Report of the Public Oversight Panel on the Comprehensive Reliability Assessment of the Vermont Yankee Nuclear Power Plant

March 17, 2009

This Report is *dedicated* to the memory of

Dr. Lawrence Hochreiter, Oversight Panel

member until September 3, 2008

THE PUBLIC OVERSIGHT PANEL REPORT

for the

Comprehensive Vertical Audit and Reliability Assessment

of the Vermont Yankee Nuclear Facility

March 17, 2009

This report conveys our findings and evaluations to the General Assembly for the purpose of making its determination whether the Entergy Nuclear Vermont Yankee plant should be authorized to operate in the state beyond the expiration of its current license on March 21, 2012.

Peter Bradford

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EXECUTIVE SUMMARY

This is the report of the Public Oversight Panel ("the Panel") created by Section 6 of Act No. 189 of the Vermont General Assembly, enacted in June 2008. The purpose of this report is to provide information to the legislature in making its determination whether the Entergy Nuclear Vermont Yankee plant should be authorized to operate in the State beyond the expiration of its current license on March 21, 2012.

Act 189 required a comprehensive vertical audit and reliability assessment ("the reliability assessment") of the Vermont Yankee Nuclear facility. The reliability assessment was performed by Nuclear Safety Associates (NSA) under contract to the Vermont Department of Public Service (DPS), and summarized in the report, *Reliability Assessment of the Vermont Yankee Nuclear Facility*, 12/22/08 ("the NSA Report").

This Executive Summary provides a synopsis of the Panel's findings and evaluations. The main report covers the Panel's effort in more detail.

The Panel

The Panel consisted of Peter Bradford, appointed by former Speaker Gaye Symington; Arnold Gundersen, appointed by Senate President Peter Shumlin; William Sherman, appointed by Governor Jim Douglas; and David Lochbaum and Dr. Fred Sears, chosen by the Panel. Dr. Lawrence Hochreiter, originally chosen by Governor Douglas, passed away in September 2008. This report is dedicated to Dr. Hochreiter's memory.

The Panel's role has been to further transparency, public oversight, and public involvement in the various aspects of the reliability assessment. The Panel participated in weekly status conference calls and met approximately monthly during the NSA assessment process and more frequently during the drafting of the report. The Panel took an active role in defining the scope of the assessment, recommending specific attention to systems that had experienced significant operational shortcomings (the main transformer and the cooling towers). The Panel also recommended that credit be taken for the Nuclear Regulatory Commission (NRC) team inspection of the electrical system, and for periodic tests performed on portions of the containment system. In addition, the Panel asked for a management/corporate review and a sister-plant review. All of the Panel's recommendations for the scope of the assessment were taken.

The Reliability Assessment

The reliability assessment was performed by Nuclear Safety Associates (NSA) under contract to the Vermont Department of Public Service (DPS). NSA employed a team of 30 inspectors who had no association with Entergy or Vermont Yankee within the past three years. This level of inspection for reliability is unprecedented in Vermont Yankee's history.

After performing the reliability assessment, the NSA team's overall conclusion was that VY is operated reliably and that the current level of reliability can be maintained through an extended operating period provided that the areas identified by the NSA report are effectively addressed. The NSA audit team identified specific challenges to plant reliability that warrant additional management attention to ensure future reliable operations. These challenges are identified as principal conclusions, and include five management areas and three equipment items:

Management Areas

1. Procedure quality – The composition, presentation, and formatting of the majority of VY's procedures do not meet industry standards.
2. Management emphasis on worker performance – Weaknesses exist in management's emphasis on worker performance in the areas of adherence to procedures, worker accidents or injuries, and practices for maintaining plant cleanliness.
3. Adoption of certain industry best practices – ENVY has been slow to adopt an industry equipment reliability index, and ENVY does not meet industry standards for system engineer workload.
4. Use of change management methods – ENVY could do a better job in managing major changes occurring at the site.
5. Inadequate contractor oversight – There were shortcomings in oversight of contractors with regard to the structural collapse of the cooling towers.

Equipment Items

1. Condensers and condensate demineralizers – Condenser erosion and a high chemistry index are both a near-term and long-term reliability challenge. (Subsequent to the NSA assessment, ENVY modified condensate demineralizers to bring the chemistry index under control.)
2. Cooling towers – Re-evaluation of inspection methods and repair schedule should be performed. Under the current methods and repair schedule, the cooling towers challenge future plant reliability.
3. Spare main transformer – ENVY should upgrade the former main transformer to function as a spare in case of difficulty with the existing main transformer.

The Goals and Objectives of the Act

The five goals and objectives of Act 189 are stated in Section 2 of the Act, and are summarized as follows:

1. Assess the conformance to design and licensing bases;
2. Identify relevant deviations, exemptions, or waivers from regulatory requirements applicable to Vermont Yankee and applicable to new nuclear reactors, and verify whether adequate operating margins are retained;
3. Assess the facility's operational performance, and the facility's reliability for continued power production;
4. Evaluate the effectiveness of licensee self-assessments, corrective actions, and improvement plans; and
5. Determine the causes of and conclusions from significant operational shortcomings.

These goals were met, as amplified by the Panel's findings and conclusions in this report.

Panel Findings and Conclusions

As part of our review, we considered three questions:

1. **Does the Reliability Assessment meet the intent of Act 189?**

We conclude the General Assembly's overall intent in Act 189 has been met.

Notwithstanding this overall conclusion, we found a number of areas in which the NSA team could have improved its work. The audit team did an adequate job. However, individual Panel members are aware of documentation that they might have expected the audit team to discover and review, but it did not. The Panel agrees with the audit team's principal conclusions, and chooses to emphasize the following additional items:

Management issues – ENVY management needs to do a more effective job of leading VY in improvement changes and in effectively applying procedures and processes. ENVY management attention and leadership for the changes recommended by the Report are extremely important as the ENVY workforce changes with retirement and replacements of long term employees. ENVY management needs to assure adequate resources are allocated to the reliability of nonsafety-related systems.

Equipment reliability index – ENVY ranks in the bottom quartile of this index that contains a mix of historical and predictive indicators. This low ranking is troubling to the Panel.

Condenser – The state and federal decisions on operation after 2012 have held up the effort to re-tube or replace the condenser. The increased probability of reliability problems from the condenser will now extend into the early years of extended operation, if granted.

Main steam isolation valves – The Panel is concerned about significantly increased leakage of main steam isolation valves that was discovered in the 2008 refueling outage.

Flow Accelerated Corrosion – NSA was unable to complete the requested scope in this area due to an ongoing NRC investigation of an allegation. The NSA report did not benefit by review of this area.

Preventative maintenance process – Programs should be put in place to eliminate ENVY's higher-than-expected preventative maintenance backlog.

Staffing turnover issues – VY is experiencing higher staff vacancies and turnovers than in its earlier history. This staff turnover is a new challenge to VY, and it makes other recommendations, such as procedure quality, adherence to procedures, and change management, all the more important.

Use of operating experience –ENVY must use operating experience more pro-actively, specifically in non-safety areas, to maintain reliable performance.

Corrective Actions – ENVY's corrective action process should be modified so that Corrective Action Requests cannot be closed based on open Work Orders.

2. **Are the transformer fire and cooling tower collapse events indications that VY will not perform reliably in the future?**

These events are not precursors of unreliable operation in the future. VY has had very good historical performance. Yet, recently it has suffered significant operational shortcomings – the transformer fire, and the cooling tower collapse and subsequent cooling tower events. Management action is necessary to address items such as procedures, at-risk designs, operational experience, and needed resources.

3. **What steps must VY take to avoid operational shortcomings like the transformer fire and cooling tower collapse in order to maintain and improve its reliable performance?**

Entergy and ENVY management must be committed to a high standard of reliable performance, to be shown by management's satisfactorily addressing the items in the NSA Report and the Panel Report. Furthermore, it is important to establish a verification process to see that improvements are accomplished and the commitment to reliability remains high.

