of loss of coolant. This can be done with fixed and transportable equipment. Examples of fixed equipment are water cannons mounted near the pool and hose bibs attached to building walls near the pool. Transportable equipment can be similar to that used in the Fukushima accident – hose trucks to spray water into the pool. Additional pumps, heat exchangers, piping and wiring can also be located at the reactor site in case of cooling or coolant failure. Connections to on-site diesel generators are essential in the case of off-site power loss.

In the aftermath of the Fukushima accident a number of regulators in various countries have required the addition of equipment (both fixed and transportable) to ensure safety of the spent fuel pools. Some have gone beyond adding water addition and cooling equipment to requiring hydrogen mitigation equipment in the case of hydrogen generation from the oxidation of the zirconium cladding on spent fuel. Build up of hydrogen can result in massive explosions, as occurred in Fukushima.

Unknowns

By their nature, loss of coolant or cooling accidents at spent fuel pools are low probability, high consequence events. These events are generally difficult for society to deal with: as they may never occur, the need for investment in prevention is often questioned. At the same time, were an accident to occur, with little or no attempted prevention, the consequences could be dire, with potentially millions of people affected, and blame laid squarely on the nuclear industry.

All is not currently understood about the progression of an accident in a spent fuel pool. The ability of open-frame racks to mitigate an accident has not been investigated in detail, for instance. In its recent modeling of a spent fuel pool accident (NRC, 2014a), the NRC used two main scenarios, both using high density-type closed-cell racks: one with the cells completely full, and one with the cells partially full. They did not model the response of fuel assemblies in open-frame racks that allow significant water and air circulation.

Another area ripe for investigation is potential alternative loading patterns of recently discharged spent fuel into pools. Recent NRC analysis (2014a) suggests the advantages of using a 1 x 8 pattern where one hot fuel assembly is surrounded by 8 cold ones that provide a cold sink. The question remains whether there are other loading patterns that may be even more helpful in reducing risk of spent fuel fires in pools.

Loss of coolant accidents should be examined more closely, in particular the case where enough of the coolant is lost to uncover the spent fuel but not completely drain the pool. This situation impedes air-cooling of fuel because water blocks the circulation of air around the entire fuel assembly. As a result it is important to understand how much time it would take for spent fuel to heat up to ignition temperatures.

Over the longer term new more accident-tolerant fuels should be investigated, including cladding materials that would resist reactions with steam that produce hydrogen. Spent fuel management can be made safer, but first it is necessary to understand the range of options to promote safe spent fuel pool storage.

Conclusions

Spent fuel pools are a necessary part of nuclear reactor operation. They very simply provide the necessary thermal cooling, criticality control, and radiation protection needed for spent nuclear fuel. But they are not without risk. I would argue that the back end of the fuel cycle, especially at reactors, has not received the attention to safety and management it needs. Management of spent fuel after discharge from the reactor requires careful thought and safety analysis. Surprisingly, regulators in some countries have taken a laissez-faire attitude to the back end of the fuel cycle at reactors. For instance, the U.S. NRC does not require its licensees to report quantities of spent fuel, spent fuel pool loading patterns, loading patterns directly after discharge, whether full-core offload is maintained in the pool, and other pertinent information.

With the back end of the fuel cycle there are straightforward options for managing spent fuel to ensure safety. Spent fuel pools at reactors could be used as in Sweden and France – for recently discharged fuel, which is moved offsite quickly. They can also be used to hold fuel less than 5 years old. After 5 years of cooling, spent fuel can be transferred to passive dry storage. Spent fuel can be discharged into rack loading patterns that ensure the safest configuration in the case of loss of cooling or coolant accidents. Finally, open frame racks can be used to maximize the potential for air circulation in a loss of coolant accident.

III. REFERENCES AND ENDNOTES

Alvarez and others (2003) Reducing the hazards from stored spent power-reactor fuel in the United States, *Science and Global Security*, **11**, p. 1-51.

Canadian Nuclear Safety Commission (2015) High Level Radioactive Waste, from CNSC's website: http://nuclearsafety.gc.ca/eng/waste/high-level-waste/index.cfm#Wet, modified: 2/23/2015, accessed 9/4/2015.

Entergy (2012) Entergy to Begin Removing Spent Fuel from Unit 3 Spent Fuel Pool, September 14, 2012, http://www.entergy.com/news_room/newsrelease.aspx?NR_ID=2549.

Government Accountability Office (2012) Spent Nuclear Fuel: Accumulating Quantities at Commercial Reactors Present Storage and

Government Accountability Office (2012) Spent Nuclear Fuel: Accumulating Quantities at Commercial Reactors Present Storage and Other Challenges, GAO-12-797, August, 2012.

Hozer and others (2009) Activity release from damaged fuel during the Paks-2 cleaning tank incident in the spent fuel storage pool, *Journal of Nuclear Materials*, 392, pp. 90-94.

International Atomic Energy Agency (2009) OECD-IAEA Paks Fuel Project Final Report, Vienna.

International Panel on Fissile Materials (2011) Managing Spent Fuel from Nuclear Power Reactors: Experience and Lessons from Around the World, September, 2011.

Macfarlane (2014) Chairman Macfarlane's Comments on COMSECY-13-0030 Staff Evaluation and Recommendation for Japan Lessons-Learned Tier 3 Issue on Expedited Transfer of Spent Fuel, April 8, 2014.

National Research Council, 2006, Safety and Security of Commercial Spent Nuclear Fuel: Public Report, Washington, DC: National Academies Press.

National Research Council, 2016, Lessons Learned from the Fukushima Accidentfor Improving Safety and Security of Nuclear Plants, Phase 2, Washington, DC: National Academies Press.

Nuclear Energy Agency, 2015, Status on Spent Fuel Pools under Loss-of-Colling and Loss-of-Coolant Accident Conditions, Nuclear Safety NEA/CSNI/R(2010)2, May 2015, OECD.

Nuclear Regulatory Commission (undated) Boiling Water Reactor Systems, Reactor Concepts Manual, USNRC Technical Training Center, https://www.nrc.gov/reading-rm/basic-ref/students/for-educators/03.pdf

Nuclear Regulatory Commission (2001) Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants, NUREG-1738.

Nuclear Regulatory Commission (2014a) Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a US Mark I Boiling Water Reactor, NUREG-2161.

Nuclear Regulatory Commission (2014b) Policy Issue Information: SECY-14-0136, Response to Commission Direction on Spent Fuel Pool Limited Term Operational Vulnerabilities, November 26, 2014.

Oak Ridge National Laboratory (2011) Decay Heat Calculations for PWR and BWR Assemblies Fueled with Uranium and Plutonium Mixed Oxide Fuel Using Scale, ORNL/TM-2011/290, September, 2011.

Wang, and others (2012) Study of Fukushima Daiichi nuclear power station unit 4 spent-fuel pool, *Nuclear Technology*, 180, pp. 205-215.

Xu, M. Kazimi, and M Driscoll (2005) Impact of high burnup on PWR spent fuel characteristics, *Nuclear Science and Engineering*, 151, pp. 261-273.

ENDNOTES

[1] In the Three Mile Island accident in 1979, even though the reactor suffered a partial meltdown, radioactivity generated did not contaminate the surrounding area because the containment operated as planned and contained the radionuclides. Conversely, the Chernobyl reactor that melted down in 1986 did not have containment and as a result contaminated a huge swath of land.

[2] PWR spent fuel pools also use borated water for criticality control (Nuclear Energy Agency, 2015).

[3] At some US nuclear power plants, the guard force makes up one third of the entire workforce at the plant.

[4] Transferring spent fuel from the pool to dry storage requires a crane strong enough to lift the loaded cask, space in the pool to emplace the cask, facilities at the reactor site to decontaminate and seal the cask, a specially-designed transfer vehicle to move the filled cask to the storage site. As a case in point, the Indian Point power plant in New York did not have the capability until 3 years ago to remove spent fuel from unit 3's pool because it could not accommodate the large crane needed to lift loaded casks. To resolve the problem they added a smaller crane to lift a small, water-filled transfer cask with 12 fuel assemblies. This transfer cask is brought to unit 2's spent fuel pool where a full-size storage cask can be loaded (Entergy, 2012).

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Criteria and Planning Guidance for Ex-Plant Harvesting to Support Subsequent License Renewal

December 2017

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Prepared for the U.S. Nuclear Regulatory Commission
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Abstract

As U.S. nuclear power plants look to subsequent license renewal (SLR) to operate for a 20-year period beyond 60 years, the U.S. Nuclear Regulatory Commission and the industry will be addressing technical issues around the capability of long-lived passive components to meet their functionality objectives. A key challenge will be to better understand likely materials degradation mechanisms in these components and their impacts on component functionality and safety margins. Research addressing many of the remaining technical gaps in these areas for SLR may greatly benefit from materials sampled from plants (decommissioned or operating). Because of the cost and inefficiency of piecemeal sampling, there is a need for a strategic and systematic approach to sampling materials from structures, systems, and components (SSC) in both operating and decommissioned plants. This document describes a potential approach for sampling (harvesting) materials that focuses on prioritizing materials for sampling using a number of criteria. These criteria are based on an evaluation of technical gaps identified in the literature, research needs to address these technical gaps, and lessons learned from previous harvesting campaigns. The document also describes a process for planning future harvesting campaigns; such a plan would include an understanding of the harvesting priorities, available materials, and the planned use of the materials to address the technical gaps.

Summary

The decommissioning of some nuclear power plants (NPPs) in the United States after extended operation provides an opportunity to address a number of materials degradation questions that add to confidence in the aging management systems used by the nuclear industry. Addressing these questions is expected to provide reasonable assurance that systems, structures, and components (SSCs) are able to meet their safety functions. Many of the remaining questions regarding degradation of materials will likely require a combination of laboratory studies as well as other research conducted on materials sampled from plants (decommissioned or operating).

Evaluation of material properties of SSCs from operating or decommissioned NPPs can provide a basis for comparison with results of laboratory studies and calculations to increase confidence that long-lived passive components will be capable of meeting their functional requirements during operation beyond 60 years. A strategic and systematic approach to sampling materials from SSCs in both operating and decommissioned plants will help reduce costs and improve efficiency of materials harvesting. In turn, the ability to efficiently harvest materials is expected to lead to opportunities for benchmarking laboratory-scale studies on materials aging, identifying constraints on materials/components replacement in operating plants, and determining condition assessment methods that may be applied to these components in the field.

This document describes a potential approach for prioritizing sampling (harvesting) materials using a number of criteria that incorporate knowledge about the specific technical gaps closed through the sampling process. At the highest level, the major criteria are:

- Unique field aspects, if any, that drive the importance of harvesting the material
- Ease of laboratory replication of material and environment combination
- Applicability of harvested material for addressing critical gaps (dose rate issues, etc.)
- Availability of reliable in-service inspection techniques for the material
- Availability of materials for harvesting.

A number of information sources on materials degradation in NPPs were reviewed to assess key technical gaps that may be relevant for SLR. Information from these sources were cross-referenced (where possible) and collated to assess harvesting priority. In this document, several examples of this process are described, along with experiences from harvesting materials at several operating and closed plants. Using these lessons learned from previous harvesting campaigns, a harvesting process is defined that includes many of the criteria that should be taken into account during any harvesting campaign.

The use of information tools can assist with this harvesting process, and one concept for such a tool is described in this document. This tool is expected to provide a mechanism for easily sorting and searching through information from multiple sources, integrate subject matter expert input into the technical gaps assessment and prioritization process, and generate the appropriate prioritized harvesting plan. In theory, such a tool could be extended to include a mechanism for collating the findings from any research conducted using the harvested material and enable a seamless way for accessing the necessary information for any subsequent decisions.

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Acronyms and Abbreviations

ALARA	as low as reasonably achievable
AMP	aging management program
ASME	American Society of Mechanical Engineers
BWR	boiling water reactor
CASS	cast austenitic stainless steel
CM	condition monitoring
Code	ASME Boiler and Pressure Vessel Code
DBE	design basis event
DMW	dissimilar metal weld
dpa	displacements per atom
EAB	elongation-at-break
EMDA	enhanced materials degradation assessment
EPR	ethylene propylene rubber
EPRI	Electric Power Research Institute
GALL	Generic Aging Lessons Learned
IASCC	irradiation-assisted stress corrosion cracking
ISI	in-service inspection
LWR	light water reactor
NDE	nondestructive evaluation
NPP	nuclear power plant
NRC	U.S. Nuclear Regulatory Commission
OE	operating experience
OMB	outside the missile barrier
PMDA	proactive materials degradation assessment
PWR	pressurized water reactor
RPV	reactor pressure vessel
RRIM	Reactor Reliability and Integrity Management
SCC	stress corrosion crack
SLR	subsequent license renewal
SME	subject matter expert
SSC	structures, systems and components
XLPE	crosslinked polyethylene
XLPO	crosslinked polyolefin

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1.0 Introduction

The nuclear power fleet in the United States currently consists of approximately 98 operating reactors, of which 87, as of October 2017, have received licenses to operate beyond the original license period of 40 years (NRC N.D., Appendix A). The license renewal for these plants extends their operating life to 60 years and the U.S. nuclear power industry is now looking at a further extension of this operating license period.

The U.S. Nuclear Regulatory Commission (NRC) regulations in 10 CFR 54.31(d) allow nuclear power plants (NPPs) to renew their licenses for successive 20-year periods. The biggest challenges for the NRC and the industry will be addressing the major technical issues for this second ("subsequent") license renewal (SLR) beyond 60 years. As summarized in SECY-14-0016 (SECY-14-0016 2014; Vietti-Cook 2014), the most significant technical issue challenging power reactor operation beyond 60 years is assuring long-lived passive components are capable of meeting their safety functions. In particular, the accumulation of degradation in four classes of systems, structures, and components (SSCs) is of concern (INL 2016):

- Reactor pressure vessel (RPV)
- Reactor internals and primary system components
- Concrete and containment degradation
- Electrical cables.

Understanding the causes and control of degradation mechanisms forms the basis for developing aging management programs (AMPs) to ensure the continued functionality of and maintenance of safety margins for NPP SSCs. The AMPs, along with the appropriate technical basis, are used to demonstrate reasonable assurance of safe operation of the SSCs during the SLR period.

