TVA's Bad **Nuclear** Bet:

Gambling BILLION$ on Bellefonte **Reactors**

Prepared by the Southern Alliance for Clean Energy

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August 2011

Executive Summary

"The circumstances for Bellefonte Units 1 and 2 are unique; no other licensee has ever given up its construction permits, partially dismantled the plant and allowed the facility to degrade, then requested that the permits be reissued."
-Joseph F. Williams, NRC Senior Project Manager[1]

The history of the Tennessee Valley Authority's (TVA) Bellefonte site in Jackson County, Alabama spans nearly 40 years. A total of four reactors have been proposed, and billions of dollars have been spent, but not a single kilowatt of electricity has ever been produced. After allowing the site to sit idle for more than 20 years and scrapping the facility for spare parts, TVA is now proposing to restart construction of the Bellefonte Unit 1 reactor, which may be one of the greatest gambles in the agency's history.

Southern Alliance for Clean Energy has serious concerns about TVA's push to complete the mothballed, abandoned Bellefonte reactors. Bellefonte's unique and complicated history is compounded by that fact that, in order to complete construction of the reactors, TVA faces unique and complicated problems—many worse than any other reactor project has previously faced. This report documents some of our concerns and makes it clear that finishing Bellefonte is not a gamble worth taking. Our concerns include Bellefonte's long, complicated history; multiple safety concerns that have not been addressed; the troubled history of the Babcock &Wilcox "Mark-C 205" design; the unnecessary and costly nature of Bellefonte; and additional obstacles.

In addition to our analysis, we have included an expert technical report from Mr. Arnold Gundersen, Chief Engineer of Fairewinds Associates, Inc. Mr. Gundersen is a nuclear engineer with over 39 years of nuclear industry experience and oversight including as a former Senior

[1] Joseph F. Williams, Non-Concurrence, ML083470901, November 20, 2008. Referenced as Enclosure 2 in *Staff Recommendation Related to Reinstatement of the Construction Permits for Bellefonte Nuclear Plant Units 1 and 2*, ML083230895, December 12, 2008.

Vice President Nuclear Licensee and reactor operator. The Fairewinds report can be found in its entirety in Appendix 1.[2]

Mr. Gundersen's expert analysis identifies seven specific areas of risk that, in Fairewinds' opinion, will cause further delays, additional costs, and even possible suspension of the Bellefonte project if TVA decides to move forward with its construction. They are:

1. Bellefonte's Unique Design
2. Groundwater Intrusion That Is Weakening It's Foundations
3. Missing Critical Nuclear Quality Assurance Documents and Complete Records
4. Cannibalization of Bellefonte's Operating Systems
5. Containment Problems Unique to Bellefonte
6. Historical Precedent
7. Post-Fukushima Lessons Learned

Southern Alliance for Clean Energy agrees with the conclusion drawn in the Fairewinds report: that TVA faces enormous safety, financial and scheduling risks if the TVA Board approves the decision to resurrect the Bellefonte Unit 1 reactor.

TVA is improperly characterizing the unique risk factors in its effort to complete Bellefonte Unit 1: the risks to public health and safety, the financial impacts on ratepayers and potential risk to TVA bondholders and U.S. taxpayers. In June 2011, TVA's CEO Tom Kilgore called into question TVA's ability to move forward with this project in a transparent and honest manner when he reportedly said, "Bellefonte will be the best nuclear plant that TVA has." Bellefonte project manager Ray Hubry was also quoted in the same article, grossly misrepresenting the Bellefonte project by stating, "In reality this is one of the most modern plants in the country. It's not 1974 technology."[3]

Both of these statements are far from reality. If the Bellefonte reactors are built and become operational, integral components will already be decades old, and will likely already be suffering degradation that could compromise the safety of the facility. The decision to go forward and dedicate many billions of dollars to complete reactor Unit 1 (and likely Unit 2) will be put before the TVA Board of Directors at their August 2011 meeting. It is imperative that an objective and honest portrayal of this project's significant risks be considered.

[2] The attachments to the Fairewinds report (Arnold Gundersen's CV and the Non-Concurrence by Joseph Williams) can be downloaded from the Southern Alliance for Clean Energy at: www.cleanenergy.org.

[3] Ken Bonner, "Kilgore to recommend Bellefonte completion: plant will be best in nuclear fleet," Daily Sentinel, June 3, 2011. At http://thedailysentinel.com/news/article_9fd8e13a-8d6f-11e0-8788-001cc4c03286.html?mode=story. Further similar comments can be seen on the TV show "Tennessee this Week" on June 4, 2011. At http://www.tennesseethisweek.com/2011/jun/tva-and-nuclear-power

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The Long, Complicated History of TVA's Bellefonte Nuclear Site

The history of the Tennessee Valley Authority's (TVA) Bellefonte site in Jackson County, Alabama spans nearly 40 years. TVA originally proposed building two Babcock & Wilcox (B&W) Mark-C "205" design reactors[4] at the rural site located along the banks of the Tennessee River's Guntersville Reservoir, less than 10 miles from Scottsboro, in 1973. TVA received construction permits in 1974 from the Atomic Energy Commission, an agency that no longer exists and was eventually replaced in part by the U.S. Nuclear Regulatory Commission (NRC). Construction began that same year.

After 14 years and $4 billion in construction costs, TVA halted construction of both reactors at the Bellefonte Site, citing declining power demand projections and skyrocketing costs.[5] At the time, reactor Unit 1 was 88 percent complete and Unit 2 was 58 percent complete.[6] With approval from the NRC, TVA placed both units in "deferred status" pursuant to NRC regulations. This imposed on TVA significant maintenance, inspection and reporting responsibilities to ensure the safety and integrity of the reactors should TVA decide to reinstate construction operations.

Then, after 17 additional years and hundreds of millions of dollars spent maintaining the two partially completed reactors, TVA requested in 2006 that the construction permit be terminated, and the NRC approved the request later that September.[7] At that point, TVA's regulatory responsibilities to maintain the partially constructed reactors ended, and over the following two years, TVA conducted "asset recovery" activities at the site. By the end of this period, reactor Unit 1 was estimated to be only 55 percent complete and Unit 2 just 35 percent complete.[8]

In 2007, shortly after TVA abandoned its plans for reactor Units 1 and 2, TVA proposed building two Toshiba-Westinghouse AP1000 design reactors at the Bellefonte site – labeled Unit 3 and Unit 4. The industry consortium NuStart Energy made these proposed reactors its lead reactor

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[4] The Babcock & Wilcox Mark-C "205" design has 205 fuel assemblies in the reactor core with the fuel rods in a 17 x 17 array. The other B&W design operating in the U.S. has 177 fuel assemblies in a 15 x 15 array.
[5] *Staff Recommendation Related to Reinstatement of the Construction Permits for Bellefonte Nuclear Plant Units 1 and 2*, ML083230895, COMSECY-08-0041, Enclosure 1, Staff Evaluation of Options and Bases for Recommendation Regarding Proposed Reinstatement of Construction Permits Bellefonte Nuclear Plant, Units 1 & 2, pp. 1-3, December 12, 2008.
[6] Federal Register Notice, Tennessee Valley Authority, Notice of Intent, Supplemental Environmental Impact Statement for a Single Nuclear Unit at the Bellefonte Site, August 10, 2009 (Volume 74, Number 152), Page 40000-40003. At http://edocket.access.gpo.gov/2009/E9-19045.htm
[7] U.S. Nuclear Regulatory Commission press release, September 15, 2006. At http://pbadupws.nrc.gov/docs/ML0625/ML062580144.pdf
[8] *Id.* at footnote 4.

project in the U.S.[9] This proposal was driven forward by the Nuclear Power 2010 program, whose the goal was to have two new reactors online in the U.S. by 2010; a goal that has not been reached, nor have any reactor proposals even achieved the critical first step toward completion: a combined operating license.[10, 11] In April 2009, as costs began to skyrocket for the AP1000, NuStart dropped TVA's Bellefonte 3 and 4 as the lead reactor project.

As the AP1000 proposal stalled, TVA turned their attention back to the two never-completed reactors that had been sitting idle for more than two decades. In August 2008, TVA once again proposed to complete reactor Units 1 and 2 and petitioned the NRC to reinstate the original construction permits that had been issued in 1974. The NRC granted TVA's request for reinstatement of the construction permits in February 2009 amid much controversy, including the dissenting opinions of NRC Commissioner Gregory Jaczko and NRC Senior Project Manager Joseph Williams.[12, 13] The TVA Board of Directors in now set to vote on a proposal to restart construction of reactor Unit 1 at Bellefonte. TVA's current estimate for completing this reactor is between $4 and $5 billion, with a proposed completion date between 2018 and 2020.[14]

Safety Concerns Abound Regarding TVA's Proposed Restart of the Bellefonte Reactors

Significant Safety Concerns Recently Discovered:
Progress Energy Florida's Crystal River reactor has been offline for more than three years and will cost at least $1.5 billion to repair. Bellefonte reactor Unit 1's containment vessel has suffered serious damage similar to the issue at Crystal River, but likely more severe and potentially more difficult to repair than what Progress Energy is currently dealing with.