The Panel's Overall Conclusion

Acceptable reliability of VY for operation beyond 2012 is possible if the recommendations of this report and the NSA Report are taken. Specifically, there must be a credible and public verification put in place to assure the recommendations are implemented satisfactorily and in a timely manner. This verification should be accomplished through strengthened government institutions that should be characterized by high professional competence commensurate with the tasks at hand, domination neither by specific proponents nor by specific opponents of nuclear power, resources adequate to effective performance at ENVY's expense, periodic effective reports of verification, with reports available to the public, and the ability for public interaction and recourse through structured, credible and established institutions. Also, because there are always risks for reliability from changes in management philosophy or from unexpected technical causes, the PSB and general assembly should assure that an adequate benefit is provided to Vermonters for operation beyond 2012.

Report of the Public Oversight Panel on the Comprehensive Reliability Assessment of the Vermont Yankee Nuclear Power Plant

1. INTRODUCTION

This is the report of the Public Oversight Panel ("the Panel") created by Section 6 of Act No. 189 of the 2007 Adjourned Session (2008) of the Vermont General Assembly. Act 189 established a comprehensive vertical audit and reliability assessment ("the reliability assessment") of the Vermont Yankee nuclear facility. The reliability assessment was performed by Nuclear Safety Associates (NSA) under contract to the Vermont Department of Public Service (DPS), and summarized in the report, *Reliability Assessment of the Vermont Yankee Nuclear Facility*, 12/22/08 ("the NSA Report").

Section 1.0 provides an introduction and background information related to the reliability assessment. Section 2.0, The Oversight Panel, identifies the Oversight Panel and the manner it carried out its legislative charge from Act 189. Section 3.0, The Reliability Assessment, describes the reliability assessment conducted by NSA and the Panel findings on the various aspects required by Act 189 for the assessment. Section 4.0, Panel Conclusions for the Legislature, fulfils the Panel requirement from Act 189, Section 6(d), to "publicly report its findings and evaluation to the General Assembly for the purpose of informing the legislature in making its determination whether the Entergy Nuclear Vermont Yankee plant should be authorized to operate in the state beyond the expiration of its current license on March 21, 2012."

1.1 Vermont Yankee Background

The Vermont Yankee Nuclear Power Plant (VY) is a 605 MWe Boiling Water Reactor (BWR) plant,[1] located along the Connecticut River in Vernon, Vermont. VY received its construction permit in December 1967 and its operating license on March 21, 1972. VY's original operating license would have expired in December 2007, 40 years from the date of its construction permit. In 1990, the owner was granted a postponement of 4 years and 3 months in the expiration date to allow the 40 years to run from the date of the operating license rather than the construction permit.

Vermont Yankee was originally owned by a single-asset corporation, Vermont Yankee Nuclear Power Corporation (VYNPC), which was, in turn, owned in various percentages by a group of New England utilities. Vermont utilities owned 55% of VYNPC, and utilities outside of Vermont owned 45%.

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[1] Vermont Yankee is among the group of General Electric boiling water reactor designs known as BWR/4s. Its containment is a Mark 1 type. A schematic of the major components of a BWR is shown in Appendix A.

In 2002, VYNPC sold VY to Entergy Nuclear Vermont Yankee (ENVY), a subsidiary of Entergy Corporation of New Orleans, LA ("Entergy").[2] Entergy owns eleven nuclear plants - five in the South that are utility-owned longstanding parts of Entergy and six in the Northeast and Midwest that have been purchased by Entergy. VY is a relatively new entry into the Entergy fleet. Being a part of a nuclear fleet gives VY access to wider experience and more resources than are available to a stand-alone plant.

Since purchasing VY, ENVY has engaged in three significant Nuclear Regulatory Commission (NRC) licensing initiatives. The first was a power increase ("uprate"). At the time of ENVY purchase, Vermont Yankee was a 510 MWe plant. ENVY implemented modifications and engineering verifications to increase its electrical output to 605 MWe[3]. This uprate was granted and implemented in March 2006[4]. The second licensing initiative established dry cask storage for used nuclear fuel. Dry cask storage was implemented in 2008. The third licensing initiative requested license renewal for an additional twenty years of operation. The license renewal request was filed with the NRC in January 2006. The application is under NRC review, with a decision expected in the second quarter of 2009.

In addition authorization for operation beyond March 21, 2012 must be granted by the State of Vermont. Therefore, unless ENVY receives approval for continued operation from the NRC, the Vermont Public Service Board (PSB), and the Vermont General Assembly, VY must cease operation on March 21, 2012.

VY now operates on an 18 month refueling cycle. In Fall 2008, VY completed refueling outage number 27. The next refueling outages are scheduled in Spring 2010 and Fall 2011.

1.2 Legislative Background

The State of Vermont has demonstrated a strong interest in assuring that the renewal of VY's operating license for an addition twenty years promotes the general good of Vermont and its citizens. As part of the 2002 sale of VY to ENVY, the PSB granted a certificate of public good

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[2] The Reliability Assessment Report often describes activities prior to 2002 as being performed by ENVY when in fact they were performed by VYNPC.

[3] Nuclear plant output is measured both in MWe (electric units) and MWt (thermal units). The power uprate is called a 20% uprate because reactor thermal power was increased by 20%, from 1563 MWt to 1912 MWt.

[4] Following the 20% power increase, the former owners receive approximately 83% of VY's output at fixed contract prices that expire in March, 2012. ENVY receives 17% of the output to sell to any purchaser at market prices. Vermont's current share equates to 45.7% of the new output, or approximately 275 MWe, an amount equal to about one-third of Vermont's power needs.

to ENVY only until March 21, 2012 and approved a memorandum of understanding between the DPS and ENVY requiring ENVY to seek a further certificate of public good from the PSB in order to operate beyond that date.

The General Assembly has acted with regard to license renewal in a number of ways. In Act No. 74 of the 2005-06 Session, the general assembly codified in 10 V.S.A. §6522 the requirement that ENVY had agreed to as part of the sale of VY, that it must seek a certificate of public good from the PSB prior to operating beyond March 21, 2012. In addition, 10 V.S.A. §6522(c)(4) requires that approval of the General Assembly be secured for storage of spent fuel derived from operation beyond March 21, 2012.

In Act No. 160 in 2006, the General Assembly established additional requirements associated with extended operation. A public engagement process was created. This public engagement process included studies covering long-term accountability and financial responsibility; funding plans for storage of nuclear waste after 2012 until removal from the site, assurance of funds for fulfillment of closure obligations; assurance of funds to provide for any undischarged federal responsibilities; funding for emergency management requirements and evacuation plans before and after plant closure; analysis of long-term environmental, economic, and public health issues, including issues relating to dry cask storage of nuclear waste and decommissioning options; and analysis of current economic issues.

Act 160 amended 30 V.S.A. § 248(e)(2) to require that "[n]o nuclear energy generating plant ... may be operated beyond the date permitted in any certificate of public good ... unless the general assembly approves and determines that the operation will promote the general welfare ...."

In Act 160, the Vermont Legislature further provided that "if the general assembly approves and determines that the operation of the facility beyond the date permitted in any certificate of public good granted pursuant to this title [Title 30] will promote the public welfare, then the approval of the general assembly for the storage of spent fuel derived from the operation of the Vermont Yankee nuclear power station after March 21, 2012 will also be deemed approval as required in 10 V.S.A. § 6522."

Finally, in Act 160, the General Assembly provided that, if it had not acted by July 1, 2008, the PSB might begin proceedings relating to operation and to storage of spent fuel after 2012 but could not issue a final order "until the general assembly determines that operation will promote the general welfare and grants approval for that operation".[5]

In 2008 the General Assembly passed Act No. 189, establishing the "comprehensive vertical audit and reliability assessment" and creating the Public Oversight Panel. Act 189 makes clear that Vermont wants to consider all dimensions and implications of reliability in deciding whether to permit operation beyond March 21, 2012.

[5] 30 V.S.A. §248(e)(2). The General Assembly did not act under this subsection by July 1, 2008.