Addressing many of the remaining technical gaps for SLR may require a combination of laboratory studies and other research conducted on materials sampled from plants (decommissioned or operating). Evaluation of materials properties of SSCs from decommissioned NPPs will provide a basis for comparison with results of laboratory studies and calculations to determine if long-lived passive components will be capable of meeting their safety functions during operation beyond 60 years. Because of the cost and inefficiency of piecemeal sampling (i.e., harvesting materials on an ad-hoc basis), there is a need for a strategic and systematic approach to sampling materials from SSCs in both operating and decommissioned plants.

This document describes a potential approach for sampling (harvesting) that focuses on prioritizing materials using a number of criteria. These criteria also help define the specific problems that will be addressed and the knowledge gained/technical gaps closed through the sampling process. Using a number of lessons learned from previous harvesting campaigns, a harvesting process is defined that includes many of the criteria that should be taken into account during any harvesting campaign.

2.0 Nuclear Plant Materials Harvesting

A key challenge to addressing the gaps in materials aging and degradation through 80 years of operation is the ability to perform tests that mimic the aging process in operating plants. Often, such tests are performed (and materials performance data obtained) through accelerated aging experiments, where the material under test is subjected to higher stresses (mechanical, thermal, and/or radiation) than those seen in operation. Such tests enable the experiments to be completed in a reasonable timeframe but need to be benchmarked with performance data from materials that have seen more representative service aging.

Where available, benchmarking can be performed using surveillance specimens. In most cases, however, benchmarking of laboratory tests will require harvesting materials from reactors.

Over the past several years, a number NPPs (both within the United States and elsewhere) have either permanently ceased operation or have indicated that they will shut down in the next few years. These shutdown plants provide an opportunity to extract materials that have real-world aging and provide an avenue for benchmarking laboratory-scale studies on materials aging. The resulting insights into material aging mechanisms and precise margins to failure will be essential to provide reasonable assurance that the materials/components will continue to perform their safety function throughout the plant licensing period. The extracted materials could also help in determining specific methods for condition assessment or non-destructive evaluation (NDE) that may be applied to these components in the field to assess component aging.

Note that while shutdown nuclear plants provide an unparalleled opportunity for ex-plant harvesting, similar harvesting opportunities may exist in operating plants. Scheduled repairs or replacements may provide opportunity to extract materials to address specific knowledge gaps associated with materials performance during SLR. In other instances, specific but unusual operational experience may dictate the need to harvest materials to better understand the observed phenomena.

Harvesting is not the sole answer to addressing knowledge gaps. In some cases where harvesting is most needed, such as the RPV, internals, and concrete in the shield walls, the components exist in areas with high radiation doses. Because of the need to minimize personnel radiation doses to levels as low as reasonably achievable (ALARA), worker access to these areas is stringently controlled. The benefits of harvesting may not be enough to overcome the costs of procurement, evaluation, and subsequent disposal of the materials.

Given the advantages and disadvantages associated with harvesting, there is a need for processes to identify, assess, and prioritize harvesting opportunities. The next section discusses criteria for harvesting and provides examples of applying these criteria.

3.0 Materials and Harvesting Prioritization

This section describes the sources of information used in the assessment and proposes several criteria for use in the prioritization of harvesting decisions. Several examples are included that show the application of these criteria to provide a qualitative assessment of harvesting priority.

3.1 Literature Sources

There are two general classes of degradation mechanisms that are of interest (Cattant 2014). The first class is mechanisms that lead to failure (such as corrosion, fatigue, or wear) while the second class concerns materials aging (such as irradiation embrittlement and thermal aging). In general, the second class of degradation mechanisms results in a change in material properties (reduction in toughness, increase in hardness, etc.) that can facilitate failure through one of the failure mechanisms. In this document, this distinction is not strictly followed and the terms “degradation mechanism” and “aging” are used somewhat generically to refer to either of the two classes.

A wide variety of literature exists with information on materials degradation that may be relevant to life extension of NPPs. Early materials aging insights for light water reactor components were summarized in a number of documents (Blahnik et al. 1992; Shah and MacDonald 1993; Livingston et al. 1995; Morgan and Livingston 1995; NRC 1998). More recently, the literature in this area includes the NRC Generic Aging Lessons Learned (GALL) reports (NRC 2010a, 2017b, a); *Expert Panel Report on Proactive Materials Degradation Assessment (PMDA)* (Andresen et al. 2007); *Proactive Management of Materials Degradation - A Review of Principles and Programs* (Bond et al. 2008); and *Expanded Materials Degradation Assessment (EMDA)*, NUREG-7153:

- Volume 1 (Busby 2014)
- Volume 2 (Andresen et al. 2014)
- Volume 3 (Nanstad et al. 2014)
- Volume 4 (Graves et al. 2014)
- Volume 5 (Bernstein et al. 2014)

The GALL report is the NRC staff's generic evaluation of the acceptable aging management for the period of extended operation based on the technical basis developed in the EMDA and PMDA. Based primarily on the operating experience from the fleet of operating plants in addition to EMDA and PMDA, GALL assesses the acceptable aging management approach for passive SSCs, based on material type and operating environment. The Electric Power Research Institute (EPRI) has also documented materials aging issues in the form of Materials Degradation Matrix and Issue Management Tables (EPRI 2013a, b, c). The matrix is used to document potential degradation mechanisms for primary system components, while the tables provide the basis for determining the consequence of component failures along with possible mitigation options. Further, a number of technical gaps have been identified in the understanding of degradation growth in specific materials; these are the current focus of active research by a number of organizations (IAEA 2012; McCloy et al. 2013; INL 2016).

Two factors play an important role in the ability to detect and mitigate materials degradation. First is an understanding of the materials degradation processes that contribute to the progression of degradation and, if not detected and mitigated, an eventual loss of structural integrity. The second factor is the availability of NDE methods and associated condition monitoring (CM) techniques that are capable of detecting the degradation in a timely fashion (before it grows to the point where loss of structural integrity occurs).

It is important to note that these two factors are connected and advances in one may help address any perceived deficiencies in the other. For instance, lack of a comprehensive understanding of the mechanism (how it develops and grows) may be mitigated somewhat if adequate methods for detecting the degradation are available. Likewise, lack of adequate methods for detection may be mitigated if improved understanding of the mechanisms exists.

Note that the sources of information for these two factors are not always connected. A number of studies have examined the ability to detect degradation in a timely manner. These studies have generally focused on assessing the reliability of NDE methods and the factors impacting reliability. Current techniques such as ultrasonic testing and eddy current testing that are applied for NPP in-service inspection (ISI) tend to focus on detecting signatures from mechanisms (such as cracking) that lead to failure. These studies are usually based on a comprehensive round-robin assessment of the technique, instrumentation, or personnel (Crawford et al. 2015; Meyer and Heasler 2017; Meyer et al. 2017; Ramuhalli et al. 2017). These types of studies have led to changes in the American Society of Mechanical Engineers (ASME) Boiler and

Pressure Vessel Code (hereafter the Code) around the implementation of techniques to assure reliable detection of cracking in the field (Doctor et al. 2013).

It is important to note that current NDE techniques have not seen real-time or in situ application for the detection and characterization of general materials aging. However, there is a rich set of literature that is examining the applicability of these same techniques as well as new techniques for this purpose, although the work has stayed largely in the basic research phase (Bond et al. 2009, 2011; Meyer et al. 2012; IAEA 2013; Ramuhalli et al. 2014; Fifield and Ramuhalli 2015).

3.2 Literature Assessment

The literature identified above, especially for materials degradation mechanisms, cover a broad range of materials, mechanisms, and environments, for both pressurized water reactor (PWR) and boiling water reactor (BWR) plants.

From the perspective of SLR, a number of studies, such as the EMDA and PMDA, have identified technical gaps associated with understanding the contributing factors for materials degradation development and growth. These studies, typically conducted as expert elicitations, have resulted in phenomena identification and ranking tables listing the susceptibility of materials to specific degradation mechanisms and the level of knowledge available. The tables also include general information on the environment that these materials operate in, as the specific degradation mechanisms are intimately tied to the environmental conditions in which the material operates.

It is important to note that the information in the literature sources identified in Section 3.1, while similar in form, differs in specificity. Studies such as the EMDA and PMDA have focused on specific materials (alloys, specific compositions, etc.) while other studies may refer to generic materials while recognizing that differences in material composition and grade may exist. As an example, different grades of stainless steel are used in the current nuclear power fleet and while there may be similarities in how they behave under different environmental conditions, differences that are related to specific compositional variations may drive their behavior over the long term under specific operating conditions.

A specific example of this is the structural steels used in RPVs, where compositional variations may be a driving force in the loss of fracture toughness (Sokolov and Nanstad 2016). Concern now focuses on the possibility of late-blooming phases (Malerba 2013) that may cause changes in fracture toughness over longer operating periods. However, the development of such phases appears to be a function of the specific composition and the operational environment.

Materials degradation analyses, as well as inspection methods, have tended to focus on metals and pressure boundary components, such as the phenomenon identification and ranking table analysis conducted under the PMDA effort (Andresen et al. 2007). As plants consider SLR out to 80 years of operation, concerns about non-metallic passive components are increasing. These long-lived components, broadly divided into concrete and electrical cables, are generally difficult (if not impossible) to replace and would require a significant investment if across-the-board replacement is considered. As a result, recent assessments such as the EMDA have included a significant emphasis on identifying knowledge gaps related to these long-lived non-metallic components (Bernstein et al. 2014; Graves et al. 2014). At the same time, there is increased attention being focused on developing CM and NDE methods for concrete and electrical cables, with the objective of defining methods and acceptance criteria that would provide reasonable assurance that degradation would be detected before it reaches a state where it begins to affect the safe operation of the plant.

Collectively, these studies point to several potential knowledge gaps regarding specific materials and degradation mechanisms. These knowledge gaps are related to an understanding of the conditions leading to degradation initiation and growth, and to methods for detecting and mitigating such degradation in a timely fashion. Note that this is not a blanket statement about all materials and all mechanisms; in many instances, sufficient knowledge exists about the mechanism and methods for detection such that appropriate AMPs may be used successfully to manage these mechanisms of aging and degradation out to 80 years of operation.

The implication of the foregoing discussion is that certain mechanisms and materials, within the context of SLR, may be considered as a high priority when it comes to addressing technical gaps in degradation initiation, growth, and detection; however, a systematic approach is needed to objectively identify these materials and mechanisms. This systematic approach could also identify one or more criteria that can be used in the prioritization process. From the perspective of materials harvesting, priorities may also need to account for the connection between materials degradation and CM/NDE, and include an assessment of available NDE or other CM techniques. Assuming such a prioritization can be made, the materials identified would then become the target of activities related to ex-plant harvesting.

There have been similar studies in the past, where the objective has been to develop a systematic methodology for prioritizing harvesting opportunities (Johnson Jr. et al. 2001). This study builds on these previous efforts, focuses on harvesting needs for increasing confidence in aging management for SLR, and incorporates lessons learned from harvesting efforts in the years since these previous studies.

The next several subsections describe potential criteria and provide several examples of the analysis that can be conducted using these criteria for identifying high-priority components/materials for ex-plant harvesting.

3.3 Criteria for Prioritizing Harvesting

3.3.1 Criteria

Criteria for prioritizing harvesting of components/materials need to be relevant to the organization's specific needs. For example, one of the questions that will need to be addressed is whether for a given material within a specific environment, the failure mechanisms are understood sufficiently. If so, the harvesting priority for the material exposed to this environment is likely lower. Likewise, if there are sufficient options for monitoring, mitigation, and repair, and these have been validated in representative materials/conditions, harvesting priority may be low. Uncertainty in any of these factors may drive up the priority for harvesting in an effort to reduce the uncertainty. For CM/NDE, the needs are generally about the mechanism and geometry but not how the degradation was created (accelerated vs. real time). A need also exists in simulating "realistic" degradation, and this is where limited harvesting may be useful for benchmarking purposes.

Given this background, criteria for prioritizing harvesting may be broken into five major categories, with several other lower level criteria for fine-tuning the information. At the highest level, the major criteria are:

- Unique field aspects, if any, that drive the importance of harvesting the material. This focuses on materials that are not easily available presently, such as legacy material formulations and fabrication methods that may be outdated. Also within this category would be operating experience (OE) associated with a specific class of materials in a relevant environment. If OE is available, especially for materials considered to be low in susceptibility to a specific degradation mechanism, for instance stress corrosion cracking (SCC), it may be worth harvesting the material if possible.

- Ease of laboratory replication of material and environment combination. This criterion focuses on conditions that are not easily reproducible in a laboratory environment. Of the environments of interest, radiation environments are likely to be the most challenging to duplicate. This is more so for low-dose, long-term irradiation and is a concern if dose rate effects exist that may influence the mechanism initiation and growth.
- Applicability of harvested material for addressing critical gaps. The focus of this criterion is on the ease with which the harvested material may be used in laboratory studies to address gaps in knowledge. Ideally, research plans for use of harvested materials would be in place prior to the actual harvesting. A related question would be whether, in addition to laboratory studies using characterization tools, the material can be used in degradation initiation and growth studies. In this context, re-aging of harvested materials under accelerated conditions may provide additional insights. In cable aging, such studies have been proposed (wear-out aging).
- Availability of reliable CM/NDE techniques for the material and degradation mechanism. Such techniques may compensate for any uncertainties in knowledge about the formation and growth of degradation, and enable sufficient defense in depth. Note that, even with reliable CM/NDE methods being available, harvesting may be warranted in some instances if the degradation mechanism is likely to be a generic fleet-wide issue. In these cases, the harvested material may provide insights for repair/mitigation decision-making and improving the economics of plant operation. Further, it is possible that the harvested material may be useful for developing or improving CM/NDE techniques.
- Availability of material for harvesting. Knowledge of materials used in different operating and shutdown plants as well an understanding of which materials may be available for harvesting over different time horizons (short, medium, long) is necessary.

Note that the focus of this document is on identifying harvesting needs; other parallel activities are underway (and are expected to continue into the future) to identify material availability.

These high-level criteria focus on the ability of harvested materials to address gaps in materials performance knowledge for SLR. In tabulating the answers to these criteria, a variety of information will need to be gathered, possibly using one or more of the sources identified earlier. These include expert elicitation studies (EMDA, Materials Degradation Matrix, etc.) on the susceptibility of various materials in relevant environments to a number of degradation mechanisms. In addition to the susceptibility information from these expert panels, knowledge and confidence may be gained in the specific combination of material, degradation mechanism, and environment. In parallel, information in the GALL documents associate similar combinations with relevant AMPs, while other available documents provide insights into specific knowledge gaps.