In August 2009 a loud gunshot-like noise was heard inside the containment vessel of Bellefonte reactor Unit 1. It took a week, however, for TVA staff to determine the cause of the noise: a "containment vertical tendon" had failed. On December 10, 2009, TVA acknowledged the incident in a licensee event report (LER) to the NRC.[15]

A "containment vertical tendon" is, essentially, a large steel band that wraps around the reactor's containment vessel to maintain the structural integrity of the concrete structure.[16] It is essential to the integrity of the containment vessel that these vertical tendons maintain compression on the structure because unless concrete is kept under tension, it cannot retain its form and strength,

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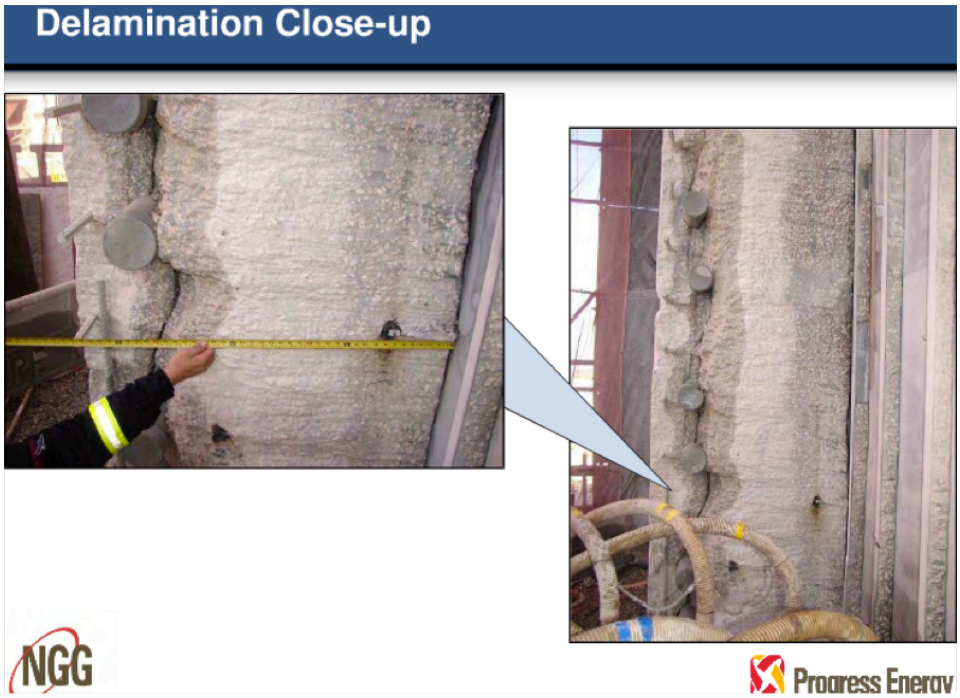
[9] See NuStart Energy's website for more information. At http://www.nustartenergy.com/faqs.
[10] Peter Bradford, "Honey, I Shrunk the Renaissance: Nuclear Revival, Climate Change, and Reality," published in ElectricyPolicy.com, October 11, 2010. At http://www.electricitypolicy.com/bradford.pdf
[11] U.S. Department of Energy (DOE), A Roadmap to Deploy New Nuclear Power Plants in the United States by 2010 Volume I, Summary Report, October 31, 2001. At http://www.ne.doe.gov/np2010/reports/ntdroadmapvolume1.pdf.
[12] U.S. Nuclear Regulatory Commission press release, February 19, 2009. At http://pbadupws.nrc.gov/docs/ML0905/ML090500171.pdf
[13] *Staff Recommendation Related to Reinstatement of the Construction Permits for Bellefonte Nuclear Plant Units 1 and 2*, ML090500374, VR-COMSECY-08-0041, February 18, 2009; Joseph F. Williams, Non-Concurrence, ML083470901, November 20, 2008.
[14] As of March 2011, TVA estimates for completing Bellefonte was more than $8 billion: $4.83 billion for Unit 1 and $3.7 billion for Unit 2. Information provided by TVA to the IRP stakeholder review group, TVA Response to Question 56, March 2011.
[15] LER 45559, December 10, 2009
[16] The containment system in a nuclear power plant is meant to contain the release of unmonitored radioactivity that is generated during regular operation of a nuclear power plant or during a serious nuclear power plant accident like that at Three Mile Island or Fukushima.

rendering it extremely unstable once nuclear activities commence. If it is not correctly tensioned, concrete will ultimately crack and fail.[17]

The cause of the failure is still uncertain. However, in subsequent reports to the NRC, TVA has concluded that sulfide in the grease used to lubricate other tendons was a contributing cause in this tendon failure, and that water had somehow entered some of the tendons so that the issue of moisture contamination may also have been a contributing factor in this failure.[18]

The experience at Progress Energy's Crystal River nuclear plant in Florida provides valuable insight into what this incident may mean for TVA's Bellefonte reactor Unit 1. The Crystal River reactor is also a B&W with near-identical containment vessel design. There, the utility purposely de-tensioned the vertical tendons in order to complete reactor upgrades. Progress and its subcontractors, with oversight, input and approval from the NRC, spent years developing a detailed plan on how to properly tackle this project. Upon inspection, it was discovered that, despite this extensive preparation, the de-tensioning had unexpectedly caused a 60-foot long by 20-foot wide crack ("delamination"[19]) in the middle of the containment wall.[20] A close-up photo is below.[21]



[17] See Appendix A of this report prepared for Southern Alliance for Clean Energy by Fairewinds Associates, Chief Engineer Arnold Gundersen, "The Risks of Reviving TVA's Bellefonte Project," August 5, 2011.
[18] See TVA's reports to the NRC re: this incident (Incident #45559). At http://www.nrc.gov/reading-rm/doc-collections/event-status/event/2009/20091211en.html#en45559
[19] "Delamination" refers to when the concrete actually separates from the sides of the containment vessel, creating a vertical gap between layers of concrete.
[20] Ivan Penn, *Continued problems at Crystal River nuclear plant could lead to reactor's closing.* St. Petersburg Times, June 15, 2011.
[21] Progress Energy, Crystal River Unit 3 Delamination Update, November 20, 2009. At http://www.fairewinds.com/content/crystal-river-delamination-update

Not only did this 60-foot long crack occur *after* Progress Energy and B&W had conducted a thorough engineering analysis, which was approved by the NRC, but a second significant crack *also* unexpectedly developed and further destabilized the containment vessel in 2011 while Progress Energy was still attempting to re-tension the suspension cables in an effort to repair the first crack. Cracking and delamination, which fundamentally destabalize containment vessels, are more likely to occur during de-tensioning and re-tensioning processes. Progress Energy is now proposing a 3-year, potentially $1.3 billion repair process to again attempt to repair the B&W containment, bringing the total period that the Crystal River reactor is forced to be offline to more than five years, and the cost of repair to more than $1.5 billion.[22]

Bellefonte Unit 1 is now facing a very similar situation, but with three important distinctions that make the Bellefonte incident more serious and potentially more costly than Crystal River:

- Bellefonte reactor Unit 1 has experienced an unintentional and rapid de-tensioning worse than the forces that caused the cracked containment at Progress Energy Crystal River;
- Neither TVA nor the NRC has inspected Bellefonte reactor Unit 1 to see if the snapped tendon caused similar cracks (delaminations) anywhere in the containment; and
- TVA has yet to begin de-tensioning all its other tendons in order to fully inspect the damage caused by the initial failure, which may induce more cracks as at Crystal River.

Events continue to unfold regarding the vertical tendon failure at TVA's Bellefonte reactor Unit 1, but it is clear that this failure raises significant safety concerns that have yet to be addressed by TVA or the NRC. The ongoing difficulties at Crystal River also fail to provide TVA and the NRC a successful project from which to glean important "lessons learned." Rather, Crystal River only highlights the very difficult and expensive nature of what is likely to ensue at Bellefonte.

Water Intrusion and Degradation of Concrete Foundation

As stated in the Fairewinds report included as Appendix A, groundwater intrusion has been an ongoing problem at the Bellefonte site since construction began because the reactor's foundation is located in a low-lying area near the Tennessee River. When construction was underway and in a state of deferment (before TVA abandoned its construction license), TVA implemented extraordinary measures to address this, but these measures were subsequently abandoned when TVA relinquished its construction permit in 2006.

Water intrusion can seriously degrade the concrete foundations of nuclear power plants and has occurred already at several sites across the country, most of which developed the degradation after just a couple decades. Bellefonte's foundations, in contrast, have now experienced over 30 years of degradation including a period of time when mitigation for and inspection of groundwater intrusion was suspended. As stated in Mr. Gundersen's technical analysis:

> *"The risk of significant foundation problems at Bellefonte originating during construction and continuing now and into its possible operating life is threefold:*
>
> - *First, TVA knowingly and deliberately allowed the foundations to deteriorate.*

[22] Michael Sasso. *Progress Enegy to repair, not close, Crystal River nuclear plant.* St. Petersburg Times, June 27, 2011. Also see Appendix A of this report prepared for Southern Alliance for Clean Energy by Fairewinds Associates, Chief Engineer Arnold Gundersen, "The Risks of Reviving TVA's Bellefonte Project," August 5, 2011, pp. 17-20.

- *Second, the foundations at Bellefonte will be 45 years old well before the reactor ever begins to generate electricity.*
- *Third, a 40 year initial life and possible 20 year life extension after that means that the underlying safety of this nuclear plant will be based on concrete that will be more than 100 years old. Given that much newer reactors are already experiencing concrete failures, this risk to the health and safety of the people of Alabama is significant and long lasting."*[23]

Loss of Quality Assurance and Cannibalization of Bellefonte:
In 2006, after almost two decades without any activity at the Bellefonte site, the NRC, at TVA's request, terminated TVA's construction permits for both reactor Unit 1 and 2. Termination of the construction license also terminated TVA's responsibility to maintain quality control measures to prevent degradation or to comply with NRC standards when performing activities at the site. For instance, as mentioned earlier, TVA stopped mitigating for groundwater intrusion that had been impacting the site. Mitigation would have been required under TVA's construction permit.