ENVY applied to the PSB for a certificate of public good for extended operation in March 2008. The PSB opened Docket No. 7440 to consider the ENVY application. Between now and July 6, 2009 the Board is scheduled to consider direct, rebuttal and surrebuttal testimony as well as hold technical hearings and receive briefs.

1.3 Definition of Reliability

Neither the NSA Report nor Act 189 defines the term reliability. In some places, the NSA Report speaks of *equipment reliability* or the *equipment reliability index.*[6] In other places, the NSA Report uses reliability to refer to *plant reliability.*[7] As a general matter, this report assesses reliability in commonly understood terms, i.e. can Vermont Yankee operate dependably and predictably at or above nuclear power industry norms. To address this question, some related concepts of reliability must also be taken into account.

Reliability in the context of electric power systems is normally used to describe the degree of assurance that customers have of receiving service. Individual plant reliability is not regulated. The grid must withstand the sudden closing of any power plant without impact on the customers. Adequate service to electric customers does not depend on the reliable operation of any one power plant.

Nuclear plants operate as many hours as possible for a combination of technical and economic reasons. Unlike gas fired plants, they have relatively low operating costs but high fixed costs. Furthermore, they are not well suited to varying their output as electric demand rises and falls. Consequently, good nuclear plant reliability requires that the plant be operated a high percentage of the hours of the year, a yardstick that the industry has met successfully for the last twenty years.

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[6] For example, p. 56 contains:

> The Nuclear Industry has standardized the Equipment Reliability (ER) processes. The ER process description at most sites is consistent with the definition promoted by the "Nuclear Industry Equipment Reliability Working Group" (ERWG) which is comprised of most of the US Nuclear Generators, the Institute of Nuclear Power Operations (INPO) and the Electric Power Research Institute (EPRI). This standardization provides transparency across the industry and allows for reliable comparisons to industry best practices. Also, the ERWG has created standard ER Performance Metrics referred to as the "ER Index" (ERI). This index includes 19 leading and lagging performance indicators that are collected and reported by a majority of US Nuclear Power Generating Companies.

[7] An example of this usage is on page A-2: "The ENVY site has been a reliable performer throughout its operating life."

The legislation creating this Panel requires that we consider the reliability of a single unit rather than the electrical power system or grid. Therefore, this report uses the term reliability in two ways. First, Section 2(3) of Act 189 sets as a goal that we "Assess the facility's operational performance, and the facility's reliability for continued power production, giving risk perspectives where appropriate."

Second, this Report speaks of *reliability* in terms of plant structure, system, and component reliability. This is roughly equivalent to the NSA Report's emphasis on *equipment reliability* or the *equipment reliability index.* The reliability of nuclear structures, systems, and components is assessed and assured through many standard practices in the nuclear industry.

1.4 Vermont Yankee Historical Reliability and Comparisons to Other Plants

VY's average capacity factor[8] for the twenty years 1988-2007 has been about 90%. From 1998-2007, VY's average capacity factor has been about 92%. The achievement of capacity factors above 90% for extended periods is considered good performance in the nuclear industry today.[9]

In two of every three years, VY has refueling outages. A three-year rolling average smooths out the differences between outage years and non-outage years. Table 1.4-1 illustrates comparative three-year rolling averages for VY from 1988 through 2007.

VYNPC was able to improve its 3-year rolling average capacity to about 95% at the time of the 2002 sale. ENVY has not been able to match this performance.[10] However, the 3-year rolling average capacity factors above 91% in the ENVY years still represent highly reliable performance.

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[8] Capacity Factor is the ratio of the net electricity generated to the electricity that could have been generated at continuous full-power operation.

[9] VY's lifetime capacity factor is approximately 82%, exceptional for a plant of VY's age, The VY average capacity factor for the first fifteen years was 68%, a result of initial run-in problems, more frequent refueling outages, failed nuclear fuel, and a nine-month recirculation piping replacement outage in the mid-1980's. In addition, VY's early years predated the nuclear industry's emphasis on more reliable operation and development of methods to shorten refueling outages and reduce forced outages. In the last twenty years, the nuclear industry has adopted company and industry measures leading to greatly improved performance.

[10] The reasons for ENVY's not meeting VYNPC's levels include the extended 2004 outage to implement uprate changes, the 2004 transformer fire, and the 2007 cooling tower collapse.

Table 1.4-1[11]

Year	VY 3-Year Rolling Avg Net Cap Fac	Owner ship
1988	---	VYNPC
1989	---	VYNPC
1990	85.50	VYNPC
1991	85.57	VYNPC
1992	86.47	VYNPC
1993	84.63	VYNPC
1994	86.17	VYNPC
1995	86.97	VYNPC
1996	89.77	VYNPC
1997	89.03	VYNPC
1998	85.17	VYNPC
1999	87.20	VYNPC
2000	89.20	VYNPC
2001	95.27	VYNPC
2002	94.53	ENVY
2003	93.87	ENVY
2004	91.43	ENVY
2005	92.50	ENVY
2006	92.73	ENVY
2007	93.63	ENVY

Table 1.4-2[12]

Entergy Plants 2005-2007 Net Capacity Factors	
Fitzpatrick	96.69
Indian Pt 2	94.59
ANO-2	93.33
Vermont Yankee	**92.96**
Indian Pt 3	92.11
Grand Gulf	90.89
Pilgrim	90.57
ANO-1	90.03
Waterford 3	89.65
River Bend	88.61
Palisades	86.94
Average	91.49

Table 1.4-3[13]

Sister Plants 2005-2007 Net Capacity Factors	
Fitzpatrick	96.69
Dresden-3	95.51
Vermont Yankee	**92.96**
Quad Cities 2	92.77
Dresden-2	91.45
Nine Mile Pt-1	91.16
Pilgrim	90.57
Cooper	90.35
Duane Arnold	90.03
Hatch-1	89.9
Brunswick-1	88.7
Hatch-2	88.5
Oyster Creek	88.38
Quad Cities 1	87.7
Monticello	87.14
Brunswick-2	83.92
Average	90.36

Tables 1.4-2 and 1.4-3 compare Entergy Plants and Sister Plants to VY in a three-year average comparison for 2005-2007. Among Entergy plants, VY is 4th out of 11. Among sister plants, VY is 3rd out of 16.[14]

[11] E-mail from D. McElwee, February 17, 2009.

[12] Nuclear News, May 2008, pp 29-30.

[13] Id.

[14] The NSA Report includes a comparison of capacity factors on page B-4. The first comparison for all units using 2004 to 2006 appears consistent with the 3-year rolling average from Table1.4-1 above and the data from Table 1.4-2. Table B-4 reports that VY is in the bottom quartile of sister plants while Table 1.4.-3 above reveals that VY is actually in the top quartile in this comparison. The Table B-4 comparison is not an exact three year period. VY has three

Despite VY's reliable past performance, the plant has experienced significant operational shortcomings in the recent past. In June 2004, an electrical problem in the portion of the plant that carries electricity out of the plant resulted in a significant fire in the plant's main transformer located just outside the turbine building. In August 2007, part of the cooling tower collapsed. The structural members of the cooling tower were repaired. Yet subsequent to the repair, in 2008, another failure occurred followed by an additional occasion of cooling tower leakage.

Individually, these events were not of much reliability significance. Their importance in indicating potential areas of concern is discussed in Section 4.5.2 of this report.

1.5 Reliability and Aging Management

For plants operating beyond forty years, aging effects are the primary concern.