Specific information from these studies that would be needed include:

1. Whether the material, degradation mechanism, and environment combination rated “high susceptibility” in expert elicitation reviews such as EMDA.
2. Whether the material, degradation mechanism, and environment combination rated “low knowledge” in the expert elicitation reviews such as EMDA.
3. AMPs that may be applicable to address the combination of the material, degradation mechanism, and environment.
4. Presence of OE associated with the material, degradation mechanism, and environment combination.

5. The level of understanding of the mechanism (ranges of environmental factors, initiation times and growth rates, other factors such as compositional variations, etc.). In effect, this is related to identifying the critical gaps in knowledge and also the ease with which the material, degradation mechanism, and environment combination may be simulated in the laboratory.
6. Options for mitigation, if any. Effective mitigation techniques (including a relatively easy and inexpensive path to replacement of the component) point to a relatively high level of understanding of the degradation mechanism. As a result, the added benefits from harvesting may be limited in these instances.
7. Amount of material use (plant-wide and fleet-wide). In addition to addressing the criterion on material availability, this information also plays into an assessment of the harvesting benefit. Widespread use of a specific material under similar environmental conditions could point to a large (potentially fleet-wide) benefit from harvesting.

It is important to determine whether the expected benefits from the harvested materials will clearly reduce any uncertainty associated with the materials' performance through 80 years of operation of the plant. If so, this potentially provides benefits from the regulatory perspective, while reducing any uncertainty around safety margins in these components.

3.4 Examples

In the interest of developing the process for prioritizing harvesting further, several examples are considered in this subsection. These examples are not intended to be comprehensive, but were selected to cover the potential range of priorities as well as highlight specific aspects of harvested materials that may be considered in the harvesting decision process. In each case, the criteria described above are assessed, with the additional information listed. The result is an assessment of the priority for harvesting should the material become available due to plant retirements or planned repairs.

The first example is of a non-metallic material (electrical cable insulation), illustrating the complexity of the problem and the unknowns in aging mechanisms and performance. This is followed by an example of cast austenitic stainless steel (CASS), which highlights several unknowns in aging mechanisms and the potential limitations of accelerated laboratory aging-based tests. This provides an example of a potential medium- to high-priority harvesting need. The next example (SCC in dissimilar metal welds [DMWs]) is evaluated for two specific scenarios and is considered a low priority for harvesting. The final example of vessel internals highlights unique aspects of field-aged materials (radiation damage) that makes harvesting a valuable but perhaps expensive proposition.

3.4.1 Electrical Cables

The issues associated with aging of electrical cables are generally complicated by the diversity in materials and formulations that were used in vintage cables. Given the qualification methods used when they were put into service, utilities were able to perform time-limited aging analyses to show with a reasonable assurance that electrical cables would be able to perform their necessary function under a design-basis event through a first round of license extension. However, as utilities approach a decision on SLR, there is a general consensus that available data on long-term performance of cables is sparse and in some instances contradictory.

Generally, utilities have adopted a CM approach to aging cable management. Given the uncertainties and knowledge gaps, they do not necessarily expect the cable to last for 80 years. Rather through their CM program, they are assured that they can detect damage before it becomes critical. The damaged cables or cable sections may then be repaired or replaced.

Harvesting cables has benefits and drawbacks. On one hand, it is possible to accelerate aging in a laboratory environment; this is likely to be informative for tracking and correlating inspection techniques over a full degradation lifecycle. On the other hand, such a study is not possible with a snapshot in time of a cable from a plant where the actual temperature and dose level is not known.

However, there is concern that the aging seen in accelerated tests may not always correlate well with field aging. In particular, dose rates and total dose effects, synergistic effects of thermal and radiation aging, and diffusion-limited oxidation are all concerns for the applicability of accelerated aging. Further, there are many instances where the formulations of cable insulation material (polymers) in plants (vintage material) are different from what is available today. In these cases, harvested vintage cables can be used for studies to provide the necessary data and plug the knowledge gaps.

From a CM perspective, the most interesting harvested cable samples will have failed some in-plant test (such as walkdown, indenter, withstand test, and time and frequency domain reflectometry [TDR and FDR]). These cables can then be subjected to alternative tests (like capacitance and higher-frequency FDR) and autopsy with laboratory tests like diffusion-limited oxidation and elongation at break (EAB).

Both operating and decommissioned plants may be sources of material, particularly if there is some indication of dose and/or elevated temperature exposure. A key advantage of material from these plants is the ability to compare laboratory and NDE tests of artificially aged cable to the naturally aged cable for verification of equivalency.

Harvested cables, when subjected to laboratory aging studies (wear-out aging) may be used with destructive and NDE tests (EAB, line resonance analysis, gel-swell, micro-indenter, atomic force microscopy, indenter, etc.) for increasing confidence in the ability to detect aging of concern and provide assurance that the insulation/jacketing material has not reached its end of life (defined as 50% EAB). While some of this has been done (Bernstein et al. 2014), there are still knowledge gaps that could benefit from this work.

The Cable EMDA includes the following classifications of material:

1. Cables at 35°C–50°C (95°F–122°F) and zero dose
2. Cables at 35°C–50°C (95°F–122°F) and up to 0.01 Gy/hr. (1 rad/hr.)
3. Cables at 45°C–55°C (113°F–131°F) and up to 0.1 Gy/hr. (10 rad/hr.)
4. Cables at 45°C–55°C (113°F–131°F) and up to 1 Gy/hr. (100 rad/hr.)
5. Cables at 60°C–90°C (140°F–194°F) and zero dose
6. Medium voltage cables in long-term wet conditions

For the above categories, material considerations were:

1. Crosslinked polyethylene (XLPE) (wet cables)
2. Crosslinked polyolefin (XLPO) (not for wet conditions)
3. Modern tree retardant XLPE
4. Flame-retardant ethylene propylene rubber (EPR)
5. EPR/neoprene

6. EPR/chlorosulphonated polyethylene (CSPE)
7. Black EPR
8. Pink EPR
9. Brown EPR
10. Butyl rubber
11. Neoprene
12. CSPE
13. Chlorinated polyethylene
14. Silicone rubber (not suitable for wet conditions)

For low-temperature, low-dose cases, susceptibility to embrittlement due to radiation and thermal aging was 0 to 2 (low susceptibility), and this is a well understood issue with knowledge consistently ranking at 3 (on a scale of 0–3). As the environmental exposure exceeds 45°C and up to 0.1 Gy/hr., susceptibility increases particularly with Neoprene, silicone rubber, and CSPE and the knowledge falls to 2–3. Thus, harvesting materials (especially Neoprene, silicone rubber, and CSPE) exposed to temperatures in excess of around 45°C and low-doses is likely to be of value. Table 1 provides a summarization for one type of cable in a specific environment, as a single example of non-metallic materials. Given the critical gaps and widespread nature of their use, these are considered a high priority.

Table 1. Assessment of Electrical Cable Insulation Harvesting Priority. Insulation and jacket materials considered are EPR and CSPE, at temperatures between 45°C–55°C and dose between 0.1–0.01 Gy/hr. (1–10 rad/hr.)

Criteria	Qualitative Assessment	Comments
Unique field aspects, if any	Vintage formulations, depending on manufacturer, real-world conditions.	10–12 manufacturers of vintage cable in U.S. fleet. Within a single plant, cable types and manufacturers can vary.
Ease of laboratory replication	Low-medium (long-term aging studies necessary)	
Applicability of harvested material for addressing critical gaps	High – Wear-out aging a possibility. Evaluation of CM for field degradation.	Requires knowledge on plant conditions
Condition monitoring/ISI for detection and sizing	Low to medium. Unclear how well proposed techniques would perform for low dose rate, low temperature aging of insulation.	Access limited; long-range methods are not fully understood
Availability of material for harvesting	TBD	Needs input from utilities
EMDA susceptibility score	Generally High (2–3)	
EMDA knowledge score	Medium (mostly 2)	Some data exist on long-term aging. Inverse temperature and synergistic effects are a concern. Inverse temperature effects apply and CSPE is formulation-specific.
GALL-SLR	Documented as a potential issue	AMP updates ongoing
OE	Yes	Documented in industry publications
Level of understanding of mechanism (environmental factors, initiation and growth of degradation, related factors)	Medium	See knowledge gaps below
Options for mitigation	Low	
Ease of replacement	Medium	Possible but can get expensive depending on specific locations
Amount of Use (in a plant and fleet-wide)	High	Low-voltage and medium-voltage cables extensively used in plants
Critical gaps in knowledge	Contribution to database for dominant effects, synergistic effects, dose rate effects for understanding accelerated aging vs. field aging, develop and qualify CM techniques	
HARVESTING PRIORITY		HIGH

3.4.2 Cast Austenitic Stainless Steel

CASS is used extensively in pressure boundary components in light water reactor (LWRs) coolant systems (Chopra and Rao 2016). Applications include piping, valves, vessel internals, pumps, support structures, brackets, and flow restrictors.

OE for material degradation has not been broadly encountered under 40 years of life. Under extended service life, the main concern is loss of fracture toughness due to aging (thermal and neutron embrittlement). Stress corrosion cracking and fatigue are not considered generic concerns for CASS. Under prolonged thermal aging, elements segregate and undesirable Cr-rich regions form within the ferritic phase, leading to degradation of mechanical properties. It is not known how radiation damage will interact with thermal aging.

At present, accelerated aging of CASS in the laboratory and computer simulations of microstructural changes are the main tools used to understand the aging of CASS in service. It would be useful to harvest reactor materials to validate the current accelerated aging program, computer models, and existing regulatory positions. Microscopy and mechanical testing of harvested materials will improve our understanding of aging behavior. In addition, accelerated aging of harvested materials will provide information on new degradation mechanisms that could crop up under extended life. While radiation damage has not been a concern in CASS, it would be prudent to harvest both unirradiated material (piping, pumps, etc.) and irradiated material (reactor internals) so that radiation effects on degradation under life extension can be reliably evaluated.

Below describes how the information on CASS may be mapped into the different criteria identified above.

1. The combination of material (CASS), degradation mechanism, and environment is rated high in the EMDA mainly for fracture of PWR piping in reactor water (no irradiation) and BWR vessel internals in primary water (radiation up to 1.5 dpa).
2. Both the knowledge and confidence scores are fairly high (~2, on a scale of 0–3) for CASS for all degradation mechanisms, because there have been limited instances of degradation in the OE and those were generally attributed to poor material quality or incorrect material processing.
3. The material, mechanism, and environment for thermal aging and loss of fracture toughness can be simulated in the laboratory. However, the relation between accelerated testing time and real-world service time is not clearly validated. Synergistic effects are difficult to reproduce in the laboratory. It would be valuable to look at the heat-affected zone in welded CASS material.
4. Knowledge gaps: There is data in the literature that suggests significant loss of fracture toughness for neutron exposures between 0.5 and 5 dpa due to the interaction of neutron and thermal embrittlement effects (Chopra 2015). This interaction needs to be understood for life extension.
5. Harvested materials can be used to address critical knowledge gaps in two areas: (1) calibration and validation of current accelerated testing procedures; and (2) assessment of the combined effects of thermal aging, coolant effects, and neutron irradiation. Degradation initiation and growth studies can be conducted with harvested materials. New/improved ISI procedures may be developed to detect degradation.
6. Reduction in fracture toughness as a result of thermal embrittlement can result in significantly increased crack propagation rates. While the delta ferrite content in CASS is one of the factors that controls crack (specifically SCC) initiation susceptibility, with higher delta ferrite generally resulting in lower SCC susceptibility but higher thermal embrittlement susceptibility, it is possible that other factors (such as fabrication irregularities or cold work) play a role in increasing the susceptibility to

SCC (Byun and Busby 2012). There is also active research to address potential gaps related to SCC initiation and thermal embrittlement during SLR.

The main microstructural mechanisms of thermal aging at less than 500°C are associated with the precipitation of additional phases in the ferrite: (a) formation of a Cr-rich α′-regions through spinodal decomposition, (b) precipitation of a γ-phase (Ni, Si-rich) and $M_{23}C_6$ carbide, and (c) additional precipitation and/or growth of existing carbides and nitrides at the ferrite/austenite phase boundaries (Ruiz et al. 2013). The formation of Cr-rich α′-regions by spinodal decomposition of δ-ferrite phase is the primary mechanism for the thermal embrittlement (Byun et al. 2016). The significant material signatures in the context of condition assessment for thermal aging appears to be the amount of Cr-rich α′-regions produced by spinodal decomposition of δ-ferrite and material hardness induced by thermal aging.

7. ISI methods are being evaluated to assess their ability to detect cracking in CASS. Currently, no technologies are deployed in the field for monitoring the thermally aged condition of CASS, nor does there appear to be an obvious immediate need for such technologies.

   In the event of a pressing need for such technology, the feasibility of monitoring the thermally aged condition of steels is suggested by the sensitivity of certain magnetic and ultrasonic NDE measurements to the precipitation and growth of second phases. It is reported that magnetic hysteresis loop analysis and magnetic Barkhausen noise emission can be used to estimate the amount of a non-ferromagnetic second phase material in a ferromagnetic material (Raj et al. 2003). Dobmann (2006) has investigated magnetic loop measurements for characterizing thermal embrittlement of WB36 low alloy steel. An estimate of the amount of copper phase precipitation is obtained from magnetic coercivity and results are presented that indicate a correlation between the coercivity measurements and Vickers hardness measurements. Similar studies are underway to assess precipitation of Cr-rich phases using magnetic measurements.

Harvested components are usually not necessary for condition assessment technology development as appropriate material conditions can be achieved and investigated by accelerated aging of laboratory specimens. Harvested materials may be useful to understand the interaction of radiation and thermal aging, to calibrate accelerated aging in the laboratory against long-term service in a reactor environment, and to estimate/predict the life time of CASS components for life extension. While the NRC is not currently funding research in this area, harvested CASS materials may help provide additional data to further inform the NRC's regulatory decision-making.

The information above is summarized in Table 2.