Though other nuclear power plants have had significant problems with missing or deficient quality assurance records, it is important to note that none were apparently as severe as Bellefonte. As referenced in the Fairewinds report, the Zimmer nuclear plant in Ohio also had a complete breakdown in Quality Assurance (QA). The report compares the two situations and highlights the risks that Bellefonte may ultimately face—potentially being unable to operate even after significant time and resources are spent attempting to complete the project:

> *"However, unlike TVA Bellefonte Unit 1 where construction was completely abrogated, Zimmer's entire QA program was fully operational, yet Zimmer was still required to shut down permanently because of missing Quality Assurance records proving that the plant met all rigorous nuclear power plant QA requirements. … The Zimmer plant was more than 95% complete when the Quality Assurance record problems were discovered. The QA lapse was so problematic and irreparable that Zimmer could not be operated as a nuclear power plant."*[24]

Following the termination of TVA's permits, TVA undertook what it describes as "investment recovery" activities. Fundamentally, the plant was cannibalized. In a letter to the NRC in August 2008, TVA described these activities, including transferring approximately $49 million in equipment and materials for use at other power plants, selling approximately $16 million worth of materials to scrap vendors, and removing steam generator tubing and sections of reactor coolant system piping.[25] However, because TVA was not under NRC oversight at the time, no detailed records of what occurred during this period were kept, meaning no one knows exactly what took place or who was allowed access to the site.[26] By the end of this unregulated period,

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[23] See Appendix A of this report prepared for Southern Alliance for Clean Energy by Fairewinds Associates, Chief Engineer Arnold Gundersen, "The Risks of Reviving TVA's Bellefonte Project," August 5, 2011, pp. 8-9.
[24] *Id.* at pp 9-10.
[25] TVA letter to the Nuclear Regulatory Commission, submitted August 28, 2008. Docket Nos. 50-438 and 50-439.
[26] For a detailed discussion of the concerns raised by the treatment of the Bellefonte 1 & 2 units over the past several decades, see *Declaration of Arnold Gundersen Supporting the Blue Ridge Environmental Defense League's Contentions*. May 6, 2009. Docket Nos. 50-438 and 50-439. At http://www.fairewinds.com/content/bellefonte-units-1-and-2-tva-gundersen-testimony-nrc-may-2009-behalf-blue-ridge-environmenta

TVA's activities resulted in reactor Unit 1 going from 88 percent complete to approximately 55 percent complete. Reactor Unit 2 went from approximately 55 percent complete to 35 percent complete.[27]

In comments submitted to the Atomic Safety and Licensing Board regarding the NRC's 2009 reinstatement of TVA's construction permits, NRC Senior Project Manager Joseph Williams expressed serious concerns about the uncertainty surrounding this period of unregulated activities and the level of review conducted by the NRC before TVA's request for permit reinstatement was granted:

> *"TVA's request* [for permit termination] *was a conscious action with full knowledge that TVA would be giving up all privileges and authorization to construct the reactors. Until the reinstatement of TVA's construction permits by the NRC in 2009, all regulatory activities ceased and TVA allowed the facilities to degrade, conducted 'investment recovery' efforts, resulting in undocumented and undetermined effects on safety related structures, systems and components . . .*
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> *. . . The conclusions of the NRC staff* [to recommend reinstatement of TVA's construction permit for Units 1 and 2] *largely summarizes TVA's own economic justification for changing it's mind, but provides no evaluation of issues that are pertinent to adequately constructing the facility so it can possibly be operated safely at some future date. . . neither TVA or the NRC adequately addressed safety issues which are at the foundation of any regulatory decision. . . Given that reinstatement of the BLN Unit 1 and 2 construction permit is an unprecedented NRC regulatory action, one would have hoped that the NRC staff would have shown more regard for its mission to protect public health and safety, rather than basing it's conclusion exclusively upon TVA's economic decision."*[28]

NRC Commissioner Gregory Jaczko, now NRC Chairman, also dissented to the reinstatement of TVA's construction permits for Bellefonte.[29] In his dissenting comments, Commissioner Jaczko disapproved of TVA's request to reinstate the Bellefonte construction permits:

> *"The Policy Statement clearly places emphasis upon the need for a construction permit, even a terminated construction permit, to have a quality assurance program that is of a continuing nature throughout the period of termination. It does not provide nor does it suggest that an after-the-fact review of quality assurance records can be an adequate substitute for an ongoing quality*

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[27] Federal Register Notice, Tennessee Valley Authority, Notice of Intent, Supplemental Environmental Impact Statement for a Single Nuclear Unit at the Bellefonte Site, August 10, 2009 (Volume 74, Number 152), Page 40000-40003. At http://edocket.access.gpo.gov/2009/E9-19045.htm

[28] *Limited Appearance Statement by Joseph F. Williams Regarding Issues for Consideration by the Atomic Safety and Licensing Board*, Submitted March 5, 2010. Docket Nos: 50-438 and 50-439.

[29] *Commissioner Jaczko's Vote on COMSECY-08-0041 Staff Recommendation Related to Reinstatement of the Construction Permits for Bellefonte Nuclear Plant Units 1 and 2.* January 9, 2009.

> *assurance program. Quality assurance has been recognized as a fundamental aspect of the agency's public health and safety regime."*[30]

According to Commissioner Jaczko, the potential that undocumented work activities, introduction of unapproved chemicals, corrosion, and other unknown degradation may have occurred calls into question the integrity of safety-related structures, systems and components.[31]

Arnold Gundersen also testified before the NRC Commission on behalf of the Blue Ridge Environmental Defense League.[32] In his testimony, Mr. Gundersen elaborates on the potential risks created by not maintaining a QA program:

> *"For example, at a nuclear power plant with requisite QA programs in place, there are strict controls in the type of light bulbs allowed inside the containment. Such controls are required in order to prevent halogen contamination of the reactor vessel that may cause the vessel to fail when it is pressurized, and this is just one of thousands of critical regulations which must be enforced in order to assure nuclear safety and reliability. TVA is unable to give quantifiable assurance that every light bulb stayed in compliance with the halogen restrictions during the past three years after the license was terminated and the unsupervised cannibalization had begun, just as it is unable to delineate that thousands of other critical maintenance requirements were performed in its unsupervised and unmonitored environment. . ."*[33]

In sum, TVA's failure to maintain QA protocols once it abandoned Bellefonte's construction permit and undertook "investment recovery" activities creates significant concerns about TVA's ability to maintain the safety of these reactors should they eventually be brought online.

As of August 2011, challenges are still pending in federal court over the NRC's decision for reinstatement and the ad hoc process it used to reach this decision.[34] In its challenge to the NRC's reinstatement of TVA's construction license, the Blue Ridge Environmental Defense League asserts that the NRC violated the National Environmental Policy Act by failing to conduct an adequate review of the project's potential environmental impacts; that the NRC does not have statutory authority to reinstate a previously terminated construction license; and that the NRC must require TVA to re-apply for a construction license under current legal standards instead of summarily reinstating a 40-year old construction license after minimal review.[35]

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[30] *Id.* at p. 1 – 3.
[31] *Id.*
[32] *Declaration of Arnold Gundersen Supporting the Blue Ridge Environmental Defense League's Contentions.* May 6, 2009. Docket Nos. 50-438 and 50-439. At http://www.fairewinds.com/content/bellefonte-units-1-and-2-tva-gundersen-testimony-nrc-may-2009-behalf-blue-ridge-environmenta
[33] *Id.* at 6 – 8.
[34] In the United States Court of Appeals for the District of Columbia Circuit, filed March 30, 2009, Case no. 09-1112, Blue Ridge Environmental Defense League v. Nuclear Regulatory Commission.
[35] *Id.* See also: *Briefing Paper: Opposing Tennessee Valley Authority's Bellefonte Nuclear Power Station.* Blue Ridge Environmental Defense League. July 2011. Available at www.BREDL.org.

Babcock &Wilcox-Designed Reactors Have Reported Safety Problems:
Other similar B&W-designed reactors have also raised safety concerns that are relevant to TVA's Bellefonte site. The B&W Mark-B design reactor is a smaller version of the proposed Mark-C 205 reactors at Bellefonte with almost identical containment and fuel storage systems. Nine of these Mark-B reactors have operated in the U.S., and two were shut down prematurely: Rancho Seco near Sacramento, California; and the Three Mile Island reactor Unit 2 in Pennsylvania, which operated for just over one year before the infamous 1979 accident.[36]

In 1986, the Union of Concerned Scientists (UCS) submitted a report to the NRC documenting the organization's serious concerns with the B&W reactor designs and the agency's continued failure to address the well-known safety problems.[37] In its report, UCS explained why nuclear power plants designed by Babcock and Wilcox are inherently more susceptible to accidents than other pressurized water reactors. UCS based this conclusion on the operating history of B&W-designed reactors and numerous technical reports from the NRC itself. The report concludes:

> *"B&W reactors are extremely sensitive to events that would be innocuous to other PWRs* [pressure water reactors]. *The inherent instability of reactor temperature and pressure after a disturbance in the main feedwater system results from B&W's unique steam generators and small pressurizer. The 'non-safety grade' auxiliary feedwater system, Integrated Control System, and non-nuclear instrumentation not only have been proven incapable of compensating for this inherent sensitivity, they have themselves been the initiating cause of many events with safety significance. The combination of these attributes of B&W-designed plants has resulted in severe undercooling and overcooling events that repeatedly challenge the plants' safety systems, make unreasonable demands on the operators, and pose serious safety hazards."*[38]

The Troubled History of the B&W Mark-C 205 Design
Only five B&W Mark-C 205 design reactors were ever proposed worldwide (two were for Bellefonte); none have been completed in the U.S. In addition to the two reactors proposed for TVA's Bellefonte site, two more were partially constructed at the Hanford Nuclear Reservation near Walla Walla, Washington, known as Washington Nuclear Plant Units 1 and 4 (WNP-1 and WNP-4). The fifth, completed in Germany at the Mühlheim-Kärlich (KMK) nuclear site, operated for just 13 months before being shut down.

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[36] U.S. Nuclear Regulatory Commission, Information Digest, 2010-2011, NUREG-1350, Vol. 22, Appendix A, U.S. Commercial Power Reactors and Appendix B, U.S. Commercial Nuclear Reactors Formerly Licensed to Operate (Permanently Shutdown). At http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1350/
[37] Union of Concerned Scientists, *Safety Risks at Babcock & Wilcox Reactors: A Brief Summary*, February 28, 1986.
[38] *Id.* at 7. See also: United Press International, "Group urges construction halt at TVA plant," February 10, 1987.