The U.S. Office of Technology Assessment conducted a 1993 review entitled "Aging Nuclear Power Plants", which observed

> For nuclear power plants, aging degradation is defined as the cumulative degradation that occurs with the passage of time in systems, structures and components that can, if unchecked, lead to a loss of function .....The basic processes of aging are generally, if imperfectly, understood; continuing experience and research provide ongoing improvements in scientific understanding and ability to predict and address the effects.[15]

Concurrent with and subsequent to this 1993 statement by the U.S. Office of Technology Assessment, copious research was conducted and evaluated with regard to the aging of nuclear plant systems, structures, and components. In December 1996, the NRC published NUREG/CR-6490, "Nuclear Power Plant Generic Aging Lessons Learned (GALL)," which is a systematic compilation of plant aging information. The NUREG/CR-6490 report was based on information in over 500 documents: Nuclear Plant Aging Research (NPAR) program reports sponsored by the Office of Nuclear Regulatory Research, Nuclear Management and Resources Council (NUMARC, now NEI) industry reports addressing license renewal for major structures and components, licensee event reports (LERs), information notices, generic letters, bulletins, and information from reports provided by the Union of Concerned Scientists (UCS) in a letter dated May 5, 2000.[16]

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refueling years and only one non-refueling year. It is not clear what refueling schedules the sister plants had. The data from Table 1.4-3 is gives a more accurate comparison.

[15] U.S. Congress, Office of Technology Assessment, Aging Nuclear Power Plants: Managing Plant Life and Decommissioning, 1993, p. 9.

[16] NUREG-1801, Volume 1, Revision 1, "Generic Aging Lessons Learned Report, September 2005, p. 1.

The NRC's most recent and comprehensive regulatory compilation of aging programs is "Generic Aging Lessons Learned (GALL) Report" (NUREG-1801, Volume 1 and Volume 2, Revision 1) dated September 2005. The GALL Report contains the NRC's generic evaluation of existing plant aging management processes and documents the technical basis for determining where existing aging management programs are adequate without modification, and where existing programs should be augmented for extended operation.

The first U.S. plants actually to operate beyond forty years will do so in 2009,[17] so the nuclear industry is just beginning to gain, analyze and apply experience with plants of this vintage.

The NRC has established a process for reviewing the management of aging beyond forty years.[18] In accordance with this process, ENVY's January 27, 2006 license renewal application evaluates aging management beyond the original forty years, including safety-related structures, systems, and components and also those non-safety structures, systems, and components whose failure could prevent satisfactory accomplishment of any safety-related functions. The age management plan for license renewal includes all the systems included in the scope of the reliability assessment. As part of its license renewal application, ENVY committed to implementing a comprehensive aging management program, consistent with the GALL Report, by 2012.

The NSA audit team concluded, "ENVY can be a reliable station beyond its current operating license provided that the areas identified in the following principal conclusions are effectively addressed".[19]

Subject to the Panel comments throughout this report, we share this conclusion. However, no report written in 2009 can provide firm assurances as to events between now and 2032. ENVY has committed to thirty-nine specific long range programs for aging management,[20] but these programs are only commitments that have not yet been developed. The NSA team identifies a need to establish a more comprehensive/integrated asset management and long range planning program with regard to these aging management items.[21]

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[17] Fifty plants have been granted license renewals allowing operation beyond 40 years. Another 18 have applications under NRC review.

[18] 10 C.F.R. Part 54, *Requirements for Renewal of Operating Licenses for Nuclear Power Plants.*

[19] NSA Report, p. 2.

[20] NSA Report, pp. 65-67.

[21] NSA Report, p. 67.

The Panel agrees with the NSA team's identification of the need for a more comprehensive and integrated asset management and long range planning program, and believes that continuing State verification must monitor the implementation of these aging management programs.

1.6 The Reliability Assessment Report and Nuclear Safety

The Legislature's purpose in enacting Act 189 was "to provide for a thorough, independent, and public assessment of the *reliability* of the systems, structures, and components of the Entergy Nuclear Vermont Yankee facility." Act 189, § 1(d) (emphasis added). The U.S. Atomic Energy Act preempts states from regulating radiological health and safety but not reliability.[22] The NSA Reliability Assessment is strictly a review of reliability.

Still, nothing prevents our venturing the following observations on the potential interplay of reliability considerations and safety:

- Events and lapses that undermine reliability can undermine safety, and vice versa. A plant's capacity factor suffers during an extended shutdown, whatever the cause.

- Extended, even permanent, shutdowns have resulted from events beginning in systems not considered to be safety related.

- The improved reliability achieved by the nuclear industry has been accompanied by a decline in events requiring rapid shutdown of nuclear power plants, a gain for both reliability and for safety.

- The NSA team's and the Panel's evaluation of VY's future reliability required some review of the plant's safety systems. The NSA Report rightly states: "This report assesses reliability at ENVY, not safety. However, when a safety-related function does not perform properly, it can impact reliability by causing forced outages or power derates".[23]

- DPS, through a memo of understanding with VY has for many years participated in safety-related inspections and has used the knowledge so acquired to inform Vermont government in many aspects of its decision making regarding Vermont Yankee.

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[22] "Congress, in passing the 1954 Act and in subsequently amending it, intended.....that the States retain their traditional responsibility in the field of regulating electrical utilities for determining questions of need, *reliability*, cost, and other related state concerns." *Pacific Gas & Electric Company v. State Energy Resources Conservation & Development Commission,* 461 U.S. 190, 103 S. Ct. 1713 (1983) (emphasis added).

[23] NSA Report, p. 96

As required by Act 189, the consultants and the Oversight Panel looked at both safety and non-safety systems to determine VY's future reliability. Specifically:

- Act 189 directed the consultants to conduct a vertical slice of seven systems at the VY plant, five of which are all or in part safety-related systems. Act 189, § 3(a) (2) (emergency core cooling system), (a)(3) (condensate feed water system), (a)(4) (primary containment system), (a)(5) (heat removal system), (a)(6) (underground piping system that carries radionuclides).

- Act 189 likewise directed that the comprehensive reliability assessment include an investigation of the physical and electrical separation of safety-related cables. Act 189, § 3(c).

- Act 189 instructed that the vertical slice reviews include safety-related inquiries. See, e.g., Act 189, §4(4) ("[H]ave any unanticipated system operations outcomes been duly corrected or compensated in all safety and reliability operations and procedures?"); (4)(10) ("Have changes to the plant since its original construction been reviewed to ensure that safety margins have not been reduced?"); (4)(10) ("Are all systems still 'single failure proof'?).

After conducting its review, as explained below in Section 3.4.5, the NSA team identified six areas that it considered challenges to plant reliability:

1. Procedure quality issues;
2. Human performance issues;
3. System and Technical Focus Areas (condensers, cooling towers, spare main transformer);
4. Delays in adopting industry equipment reliability (ER) best practices;
5. Ineffective Use of Change Management; and
6. Shortcomings in contractor oversight.

See NSA Report, Executive Summary, pp. 2-7. Three of these items - procedure quality issues, human performance issues, and ineffective use of change management - apply to both nuclear safety and to reliability. A safety inspection might well have uncovered the same challenges. The Panel concludes that the NSA Audit has accomplished many of the aspects of a comprehensive safety assessment. However, the Panel draws no safety related conclusions. The NSA team's and the Panel's scope was exclusively on the impact of these challenges on the reliability of the Vermont Yankee power plant.

2. THE OVERSIGHT PANEL

2.1 Selection of the Panel

Act 189 became law on June 5, 2008. It provided for the appointment of three members, one each by the Governor, the Senate President and the House Speaker. The Panel was empowered to name two additional members.

As of July 1, the Panel came into existence. Governor Jim Douglas appointed Dr. Lawrence Hochreiter. Senate President Peter Shumlin appointed Arnold Gundersen. Speaker Gaye Symington appointed Peter Bradford.

On September 3, shortly after the second meeting of the Panel, Dr. Hochreiter passed away. . Later in September, the Panel members (consisting at that time of Messrs. Gundersen and Bradford) added David Lochbaum and Dr. Fred Sears to the Panel pursuant to understandings reached with Dr. Hochreiter before his death. On September 26, Governor Douglas named William Sherman to replace Dr. Hochreiter. All three appointments were announced on September 26.[24]

Act 189 empowered the Panel to name its own chairman. The original panelists agreed to rotate the chairmanship in three equal shifts. This rotation was modified somewhat in light of Dr. Hochreiter's death. Mr. Gundersen served as chair from mid-July through mid-October. Mr. Sherman served from then until January 1. Mr. Bradford chaired the Panel in 2009.