Table 2. Summary of Harvesting Criteria for CASS, for All Mechanisms, in Reactor Water in Primary Loop Components

Criteria	Qualitative Assessment	Comments
Unique field aspects, if any	Vintage material, synergistic effects (especially radiation)	
Ease of laboratory replication	Low-medium	Gap relating accelerated aging studies to real-world service time
Applicability of harvested material for addressing critical gaps	Calibrate and validate accelerated aging procedures; assessment of the combined effects of thermal aging, coolant effects, and neutron irradiation; degradation initiation and growth studies; new/improved ISI procedures.	Potential need to validate methods for simulating SCC
Condition monitoring/ISI for detection and sizing	Limited (medium difficulty). Coarse-grained materials challenge ultrasonic testing. Challenge for meeting detection and sizing accuracy in thick-walled specimens.	Condition assessment methods for SLR may be unconventional. Access issues dictate probability of detection and sizing performance. Harvested materials useful to study issue and develop workarounds. Cases in the Code. Appendix to Section XI.
Availability of material	TBD	Needs input from utilities
EMDA susceptibility score	Generally high	BWR piping in reactor water (no irradiation), BWRs up to ~1.2 dpa, some PWR internals in primary water (up to 0.5 dpa)
EMDA knowledge, confidence score	Medium	All mechanisms
GALL-SLR	Variety of structures and similar components identified	No specifics on material composition
OE	Limited	Mostly due to poor material quality or incorrect processing
Level of understanding of mechanism (environmental factors, initiation and growth of degradation, related factors)	Medium	See knowledge gaps
Options for mitigation	Low	
Ease of replacement	Low	
Amount of use (in a plant and fleet-wide)	High (use of highest susceptibility CASS – CF8M – is lower)	Diversity in material composition and microstructure across plants. CF8M used in about 1/3 of PWRs that use CASS for Class 1 piping.
Critical gaps in knowledge	Synergistic effects of radiation and thermal embrittlement on fracture toughness, relation between accelerated tests and real-world service time, in-service material composition and microstructure	Multiple studies available using accelerated tests
HARVESTING PRIORITY	MEDIUM-HIGH	

3.4.3 Dissimilar Metal Welds

DMW joints are extensively used in NPP primary systems, and encompass a host of materials and locations. DMW are generally used to join ferritic and austenitic piping components, and employ either austenitic or nickel-alloy materials as the weld material. The ferritic end is buttered with several layers of a material close in properties to the main (austenitic) weld material, with a post-weld heat treatment usually applied to reduce residual stresses (Taylor et al. 2006).

A challenge with DMW is the presence of different materials within the weld, resulting in different material properties. These differences can result in reduced material toughness near some of the interfaces. Localized high temperatures and residual stresses may increase susceptibility to SCC in certain environments. Operating experience has also shown the possibility of cracking in such welds.

Below briefly describes how information on DMW may be mapped into the different criteria identified above. The focus is on Alloy 82/182 welds in these examples, given their wide use.

1. For the combination of DMW and primary reactor water at temperatures between 100°–150°F, the susceptibility to SCC is low (1–2 on a scale of 0–3). With higher pressures and temperatures, the susceptibility increases.
2. Both knowledge and confidence scores are fairly high because OE and laboratory studies have shown numerous evidence of SCC in materials at high temperatures and pressures. In contrast, there is limited OE for cracking at lower temperatures and pressures.
3. There is general consensus on the combination of factors that leads to crack initiation in these materials. These conditions can be simulated in the laboratory in accelerated aging tests. Limited data on crack growth rates in DMW materials have been generated in accelerated aging tests but it is not clear how well the data matches field experience.
4. Crack initiation in these materials is a function of several factors including the residual stresses and welding temperature variations. There is limited data on crack initiation in DMWs in general and may require additional studies.
5. Harvested materials may be used to address technical gaps related to crack initiation susceptibility and crack growth rates. However, it is likely that only a limited set of harvested materials may be needed (if any), given the ease with which the environmental conditions in operating plants may be replicated in a laboratory.
6. Several studies have demonstrated the viability of using one or more NDE techniques for detecting, characterizing, and monitoring SCC growth in these materials. While the reliability of these methods is still a topic of active interest, preliminary data appear to indicate the possibility of detecting and sizing to ASME Code requirements.

Tables 3 and 4 show a similar analysis summary for SCC in 82/182 welds in different environments. In this case, given the level of knowledge available about the susceptibility of the material to cracking when exposed to the environment and the options for detecting such cracking, these materials are considered to be at a lower priority level.

Table 3. Example Assessment for SCC in DMW: 82/182 Welds, for SCC, in PWR Primary Environments (Borated Demineralized Water (normally stagnant), 100°F–150°F, 640 psia). Components: ECCS Accumulator Piping to Cold Leg.

Criteria	Qualitative Assessment	Comments
Unique field aspects, if any	Vintage material	
Ease of laboratory replication	Medium/high	
Applicability of harvested material for addressing critical gaps	Calibrate and validate accelerated aging procedures; degradation initiation and growth studies	
Condition monitoring/ISI for detection and sizing	Available techniques may be sufficient for reasonable assurance of detection	Detection and sizing capability TBD but generally capable of meeting acceptance criteria set in the Code
Availability of material	TBD	Needs input from utilities
EMDA susceptibility score	Low-medium	Temperatures considered too low for SCC to be concern. However, cracking is a generic concern for these materials.
EMDA knowledge, confidence score	Generally high	
GALL-SLR	Nothing obvious listed for environment for this example.	AMPs are for components similar to the one listed above
OE	No.	Nothing was identified in Licensee Event Report searches to date
Level of understanding of mechanism (environmental factors, initiation and growth of degradation, related factors)	Medium-high	
Options for mitigation	Low	Given low susceptibility, this may not be an issue
Ease of replacement	Low	Given low susceptibility, this may not be an issue
Amount of use (in a plant and fleet-wide)	High	
Critical gaps in knowledge	Crack initiation time	Crack initiation probability considered low for the environment listed
HARVESTING PRIORITY	LOW	
ECCS = emergency core coolant injection system		

Table 4. Example of SCC in DMW: SCC in 82/182 Welds in PWR Primary Environment (reactor water, 653°F, 2250 psia) for Components: RCS Pressurizer DMWs, RPV DMWs, RCS SG, ECCS Accumulator Piping to Cold Leg, ECCS CVCS Piping to RCS Cold Leg

Criteria	Qualitative Assessment	Comments
Unique field aspects, if any	Vintage material	
Ease of laboratory replication	Medium/high	See gap on relating accelerated aging studies to real-world service time
Applicability of harvested material for addressing critical gaps	Calibrate and validate accelerated aging procedures, degradation initiation and growth studies, new/improved ISI procedures	Multiple studies available on SCC initiation and growth in nickel alloys and DMWs, mitigation proposals (overlay) also being studied.
Condition monitoring/ISI for detection and sizing	Available techniques appear sufficient for reasonable assurance of detection in pressure boundary components (ultrasonic testing, eddy current testing) and internals (visual testing). Generally easy to apply ISI (assuming access).	Potential need to validate methods for simulating SCC. Access issues dictate probability of detection and sizing performance. Detection and sizing generally capable of meeting acceptance criteria set in the Code.
Availability of material	TBD	Needs input from utilities
EMDA susceptibility score	Generally high	
EMDA knowledge score	Generally high	
GALL-SLR	Variety of structures and similar components identified, but no specifics on materials available	AMP XI. M7, M1, M2, M19: SG, Water Chem., ISI
OE	Yes	
Level of understanding of mechanism (environmental factors, initiation and growth of degradation, related factors)	Medium-high	See knowledge gaps
Options for mitigation	Low	
Ease of replacement	Low	
Amount of use (in a plant and fleet-wide)	High	
Critical gaps in knowledge	Crack growth rates, crack initiation time	Multiple studies available on SCC initiation and growth in nickel alloys and DMWs, mitigation proposals (overlay) also being studied.
HARVESTING PRIORITY	LOW	Multiple ongoing studies, significant advances in degradation understanding, availability of NDE drive priority assessment.

ECCS = emergency core coolant injection system
RCS = reactor coolant system

3.4.4 Vessel Internals

Vessel internals comprise a wide range of structures and components, with one defining characteristic: they are all exposed to the highest fluences within a NPP. Vessel internals are generally made of austenitic stainless steels (typically 304 or 316L) and the materials may be subjected to several processing steps, including cold work and welding, to form the component. Given the potentially high fluences experienced by these materials, several degradation mechanisms may occur over time, including irradiation-assisted SCC (IASCC), as well as other irradiation-assisted processes.

In the case of austenitic stainless steel exposed to irradiation and the primary systems water environments in LWRs, the following generic assessments may be made:

1. Susceptibility and confidence scores for SCC and other degradation mechanisms are generally high.
2. Knowledge scores are generally low-medium but this is a function of the specific degradation mechanism and specific environmental information.
3. OE has shown a number of cracks initiating and growing in baffle former bolts.
4. Critical gaps in knowledge include the specifics of irradiation-assisted degradation mechanisms—factors contributing to initiation and growth. A number of microstructural changes are possible in the presence of radiation, including void swelling, segregation, and precipitation. Gaps exist in understanding the factors that contribute to these mechanisms and their impact on the material functional performance.
5. ISI methods exist that can detect the presence of cracking and dimensional changes in components. The reliability of these methods is a function of several factors, including the critical flaw size (i.e., flaw length and through-thickness depth beyond which the structural integrity of the component may be affected with continued operation), physical access for inspection, and a number of factors associated with the inspection deployment technology.
6. Internal components embody certain unique aspects that are hard to duplicate in the laboratory. Unlike DMW, and to some extent CASS, the environmental conditions (especially higher fluences) are hard to generate in the laboratory. Even with access to specialized facilities, there is concern that degradation mechanisms may be flux rate- and spectrum-dependent, indicating that accelerated aging conditions typically encountered in test facilities may not be representative of the field-aged component. In this respect, internal components resemble electrical cables in that there is some evidence that field aging results in different microstructural conditions than accelerated conditions; at the same time, like cables (but unlike most metallic components including DMW and CASS), at least some internal components may be amenable to replacement.

Collectively, these criteria drive the need for harvesting internal components if available and result in a prioritization of medium to high.

Table 5. Example of Vessel Internals for Degradation in Austenitic Stainless Steels for Vessel Internals

Criteria	Qualitative Assessment	Comments
Unique field aspects, if any	High-fluence irradiation; vintage material	
Ease of laboratory replication	Low	Accelerated aging tests vs field aging service time
Applicability of harvested material for addressing critical gaps	Mechanisms of irradiation-assisted degradation—microstructure and mechanical properties	Re-irradiation may assist with understanding materials performance at SLR fluences.
Condition assessment/ISI	Available techniques (ultrasonic, visual) may be sufficient for reasonable assurance of detection. Sizing – maybe. Ease of ISI can be low depending on access.	Access issues may dictate probability of detection and sizing performance. Challenging environment for continuous monitoring.
Availability of material	Some materials being harvested; closed plants may provide additional opportunity	
EMDA susceptibility score	Generally high	Based on OE primarily
EMDA knowledge score	Generally low	
GALL-SLR	Variety of structures and similar components identified, but no specifics on materials available	
OE	Yes	Baffle bolt cracking, cracking in other internal components
Level of understanding of mechanism (environmental factors, initiation and growth of degradation, related factors)	Low-medium	See knowledge gaps
Options for mitigation	Low	
Ease of replacement	Depends on component	Some components (for instance, baffle bolts) can be replaced relatively easily.
Amount of use (in a plant and fleet-wide)	High	
Critical gaps in knowledge	Degradation mechanisms (IASCC, swelling, segregation, etc.), flux rate and irradiation spectrum effects, microstructural property changes, and links to mechanical properties.	
HARVESTING PRIORITY	HIGH	Unique field aspects and degradation mechanisms drive this prioritization.

4.0 Harvesting Plans

4.1 Ex-plant Harvesting Experience

4.1.1 Harvesting Projects

Harvesting activities have been carried out at a number of plants in years past. These have included decommissioned plants as well as cancelled or terminated plants. Of the cancelled or terminated plants, the harvesting effort appears to have been opportunistic and focused on accessing components that were fabricated, but not commissioned. Examples of these plants include Shoreham, River Bend Unit 2, and the Washington Public Power Supply System Units 1 and 3. In these cases, the focus was primarily on harvesting metallic components with a view to obtaining as-built materials for studies on crack growth, fracture toughness, and fabrication flaw density.

In recent years, harvesting efforts have generally focused on accessing materials from plants that have been decommissioned. The bulk of the effort appears to have been on three plants—Zion (both units) and Crystal River Unit 3 (all in the U.S.), and Zorita (in Spain). Zion is a decommissioned two-unit Westinghouse-designed four-loop PWR facility. The units were commissioned in 1973, permanently shut down in 1998, and placed into SAFSTOR in 2010 (Rosseel et al. 2016a). Crystal River Unit 3 is a PWR that ceased operation in 2013. Zorita is a 160-MWe PWR designed by the Westinghouse Electric Corporation, and operated for approximately 38 years (NRC 2010b). It was permanently disconnected from the national power grid on April 30, 2006. During this period, approximately 26.4 effective full-power years of reactor operation were accumulated and the highest fluence on the reactor vessel internals was estimated to be 58 dpa. A number of other plants that have ceased operations have been identified as potential sources of material for harvesting and include Kewaunee and San Onofre Generating Station (both units). At the same time, a limited amount of harvesting has been attempted at several other plants, usually in conjunction with a repair or replacement activity.

4.1.2 Cable Harvesting Experience

4.1.2.1 Background

The nuclear power cable community has long recognized the value of aged cable samples. For instance, EPRI developed a Cable Harvesting Users Guide website[1] that continues to accept recommendations from the community and provides guidelines to maximize the value of harvested cable. The guide indicates that the purpose of harvesting is to determine present condition, remaining life, and allow forensic analysis for insight into actual field-aging mechanisms and determine their influence on long-term performance. The guide is intended to benefit the utility in the following ways:

- If a utility identifies cables that are judged to be limiting by use, type, and/or operating environment, and the cables are shown to be acceptable with adequate remaining life, that utility may be able to demonstrate that work required by the regulatory authorities for other cables may be deferrable.

(1) EPRI. 2014. *Plant Engineering: Field Guide for Harvesting Service-Aged Cable (Cable Harvesting Guide) Version 2014*. EPRI Report 3002002994, Electric Power Research Institute (EPRI), Palo Alto, California. EPRI members may access this software at http://cableharvest.epri.com.