The Failed U.S. Experience (Not Including Bellefonte…)

The WNP-1 and WNP-4 reactors followed a fate remarkably similar to TVA's first attempt to build reactor Units 1 and 2 at Bellefonte. After beginning construction in the early 1970s, the Washington Public Power Supply System (WPPSS), now Energy Northwest, halted construction on both reactors by 1982 because of "financial problems and uncertainties concerning future electric power demand."[39] At the time, WNP-1 and 4 were 63 percent and 16 percent complete, respectively.[40] WNP-4 became part of the largest municipal bond default in U.S. history ($2.25 billion), leading to more than 60 lawsuits and the country's largest securities fraud case in history at the time.[41] After considering the feasibility of restarting construction of WPN-1, Energy Northwest finally abandoned the project in 2005, citing costs that were "too high to be economical."[42] That was three years *before* TVA decided to revisit the idea of completing Bellefonte, which calls into question why TVA considers project completion an affordable option whereas Energy Northwest did not. The NRC approved termination of Energy Northwest's construction permits for both reactors in 2007.[43]

The Failed German Experience

The Mühlheim-Kärlich (KMK) reactor in Germany was the only B&W Mark-C 205 design ever completed and brought online. It also had a troubled history. Construction began in 1975 and two decades passed before the reactor was connected to the electricity grid in March 1986. The reactor was permanently shut down in September 1988.[44] During that short time, the reactor operated for less than 7,500 hours (less than a full years' worth of hours), which is extremely limited, and had a cumulative operating factor of only 31 percent.[45]

The shutdown of KMK was apparently due to several factors; most notably seismic issues at the original site location. The final site location was moved without the proper permitting to allow that change. Consequently, the Federal Administrative Court rescinded the operating license in September 1988, causing the shutdown. A court battle ensued, and in late 1995, the Higher Administrative Court of Rhineland-Palatinate determined that the licensing authority had made many mistakes when investigating and assessing the reactor's ability to withstand earthquakes, which led to an underestimation of the seismic hazards. This decision was challenged, but in January 1998 the Federal Constitutional Court confirmed the position of the Higher Administrative Court. Decommissioning began in 2004.[46]

In comparison to modern reactors' operating timeframe, which are measured by 'reactor years,'

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[39] U.S. Government Accountability Office, Report to the Honorable Brock Adams, U.S. Senate, Nuclear Science: Issues Associated with Completing WNP-1 as a Defense Materials Production Reactor, GAO/RCED-88-222, September 1988, p.3. At http://archive.gao.gov/d17t6/136971.pdf

[40] Washington Public Power Supply System (WPPSS) WNP-4 & 5 1981 Bond Statement excerpt, March 17, 1981.

[41] Chip Brown, The Washington Post, "Whoops: Darkness to Dawn: Am Ambitious Nuclear Empire Goes Awry," December 2, 1984.

[42] Energy Northwest, 2002 Annual Financial Report for Nuclear Project 1, ML030280696, January 14, 2003, p.6.

[43] U.S. NRC, Letter to Mr. J.V. Parrish re: Energy Northwest Nuclear Project No. 1 – Termination of Construction Permit CPPR-134 (TAC NO. MC9245), ML070220011, February 7, 2008. At http://pbadupws.nrc.gov/docs/ML0702/ML070220011.pdf.

[44] International Atomic Energy Agency (IAEA), Nuclear Power Reactor Details - MUELHEIM-KAERLICH (KMK). At http://www.iaea.org/cgi-bin/db.page.pl/pris.prdeta.htm?country=DE&site=MUELHEIM-KAERLICH&units=&refno=22&link=HOT&sort=Reactor.Status,&sortlong=By%20Status

[45] *Id.*

[46] Summary of KMK history from Helmut Hirsch, scientific consultant on nuclear safety, Neustadt, Germany in an E-mail communication with Sara Barczak on June 12, 2011.

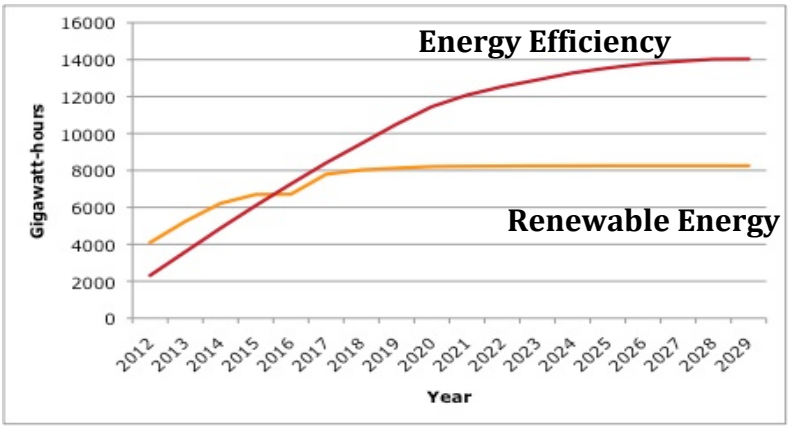
the complete operating history of the B&W Mark-C 205 reactor, a design completed in the 1960s, can be measured in 'reactor hours.' The severely limited worldwide operational history of this reactor makes any conclusion about the safety of this reactor suspect, especially considering that, to our knowledge, the B&W design has never been updated to conform to modern operational or safety standards.

Bellefonte is Not Needed and is Too Costly

TVA's Flawed Analysis:
TVA's assertion that Bellefonte reactor Unit 1 is necessary to meet the Valley's growing energy rests on its recently completed integrated resource plan (IRP). However, as the Southern Alliance for Clean Energy identified in response to TVA's Draft IRP, the IRP suffers from several flaws that inappropriately skew the IRP's recommendations in favor of nuclear reactors at the Bellefonte site.[47]

The most glaring flaw in TVA's IRP analysis is the arbitrary limits that TVA staff place on both energy efficiency and renewable energy development. None of the potential strategies considered by TVA staff in the Final IRP include significant energy efficiency or renewable energy development after approximately 2020. For example, TVA's most aggressive renewable energy portfolio increases by 4,199 Gigawatt-hours[48] of annual renewable energy generation between 2012 and 2020, but only adds another 44 Gigawatt-hours between 2020 and 2029. Energy efficiency increases by 9,138 Gigawatt-hours between 2012 and 2020, but only 2,581 Gigawatt-hours between 2020 and 2029. The following chart shows the planned additions of renewable energy and energy efficiency in TVA's preferred IRP strategy.[49]

TVA's Planned Energy Efficiency and Renewable Energy Additions Through 2029



Source: TVA data presented to Southern Alliance for Clean Energy, March 2011

[47] SACE IRP comments submitted on November 15, 2010; available at: http://www.cleanenergy.org/images/files/SACE_TVA_IRP_Comments_wAppx.pdf
[48] A Gigawatt-hour is a measure of energy actually produced. One Gigawatt-hour equals one million kilowatt-hours.
[49] Note that the curves shown are not generated by the IRP model, but are created by TVA staff and inserted into the model. In this way, TVA staff is able to manipulate the IRP analysis, limiting the contributions of renewables and efficiency based on incorrect assumptions that these resources cannot continue to grow beyond 2020. For a complete description of the flawed assumptions that TVA relied on, see SACE comments in response to TVA's Draft IRP, *Id.* at footnote 46.

The constraints on energy efficiency and renewable energy inserted into the IRP analysis by TVA staff arbitrarily limit the IRP's options for meeting energy demand in 2020 and beyond. It is no coincidence that the IRP recommends significantly higher levels of capacity additions, including the proposed Bellefonte project, during this timeframe.

SACE also outlined several additional flaws in TVA's IRP analysis in our comments responding to TVA's Draft IRP:

- Unreasonably high price forecasts for natural gas during the planning period, which place natural gas at an artificial disadvantage to new nuclear generation;
- Unreasonably high demand growth forecasts, which lead to higher levels of capacity additions than are likely to be necessary; and
- Inaccurate assessments of the potential and availability of in-Valley renewable energy and energy efficiency resources.

Each of these flaws artificially skews the IRP's recommended planning strategy in favor of the proposed Bellefonte project. As such, TVA has yet to show why the Valley needs such a costly and risky energy source to meet future energy demand.

TVA's Shaky Financials:
A review of TVA's 2010 Annual Report to the Securities and Exchange Commission[50] quickly reveals that the proposed Bellefonte project will require significantly raising either TVA's debt load or the rates TVA charges its customers.

TVA's current long-term debt, as of September 2010, is $23.4 billion.[51] Even without the expense of the proposed Bellefonte project, TVA will face serious financial difficulties in coming years if the agency intends to remain below its statutorily mandated $30 billion debt limit.[52] The table below shows key financial indicators for the 2008 through 2010 period.

Key TVA Financial Indicators (in $millions)

	2010	2009	2008
TVA Operating Revenues ($Billion)	10,874	11,255	10,382
TVA Operating Expenses ($Billion)	8,632	9,282	8,198
Interest Payments ($Billion)	1,294	1,272	1,376
Net Annual Income	**$972**	**$726**	**$817**

Source: TVA 10-K Annual Report, p. 77.

[50] Available at: http://www.tva.gov/finance/reports/index.htm
[51] TVA Annual Report, p. 46. Note that this estimate only includes TVA's long-term bond indebtedness and does not include capital leases, leaseback obligations or energy prepayment obligations. It is unclear whether these additional obligations count towards TVA's statutory debt limit.
[52] TVA's debt limit is codified in the TVA Act, 16 U.S.C. 831 § 15d(a)

TVA's net annual income for the 2008 through 2010 period did not exceed $1 billion for any given year. However, even without the cost of completing Bellefonte reactor Unit 1, TVA is planning capital expenditures that far exceed its typical net annual income.

TVA Planned Capital Expenditures (in $millions)

	2010 (actual)	2011	2012	2013
Anticipated capital expenditures (not including Bellefonte reactor Unit 1)	$2,023	$2,504	$2,641	$2,696

Source: TVA 10-K Annual Report, p. 57.

These planned expenditures, far in excess of any reasonable expectation of TVA's net annual income, will raise one of two implications: a) TVA will exceed its $30 billion statutory debt cap in the very near future and require additional statutory authority to borrow more; or b) TVA will need to raise an additional billion dollars or more annually through rates charged to its customers to cover its expected capital expenditures.

The Valley has already begun to experience the effects of TVA's financial shortcomings. In August 2009, Kim Green, then TVA's Chief Financial Officer, reported to the TVA Board a projected $7.2 billion shortfall between 2009 and 2012 (not including any anticipated spending on the Bellefonte project) that needed to be addressed.[53] In response to this outlook, the TVA Board approved a plan to cut costs by $1.9 billion and increase TVA's debt load by $2.8 billion,[54] leaving another $2.5 billion unaccounted for. To begin closing this financial gap, TVA's Board of Directors also approved an 8 percent base-rate increase for fiscal year 2010.