2.2 Panel Methodology

The Panel's overall role was to further transparency, public oversight and public involvement in the various aspects of the Reliability Assessment. Act 189 gave the Oversight Panel three fundamental responsibilities to be discharged in the context of the overall intent, purpose, goals and objectives of the law:

1. To consult with the DPS in designing the work plan and time frame for the comprehensive reliability assessment [Act 189 §§ 3(b), 5(a) & 5(b)]).

2. To consult with the DPS regarding selection of the audit inspection team (Act 189 §7).

[24] Biographies of the Panel members are at Appendix B. Mr. Lochbaum left the Union of Concerned Scientists in mid-February. He joined the NRC in early March. He has taken no part in the Panel's work since February 17.

3. To "publicly report its findings and evaluation of the comprehensive reliability assessment to the General Assembly for the purpose of informing the legislature in making its determination whether the Entergy Vermont Yankee plant should be authorized to operate in the state beyond the expiration of its current license on March 21, 2012" ([Act 189 §6(d)].[25]

In evaluating the Reliability Assessment, the Panel saw three questions as particularly important:

- Does the NSA Reliability Assessment meet the intent of Act 189?
- Are the transformer fire and cooling tower collapse events indications that VY will not perform reliably in the future?
- What steps must VY take to avoid operational shortcomings like the transformer fire and cooling tower collapse for reliable performance in the future?

The Panel met approximately monthly for two days at a time from July through the end of 2008, with a special meeting of two panelists with the consultant team leader in mid-August. It has met every two weeks in 2009. The December meeting included a tour of the VY plant.

All of the meetings included time for the Panel to meet in executive session. Representatives of the DPS were present for a portion of each the 2008 meetings and have provided extensive assistance and logistical support to the Panel. The Panel also benefited greatly from the assistance of Assistant Attorney General Rebecca Ellis.

Entergy made presentations in meetings in July, August, January and February. Nuclear Safety Associates made presentations at each meeting from the time of their retention in September through the first January meeting. The NRC made presentations in July and October. Three Panel Members also attended the October 14 public NRC meeting in Brattleboro regarding the cooling tower failures. Three members of the Panel also briefed the Vermont State Nuclear Advisory Panel (VSNAP) on the audit process in late November.

In addition to these meetings, the Panel had weekly conference calls with DPS representatives (and sometimes NSA) from September through November to review the progress of the audit. Also, in accordance with Section 6(c) of Act 189, the Panel has had access to all records and documents consulted and generated in developing and conducting the reliability assessment and to records and documents generated in any other audit of the Vermont Yankee Nuclear facility

[25] In October 2008, the Panel requested and was granted an extension of the deadline for completing its work from January 30, 2009 to February 27, 2009 due to the fact that the NSA report could not be available before December 22. On January 30, 2009, the General Assembly instructed the Panel to submit its report on March 17, 2009.

pertinent to the reliability assessment.[26] In the discharge of its responsibilities, the Panel has generally supported the right of any member to pursue any issue that seemed to that member to be relevant to the Panel's responsibilities.

After considerable discussion, DPS and the Panel arrived at an agreed-upon scope of work for the reliability assessment that was memorialized in a letter from the Panel to the DPS on October 28, 2008, and thereafter in the NSA scope of work. That scope matrix, which is Appendix C to this Report, modifies the statutory scope (in the manner provided for in Act 189 §§ 3(b), 5(a) & 5(b)) as described in Section 3.1 of this Report.

The Panel concluded that it had no role to play in the drafting of the NSA comprehensive reliability audit that was made public on December 22. Neither our responsibilities nor the tight schedules constraining both us and the DPS were conducive to such involvement. A spot check of changes made between submission of the draft NSA report to DPS on December 16 and the public release of the report on December 22 uncovered no changes affecting recommendations or fundamental conclusions.

The Panel did review the December 22 NSA report and asked questions of NSA at our meeting of January 7 and 8. These questions were answered by NSA in January and February. The drafting of our own Report commenced in early January and was completed in March.

[26] Two Panel Members, Mr. Gundersen and Mr. Sherman, elected to receive data disks of this information provided by VY. These disks represented all the information provided to NSA through its data requests during the audit for its December 22 2008 report.

3. THE NSA RELIABILITY ASSESSMENT

3.1 Scope of the NSA Reliability Assessment (Act 189, Section 3)

The scope of the Reliability Assessment is the Appendix C Regulatory Assessment Matrix. . The same matrix is Appendix D of the NSA Report.

Panel Actions in Overseeing the Scope of the NSA Report

The General Assembly designated the scope for the Reliability Assessment in Section 3 of Act 189. This section identifies seven whole plant systems for comprehensive, in-depth assessment:

1. An electrical system: the back-up or stand-by electrical system, including the diesel generators, batteries, the Vernon dam tie, and all associated electrical connections and controls.

2. An emergency system: the emergency core cooling system, including both high- and low-pressure injection systems.

3. A mechanical system: the condensate feed water system, including the condenser.

4. The primary containment system, including all associated systems, structures, and components, such as dry well shell, torus supports, residual heat removal system, isolation valves, containment spray, and adequate suction.

5. A heat removal system: the cooling towers and alternate cooling system, including both cooling tower cells used for normal cooling and those that are emergency related towers.

6. A cooling system dependent upon Connecticut River water: alternate cooling system and emergency service water.

7. An underground piping system that carries radionuclides.

In addition, Act 189 Section 3 requires an assessment of a generic systems issue: cable separation - separation of safety systems, including physical and electrical separation.

Regarding the scope of the assessment, the Panel understood its charge as follows: Act 189 Section 3(b) states that additional systems for the Reliability Assessment may be selected by the Panel, in conjunction with DPS. Act 189 Section 5(a) states that the provisions of the act shall be followed unless DPS, in consultation with the Panel, determines that employing such provisions would be inefficient or ineffective. In addition, Act 189 Section 5(b) allows DPS, in conjunction with the Panel, to add items necessary to provide a complete assessment. Based on these provisions, the Panel recommended additions or modifications of the scope.

Panel recommendations were provided on the matrix reproduced in Appendix C of this report. DPS accepted all of the Panel's recommendations, and NSA used the matrix as the basis for its assessment.

The Panel recommended the following adjustments for the scope identified in Section 3 of Act 189:

1. The Panel was informed that there were no systems with underground piping that carry radioactivity at VY.[27] Therefore the Panel recommended that the review of the service water system, Act 189 §3(6) ("a cooling system dependent upon Connecticut River water"), which has buried non-radioactive piping, specifically include a review of ENVY's Buried Pipe and Tank Inspection Program

2. The Panel recognized that management aspects were particularly important to continuing reliable operation. Therefore the Panel recommended a specific management and corporate review, and advised as to the scope of work for this effort.

3. The Panel understood that comparisons with nuclear plants of the same type and vintage as VY would yield useful reliability information. The Panel recommended a sister plant review, and participated in the review and approval of the scope for this effort.

4. The Panel recognized that NRC had performed significant in-depth inspections of certain systems identified by the General Assembly in Section 3 of the Act[28]. The Panel clarified that the NSA team could rely on NRC in-depth inspections, as they applied to systems in Act 189, Section 3. Therefore, the Panel determined that a new vertical inspection of the electrical systems, Act 189 §3(1), was not necessary since a vertical inspection of these systems was conducted in 1992. In addition, an in-depth inspection of the Vernon Tie was performed in 2004. Rather, the Panel recommended that only implementation of the NRC findings, and changes since the NRC inspection, be included in NSA's scope. .

5. Because of the fire in the main transformer in 2004, the Panel recommended that a vertical audit of the main transformer and switchyard replace the electrical systems from Act 189 §3(1).

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[27] There is a buried chemistry laboratory drain pipe that once carried radioactive material. In the early 1990's, this drain was discovered to be leaking. After review, the NRC approved its being abandoned in place. The current chemistry laboratory drain is not buried. VY's decommissioning plan accounts for the disposal of contaminated soil from this leakage.