- Evaluation of service-aged cables is one strategy for determining the limits of remaining life for NPP cables. Equally important to understanding and managing aging of in-service cables is to gain practical insight into those cable material and construction systems that can be demonstrated to have performed well.

Key candidates for removal and harvesting are:

- Cables that have experienced unanticipated in-service failures
- Cables with observed aging degradation under specific service conditions
- Cables from systems identified by the plant as those with specific concerns (e.g., high safety significance or particular vulnerability)
- Cables from systems with plant-unique service or environmental conditions (e.g., salt water infiltration or water immersion, high operating temperature, high radiation)
- Cables that are examples from a large installed base; may include cables of particular construction and materials, from a single manufacturer, or of a single manufacturing vintage.

While it is recognized that cable harvesting may occur in conjunction with an environment where the task is secondary to either returning a plant to service or plant dismantlement, recognition of a best-practice removal protocol is helpful to maximizing the value of the harvested cable. Recommended cable removal protocol includes:

- Clearly identifying the cable to be removed
- Photographing the cable environment prior to removal
- Tagging or somehow unambiguously identifying the cable prior to or just after removal.

As long a section of cable as possible should be removed. Terminations, splices, and cable accessories should be retained as much as possible.

Identification of interesting parameters associated with the cable can include and should consider:

- Cable physical description
  - Cable category (instrumentation and control, low voltage, medium voltage)
  - Construction (configuration, number of conductors)
  - Manufacturer/date
  - Materials (jacket, insulation, conductor jacket)
  - Cable lengths and segments
- Service parameters
  - System
  - Service application
  - Current and voltage
  - Duty factor
  - Safety and maintenance rule significance
  - Age in service

- Installation data
  - Installation location (building, outside, buried)
  - Terminations
  - Supporting structures or conveyances
- Stressors
  - Installation
  - In-service mechanical and structural
  - Environmental degradation
  - Other damage potential
- Plant fleet cable experience
  - Testing interval and history
  - In-service failure or degradation
  - Other

4.1.2.2 Known Naturally Aged Harvested Cable Examples

On May 19, 2016, Zion Solutions harvested and placed into six steel drums, four sets of Zion Unit 2 cables with lengths up to 30 ft. of XLPO, low- or high-density polyethylene, EPR, silicone, Hypalon, etc., in collaboration with the NRC. Cables were harvested from:

- Accumulator discharge motor operated valve cabling, outside the missile barrier (OMB), lower level of containment
- Instrumentation cables – instrument racks, OMB, lower-level containment
- Air-operated valve cabling, OMB, lower level of containment
- Cables in electrical penetrations, OMB, containment; elevation 617 ft.

A test plan for these cables has been developed and tests such as EAB and additional aging/qualification tests have been initiated (as of the writing of this report).

Harvesting of cables was also recently performed at the Crystal River Unit 3 plant, which was shut down in 2009 for refueling and an uprate. The construction efforts caused damage to the containment structure that was ultimately determined to be too costly to repair. In 2013, it was announced that Crystal River Unit 3 would not restart and decommissioning activity was begun. Cables were harvested from the plant in 2015. Photographs were taken for many of these cables inside the plant just prior to their removal. Some of these cables have asbestos filler between the jacket and insulation; however, this is a recognized hazard that can be managed with minimal additional precautions as long as testing does not include jacket removal. A research plan has been developed for harvested high-priority cables (Fifield 2016) and is currently being executed.

Several cables were also removed from service from the Fermi nuclear station in 2015 for forensic examination. The cables were:

- 5C/#16AWG, 600V, Rockbestos XLPE/Neoprene (~ service from 1978–2010; 32 years)
- 4C/#12AWG, 600V, Okonite EPR-Neoprene/ Hypalon (~1977–2010; 31 years)

All XLPE insulations were determined to be like new based on indenter modulus and EAB. Neoprene jackets were approaching embrittlement level. The EPR-Neoprene/Hypalon jacket showed signs of aging based on both indenter modulus and EAB (Anandakumaran and Auler 2015).

In contrast to cables removed from (now closed) plants, there have been a number of examples of naturally aged cables harvested from storage. For instance, several warehouse-aged cables that had been purchased and stored for more than 20 years but not placed in service were made available to EPRI by the Palo Verde plant for evaluation. Testing at EPRI confirmed that cable insulation degradation when not exposed to severe environmental or operation stresses was limited.(1)

A third source has been cables removed from service due to failure of the cable (generally based on failing one or more tests conducted in the field). While such failures appear to be relatively rare in the field, removal of cables to prevent a future failure may occur after visual or electrical testing indicates a potential problem. In 2015, a 1000V three-phase cable with cracked Neoprene jacket and EPR insulation was removed from service at the Beaver Valley NPP after failing electrical test acceptance criteria. Forensic examination of the cable revealed tensile stresses in excess of ultimate yield strain. Chlorine and its compounds (probably hydrochloric and chloric acid) were found to contaminate the cable surface including crack walls, forming a conductive path between cable conductor and ground (Fryszczyn 2015). Several cables were also removed from the Kewaunee turbine building and sent to Analysis and Measurement Services Corp. for forensic evaluation in 2015. Cables included Boston Insulated Wire two-conductor 12 AWG CSPE jacket/CSPE insulation cable; Kerite three-conductor 12 AWG XLPO jacket/XLPO insulation cable; and Okonite four-conductor, 14 AWG Neoprene jacket/cloth wrap/EPR-Neoprene insulation. Of three naturally aged cables tested, two showed no signs of aging degradation and one showed signs of significant degradation for only the jacket (Toll 2015).

Several other harvested cables (from a number of plants) contributed to a series of reports on medium-voltage cable aging failure mechanisms mainly on butyl rubber and different types of EPR cables. It has been observed that the cables do not degrade homogeneously in water, but in discrete locations, enabling operators to isolate the degraded cable section, remove it, and splice in a new section (EPRI 2015).

4.1.3 Harvesting of Internals

4.1.3.1 Background

In recent years, OE has identified several examples of cracking in internal components, including baffle bolts, jet pump risers, core shroud, etc. A number of mechanisms are of interest, including IASCC. Given that the vessel internal components see some of the highest fluences, the acquisition of materials from these components is likely to provide a great deal of information about the behavior of these materials at high fluences. Some specific topics that are of interest include:

- Quantifying materials performance in the presence of irradiation-induced processes such as segregation, swelling, and precipitation
- Crack initiation and growth rates in the presence of irradiation-induced processes

(1) Andrew Mantey (EPRI), Personal communication.

4.1.3.2 Known Examples

A number of harvesting efforts have been initiated in the United States and elsewhere to acquire vessel internal components. In the United States, recent efforts have included the harvesting of baffle-former bolts. The harvesting, in this case, was focused on acquiring bolts that were withdrawn from service (and replaced with improved materials) for the purposes of post-service examination (Leonard et al. 2015). These were primarily used for laboratory studies to determine the degradation mechanism and if evidence of IASCC existed with some or all of the bolts.

Similar harvesting efforts are underway at Zorita (Hiser et al. 2015), with the objective being to acquire and test materials that have experienced a range of fluences. Planned studies in this case include mechanical testing of the samples as well as testing to determine crack initiation and growth rates. In the case of Zorita, the focus is on baffle plate materials and core-barrel weld materials. These materials have been exposed to different levels of irradiation, and welds and heat-affected zone. Additional studies are planned with post-harvesting irradiation of selected specimens.

Other baffle-bolt harvesting efforts have been based on industry OE (EPRI 2017; NRC 2017c; Smith and Burke 2017).

4.1.4 Harvesting of RPV Materials

4.1.4.1 Background

RPV-related materials harvesting has a long history in the nuclear power community. The harvesting has generally been to address several questions related to the performance of the pressure vessel in the presence of irradiation and assess its likely performance under abnormal conditions. RPV materials must withstand a harsh operating environment, including neutron irradiation and time at temperature, given their function as part of the pressure boundary. Specific questions that have been raised about RPV materials include:

- Improving understanding of mechanisms driving embrittlement in RPV steels and reducing predictive uncertainties for embrittlement
- Quantifying loss of fracture toughness due to irradiation embrittlement
- Quantifying fabrication and service-induced flaws (if any) in RPV materials
- Developing techniques for mitigating embrittlement.

Clearly, the harvesting of RPV material from an operating plant is unlikely. Instead, a significant amount of studies have focused on the use of surveillance specimens that are placed inside the reactor vessel and harvested during periodic plant refueling outages. This approach also allows for supplemental capsules to be inserted into an operating reactor for a relatively short time and still get meaningful results. The exception to this is harvesting materials from terminated or cancelled plants. These are briefly summarized below.

4.1.4.2 Known Examples

A number of specimens from the beltline weld region were harvested from cancelled or terminated plants, such as the Shoreham plant. In these instances, fabricated components (especially the RPV) were accessed for the harvesting effort. These were selected specifically for studies around fabrication flaw density in the beltline weld region, and knowledge gained on fabrication flaw size and distribution in

RPVs played a role in the development of 10CFR50.61a. The harvesting priorities in these cases were driven by the specific needs of the research and included sufficient material on either side of the weld to enable studies on the weld and adjacent material.

In recent years, harvesting from the Zion Unit 1 RPV has been the focus of the U.S. Department of Energy's effort (Rosseel et al. 2016b). An appropriate segmentation plan has been developed for the RPV to gather material from the beltline weld region, between the upper and lower vertical welds. Both base-metal regions and beltline weld regions are included in the harvested sections and are planned for use in laboratory studies. Comparisons with fracture toughness of surveillance specimens are expected to provide insights into the changes in fracture toughness over time.

4.1.5 General Lessons Learned from Harvesting Examples

The ability to harvest field-aged materials has generally proven to be successful, but a number of lessons can be learned from these experiences.

In general, information on the exact environment in which the material was operating may not be available. Often, all that is available (especially after a plant has closed and is in the decommissioning phase) is the total number of years the material was used while the plant was in operation and a general idea of the environment based on its location. While the environmental conditions for some components (such as RPV or internals) can be calculated relatively precisely based on plant operational data, the lack of such information can be problematic for components exposed to localized extreme environments. For instance in the case of cables, the possibility of localized hot spots (from uninsulated piping close by) may be a contributor to significant local thermal aging. This type of information is more readily available when the cable is harvested from an operating plant and additional measurements of environmental conditions may be taken prior to harvesting (for instance, through infrared thermography measurements).

Recent experiences (such as Zion and Crystal River Unit 3) showed the process of harvesting can be expensive. A related challenge was the complexity of securing engineering and labor support for a forensic harvesting task when the primary contractor in charge of the operation is primarily focused on dismantling the plant.

While harvesting materials with known degradation issues is always useful, in the case of harvesting post-plant closure, it may also be a challenge. Such information may not be readily available without performing some form of inspection. Given the challenges associated with securing engineering and labor support for harvesting, obtaining the necessary support is likely to be difficult.

4.2 Harvesting Plans General Requirements

With the experience to date harvesting materials from plants and the associated lessons learned, several best practices may be identified for future strategic harvesting exercises. Prior to developing a harvesting plan, the following will need to be addressed:

- Clearly identifying the need for harvesting the material. This will require defining the knowledge gaps that will be addressed and how these gaps are relevant to SLR.
- How the harvested material will be used. This will require development of a research plan (even if at a high level initially) that will be executed with the harvested material and how the studies are expected to close the knowledge gap. Several excellent examples exist for research plans (for instance, Leonard et al. 2015; Fifield 2016).

- Determine the necessary resources for harvesting. Use the justification and prioritization for harvesting to secure the necessary engineering/labor support prior to beginning the procedure. In discussions with technical staff who have been involved in harvesting activities, this was the number one item raised, especially when the harvesting activity is an adjunct to decommissioning the plant. In this case, the decontamination and decommissioning activities take precedence and the harvesting activity will need to accommodate any changes in schedules necessary to ensure that the primary activity is completed on schedule.
- Timeline for harvesting. A fall out of the resource planning issue above is the need for developing the harvesting plan, and, in consultation with plant personnel, a notional schedule for the harvesting.
- Post-harvesting receipt of material. The plan should also include information on where the material will be sent and in what form (complete component, segmented into smaller pieces, etc.), condition of the material after harvesting (contaminated, if cleaned to what extent, etc.).
  - Should include information on additional locations to which the material may be sent from its primary storage/use location to ensure appropriate planning can be initiated at the primary recipient facility as well as at any secondary recipient facilities.
  - A requirements document is mandatory that covers receiving and working with the material. In particular, if the material is to be handled as radioactive material, additional precautions will need to be taken for both shipping, storage, and use in research. Activated and/or contaminated material may require hot-cells for storage and use.
  - Note: Depending on the material and its condition (contaminated, activated), regulations for shipping (U.S. Department of Transportation regulations) will vary and need to be accounted for in scope, schedule, and budget for the harvesting activity.
  - Depending on its eventual end-use location, necessary approvals should be in place prior to executing the harvesting plan.
- Waste handling. Depending on the material and research plan for its use, provisions will need to be made to handle any waste streams generated during the process. This includes not only the waste generated during harvesting but subsequently during research. Specimens created from harvested material may need to be stored for longer terms, and provisions are necessary for long-term storage of the material if necessary.

Note the prioritization approach described earlier in this document provides a potential pathway to identifying the knowledge gaps, relevance to SLR, and defining the priority for harvesting the specific material. The associated research plan should include, in addition to a description of the specific research and expected outcomes that close the technical gaps, a pathway to using the information in a practical manner for addressing SLR needs. This may happen, for instance, through propagating the technical findings into the relevant technical literature and codes and standards.

A number of elements need to be kept in mind as the harvesting plan is developed. These include:

- Clearly identifying the component/material to be removed. Labels, tags, etc. are possible ways in which the component (or location on a component, if only a portion is being harvested) can be identified. Given the need to potentially coordinate the harvesting activity with other activities at the site, such identification can reduce the potential for mistaken harvesting of material.
- Documenting the environment in the vicinity of the component prior to removal. This includes not only the temperature, radiation, etc., but also the presence of other components in close proximity and how they interact with the component being harvested. For instance, vibration from a nearby pump may play a role in accelerating degradation in the component being harvested.