TVA estimates that completing Bellefonte reactor Unit 1 will cost between $4 and 5 billion through 2020, an average of between $400 and $500 million per year in additional capital expenses.[55] Considering TVA's existing budget shortfalls, it is difficult to imagine a scenario where TVA's expected capital costs are met without either a significant increase in TVA's debt limit or a significant increase in the rates TVA charges for electricity. The proposed completion of Bellefonte reactor Unit 1 significantly exacerbates TVA's financial difficulties.

Additional Obstacles and Concerns Regarding Bellefonte Completion

Flooding and Seismic Concerns:

In addition to the safety concerns raised by the B&W Mark-C 205 design, the geographic location of the proposed Bellefonte site raises additional concerns related to the potential for seismic activity at or near the site and the threat of flooding due to its low-lying location in proximity to the Tennessee River. Furthermore, the original 1974 construction permit for Bellefonte reactor Units 1 and 2 relied on data that is now more than 40 years old and more recent data suggested additional risks must be considered.

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[53] August 20, 2009 presentation by Kim Greene at TVA meeting of the Board of Directors, available at: http://www.tva.gov/abouttva/board/pdf/august_20_board.pdf

[54] At this time, TVA also approved a change in financing assumptions for capital expenditures from 65% to 100%.

[55] TVA capital expenses on Bellefonte Unit 1 will likely not be consistent from year to year. A more likely scenario is that costs will be smaller in the early years, dramatically increase in the middle years and then winding down in the outer years of the project.

NRC Senior Inspector Joseph F. Williams discussed the risk of flooding at the Bellefonte site in his objection to reinstating TVA's construction permits.[56]

> *"…The NRC staff is concerned that the site may be vulnerable to flood levels higher than calculated by TVA, so the acceptability of the site and the adequacy of design features protecting the site have not yet been determined . . . The existing flooding analysis reviewed as part of the construction permit of the Preliminary Safety Analysis Report in the early 1970s and the operating license application may not be conservative, which could lead to the need for design changes to mitigate the effects of higher flood levels."*

The potential for seismic activity adds to the concerns regarding the site itself. The Bellefonte site is near the Eastern Tennessee Seismic Zone, the largest and second-most-active seismic zone in the eastern United States. Powerful earthquakes have occurred in this zone as recently as the 4.6-magnitude earthquake near Fort Payne, Alabama, in 2003.[57]

In 2010, the NRC published new estimates of the earthquake risk at existing nuclear reactors in the central and eastern U.S. based in part on new data and seismic maps released by the USGS in 2008.[58] The new estimated risk at the typical U.S. plant more than tripled, leading the NRC task force to send two recommendations to NRC management: first, to move the issue over from the research staff to the regulatory staff, essentially moving it from study to action; and second, to determine whether some nuclear power plants need a "backfit," or additional construction to protect them from earthquakes.[59]

Bellefonte was not included in this study. However, all of TVA's currently operating reactors showed substantial increases in risk: Browns Ferry 1: 270 percent increase; Browns Ferry 2 and 3: 238 percent increase; Watts Bar 1: 543 percent increase; and Sequoyah 1 and 2 are now ranked as having the fourth-highest risk of an earthquake causing core damage with a 420 percent increase over previous estimates.[60] Given the Bellefonte site's close proximity to TVA's other nuclear plants and its proximity to the Eastern Tennessee Seismic Zone, its risk of earthquake would likely increase significantly over what was originally estimated in TVA's 1974 construction permit application.

Bellefonte in a Post-Fukushima World:

In light of the devastating and ongoing nuclear crisis at the Fukushima-Daiichi nuclear facility in Japan, the NRC has begun evaluating "lessons learned" and possible regulatory, procedural and/or design changes that may be needed here in the U.S. for both existing and proposed reactors. In the NRC Fukushima Near-Term Task Force report released on July 12, 2011, TVA's

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[56] Joseph F. Williams, Non-Concurrence, ML083470901, November 20, 2008, p.4.
[57] U.S. Army Corps of Engineers, ERDC/GSL, Don E. Yule and Tina H. Grau, *Earthquake Event Report for the North Alabama 29 April 2003 Mw = 4.6 Earthquake*, October 2003. At http://geoscience.wes.army.mil/04292003AL_EQ.pdf
[58] U.S. NRC, Memo from P. Hiland to B. Sheron Re: Results of Safety/risk assessment of Generic Issue 199, ML100270598, September 2, 2010. Full memo with August 2010 report at http://msnbcmedia.msn.com/i/msnbc/Sections/NEWS/quake%20nrc%20risk%20estimates.pdf.
[59] Bill Dedman, MSNBC.com, "What are the odds? US nuke plants ranked by quake risk," March 17, 2011 at http://www.msnbc.msn.com/id/42103936/ns/world_news-asia-pacific/
[60] *Id.*

proposals to complete Bellefonte reactor Unit 1and Watts Bar reactor Unit 2 were specifically mentioned. According to the report:[61]

> *"For the two plants with reactivated construction permits (Watts Bar Unit 2 and Bellefonte Unit 1), the Task Force recommends that those operating license reviews and the licensing itself include all of the near-term actions and any of the recommended rule changes that have been completed at the time of licensing. Any additional rule changes would be imposed on the plants in the same manner as for other operating reactors."*

Several of the 12 main recommendations from the Task Force deal with two issues that are identified concerns at Bellefonte: flooding and seismic issues. Bellefonte Unit 1 and Watts Bar 2 were again identified at the Near-Term Task Force briefing to the NRC Commissioners in July regarding the report. The Task Force specifically recommended that the NRC implement the report's seismic and flooding design basis recommendations, among others, before issuing the operating license.[62]

[61] U.S Nuclear Regulatory Commission, Enhancing Reactor Safety in the 21st Century, The Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, ML111861807, July 12, 2011, p.72. At http://pbadupws.nrc.gov/docs/ML1118/ML111861807.pdf

[62] U.S NRC, Fukushima Near-Term Task Force, Briefing on the Task Force Review of NRC Processes and Regulations Following Events in Japan, July 19, 2011, slide 27. At http://www.nrc.gov/reading-rm/doc-collections/commission/slides/2011/slides-20110719.pdf

APPENDIX 1

The Risks of Reviving TVA's Bellefonte Project

Report Prepared for Southern Alliance for Clean Energy (SACE)

Fairewinds Associates, Inc
Arnie Gundersen, Chief Engineer

August 3, 2011

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Introduction and Background

The Tennessee Valley Authority (TVA) has requested permission from the NRC to complete construction and begin operation of the previously terminated TVA Bellefonte Nuclear Unit 1 located in Hollywood, Alabama. At this point in time, TVA believes it may be able to have Bellefonte Unit 1 operational by 2018 if all construction timetables are met. The Babcock and Wilcox (B&W) design used at Bellefonte was originally licensed for construction in 1974. However, the original B&W nuclear design originated in the 1960s.

This report identifies seven specific areas of risk that in Fairewinds' opinion will cause further delays, additional costs and even possible suspension of the Bellefonte project if TVA decides to move forward with its construction. The seven areas of specific risk are:

1. **Bellefonte's Unique Design**
2. **Groundwater Intrusion That Is Weakening It's Foundations**
3. **Missing Critical Nuclear QA Documents and Complete Records**
4. **Cannibalization of Bellefonte's Operating Systems**
5. **Containment Problems Unique to Bellefonte**
6. **Historical Precedent**
7. **Post Fukushima Lessons Learned**

Bellefonte's Unique Design

The Babcock and Wilcox (B&W) design used at Bellefonte is quite unique because B&W chose to use Once Through Steam Generators (OTSG) that have less residual (surge) volume in comparison other Pressurized Water Reactor (PWR) designs created by

competitors Westinghouse and Combustion Engineering. Unfortunately the unforgiving B&W design was a factor 1978 Three Mile Island (TMI) Unit 2 accident. By choosing the OTSG technology TVA has also chosen and created the unique and problematic Bellefonte Unit 1 containment design. Only 8 of the 104 operating United States (US) nuclear reactors have been constructed with the B&W design, and these are Three Mile Island 1 (PA), Crystal River 3 (FL), Davis Bessie 1 (OH), Arkansas Nuclear One (ANO) Units 1 and 2, and Oconee 1, 2, and 3 (SC).

After the Three Mile Island (TMI) nuclear accident, there was a nationwide mass exodus by utilities away from other previously planned B&W nuclear reactors, and the fourteen other US B&W reactors of a similar design to Bellefonte were cancelled. The cancelled B&W nuclear plants included: Washington Public Power District Units 1 and 4, Pebble Springs Units 1 and 2, Vandalia Unit 1, Crystal River Unit 4, Davis-Besse Units 2 and 3, Sears Island Unit 1, Sterling Unit 1, Sundesert Units 1 and 2, Tyrone Unit 1 and 2. Additionally, two other US B&W nuclear plants were shutdown: Three Mile Island 2, following its accident, and Rancho Seco in Sacramento, CA, which had an overall lifetime operational reliability of less than 40%. Moreover, no other B&W reactors were ever sold within the United States after TMI, and the only B&W reactor that was ever sold outside the US was the Mulheim Karlich A-Reactor[1] located in Germany. The Mulheim Karlich A-Reactor was operated for less than two years before it was

[1] http://www.iaea.org/cgi-bin/db.page.pl/pris.prdeta.htm?country=DE&site=MUELHEIM-KAERLICH&units=&refno=22&link=HOT&sort=Reactor.Status,&sortlong=By%20Status (Last viewed August 3, 2011)

permanently shut down in 1988. The eight remaining operating B&W reactors represent less than 2 percent of nuclear power plants worldwide.

More importantly, the particular reactor at Bellefonte is even more unique than the other eight B&W reactors that are smaller than the reactor proposed at Bellefonte. The remaining eight operating B&W reactors are the 177-design, meaning that the core has 177 fuel bundles with a 15 by 15 array of fuel rods in each bundle. Bellefonte is the 205-design meaning that it has 205 bundles of nuclear fuel, each of which has a 17x17 fuel bundle array. Only five of the B&W 205-design were ever ordered and one, the Muhlheim-Karlich nuclear plant in Germany, was ever built. It operated only briefly 25 years ago before being shut down entirely in 1988. This brief operating experience with the unsuccessful Muhlheim-Karlich B&W nuclear plant 205-design occurred 25 years ago, and worldwide, its records are the only operational history of a nuclear power plant with the B&W Bellefonte 205 reactor design. Furthermore, the B&W 205 nuclear power plant that TVA is attempting to construct at Bellefonte Unit 1 was originally designed during the 1960s and is literally the only one of its design anywhere in the world.