[28] NRC performed risk-based component design basis inspections (CDBIs) at VY in 2004, 2006 and 2008. The history and development of the CDBI is beyond the scope of this report. However, the first ever CDBI was performed at VY in 2004. . The risk-based CDBIs are improvements to the former vertical, safety system functional inspections that were performed at two-year intervals at VY prior to 2004.

6. The Panel determined that a vertical review of a portion of the containment systems, Act 189 §3(4), would be inefficient. Since periodic tests have been performed on the drywell shell, torus, and isolation valves, the Panel recommended a review of these test results, rather than a full vertical review. The vertical review of the residual heat removal system, containment spray system, and adequate suction was recommended, as included in Act 189 §3(4).

7. The Panel noted that Section 2(2) of Act 189 included a review of the VY design against new plant requirements. The Panel recommended this be accomplished by review of two of the vertical slice systems against the NRC Standard Review Plan[29] applicable to that system.

8. The Panel requested review regarding the flow accelerated corrosion program that monitors the reduction from plant operation of the thickness of pipe walls.

In addition to these recommendations, the Panel asked for specific information regarding the failure of the reactor building crane when lifting the first dry cask storage container.

Panel Findings Regarding the Scope of the Assessment

The Panel finds that DPS and NSA accepted all its recommendations for the scope as reflected in the matrix in Appendix C.

3.2 NSA Reliability Assessment Methodology (Act 189, Sections 4 and 5)

In Act 189, Section 4, Specific Audit Inquiries, indicated "The audit of each system shall include physical and documentation examination of the entire system, including each system's relevant components." Section 4 further identified thirteen specific inquiries to be addressed.

Section 5, Design and Methodology, further indicated how the DPS in consultation with the Panel was to design the vertical and horizontal investigations that would be conducted by the audit.

The following provides a brief summary of how these sections of the Act were carried out. The Panel, in consultation with the DPS, recognized the daunting challenge of conducting the audit within the time limits of the Act, and thus recommended some scope changes to achieve a satisfactory overall assessment of ENVY's continuing ability to provide reliable operation for the future.

[29] The Standard Review Plan (NUREG-0800) is an NRC document that is used to review the license applications for new plants.

Description of Methodology

NSA under contract to the DPS performed the Reliability Assessment required by Act 189. The results of that assessment, conducted primarily during the third and fourth quarters of 2008, are described in the NSA Report. A NSA team of 30 NSA contractors performed the assessment. NSA contractors currently provide similar consulting and assessment services within the nuclear power industry. The NSA contractors performing this assessment represent a broad spectrum of executive, management, and supervisory experience in the operation, maintenance, engineering, modification, analysis and oversight of nuclear power plants. The NSA Report provides (at pages 8 and 9) a brief description of the methodology employed by NSA in conducting the assessment.

Numbers of team inspections have been conducted at Vermont Yankee over its operating life. The numbers of inspectors have ranged from a few inspectors to teams of seven or eight auditing against safety regulations. However, a team of 30 inspectors focused on reliability is unprecedented in Vermont Yankee's history.

The NSA team worked for more than 7400 hours. The Oversight Panel notes that this is significantly less than some estimates furnished to the Legislature for the time necessary to accomplish the tasks contemplated by Act 189. Act 189 in fact contains no specific person hour requirements. An assessment of this sort is necessarily an audit. One hundred percent of the systems and documents cannot be examined. Nor can all possible individuals be interviewed at length. The Panel did not find reason to conclude that additional hours would have been likely to change the NSA conclusions in any fundamental way.

The NSA assessment was generally responsive to the requirements of Act and to additional areas of inquiry requested by the Panel.

Following the December 22, 2008 release of the Report, the Panel met with NSA and the DPS as well as ENVY personnel to seek clarification of information and conclusions contained in the Report. Revisions to the Report to release most of the redactions (dated January 15, 2009) in the Report and to provide clarifications were issued during the first quarter of 2009. In addition to the expertise of the Oversight Panel members and numerous documents with which they are familiar, this report draws from the NSA Report as well as the Technical Information Addendum, the response to Oversight Panel Questions, the Reliability Assessment Errata Sheet, and the Search Result for Envy Regulatory Exemptions, Deviations and Waivers material that was provided by NSA in February 2009. Further, it draws on information provided by ENVY (February 2009) in response to the NSA Report and on information furnished pursuant to Section 6(c) of Act 189 (see footnote 26). Appendix D lists specific documents relied on by the Panel members in their considerations.

As required by Act 189, the NSA team members had no association with ENVY or Entergy within the past three years. Their conduct of reviews and assessments were based on their experience and on expectations for high performing nuclear plants both within the US and abroad. These experiences and expectations were applied to the evaluations of ENVY systems, structures, components, station processes and procedures, staffing, training and management and

organizational effectiveness to determine NSA conclusions as to the reliability of ENVY operations for the license extension period beyond 2012. In doing so the NSA team drew upon both past and current performance as well as existing procedures and personnel.

NSA used the thirteen specific audit inquiries from section 4 of Act 189 as a basis for organizing its audit and for presenting its assessment.

NSA interviewed personnel at all levels of ENVY ranging from workers, operators, and engineers to station supervisors and managers as well as Entergy site and off-site corporate executives. They reviewed station records, processes, and procedures as well as corporate level policies, procedures, and processes. NSA conducted independent assessments of corrective actions from several recent significant operational events (cooling tower failures and transformer fire/electrical duct work failure) and compared their results with the ENVY assessments. They reviewed numerous ENVY documents that included Design Bases Documents, maintenance and modification records, and engineering evaluations. Training effectiveness and capabilities were examined. Staffing (current and future) was assessed. Resource allocation at both station and corporate level for capital improvements and for day-to-day operations were examined. For the systems assessed, the long-term impact of the 20% power uprate was assessed. Listing of policies, procedures, evaluations, and design documents used in the assessment are contained in each section of the Report.

As important as the review of documentation was in the NSA assessments, their walkdowns of the facility and the observations of personnel performance were at least as important in assessing future reliability for VY. The walkdowns and observations gave concrete evidence of whether staffing was adequate and capable of reliably operating and maintaining VY beyond 2012. . They also provided evidence as to whether VY management were actively promoting and reinforcing the proper application of existing processes and procedures as well as identifying and addressing improvements.

NSA identified for each area/system assessed, based on the NSA team's experience and expectations for long term reliability, whether ENVY was performing at the top levels of the industry or whether performance related to reliability needed monitoring or improvement. The Panel report indicates our assessment of the NSA conclusions. NSA made their assessments both for specific vertical system slices called out in the Act and for broader considerations, which cut across the overall ENVY organization and facility.

Panel Findings Regarding Methodology

The Panel finds that the methodology used by the NSA Reliability Assessment was generally appropriate and responsive to Sections 4 and 5 of the Act. Their methodology coupled with the depth and breadth of the NSA team's experience and background produced a reasonable assessment of ENVY's recent and current processes, procedures, and actions. Further the NSA methodology served as a foundation for NSA to provide a reasoned judgment as to ENVY's ability to achieve reliable operation for the future. The methodology also identified areas that

need management attention and/or improvement in order to provide reasonable assurance of reliable operation for the period of time where license extension would permit extended operation.

The Panel believes that the conclusions presented by the Report are generally supported by the methodology used and represent a reasoned assessment of current conditions as well as the potential for ENVY to achieve reliable operation of VY for the period of license extension with the inclusion of the Panel's additional concerns.

3.3 Specific Areas of Review Requested by the Oversight Panel

3.3.1 Management and Corporate Review

Section 1.0, Management and Organizational Performance Assessment, of the NSA Report contains a broad and comprehensive assessment of the ENVY management and organization. Other sections of the Report contain much the same material but more focused on the specifics of the particular vertical slice or coverage of those individual sections. Section 1.0 thus provides a good overview without becoming mired in technical details of the other sections.