  - Radiation surveys of materials may be needed before and after harvesting to determine if the material is contaminated or can be free-released. This also provides information on necessary decontamination activities that may be needed.
  - The level of contamination and activation of the material will dictate the actual harvesting approach to meet ALARA requirements.
- Information about the condition (degradation and aging) should be documented if available. If possible, additional measurements should be taken before or after harvesting to confirm the condition of the material prior to its use in any aging-related studies.
- As large a section of material as possible should be removed. Note that this may be constrained by budget or dose to personnel. Any special features (such as terminations, splices, and cable accessories for the case of cable harvesting; welds, heat-affected zone, and base metal for similar and dissimilar welds) should be identified in the harvesting plan, and if necessary, retained.

Parameters that will need to be documented (if available) during this process include:

- Physical description
  - Category (examples: nozzle weld, instrumentation and control cable, medium voltage cable, baffle bolt)
  - Construction information (configuration, special processes used)
  - Manufacturer/date
  - Materials comprising the component to be harvested or composition
  - Dimensions and special features
- Service parameters
  - System
  - Service application
  - Usage parameters (how often was it used if intermittently used)
  - Safety/maintenance rule significance
  - Age in service
- Installation data
  - Installation location (containment, auxiliary building, other building, outside, buried)
  - Connected components
  - Supporting structures or conveyances
- Stressors
  - Installation
  - In-service mechanical and structural
  - Environmental degradation: temperature, pressure, fluence, humidity
  - Other damage potential
- Plant/fleet experience
  - Testing interval and history

– In-service failure or degradation

– Available data on inspections for degradation

Note that generating all the necessary harvesting plan information is time consuming and, where possible, should be assembled before any opportunities arise for harvesting. Critical details that will require knowledge about the harvesting plant/location are who will perform the harvesting, when will harvesting be performed, where is the material, what is its condition, and how much should be harvested? Having the rest of the information pre-assembled will provide a significant advantage towards speeding up the procedure. For this purpose, having the necessary information available, perhaps in a searchable database, will facilitate the process.

5.0 Information Tools for Harvesting Planning

The previous sections dealt primarily with approaches for prioritizing the needs for harvesting of materials from plants for addressing one or more issues. Identification of technical gaps and development of a harvesting plan to address some of these gaps will require other information. Such information can include the state of knowledge about materials performance, availability of materials for harvesting, and operational experience.

Key to efficient use of this information is an integrated tool set that will enable rapid assessment of technical gaps and well-informed decisions on harvesting. This section briefly describes a potential tool suite for this purpose.

5.1 Reactor Reliability and Integrity Management Library

5.1.1 Overview

The Reactor Reliability and Integrity Management (RRIM) Library is envisioned as a suite of integrated tools (Figure 1) that focus on providing decision makers with necessary information to deliver informed recommendations based on the available data. The following tools have been identified as critical to development of the RRIM Library:

- Generic plant framework
- Knowledge repository
- Harvesting management

Each of these tools is described below in greater detail. It is important to note that these are only envisioned tools at this time. As harvesting needs increase, it is likely the tool sets described here will be augmented or modified to account for emerging requirements for a decision-making tool suite in this area.

5.1.1.1 Generic Plant Framework

Generic aging lessons learned plans are categorized by plant type (PWR or BWR), structure and/or component, material, environment, and aging effect/mechanism. From a RRIM tool suite perspective, this information is assigned to the Generic Aging Management Plans block in Figure 1; this block is merely intended to illustrate that the aging management plans are informed by insights from GALL as well as a variety of other literature sources on materials degradation. This categorization provides a construct that may be used to align information from other sources to define a high-level categorization of the various elements that are of concern in a plant. This construct will be the basis for the generic plant framework in RRIM. Input from subject matter experts (SMEs) will be needed to map the knowledge elements to the framework, as each of the sources provides differing levels of granularity on the descriptions of the structure and/or components, environment, and materials. The framework will be used to further align data from other sources, which may have varying levels of detail, into a similar higher level categorization. Sources of information include the PMDA and EMDA documents.

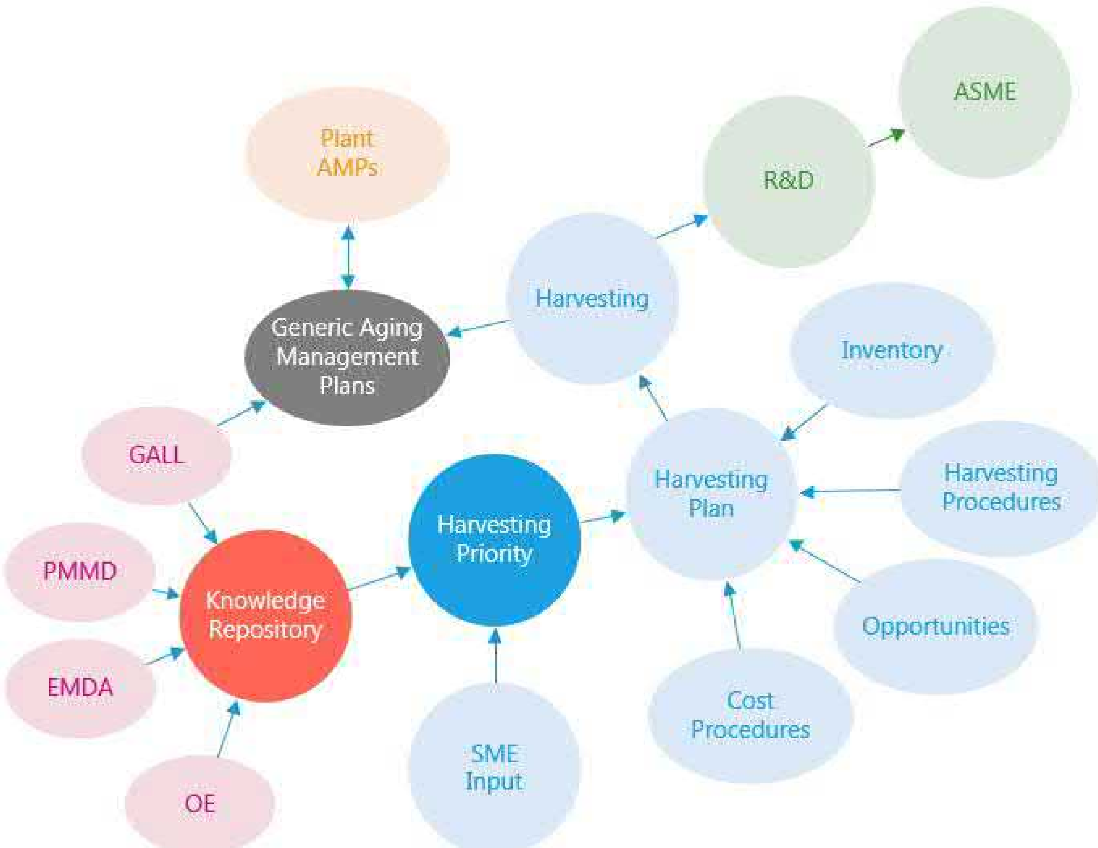

Figure 1. Reactor Reliability and Integrity Management Library Concept

5.1.1.2 Knowledge Repository

The knowledge repository will enable the correlation of a variety of information sources by mapping the data to the generic plant framework and providing searching capabilities.

The tool is envisioned to contain static content, such as information from the PMDA or EMDA. For example, the current proactive management of materials degradation tool (http://pmmd.pnl.gov) provides searching capabilities to visualize the susceptibility, confidence, and knowledge and search by the parts and degradation mechanisms as defined in the document; however, EMDA defines the parts differently.

The knowledge management tool will align the content of sources such as the EMDA and PMDA and map them into to a common structure and component list that would enable searching across both documents. The tool will also contain capabilities to automatically extract information from publicly available relevant sites, such as the Licensee Event Report, so that new information (particularly about relevant operational experience) is automatically added. The system will provide a best attempt at mapping to the generic plant framework; however, SME input may be required to validate these mappings.

5.1.1.3 Harvesting Management

As described earlier, harvesting has several phases, including determining the priority, developing a plan to complete the harvesting, conducting the actual harvesting of materials, and eventual use of the material (including the dissemination of results from research conducted on the material). The harvesting management tool is envisioned to support the lifecycle of the process.

This tool can be used to facilitate the harvesting prioritization as shown in the previous sections. We envision the tool as being capable of generating the unique combinations of materials, degradation mechanisms, and environments to create an entry for each unique combination within the harvesting management tool. The tool is expected to include the capability for automatically augmenting the entries with knowledge from the repository. After harvesting priorities have been determined by an SME, the tool will identify new knowledge that may impact the priorities. The tool will provide a mechanism to facilitate development of a justification, which is a key element in the preparation of harvesting plans.

The tool will also need mechanisms to capture costs, inventory, procedures, and opportunities related to harvesting. This information, augmented with priority and justification, will be the elements that provide the basis for the decision to develop a plan. The tool is also expected to facilitate capturing the results, including images and observations about the materials harvested.

5.1.2 Work to Date

A demonstration website[(1)] was set up to model what the knowledge repository may look like (Figure 2). The demonstration site only contains OEs as a sample data set; SME expertise would be needed to incorporate documents such as the proactive management of materials degradation tool, EMDA, and GALL into discrete knowledge elements. The visualization below provides an example of publicly available information about plant OE, along with the ability to search and sort the information (from more than one source, including public websites and a subset of EMDA information) by SSC type, material, environment, and degradation mechanism. The demonstration site for the knowledge repository would be one starting point for a detailed analysis of the required capabilities for the RRIM tool suite described earlier.

[1] http://hagar.pnl.gov/srs/dev/latest/v3/src/nrc/. Note: Website is only available to NRC.

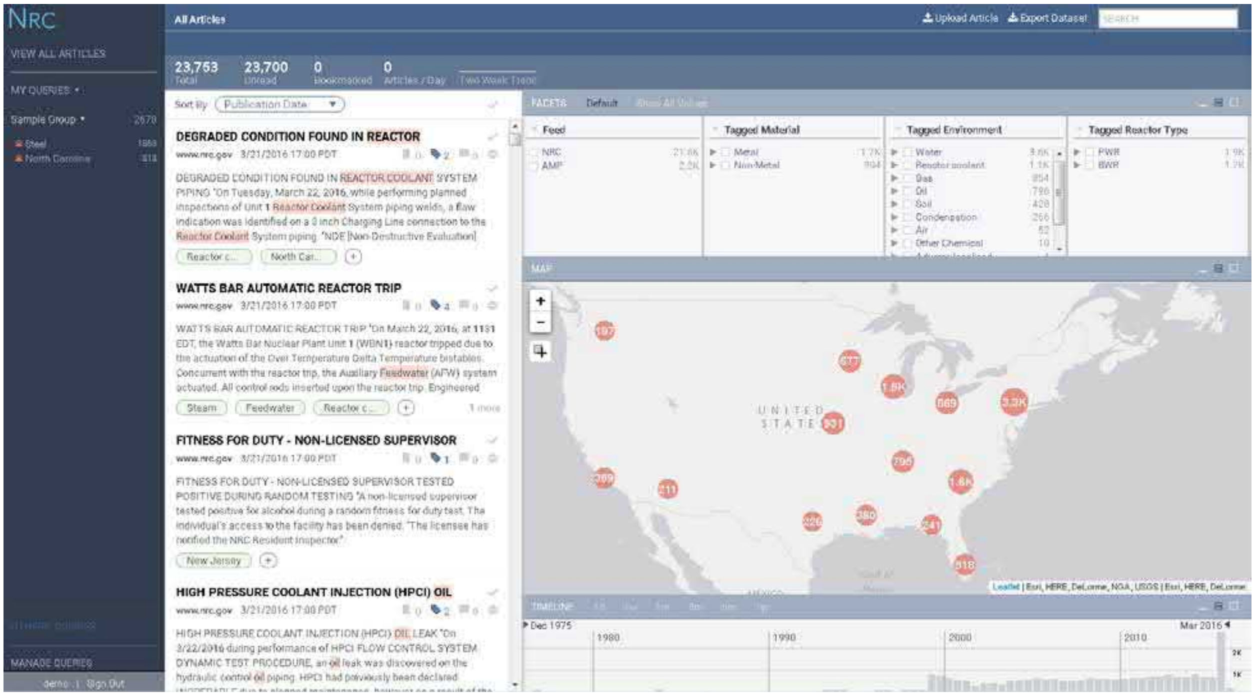

Figure 2. Example Visualization of Knowledge Repository to Support Harvesting Decision-Making

6.0 Summary and Path Forward

Addressing many of the remaining technical gaps identified in the EMDA for SLR may require accessing materials sampled from plants (decommissioned or operating). Such materials may be used to better understand actual material property changes with plant age and improve understanding of the initiation and growth of degradation mechanisms of relevance to SLR. Evaluation of material properties in SSCs from actual decommissioned NPPs will also provide a basis for comparison with results of laboratory tests and calculations.

Given the costs associated with any harvesting effort, potential approaches will need to prioritize materials using a number of criteria, including:

- Unique field aspects that drive the importance of harvesting the material
- Ease of laboratory replication of material and environment combination
- Applicability of harvested material for addressing critical gaps (dose rate issues, etc.)
- Availability of reliable ISI techniques for the material
- Availability of an inventory for harvesting.

These criteria help define the specific problems that will be addressed and the knowledge gained and technical gaps closed through the use of the harvested materials. A number of other factors (such as access to the material for harvesting, ability to work with the potentially contaminated material, and the plan for research using the material) play a role in defining the harvesting plan. A number of lessons may be learned from previous campaigns and these lessons can be used to develop a generic harvesting plan that can be customized for the specific needs and opportunities at hand.

A number of open questions remain in this context and will need to be addressed in follow-on research. These include:

- Requirements definition for an information tool such as RRIM. In the near term, such a tool can help as a searchable repository for identifying technical gaps. In the longer term, the tool can also assist as a repository of harvesting opportunities and with the prioritization using the criteria defined.
- Gaps assessment with respect to applying harvested materials for research and development.

7.0 References

Anandakumaran K and J Auler. 2015. "Condition Monitoring of LV Cables from Detroit Edison's Fermi II NPP." Presented at *EPRI Cable Users Group,* Columbia, South Carolina.

Andresen PL, FP Ford, K Gott, RL Jones, PM Scott, T Shoji, RW Staehle and RL Tapping. 2007. *Expert Panel Report on Proactive Materials Degradation Assessment*. NUREG/CR-6923, BNL-NUREG-77111-2006, U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession No. ML070710257.