New York State Electric and Gas (NYSEG) placed the last nuclear power plant order ever made in 1978, shortly before the TMI accident. As the lead nuclear engineer for New York State Electric and Gas in 1978, I completed a thorough analysis and evaluation of the B&W design and compared it to the Westinghouse and Combustion Engineering (CE) designs. Even prior to the TMI accident it was evident during a thorough engineering evaluation that the B&W design is less than robust in comparison to both the

CE and Westinghouse designs. Thus, NYSE&G did not place its order with B&W, and instead chose CE's design.

By the time the proposed Bellefonte Unit 1 nuclear plant may become operational, five decades will have elapsed since its design was begun. Americans were walking on the moon when the Bellefonte nuclear plants were originally designed. The space shuttle was designed, flew more than 100 missions and was completely retired during the time that Bellafonte Unit 1 sat idle and unattended. Six major nuclear accidents (TMI, Browns Ferry, Chernobyl, and Fukushima 1, 2 and 3) have occurred since Bellefonte Unit 1 received its construction permit. Does such a timespan matter? Yes, just like the story of Rip Van Winkle, the world has moved on with significant technical advances while the Bellefonte nuclear power plant slept idly and unkempt.

As one drives toward the Bellefonte nuclear plant, the cooling towers, containment building, and turbine hall appear to be impressive physical structures. However, first impressions can be incredibly deceiving. Much like a wooden boat at dry dock that may look impressive yet contain significant dry rot, the long period during which the TVA Bellefonte plant has sat idle and empty has most likely caused serious degradation of its concrete foundation as evidenced at a minimum of four other aging nuclear power plants.

Groundwater Intrusion

While the structures may appear to be substantial from a distance, it is essential to the evaluation process that TVA's Board of Directors recognizes that the majority of

Bellefonte's foundation construction work was completed almost 40 years ago. Excavating and laying the foundation for the massive power plant structures are the first stage of mechanical production during each nuclear power plant's construction phase. Moreover, most of the excavation work at Bellefonte was completed prior to 1980. Therefore, the concrete at Bellefonte Unit 1 has been subject to underground degradation for more than 35 years, and Bellefonte Unit 1 has not yet been subject to operational stresses.

At least four currently operating US nuclear power reactors are already experiencing significant concrete degradation in their foundations, including Millstone in Connecticut (1996), Salem (2003) and Oyster Creek (2011) in New Jersey, and Seabrook (2011) in New Hampshire. Three of these plants had only been operating 20 years or less when their concrete began to fail. The trend in concrete failure at nuclear power plants is increasing as the fleet of operating nuclear power plants continues to age. Unfortunately, foundations cannot be easily inspected unless extreme damage is already evident, so it is most likely that many other nuclear power plants are experiencing such concrete degradation, but a simple visual inspection will not likely pick up such issue.

The evidence Fairewinds reviewed in the NRC's Bellefonte file indicates that ground water has been intruding into its foundations for the past 35 years. Not only that, but in order to prevent continuous damage to the Bellefonte Unit 1 foundations, TVA installed a system to continuously remove ground water, similar to a basement sump pump but on a much larger scale. The groundwater intrusion issue was so significant that TVA installed

specialized sump-style pumps to remove foundation water beginning early in the concrete foundation construction process until they were shut off in 2006 when TVA decided to abandon its Bellefonte nuclear power plant project and cannibalize the site by selling off scrap metal. Only two years later, TVA changed its mind once again and slowly began the process of "performing repairs to eliminate water intrusion, indicating the facility has not been maintained in a manner that would prevent serious degradation" according to the Nuclear Regulatory Commission.[2]

Concrete foundation performance failure is the most insidious form of age related degradation in a nuclear power plant. By definition, concrete foundation performance is underground and impossible to see. The sheer size of the nuclear buildings above these foundations makes adequate foundations essential and impossible to completely repair. The risk of significant foundation problems at Bellefonte originating during construction and continuing now and into its possible operating life is threefold:

- First, TVA knowingly and deliberately allowed the foundations to deteriorate.
- Second, the foundations at Bellefonte will be 45 years old well before the reactor ever begins to generate electricity.
- Third, a 40 year initial life and possible 20 year life extension after that means that the underlying safety of this nuclear plant will be based on concrete that will be more than 100 years old. Given that much newer reactors are already

[2] *NON-CONCURRENCE BY JOSEPH WILLIAMS REGARDING STAFF APPROACH TENNESSEE VALLEY AUTHORITY REQUEST TO REINSTATE CONSTRUCTION PERMITS BELLEFONTE NUCLEAR PLANT. UNITS 1 AND 2*, ML083230895, 2008-0041comscy-enclosure2, November 20, 2008. Attachment 2.

experiencing concrete failures, this risk to the health and safety of the people of Alabama is significant and long lasting.

Quality Assurance (QA) Breakdown

Not only has the Bellefonte nuclear power plant been left idle and uncompleted for approximately 35 years, but also for several of those years the unit was completely abandoned and cannibalized. According to the Nuclear Regulatory Commission, no quality control system was in place at Bellefonte Unit 1 between 2006 and 2008. Those QA processes and QA systems are required by nuclear law 10-CFR-50 General Design Criteria 1 and 10-CFR-50 Appendix B to assure that the nuclear components would in fact remain usable. At TVA Bellefonte Unit 1 those QA processes were totally eliminated for two full years assuring that there is no chain of custody of nuclear components to assure that what is inside the power plant is indeed what was designed to be there and of nuclear grade material. Since the 2006 cannibalization of Bellefonte Unit 1, TVA is simply unable to provide or document the requisite formal QA process that nuclear operations occurred and there are no longer adequate records that may be relied upon to substantiate that the nuclear work that began in 1974 to facilitate this specific design has in fact not been compromised.

It should have been obvious to TVA that cannibalizing the plant would mean that 35-years of QA records were invalid and nullified according to General Design Criteria when TVA applied to the NRC to have its Bellefonte license reinstated. Instead, TVA waited until the NRC had agreed to reinstate the license for Bellefonte Unit 1 before it even began to evaluate the effects of its cannibalization. It was not until May 2009 that

TVA announced that there were no longer applicable and cohesive QA records for Bellefonte Unit 1. Calling it a *Configuration Control Lapse: Description Of Deficiency*, TVA's LER said,

> Configuration control was not maintained and physical equipment issues were not documented under a Quality Assurance Plan for the period of time from in which Construction Permits CPPR-122 and CPPR-123 were withdrawn until they were reinstated.[3]

Suspending the QA program for several years calls into question every design document and design or equipment design change TVA has implemented throughout the lifetime of TVA Bellefonte Unit 1. Now there is absolutely no method of substantiating that QA produced equipment meets necessary and rigorous nuclear QA standards required by federal law for all nuclear power plant projects.

Bellefonte is not the only US nuclear power plant that has encountered serious problems with missing or deficient QA records. The Cincinnati Power and Light William H. Zimmer Nuclear Power Plant in Moscow, Ohio had a complete breakdown in Quality Assurance. While Zimmer was not a B&W design, it was a nuclear plant and therefore had to abide by the rigorous nuclear power plant QA protocol upon which nuclear risk, design, and licenses are predicated. However, unlike TVA Bellefonte Unit 1 where construction was completely abrogated, Zimmer's entire QA program was fully operational, yet Zimmer was still required to shut down permanently because of missing Quality Assurance records proving that the plant met all rigorous nuclear power plant QA requirements. Moreover, the NRC itself said that the quality of work at Zimmer was

[3] *Configuration Control Lapse: Description Of Deficiency* LER 45066, May 14, 2009.

"indeterminate"[4] because of breakdowns in the Quality Assurance records system.

The Zimmer plant was more than 95% complete when the Quality Assurance record problems were discovered. The QA lapse was so problematic and irreparable that Zimmer could not be operated as a nuclear power plant and was forced to convert to a coal-fired power plant because the systems, structures and components at Zimmer were unable to meet the strict Nuclear Quality Assurance Standards. While the Quality Assurance record trail for Zimmer did not meet the rigor of Nuclear Quality Assurance Standards and therefore it could not be operated as a nuclear power plant, it did meet the requirements for conversion to a coal-fired plant with its more lenient records requirements.

The several year suspension of the entire Quality Assurance Program at TVA's Bellefonte Unit 1 is much more problematic than the lack of adequate Quality Assurance records that led to the cancelation of the Zimmer nuclear power plant and its conversion to a coal-fired power plant. When the Bellefonte unit was cannibalized, there was no NRC approved quality assurance records system in place. Reconstituting this step-by-step critical assessment of every piece of equipment within the plant, as is required by law, will be impossible to achieve without dismantling the entire plant and reconstructing it part by part.

It is important to reinforce that when the Zimmer plant failed to have sufficient QA

[4] *Cincinnati Magazine,* September 1983, Page 83

records in place to document its ability to be operated safely and reliably as a nuclear power plant, it was better positioned than Bellefonte is today to go through the necessarily rigorous nuclear power QA process. The Zimmer facility had hundreds of QA staff working under an NRC approved and supervised plan for the entire duration. Bellefonte, on the other hand, has had no QA plan in place and no personnel available to implement the requisite QA plan. More importantly, critical equipment, pipes, and metal parts were not stripped away at the Zimmer facility as they were at Bellefonte when it was gutted and major components were sold as scrap. Zimmer also retained all of its NRC approved records system until well after the decision was made to terminate its nuclear construction permit.

In summation, due to the lack of a viable and rigorous required nuclear Quality Assurance Program during the time that Bellefonte was shut down and cannibalized for its scrap metal value, it is my professional opinion that attempting to rebuild Bellefonte Unit 1 as a nuclear power plant is doomed to failure. Such an attempt also places a huge cost burden upon TVA's ratepayers for a product that ultimately may not be deliverable.