In general the NSA Report found that ENVY management and organization are appropriate. However, it also found that ENVY management needs to do a more effective job of leading the VY organization in improvement changes and in effectively and consistently applying procedures and processes. The Report further found that procedures need improvement to move from relying on skill of the trade and individual's historical knowledge to providing full and complete instructions in a consistent format; this would then assure that trained and qualified personnel would correctly perform assigned tasks. NSA also found that management needed to assure that procedures are consistently adhered to; especially with regard to the cooling tower modifications and repairs. Additionally the NSA Report indicated a need for improvements in the use of operational experience from other organizations as well as more in-depth inquiry as to events at VY as part of the corrective action program.

Panel Findings Regarding Management and Corporate Review

The Panel finds that the recommendations for improvement contained within the Report were appropriate. ENVY attention to the recommendations is necessary to provide reasonable assurance of continuing reliable operation of VY for the future and especially over the period of operation that would be allowed by license extension. The Panel finds management attention and leadership for the changes recommended by the Report and those identified in Section 4.6 are extremely important as the VY workforce changes with retirement and replacement of long term employees.

3.3.2 Sister Plant Review

The sister plant review was one of the reliability assessment items which was added by the Panel. The sister plant review examined performance data, staffing, and equipment reliability. Overall industry data was used for comparison purposes as well as looking at a smaller comparison group for other plants of similar power and age as well as in comparison with other Entergy plants.

Based on the performance data VY is in the middle of the industry; the plant had been in the upper half of the industry for the period 2004 to 2006 but showed a decline for 2007 and 2008. Major contributors to this decline were associated with the cooling towers collapse and feedwater chemistry.

The staffing comparisons show that VY's authorized staffing levels, including long term contractors, are reasonable with respect to the industry and with respect to sister plants. That said, it is important that ENVY aggressively pursue filling the empty positions. The Report also suggests that ENVY should give attention to the workload of those system engineers/managers assigned to oversee system performance because they may be overloaded.

Although the current authorized staffing levels seem appropriate for routine operations, the suggestions for improvement contained in the NSA Report point to the need for some additional temporary staffing to achieve these improvements particularly in the areas of training, procedure upgrades, use of operations experience, and improvement of system engineering. With the numerous age management programs required for any post-2012 operation, consideration of temporary staffing to assure successful implementation of improvements and avoid incidents such as the transformer fire and cooling tower collapse is warranted.

With regard to equipment reliability the industry has moved to a uniform set of metrics over the past several years. VY ranks in the lowest quartile of performers by those metrics. ENVY has been slow to adopt this set of metrics. The two plant shutdowns associated with the cooling tower collapse and the isophase duct bus are significant contributors as are the chemistry index and preventative and elective maintenance metrics.

Panel Findings Regarding Sister Plant Review

The Panel generally agrees with the Report in its comparisons with the industry as well as sister plants except as expressed in our Section 1.3 (figures 1.4(2 and3) regarding capacity factors for sister plants (page B-4 of the NSA Report). Both the performance index and the equipment reliability metrics use multi-years averages to account for long-term trends and refueling outages. It will take several years to reverse the current status. The Report contains a number of suggestions which if implemented would support improvement of ENVY's performance and better assure continued long-term reliability.

3.4 NSA Assessment Goals and Objectives (Act 189, Section 2)

3.4.1 Conformance with Design and Licensing Bases for Up to 120 Percent of Original Power Level (Act 189, Section 2(1))

Section 2(1) of Act 189 defined a goal of the reliability assessment to be an assessment of VY to its design and licensing bases for operation up to 120 percent of the original power level. To satisfy this goal, Section 4(1) of the Act required the inquiries into the six systems identified for the NSA audit team to evaluate designs against applicable codes and standards and Section 4(10) required the inquiries to evaluate whether operational margins had been reduced by the power uprate.

Plant owners are required by federal regulations to operate nuclear power reactors within pre-approved design and licensing bases. §50.59 to Title 10 of the Code of Federal Regulations, for example, require plant owners to evaluate proposed changes to the facility or its operating procedures against the design and licensing bases. If the proposed changes fall within pre-approved bounds, the owner may make the changes. Otherwise, NRC's formal approval is necessary for the changes. The NRC's approval, such as in the recent case of power uprate, revises the design and licensing bases.

NSA Assessment Findings and Conclusions

The NSA team evaluated the conformance of the plant to its design and licensing bases through several tasks. For example, NSA team members walked down accessible portions of the high pressure coolant injection system as a check against design and licensing bases requirements. The audit team examined the administrative controls used to assure operation within design and licensing bases requirements, then assessed the efficacy of the implementation of these controls during the inquiries into the six specific systems. The NSA team's system-level inquiries included reviewing NRC inspections conducted on those systems as well as Vermont Yankee's reports to the NRC following discoveries of design and licensing bases problems.

The NSA audit team concluded that controls over plant modifications and operations were appropriate to assure that the facility conforms to its design and licensing bases, including operation at the uprated power level.

Public Oversight Panel Conclusions

The Panel concludes that the NSA team's efforts, with one exception, were thorough enough to accurately access conformance with applicable design and licensing bases requirements. The exception involves the improperly analyzed design change to the cooling towers after their collapse in 2007 that contributed to the leakage identified in July 2008.

The NSA audit team documented in Appendix G of its report its evaluation of ENVY's root cause assessments for the cooling tower problems. The NSA team described how ENVY followed its procedures to perform an "at-risk" design change to cooling tower 1-1. The "at-risk" design change process allows work and reactor operation to continue despite some design issues still being resolved, provided the design issues are resolved prior to returning the modified equipment to service. Questions arose during cooling tower inspections and repairs in May 2008 as to how the fiberglass reinforced plastic used to replace original wooden vertical columns was connected to horizontal cross-members supporting the distribution pipe. The original configuration featured a three-clip connection while the replacement connections sometimes used two clips. In July 2008, leaks from the distribution pipe were identified and found to have been caused by failed, degraded and missing connections between the fiberglass reinforced piping and the cross-member supports.

The NSA audit team essentially concluded that ENVY failed to properly follow its "at-risk" design change procedure along the way to a bad outcome. Specifically, ENVY failed to adequately evaluate all design issues prior to returning the modified cooling towers to service in May 2008. The Panel agrees with the NSA team that ENVY certainly learned lessons from the various cooling tower events. But the audit team did not provide the Panel with tangible evidence to conclude that ENVY will successfully apply its "at-risk" design change process in the future. Mere awareness of past lessons learned falls short of adequate protection against future lessons. To reduce the likelihood of additional reliability surprises, the Panel strongly recommends that ENVY revise its design change process to better manage "at-risk" changes.

3.4.2 Deviations from Regulatory Requirements (Act 189, Section 2(2))

Section 2(2) of Act 189 defined a goal of the reliability assessment to "identify all relevant deviations, exemptions, or waivers from regulatory requirements applicable to VY, and from regulatory requirements applicable to new nuclear reactors, and to verify whether adequate operating margins are retained despite the cumulative effect of any deviations, exemptions, or waivers for the present licensed power level for the proposed period of license extension".

To satisfy this goal with regard to regulatory requirements currently applicable to VY, Section 4(1) of the Act required the inquiries into the six systems identified for the NSA audit team to evaluate designs against applicable codes and standards and Section 4(10) required the inquiries to evaluate whether operational margins had been reduced by the power uprate. With regard to new plant requirements, the Panel recommended that this be accomplished by review of two of the vertical slice systems against the NRC Standard Review Plan[30] applicable to that system.

[30] See footnote 29. There are Standard Review Plan sections for each section of the Safety Analysis Report that must be filed by an applicant, and the Safety Analysis Report is organized by plant systems. The Standard Review Plan includes a summary of the requirements that the systems of the nuclear plant must meet.

NSA Assessment Findings and Conclusions

The NSA audit team reviewed the processes and procedures that control deviations, exemptions, and waivers from regulatory requirements applicable to VY. The team was satisfied that the systems it reviewed appropriately implemented these processes and procedures. The NSA audit team did not identify deviations, exemptions, and waivers, but rather took the approach that, since they were reviewed and approved by NRC, they were no longer deviations, exemptions, or waivers. In response to Panel questions, the audit team identified approximately 74 exemptions related to cable separation and approximately 17 exemptions related to the reactor containment. Of the 74 cable separation exemptions, the team identified eleven specific exemptions that were identified in VY's Safe Shutdown Capability Analysis. The team concluded that none of the exemptions appear to have a cumulative effect, nor do any appear to layer over the top of one another.