Andresen PL, K Arioka, S Bruemmer, J Busby, R Dyle, P Ford, K Gott, A Hull and R Staehle. 2014. *Expanded Materials Degradation Assessment (EMDA): Aging of Core Internals and Piping Systems*. NUREG/CR-7153, Vol. 2, U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession No. ML14279A331.

Bernstein R, S Burnay, C Doutt, K Gillen, R Konnik, S Ray, KL Simmons, G Toman and G Von White II. 2014. *Expanded Materials Degradation Assessment (EMDA): Aging of Cables and Cable Systems*. NUREG/CR-7153, Vol. 5; ORNL/TM-2013/532, U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession No. ML14279A461.

Blahnik DE, DA Casada, JL Edson, DL Fineman, WE Gunther, HD Haynes, KR Hoopingarner, MJ Jacobus, DB Jarrell, RC Kryter, HL Magelby, GA Murphy and MM Subudhi. 1992. *Insights Gained from Aging Research*. NUREG/CR-5643, BNL-NUREG-52323, U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession No. ML041530264.

Bond LJ, SR Doctor and TT Taylor. 2008. *Proactive Management of Materials Degradation - A Review of Principles and Programs*. PNNL-17779, Pacific Northwest National Laboratory, Richland, Washington.

Bond LJ, SR Doctor, JW Griffin, AB Hull and SN Malik. 2009. "Damage Assessment Technologies for Prognostics and Proactive Management of Materials Degradation (PMMD)." In *6th International Topical Meeting on Nuclear Plant Instrumentation, Control, and Human-Machine Interface Technologies*. April 5-9, 2009, Knoxville, Tennessee. American Nuclear Society, La Grange Park, Illinois.

Bond LJ, SR Doctor, JW Griffin, AB Hull and SN Malik. 2011. "Damage Assessment Technologies for Prognostics and Proactive Management of Materials Degradation (PMMD)." *Nuclear Technology* 173:46-55. DOI: 10.13182/NT173-46.

Busby JT. 2014. *Expanded Materials Degradation Assessment (EMDA): Executive Summary of EMDA Process and Results*. NUREG/CR-7153, Vol. 1, U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession No. ML14279A321.

Byun TS and JT Busby. 2012. *Cast Stainless Steel Aging Research Plan*. ORNL/LTR-2012/440, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Byun TS, Y Yang, NR Overman and JT Busby. 2016. "Thermal Aging Phenomena in Cast Duplex Stainless Steels." *The Journal of The Minerals, Metals & Materials Society* 68(2):507-516. DOI: 10.1007/s11837-015-1709-9.

Cattant F. 2014. *Materials Ageing in Light Water Reactors - Handbook of Destructive Assays*, Lavoisier, Paris, France. ISBN 978-2-7430-1555-8.

Chopra OK. 2015. *Effects of Thermal Aging and Neutron Irradiation on Crack Growth Rate and Fracture Toughness of Cast Stainless Steels and Austenitic Stainless Steel Welds*. NUREG/CR-7185, U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession No. ML15202A007.

Chopra OK and AS Rao. 2016. *Estimation of Fracture Toughness of Cast Stainless Steel During Thermal Aging in LWR Systems*. NUREG/CR-4513, ANL-15/08, Revision 2, U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession No. ML16145A082.

Crawford SL, AD Cinson, AA Diaz and MT Anderson. 2015. *Phased Array Ultrasonic Examination of Reactor Coolant System (Carbon Steel-to-CASS) Dissimilar Metal Weld Mockup Specimen*. PNNL-24920, Pacific Northwest National Laboratory, Richland, Washington. ADAMS Accession No. ML16041A137.

Dobmann G. 2006. "NDE for Material Characterization of Aging Due to Thermal Embrittlement, Fatigue and Neutron Degradation." *International Journal of Materials and Product Technology* 26:122-139. DOI: 10.1504/IJMPT.2006.008984.

Doctor SR, SE Cumblidge, TT Taylor and MT Anderson. 2013. *The Technical Basis Supporting ASME Code, Section XI, Appendix VIII: Performance Demonstration for Ultrasonic Examination Systems*. NUREG/CR-7165; PNNL-19014, Rev. 2, U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession No. ML13144A107.

EPRI. 2013a. *Materials Reliability Program: Pressurized Water Reactor Issue Management Tables - Revision 3 (MRP-205)*. Final Report 3002000634, Electric Power Research Institute, Palo Alto, California.

EPRI. 2013b. *EPRI Materials Degradation Matrix, Revision 3*. Final Report 3002000628, Electric Power Research Institute, Palo Alto, California.

EPRI. 2013c. *BWRVIP-167NP, Revision 3: BWR Vessel and Internals Project - Boiling Water Reactor Issue Management Tables*. Technical Report 3002000690, Electric Power Research Institute, Palo Alto, California.

EPRI. 2015. "CSI: EPRI – Uncovering the Clues to Cable Aging." Electric Power Research Institute (EPRI), Palo Alto, California. http://www.epri.com/Documents/New%20and%20Noteworthy/Cable%20Aging%20Mar%202015.pdf.

EPRI. 2017. "Joint EPRI MPR/PWR Owners Group, Baffle-Former-Bolt Focus Group, Update." Presented at *Industry-NRC Exchange Meeting*, May 23, 2017, Rockville, Maryland. ADAMS Accession No. ML17142A001.

Fifield LS and P Ramuhalli. 2015. "Progress in Assessment of Non-Destructive Techniques for Evaluating the State of Aging Cables in Nuclear Power Plants." In *17th International Conference on Environmental Degradation of Materials in Nuclear Power Systems -- Water Reactors*. August 9–12, 2015, Ottawa, Ontario, Canada.

Fifield LS. 2016. *Status Report and Research Plan for Cables Harvested from Crystal River Unit 3 Nuclear Generating Plant*. PNNL-25833, Pacific Northwest National Laboratory, Richland, Washington.

Fryszczyn B. 2015. "1000 V Cable with Cracked EPR Insulation." Presented at *2015 IEEE/ICC/PES Insulated Conductors Committee Fall Meeting (PES ICC)*, November 1-4, 2015, Tucson, Arizona. Available at http://www.pesicc.org/iccwebsite/publications/icc_minutes_toc.htm.

Graves H, YL Pape, DJ Naus, J Rashid, V Saourma, A Sheikh and J Wall. 2014. *Expanded Materials Degradation Assessment (EMDA): Aging of Concrete and Civil Structures*. NUREG/CR-7153, Vol. 4, U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession No. ML14279A430.

Hiser M, A Rao and R Tregoning. 2015. "NRC Zorita Materials Research." U.S. Nuclear Regulatory Commission, Washington, D.C. https://www.nrc.gov/docs/ML1503/ML15034A202.pdf.

IAEA. 2012. *Third International Conference on Nuclear Power Plant Life Management (PLiM) for Long Term Operations (LTO)*, May 14-18, 2012, Salt Lake City, Utah. International Atomic Energy Agency, Vienna, Austria. https://inis.iaea.org/search/search.aspx?orig_q=source:%22IAEA-CN--194%22.

IAEA. 2013. *Advanced Surveillance, Diagnostic and Prognostic Techniques in Monitoring Structures, Systems and Components in Nuclear Power Plants*. IAEA Nuclear Energy Series No. NP-T-3.14, International Atomic Energy Agency, Vienna, Austria.

INL. 2016. *DOE-NE Light Water Reactor Sustainability Program and EPRI Long Term Operations Program – Joint Research and Development Plan*. INL/EXT-12-24562, Revision 5, Idaho National Laboratory (INL), Idaho Falls, Idaho. Available at https://lwrs.inl.gov/Technical%20Integration%20Office/DOE-NE_LWRS_Program_and_EPRI_Long_Term_Operations_Program_Joint_Research_and_Development_Plan.pdf.

Johnson Jr. AB, SK Sundaram and FA Garner. 2001. *Program Plan for Acquiring and Examining Naturally Aged Materials and Components for Nuclear Reactors*. PNNL-13930, Pacific Northwest National Laboratory, Richland, Washington.

Leonard KJ, M Sokolov and MN Gussev. 2015. *Post-Service Examination of PWR Baffle Bolts: Part I – Examination and Test Plan*. ORNL/LTR-2015/193, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Livingston JV, S Chattopadhyay, KR Hoopingarner, EA Pugh, WC Morgan, GD Springer and RA Pawlowski. 1995. *A Review of Information for Managing Aging in Nuclear Power Plants*. PNNL-10717, Part 2 of 2, Pacific Northwest National Laboratory, Richland, Washington.

Malerba L. 2013. "Are Late Blooming Effects a Real Concern? Some Considerations Based on Atomistic Simulations." In *Technical Meeting On Degradation Of Primary System Components Of Water Cooled Nuclear Power Plants: Current Issues And Future Challenges*. November 5-8, 2013, Vienna, Austria. IAEA, Vienna, Austria. Available at https://www.iaea.org/NuclearPower/Downloadable/Meetings/2013/2013-11-05-11-08-TM-NPE/22-1.Malerba_Belgium.pdf.

McCloy JS, RO Montgomery, P Ramuhalli, RM Meyer, SY Hu, Y Li, CH Henager Jr. and BR Johnson. 2013. *Materials Degradation and Detection (MD2): Deep Dive Final Report*. PNNL-22309, Pacific Northwest National Laboratory, Richland, Washington.

Meyer RM, LJ Bond and P Ramuhalli. 2012. "Online Condition Monitoring to Enable Extended Operation of Nuclear Power Plants." *International Journal of Nuclear Safety and Simulation* 3(1):31-50.

Meyer RM and PG Heasler. 2017. *Results of Blind Testing for the Program to Assess the Reliability of Emerging Nondestructive Techniques*. NUREG/CR-7235, PNNL-24196, U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession No. ML17159A466.

Meyer RM, AE Holmes and PG Heasler. 2017. *Results of Open Testing for the Program to Assess the Reliability of Emerging Nondestructive Techniques*. NUREG/CR-7236, PNNL-24708, U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession No. ML17223A700 and ML17223A704.

Morgan WC and JV Livingston. 1995. *A Review of Information for Managing Aging in Nuclear Power Plants*. PNNL-10717, Part 1 of 2, Pacific Northwest National Laboratory, Richland, Washington.

Nanstad RK, TM Rosseel, MA Sokolov, WL Server, T Arai, N Soneda, R Dyle, GR Odette, MT Kirk, BN Burgos and JB Hall. 2014. *Expanded Materials Degradation Assessment (EMDA): Aging of Reactor Pressure Vessels*. NUREG/CR-7153, Vol. 3, U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession No. ML14279A349.

NRC. 1998. *Proceedings of the 25th Water Reactor Safety Information Meeting*. NUREG/CP-0162, U.S. Nuclear Regulatory Commission, Washington, D.C. Volumes 1-3. ADAMS Accession Nos. ML021710831, ML15133A341, and ML16355A314.

NRC. 2010a. *Generic Aging Lessons Learned (GALL) Report - Final Report*. NUREG-1801, Rev. 2, U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession No. ML103490041.

NRC. 2010b. *Zorita Internals Research Project*. NRC-04-10-0150, U.S. Nuclear Regulatory Commission, Washington, D.C. Available at https://www.nrc.gov/docs/ML1027/ML102700387.pdf. ADAMS Accession No. ML102700387.

NRC. 2017a. *Generic Aging Lessons Learned for Subsequent License Renewal (GALL-SLR) Report, Volume 2*. NUREG-2191, U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession No. ML17187A204.

NRC. 2017b. *Generic Aging Lessons Learned for Subsequent License Renewal (GALL-SLR) Report, Volume 1*. NUREG-2191, U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession No. ML17187A031.

NRC. 2017c. *July 12 and 13, 2017 Baffle Bolt and MRP-227, Rev 1 RAIs Meeting*. U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession No. ML17158164.

NRC. N.D. *NRC Digest Appendices*. U.S. Nuclear Regulatory Commission, Washington, D.C. This edition of the Digest provides a snapshot of data; for the most current information and data collection, please visit the NRC Web site Dataset Index Web page at http://www.nrc.gov/reading-rm/doc-collections/datasets/. ADAMS Accession No. ML16245A069.

Raj B, V Moorthy, T Jayakumar and KBS Rao. 2003. "Assessment of Microstructures and Mechanical Behaviour of Metallic Materials through Non-destructive Characterisation." *International Materials Reviews* 48(5):273-325. DOI: 10.1179/095066003225010254.

Ramuhalli P, KL Simmons, JR Tedeschi, AM Jones, AF Pardini, MS Prowant, LS Fifield and MP Westman. 2014. "Progress Towards Determining Remaining Useful Life of Aging Cables in Nuclear Power Plants using Non-destructive Evaluation." In *ANS Winter Meeting 2014*. November 11, 2014, Anaheim, California. American Nuclear Society. PNNL-SA-106536.

Ramuhalli P, PG Heasler, TL Moran, A Holmes and MT Anderson. 2017. *Reliability Assessment of Remote Visual Examination.* NUREG/CR-7246; PNNL-27003, U.S. Nuclear Regulatory Commission, Washington, D.C.

Rosseel T, M Sokolov and R Nanstad. 2016a. *Report on the Harvesting and Acquisition of Zion Unit 1 Reactor Pressure Vessel Segments*. ORNL/TM-2016/240, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Rosseel TM, MA Sokolov, X Chen and RK Nanstad. 2016b. *Light Water Reactor Sustainability Program: Zion Unit 1 Reactor Pressure Vessel Sample Acquisition: Phase 2 and Phase 3 Status Report*. ORNL/TM-2016/561, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Ruiz A, N Ortiz, A Medina, JY Kim and LJ Jacobs. 2013. "Application of Ultrasonic Methods for Early Detection of Thermal Damage in 2205 Duplex Stainless Steel." *NDT & E International* 54:19-26. DOI: 10.1016/j.ndteint.2012.11.009.

SECY-14-0016. 2014. *Ongoing Staff Activities to Assess Regulatory Considerations for Power Reactor Subsequent License Renewal*. U.S. Nuclear Regulatory Commission, Washington, D.C. Policy Issue Notation Vote, dated January 31, 2014. ADAMS Accession No. ML14050A306.