Cannibalization

Not only is the condition of the concrete foundation likely to be substandard and the QA records for the Bellefonte plant in complete disarray, but also the plant systems have been cannibalized. NRC Senior Project Manager Joseph Williams also identified these very same broad weaknesses when the NRC reinstated the construction permits for Bellefonte

Unit 1. In his analysis[5] Williams said,

> TVA's August 26, 2008, letter claims that it is "maintaining the site in a stable condition." However, the letter also states that TVA has taken action to dismantle parts of the facility, and describes how TVA has taken action to end degradation of the facility, including repairs to eliminate water intrusion and to seal off equipment affected by its investment recovery efforts. Therefore, the meaning of TVA's statement regarding the stable condition of the facility is not clear. However, it is apparent that the facility has not been preserved in the same state it was when the construction permits were terminated. As noted, these activities were not conducted in a manner consistent with NRC regulations.

After abrogating its construction permit in 2006, Bellefonte Unit 1 was cannibalized and gutted by transferring equipment valued at approximately $49 Million to other TVA nuclear and fossil-fueled plants. At the same time that equipment was transferred to other TVA power plants, the company also opened the plant to contractors who came in and removed steam generator tubes, main condensers, and steel tubes from heat exchangers and sold all this equipment to scrap vendors for approximately $16 Million. Unfortunately, the workers performing demolition work do not meet the same standard of care as workers constructing a sophisticated nuclear power plant.

When Bellefonte Unit 1 was stripped of its valuable and critical equipment, TVA clearly violated NRC regulations requiring the creation and continued maintenance of special protective environments for critical components. Simple issues such as preventing rodents from eating electrical insulation and preservation of special controlled

[5] *NON-CONCURRENCE BY JOSEPH WILLIAMS REGARDING STAFF APPROACH TENNESSEE VALLEY AUTHORITY REQUEST TO REINSTATE CONSTRUCTION PERMITS BELLEFONTE NUCLEAR PLANT. UNITS 1 AND 2*, ML083230895, 2008-0041comscy-enclosure2, November 20, 2008. Attachment 2.

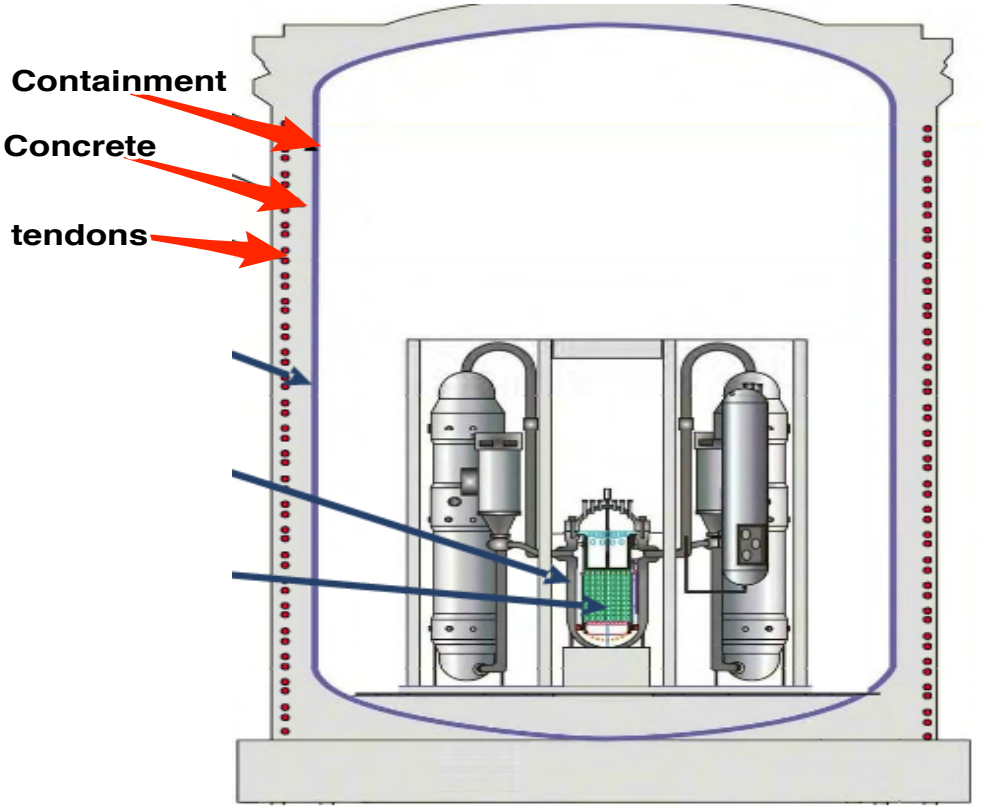
environments have immediate short-term problems such as surface rust and rodent control. Also stripping TVA Bellefonte Unit 1 did not protect the entire complex from the introduction of chemicals or other as yet unknown contaminants that could cause metallurgical or equipment problems if the building was to be used as a nuclear power plant.

For example, at a nuclear power plant with the requisite QA program in place, there are strict controls on the type of light bulbs that are allowed inside the containment. Such controls are required in order to prevent halogen contamination of the reactor vessel that may cause the vessel to fail when it is pressurized, and this is just one of thousands of critical regulations that must be enforced in order to assure nuclear safety and reliability. TVA is unable to give quantifiable assurance that every light bulb stayed in compliance with the halogen restrictions during the unsupervised dismantlement and cannibalization of Bellefonte Unit 1. Furthermore, there is no method by which to delineate that thousands of other critical maintenance requirements were performed in this unsupervised and unmonitored environment.

Containment Issues

As stated earlier, the B&W's Once Through Steam Generator (OTSG) design is unique in the nuclear industry. More than 98% of all the operating reactors do NOT use this design. In order to create this OTSG design, the pipe that takes hot water out of the nuclear reactor core and into the steam generator (called the hot leg) travels vertically up from the reactor and into the top of the steam generator. This design is called a "candy cane" design. Out of necessity, this "candy cane" design also requires a containment that

is taller than other pressurized water reactor (PWR) design that use “U Tubes” that enter the steam generator at the bottom, not the top. In addition to having a taller containment B&W’s OTSG containment is also heavier because the candy cane design requires more shielding at a higher elevations.



Since the tendons snapped on the Bellefonte Unit 1 Containment in 2009, both the NRC and TVA have been well aware that the containment at Bellefonte Unit 1 is severely degraded. First, in August 2009, a loud gunshot like noise was heard inside the containment. Finally, 100 days later, on December 10, 2009 Bellefonte acknowledged in LER 45559 that the Containment at Bellefonte Unit 1 had been compromised.

> Inspection of failed Unit 1 Reactor Building Containment Vertical Tendon V9 coupling indicates a potential for an unknown common mode failure mechanism for BLN Containment vertical tendon rock anchor couplings.

> Unit 1 Reactor Building Containment Vertical Tendon V9 experienced a failure of the rock anchor/tendon anchor coupling on August 17, 2009 at approximately 1400 CDT. The time of failure was identified based on a loud noise bang reported by several individuals. Initial investigation failed to reveal the source of the noise. The failed tendon was discovered on August 24, 2009 during a tour of U1 Tendon Gallery, elevation 607. Unsafe conditions previously precluded an inspection of the failed coupling for proper installation or component specific damage. The failed tendon coupling was inspected on 11/23/2009 and showed no signs of component specific damage or improper installation creating the potential for an unknown common mode failure.[6]

The magnitude of a containment failure prior to operation of a nuclear power plant cannot be underestimated. Since 2009, Bellefonte has issued four update reports to the NRC in an attempt to explain how it might resolve this problem.

1. First, TVA/Bellefonte discovered that sulfide in the grease that is used to lubricate other tendons was a contributing cause in this tendon failure.
2. Second, TVA/Bellefonte discovered that water has somehow entered some of the tendons so that the issue of moisture contamination may also have been a contributing factor in this failure.

The containment system in a nuclear power plant is meant to contain the release of unmonitored radioactivity that is generated during regular operation of a nuclear power plant and to contain any radioactivity generated during a serious nuclear power plant accident like that at Three Mile Island or Fukushima. Containments must hold their integrity in order to contain the release of radioactive isotopes and meet the corporations' and regulators' primary responsibility to protect public health and safety.

[6] LER 45559, December 10, 2009

In order to determine the total magnitude of Bellefonte's containment degradation, a complete detensioning of the Bellefonte Unit 1 containment will be necessary. This means that every bolt throughout the containment system will have to be systematically loosened (detensioned) and then gradually and systematically retensioned in order to recreate a fully functioning containment system. Unless concrete is kept under tension, it cannot retain its form and strength. Concrete has no tensile strength but rather is effective only under compression. The TVA Bellefonte Unit 1 containment cannot retain its form and strength unless it is not correctly tensioned. Concrete will ultimately crack if it is not correctly tensioned.

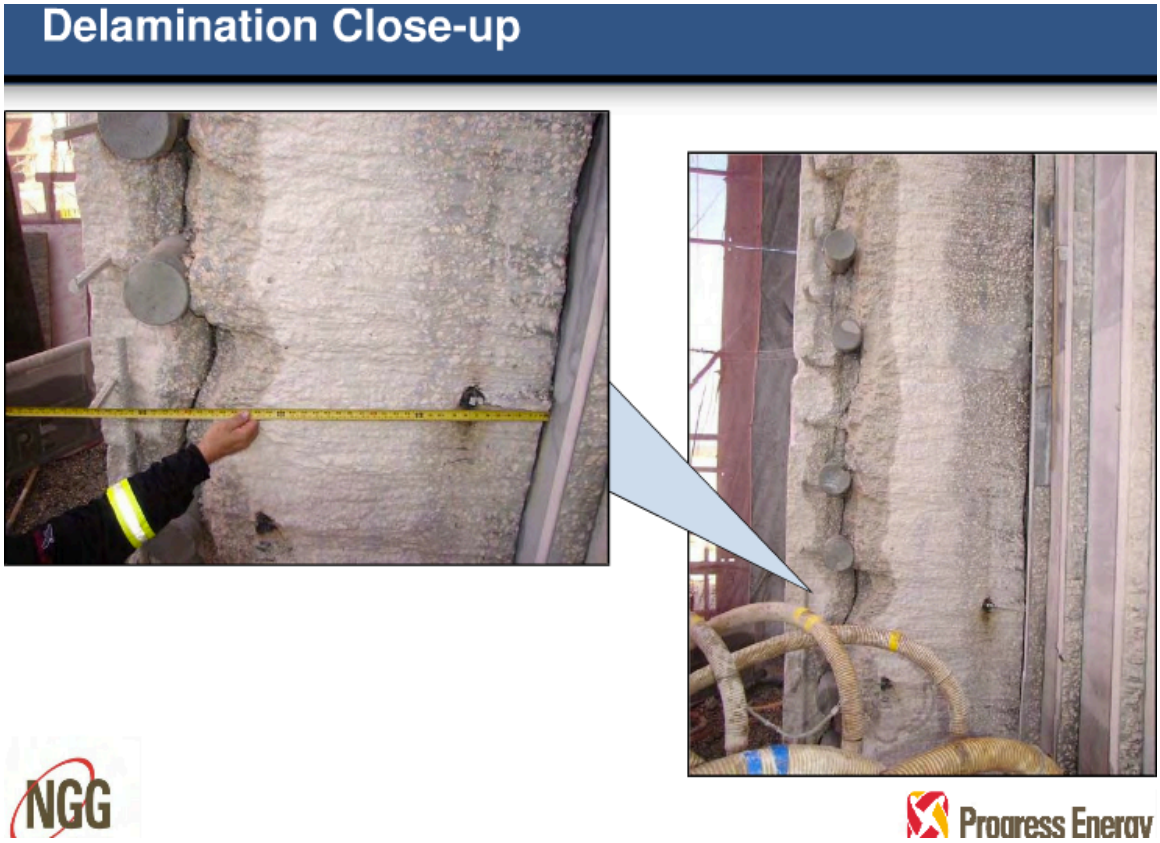
In its March 2011 report, *Containment Vertical Tendon Coupling Failure - Fourth Interim Report,* to the NRC, Bellefonte still failed to resolve the magnitude of its containment tendon issue although work on a plan to detension the containment has finally been authorized.

> Work has been authorized for the development of a containment vertical tendon detensioning plan, taking into consideration the Crystal River containment concrete delamination experience in which the sequence of detensioning was found to be a factor in concrete cracking. Once a detensioning plan has been developed, an independent review will be conducted prior to the start of containment detensioning activities. After approval of the final detensioning plan, TVA will detension the tendons according to the plan to perform the remaining NDE to support completion of the extent of condition evaluation.[7]

Detensioning a Babcock and Wilcox containment is an extraordinarily risky proposition. After years of preparation and analysis, the B&W containment at Progress Energy's Crystal River nuclear power plant in Florida was detensioned in mid 2009. This

[7]*Containment Vertical Tendon Coupling Failure - Fourth Interim Report*, TVA Letter the NRC, March 29, 2011

detensioning caused a 60-foot long by 20-foot wide crack (delamination[8]) to occur the middle of the containment wall as noted in the photo below.



Not only did this 60-foot long crack occur after Progress Energy and B&W had conducted a thorough engineering analysis that was approved by the NRC, more importantly, a second crack developed in 2011 while Progress Energy was still attempting to repair the first crack Crystal River. Once again, the recovery process was thoroughly re-engineered and approved by the NRC and yet it failed for a second time. The net effect of both of these two Crystal River cracks is that a 5-year repair process

[8] Progress Energy Crystal River Delamination (Crack) in the concrete Containment http://www.fairewinds.com/content/crystal-river-delamination-update

will be required to finally repair this Babcock and Wilcox containment, if indeed they can be repaired at all. Clearly, scientific understanding of how these cracks developed is lacking.

What is known is that the two Crystal River cracks developed after one or more tendons were detensioned. Fairewinds believes that this is the same scenario that Bellefonte Unit 1 is now facing with five important distinctions:

1. TVA Bellefonte Unit 1 has already experienced a rapid detensioning worse than those forces that caused the first delamination at Progress Energy Crystal River.
2. TVA Bellefonte Unit 1 has not yet inspected its containment to see if the initial snapped tendon in 2009 caused similar cracks or delamination anywhere in the containment.
3. TVA Bellefonte Unit 1 has found systemic problems in other tendons that will require a complete detensioning of the entire containment tendon system like the one that was performed at Crystal River.
4. TVA Bellefonte Unit 1 has yet to begin the process of detensioning all its other tendons, which may induce more cracks like those that occurred at Crystal River.
5. Competent engineers have spent tens of thousands of hours at a huge cost analyzing the first and second failures at Crystal River and still are unable to anticipate or prevent cracking.

The aftermath of Fukushima has shown us that three independent containment systems failed. In the event of a design basis accident how will the public be assured that health

and safety will not be put at risk with TVA Bellefonte Unit 1 and its compromised containment system?

The financial and scheduling ramifications of the containment tendon failures at TVA Bellefonte Unit 1 have introduced enormous risk into the proposed plan to complete construction by TVA at Bellefonte Unit 1. Progress Energy's Crystal River containment integrity failure and delamination shows that it will take at least five years (2009-2014) for these cracks to be repaired, if indeed they can ever be repaired. The Crystal River repair outage on a B&W containment system similar to that at TVA Bellefonte Unit 1 will be the longest repair to any operating reactor in the history of nuclear power. It will be unclear that the repairs have been effective until 2014 at the earliest. Additionally, the lessons learned at the Crystal River nuclear power plant will not be available for review and possible transfer to TVA Bellefonte Unit 1 until at least 2014. Fairewinds believes that any problems encountered at Crystal River in its repair attempts on the B&W containment will further delay continued construction on TVA Bellefonte Unit 1.

Historical Precedent

TVA is not the only utility that has faced a decision on whether or not to revive an aging Babcock and Wilcox reactor after construction has been terminated. Washington Nuclear Project-1 (WNP-1) was mothballed when it was 63 percent complete, but its construction permit was never terminated and its environmental controls assuring that the plant did not deteriorate remained in place as did its QA management and record system. The Board of Energy Northwest, owners of WNP-1, commissioned a study to assess the risk of

renewing construction at WNP-1. The 2003 report[9] commissioned by the Board stated:

> Three separate teams of consultants (Bechtel Power Corp., R.W. Beck, and Goldschmidt Imeson) retained by the Executive Board to conduct the investigation unequivocally concluded that completing the plant was neither economically nor politically feasible.
>
> Energy Northwest's senior management team then prepared a supplemental report examining the impact of changing assumptions and variables. The team's report did not fundamentally contradict the findings of Bechtel and R. W. Beck that the total cost to complete WNP-1 would be approximately $4.2 billion including financing expenses.

Since moving forward on constructing WNP-1 was too risky and would take at least 6-years and cost more $4.2 Billion, Energy Northwest requested termination of the WNP-1 construction permit and discontinuation of all QA protocols. Energy Northwest's request to end WNP-1's nuclear power plant construction license was granted by the NRC February 8, 2007.

In many ways, the 2003 WNP-1 analysis presented to the Board of Directors of Energy Northwest contained significantly less risk and uncertainty than the decision the TVA Board of Directors faces eight years later in 2011. In 2003, the Babcock & Wilcox WNP-1 still had an NRC license and a fully functioning Quality Assurance program to assure that the plant's condition met the rigorous nuclear power plant safety and QA requirement during the time period it was mothballed. In comparison, TVA not only completely terminated its Babcock & Wilcox nuclear construction permit for its Bellefonte Unit 1, it also eliminated any environmental protection for equipment,

[9] *Energy Northwest Executive Board Review of Nuclear Program*, January 23, 2003, Energy Northwest (page I, Executive Summary)(page 3)

cannibalized large pieces of equipment, and disemboweled the entire QA department and its requisite procedures and documentation. TVA claims that attempting to revive Bellefonte in 2011 is not risky. Yet in declining to revive WNP-1, Energy Northwest's Board of Directors reached the opposite conclusion in 2003 under circumstances far less technically challenging then those facing TVA and its Bellefonte Unit 1.

Post Fukushima Lessons Learned

In the aftermath of the significant tragedy at Fukushima many lessons learned are coming to light. To begin with, three out of three containment systems failed to contain radioactivity and failed to hold their strength as the reactor went through the substantial stresses of a design-basis accident. This series of accidents has fundamentally altered the risk assessment scenario upon which licensing and operation of nuclear power plants are predicated. Prior to the Fukushima accidents, the NRC assumed that there was no likelihood that a containment system could ever fail. The energy releases from three hydrogen explosions at Fukushima were totally unexpected and have dramatic ramifications on containment integrity and design moving forward. It would be unconscionable to further skew risk factors and threaten public health and safety by licensing and operating a less than reliable 35-year old concrete containment that appears unable to properly hold its tension even prior to the stress of operations.

Conclusion

In conclusion, Fairewinds believes that TVA faces enormous financial and scheduling risks in its decision to resurrect its Bellefonte Unit 1 nuclear power plant. First, this is an enormous commitment of scarce financial resources during a period of economic turmoil.

Second, TVA Bellefonte Unit 1 is already old in terms of the age of its concrete and steel. Third, it has a unique limited design with which the nuclear industry and NRC have little actual experience making it unlikely to have lessons learned from similar nuclear power plants. Fourth, TVA Bellefonte Unit 1 has numerous structural and Quality Assurance flaws that will most likely be insurmountable. Given the historical record on QA issues, like the one in which TVA and its Bellefonte Unit 1 find themselves immersed, is already a situation that is more challenging than the one faced by Zimmer. Fifth, in the post Fukushima environment where significant radiation has been released due to a nuclear accident, it is foolhardy to take more risks in public health and safety by utilizing a more challenging nuclear power plant design that has few industry learned lessons upon which to rely. Finally, due to aging concrete, groundwater intrusion, and compromised tendons the TVA Bellefonte Unit 1 containment may be significantly compromised in a manner that will be entirely undetectable until it fails under stress.

Attachments

1. CV Arnold Gundersen
2. *NON-CONCURRENCE BY JOSEPH WILLIAMS REGARDING STAFF APPROACH TENNESSEE VALLEY AUTHORITY REQUEST TO REINSTATE CONSTRUCTION PERMITS BELLEFONTE NUCLEAR PLANT. UNITS 1 AND 2*, ML083230895, 2008-0041comscy-enclosure2, November 20, 2008.

– End –