Shah VK and PE MacDonald. 1993. *Aging and Life Extension of Major Light Water Reactor Components*, Elsevier Science Publishers B.V., Amsterdam, The Netherlands.

Smith J and M Burke. 2017. "Hot Cell Testing of Baffle-to-Former Bolts." Presented at *Baffle Bolt and MRP-227, Rev 1 RAIs Meeting*, July 12, 2017, Washington, D.C. ADAMS Accession No. ML17192A950.

Sokolov MA and RK Nanstad. 2016. *The Assessment and Validation of Mini-Compact Tension Test Specimen Geometry and Progress in Establishing Technique for Fracture Toughness Master Curves for Reactor Pressure Vessel Steels*. ORNL/TM-2016/602, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Taylor N, C Faidy and P Gilles, Eds. 2006. *Assessment of Dissimilar Weld Integrity: Final Report of the NESC-III Project*. European Communities, Italy. Document No. EUR 22510 EN. NRC ADAMS Accession No. ML072400203. Available at https://www.nrc.gov/docs/ML0724/ML072400203.pdf.

Toll T. 2015. "Condition Assessment of Cables from Kewaunee Nuclear Power Station." Presented at *EPRI Cable User Group,* Columbia, South Carolina.

Vietti-Cook AL. 2014. *Staff Requirements - SECY-14-0016 - Ongoing Staff Activities to Assess Regulatory Considerations for Power Reactor Subsequent License Renewal*. Memorandum to Mark A. Satorius, Executive Director for Operations, August 29, 2014, U.S. Nuclear Regulatory Commission, Washington, D.C. ADAMS Accession No. ML14241A578.

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U.S. DEPARTMENT OF ENERGY

With climate change, aging nuclear plants need closer scrutiny. Turkey Point shows why.

By Caroline Reiser | September 14, 2020

A Google Maps 3-D view of Turkey Point Nuclear Generating Station, situated on the Florida coast just south of Miami. The plant relies on a 168-mile network of man-made canals to release excess heat from the reactors. Image credit: Google Maps.

Disclosure statement: The author is a legal fellow at the Natural Resources Defense Council, which is currently involved in a legal case appealing the subsequent license renewal at Turkey Point.

Last December, two nuclear reactors at Florida's Turkey Point Nuclear Generating Station, located 25 miles south of Miami, became the first reactors in the world to receive regulatory approval to remain operational for up to 80 years, meaning reactors that first came online in the 1970s could keep running beyond 2050.

The ages of the Turkey Point reactors are not unusual; of the 95 reactors currently licensed to operate in the United States, only five are less than 30 years old, while more than half are 40 or more years old. The Turkey Point reactors are a bellwether, just the first of possibly many aging nuclear reactors that will seek permission to stay online well into the middle of the century. Not long after the December decision, in March 2020, the US Nuclear Regulatory Commission granted two more reactors, located in Pennsylvania, the same extensions that it gave Turkey Point.

In pursing these extensions, the US commercial nuclear industry and its supporters collide with the realities of the aging US nuclear fleet and climate science projections. Existing safety and environmental requirements fail to provide the oversight necessary to ensure communities and the environment are protected. As nuclear reactors receive permission to operate for twice as long as originally envisaged, and in a world that, because of climate change, is drastically different from the one they were built for, the insufficiency of the existing regulatory framework is daunting.

A 40-year lifespan? At the beginning of its commercial nuclear power program, the United States designed and licensed reactors with a 40-year projected lifetime. Once the 40-year license is set to expire, regulations require the reactor owner to apply for a renewed license in order to continue operating for an additional 20 years. What the regulations don't make clear, however, is the number of times a reactor license can be renewed. What Turkey Point received last year was not its first, but its second extension—what regulators call a subsequent renewed license.

While the timeframe for the initial license was originally an economic decision, the 40-year projected life cycle reflects engineering realties. Throughout the lifetime of a reactor, the metal and concrete that make up and contain the reactor take a constant beating from the neutrons being released through nuclear fission. This causes the metal to lose flexibility, become brittle, and develop cracks and fissures. The concrete, designed to protect humans and the environment from a radioactive release, may also deteriorate over time. To ensure reactors continue to operate safely, those parts that were designed with a 40-year lifetime often must be replaced. While this may be technically achievable for some reactor parts, replacement can only go so far.

And even when it is technically conceivable to replace old reactor parts, economically it often is not. Already, nuclear reactors are closing well before their current licenses expire because of economic constraints. In today's electricity market, nuclear power struggles to compete with cheap natural gas and renewable energy. Many reactors can only stay in business with significant additional government or ratepayer subsidies. These economic constraints have led to cost-cutting measures, including reducing health, safety, and environmental safeguards.

Even more bizarre, under current regulations, nuclear operators can take up to 60 years to decommission a closed plant. Decommissioning is the process by which a nuclear reactor is dismantled to the point that it no longer requires radiation protection measures. In the case of Turkey Point, if the reactors stay online beyond 2050, decommissioning could extend into the next century, when sea level rise due to climate change is predicted to inundate southern Florida.

Nuclear plants and climate change don't mix. While proponents of nuclear energy often argue that nuclear power is a necessary tool against the climate crisis, nuclear power itself is at risk from climate change. Because reactors need huge amounts of water to operate, most existing plants sit on an ocean, lake, or riverfront. But this means that sea level rise, warmer water temperatures, and amplified droughts will all affect the ability of nuclear reactors to produce electricity. Last summer in Europe, several nuclear plants had to temporarily shut down because of increased temperatures and decreased water supplies. Such occurrences are bound to become more common as the climate becomes warmer and weather events become more extreme.

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It is especially ironic, then, that the Turkey Point reactors, perched on the southern tip of Florida, were the first to receive a subsequent renewed license. Close to half a million people live just north of the plant in Miami, and 2.7 million live in the wider Miami-Dade County. The plant sits 20 miles east of the Everglades National Park, on a piece of coastline carved out of Biscayne National Park. These surrounding natural lands are a unique, sensitive ecosystem, home to threatened and endangered species like the manatee and the American crocodile. While climate change is already stressing these people and resources directly, it is also compounding the challenges of safely running the nuclear plant.

Turkey Point is the only nuclear power plant in the United States that relies on an extensive network of cooling canals. Visible from space, the network comprises 168 miles of man-made canals spanning 5,900 acres, through which water used to cool the nuclear reactors circulates in order to release excess heat. In recent years, evaporation, coupled with reduced rainfall, has caused the canal water to become hypersaline, and that water is leaking into the groundwater, upsetting the delicate freshwater–saltwater balance and creating a plume of saltwater that threatens Miami's fresh groundwater drinking source.

Climate change is already affecting the plant in other ways, too. In 2014, increased temperatures and decreased precipitation caused canal water temperatures to rise to 99 degrees Fahrenheit, just one degree shy of a federal limit that would require the reactors to shut down—right at a time when electricity was in high demand. The plant was only able to remain open after receiving special permission from the Nuclear Regulatory Commission to exceed the 100-degree limit.

Further, in the coming decades, sea level rise is projected to reach Turkey Point's cooling canals. If the canals become flooded, then the plant cannot operate. In the meantime, increased ocean temperatures and higher sea levels will exacerbate the hypersaline plume and the threat it poses to Florida drinking water and the local ecosystem.

Perhaps even more concerning, the climate crisis is also predicted to increase the frequency and intensity of hurricanes and storm surges. While Hurricane Andrew hit Turkey Point in 1992 and Hurricane Irma just missed it in 2017, the hurricanes of the future will be very different storms from those of the past. According to a 2020 study published in Proceedings of the National Academy of Sciences, global warming has increased the chances that a hurricane will reach Category 3 or higher, meaning that the risk that a hurricane will dangerously damage the reactors is only increasing.

One might expect that these climate impacts would have given the plant's operators—and the regulators at the Nuclear Regulatory Commission—pause before granting permission to operate for an additional 20 years. Instead, the owners glossed over climate concerns in their application, and the Nuclear Regulatory Commission approved the extension without an in-depth consideration of the climate impacts.

The enfeebled license renewal process. The 20-year license renewal in the United States differs from most countries with commercial nuclear capacity, which often only approve extensions for 10 years at a time, or require extensive safety reviews to ensure that old reactors' safety functions remain "as close as possible" to those of newer reactors. In the United States, applicants simply go through a limited license renewal process that involves submitting a truncated safety and environmental application, one that the Nuclear Regulatory Commission has crafted to be virtually impossible for states, local governments, and communities to challenge.

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In this process, major safety and environmental issues have been declared off limits by a regulatory sleight of hand known as the Generic Environmental Impact Statement. In 1996, the Nuclear Regulatory Commission drafted a generic analysis of those environmental impacts it deemed would be the same for every nuclear reactor license renewal. Because the commission determined that this statement addresses a set of designated "generic" impacts, and put the result of that analysis in law, individual applicants for renewed nuclear reactor licenses are not required to address those safety and environmental issues. Rather, applicants only need to supplement that generic impact statement with an analysis of issues categorically designated "site-specific."

The only way for a state or local government or the public to challenge whether the commission's Generic Environmental Impact Statement analysis and conclusions in fact make sense to apply to a specific plant is to either ask for a rule waiver—and no waiver has ever been granted—or to wait to catch the next impact statement rewrite and challenge the agency's determination then. But while the generic impact statement is supposed to be updated every 10 years, 17 years passed before the commission finally published the first update to the statement in 2013—severely limiting the usefulness of this route for addressing concerns about specific reactors.

So, for example, the commission determined it could generically analyze the impacts of renewing a nuclear reactor's license on water quality. If someone is concerned with how climate change might exacerbate water quality impacts from the renewal of a specific reactor license, the only way to do so is by hoping the commission grants them the first ever waiver, or by waiting until the commission decides it's time to update its generic impact statement, though that will probably be years too late.

Moreover, for the site-specific environmental analysis, it is the license applicant, not the government agency, that completes the first draft, giving the reactor operator the ability to frame the analysis to its wishes. And in order to challenge any of the environmental review, a party must petition to intervene in the license proceeding as soon as the applicant submits this first draft. If a petitioner fails to raise an issue at this early point, which can be a decade before the current license expires, that party will be precluded from challenging the environmental analysis later unless they can prove that new information has become available. Finally, even if a party successfully brings a challenge before the commission, the commission can still grant the renewed license before the challenge has been fully adjudicated—as happened in the case of the Turkey Point license renewal.

The broader deregulatory binge. This paltry license renewal process is worrisome enough on its own, but it's even worse in the current atmosphere of deregulation. Nuclear safety is under assault in the United States. The Nuclear Regulatory Commission has successfully rolled back important safety initiatives and is pursuing more degraded regulatory standards. Rejecting the majority of its own staff's recommendations, in 2019 the commission implemented severely scaled down regulations based on lessons learned from the Fukushima Daiichi disaster. The commission is also proposing to decrease reactor safety inspections; allow for self-inspection and reporting by the reactor operator on a host of safety issues; require fewer "force on force" drills that test nuclear power plants' defenses against terrorist attacks; and reduce requirements for notice to the public and to state governors when problems arise.

And the Nuclear Regulatory Commission isn't the only federal agency on a deregulatory binge. The White House Council on Environmental Quality has overhauled its regulations interpreting the foundational environmental law, the National Environmental Policy Act. These changes could significantly limit the scope of projects to which the act applies, the public participation in assessing those projects (including nuclear plants), and the impacts of those projects that an agency must analyze (including climate impacts).

Obtaining a second 20-year license renewal, especially for a reactor built in the 1970s, must be a serious endeavor that considers the reasonably foreseeable safety and environmental implications. Given the risk to people and the environment, if a nuclear reactor cannot rigorously demonstrate safe functioning well into middle of the century, nearby communities must be given the time and opportunity to plan for safer and less expensive alternatives.

Keywords: Nuclear Regulatory Commission, Turkey Point, climate change, nuclear energy, nuclear safety
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Charley Bowman 9 months ago

Will the rising temperatures eventually compromise the cooling ability of the pools of spent nuclear fuel? High burn-up fuel use and rising temperatures will likely increase the time to cool the spent fuel, and expose the Turkey Point infrastructure to increasingly more powerful hurricanes. Turkey Point needs to be closed ASAP.

-5 Reply

Arnie Gundersen 9 months ago

I would also note that the storm surge for the proposed TP6/7 is higher than the storm surge from TP3/4 due to more improved modeling of global warming effects. The NRC has not modified the storm surge for TP3/4 in light of global warming.

-6 Reply

Russell Lowes 9 months ago

Thank you for bringing up these issues. However, in once sense, the whole issue of whether to have nuclear energy as an option lies in its economics and how it undermines solutions to global warming. This is how nuclear energy works against the solutions to global warming, on economic grounds. Every time you spend a dollar on nuclear energy, the utility company only delivers 4 kilowatt-hours (kWhe) or less; it is 25¢ per kWhe or more, with prices increasing. If you instead put that dollar into the solar blend (solar, wind, energy efficiency and storage), you get 8 kWhe at… Read more »

+ -6 — Reply

Victor Gilinsky 9 months ago

The author refers in boldface to the enfeebled license renewal process but only discusses in detail environmental reviews. The so-called license extension safety review is a scandal. Although the whole thing is bureaucratically elaborate, and a bonanza for industry consultants and lawyers, the only question the NRC safety reviewers address is whether the plant owners have a plan for dealing with aging equipment so that the plant can meet its current "licensing basis." The NRC reviewers are specifically forbidden by regulation from questioning that licensing basis, that is, the basis on which safety depends, even though it was set many… Read more »

+ -3 — Reply

Erin Stanton 7 months ago

I completely understand the author's concern, but we need to flip the narrative on nuclear. The industry is making leaps and bounds when it comes to creating more economically sound, and safe, reactors and replacements. Yes, nuclear power does compete with fossil fuels and renewable energy sources, but when comparing all options, nuclear energy is far superior. Especially when trying to solve climate change, which is the main goal for every energy provider. Nuclear releases less radiation into the environment than any other major energy source and their power plants operate at much higher capacity factors than renewable energy sources… Read more »

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Caroline Reiser

Caroline Reiser is a Nuclear Energy Legal Fellow at the Natural Resources Defense Council. A graduate of University of California Santa Barbara and... Read More

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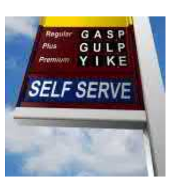

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