For new plant requirements, the NSA team chose the High Pressure Coolant Injection (HPCI) and Service Water systems to compare against the Standard Review Plans. The NSA team initially determined that the VY original and current design meets the intent of General Design Criteria (GDC - 10 C.F.R. §50, Appendix A) applicable to new plants (see Sections 2.2.14 and 2.6.14 of the NSA Report). In response to Panel questions the NSA audit team performed a more thorough review of the HPCI and service water systems against their respective standard review plans. The audit found that the VY HPCI and service water systems meet requirements for these systems on new plants.

The NSA audit team also reviewed ENVY's process for controlling margin changes, including changes for power uprate. It found that ENVY procedures require a review of all safety significant analyses prior to closure of any plant modifications to ensure safety margins have not been inappropriately reduced. Regarding power uprate, the team specifically identified that change management documents properly evaluated available margins. For the systems reviewed, the NSA team determined that changes to regulatory requirements were properly controlled and documented, and that adequate margins have been maintained.

Public Oversight Panel Conclusions

While certain aspects of this goal were not accomplished in the original NSA report, the audit team corrected these shortcomings in answer to Panel questions.

The identification of deviations, exemptions, or waivers from regulatory requirements applicable to VY was omitted from the original NSA Report. However, these deviations, exemptions, and waivers were identified in the answers to Panel questions. Similarly, for new plant requirements, the audit team only completed a partial review in the original NSA Report. In response to Panel questions, a more complete review was provided. This goal has now been met.

The Panel notes that, while the audit team found VY systems are designed to seismic criteria, the seismic criteria for new plants would assume a higher earthquake acceleration level.

A nuclear plant of VY's vintage obviously does not meet all current new plant requirements. For example, turbine buildings for new plants would most likely be oriented such that the containment and all, or almost all safety related systems structures and components outside containment are excluded from the low trajectory hazard zone in order to meet turbine missile design criteria. Also, ENVY takes credit for containment pressure developed during a postulated accident to demonstrate correct functioning of low pressure safety pumps – new plants would probably not be given this credit.

For the portion of this goal concerning whether adequate operating margins have been retained despite the cumulative effects, the audit team concluded only that, since NRC had approved changes, operating margins were therefore adequate. Implicit, but not stated by the audit team, is that NRC would not have granted approval if the cumulative effect had been inadequate. The Panel might rather have seen a discussion that power uprate was accomplished by using various operating and safety margins that existed, and that these margins were generally reduced by the power uprate.

The Panel agrees with the audit team's overall conclusion in this area. VY certainly does not meet all requirements for new plants, and NRC has granted deviations, exemptions, and waivers. The power uprate and other modifications over the years have used available margins. Nevertheless, the audit team's reliance on NRC's regulatory review and approval has a degree of validity. This review and approval, coupled with industry standards for pertaining to reliability, result in adequate operating margins and the expectation of reliable operation.

3.4.3 Causes of Significant Operational Shortcomings (Act 189, Section 2(5))

Section 2(5) of Act 189 defined a goal of the reliability assessment to "determine the cause or causes of any significant operational shortcomings identified and draw conclusions on overall performance". Two significant operational shortcomings in the recent past are the transformer fire in 2004, and the cooling tower collapse and subsequent failures of 2007 and 2008. Because of these operational shortcomings, the main transformer and the cooling towers were chosen as two of the six systems for vertical slice audit. In addition, a focused audit was conducted of the root cause analyses for the transformer fire and cooling tower collapse.

NSA Assessment Findings and Conclusions

The transformer fire event - On June 18, 2004, ENVY experienced a severe electrical fault that caused a generator trip, automatic plant shutdown, and a fire on the main transformer. The electrical fault and fire caused severe damage to the low voltage bushing box on top of the main transformer, to the generator potential transformer cabinet in the turbine building, and to the generator isophase bus[31] itself. No damage occurred to the main transformer, the unit auxiliary transformer, the main generator stator, or reactor systems.

[31] The isophase bus is the name of the electrical connection from the main generator to the main transformer. This connection carries all of the electrical power generated by the nuclear plant.

In Appendix G of the reliability assessment, the NSA team identified the cause of the event to be twofold:

- A small piece of metal foil that was part of a flexible connector became detached and caused electrical shorting and arcing within the isophase bus duct. One end of the piece of metal foil failed because of slight damage from grinding to remove excessive metal attaching the end of the connector.

- Surge arrestors meant to protect against these types of electrical faults were not properly maintained and did not perform their protective function.

The NSA audit team identified several actions that contributed to the transformer fire, including the increased air flow of isophase bus duct cooling, inadequate inspection as a result of limited access to isophase bus components, and inadequate use of operating experience. The NSA team noted that ENVY did not explicitly document consideration of either human performance deficiencies or procedural weaknesses as causal factors.

The cooling tower collapse - On August 21, 2007, a portion of one of the banks of cooling towers partially collapsed after several wooden structural supports failed while the cooling tower was in service. The weight of the cooling water, coupled with the significantly reduced structural integrity caused the main pipe carrying cooling water to separate. The resultant full flow on the cell columns and support beams collapsed a significant portion of the east side of the cooling tower.

Following the collapse, wooden structural members were replaced with fiberglass columns. However, subsequent failures occurred in 2008 because the new columns were not attached properly.

The NSA audit team determined the cause of the cooling tower collapse to be the structural failure of support columns as a result of inadequate inspection of the cooling towers. Contract inspectors used remote visual inspection techniques rather than hands-on inspections. Contractors also were allowed to use judgment to determine the sample scope for inspections. As a result, the columns that failed were not inspected by physical means. Lack of contractor oversight of cooling tower work was identified as a cause of the cooling tower collapse. There was an over reliance on the skill of the contractor. The contractor often worked from memory and did not use detailed work orders or drawings. Also, there was excessive delegation and lack of verification by ENVY. The NSA team reviewed instances of cooling tower degradation prior to 2007, and stated that the significance of this degradation had not been fully investigated and was not adequately understood. In addition, after the fact, research by ENVY personnel determined that there was industry operating experience that could have been used to more effectively assess cooling tower problems before the partial collapse occurred in 2007. These were missed opportunities to avoid the operational shortcoming.

Public Oversight Panel Conclusions

For the transformer fire, the Panel believes the piece of metal foil identified by ENVY and the NSA audit team became detached because of a significant increase in air cooling flow in the isophase bus duct. In the Spring 2004 refueling outage, ENVY installed more powerful fans to provide additional cooling for the isophase bus for power uprate. The piece of metal foil, which was degraded but remained in place for 32 years in the original bus duct cooling flow, became detached at some time after being subjected to the increased airflow from the new fans before the plant started up after the 2004 refueling outage. This detachment was undetected until after startup, when the loose piece of metal caused the shorting and subsequent fire.

ENVY had identified the need to inspect the isophase bus during the 2004 outage in conjunction with this fan upgrade, but deferred this inspection. In addition, ENVY had operating experience information available that this type of flexible connection had failed previously at other plants in the same manner. However, this operating experience was neither recognized nor heeded.

The Panel recognizes the transformer fire event as a reduction in reliability as a result of a modification for power uprate.[32]

For the cooling tower collapse, the Panel agrees with the NSA audit team's determination of cause and also the recommendation that contractor oversight is an area that must be strengthened to provide future reliable operation. The Panel also agrees that the cooling tower structural degradation events prior to 2007 were significant missed opportunities to prevent the tower collapse.

The availability of adverse operating experience prior to both the isophase bus duct and the cooling towers events should have informed managers regarding the allocations of time and resources to inspections.

For reliable operation in the future, ENVY must improve its operating experience program to provide the allocation of resources for inspections of non-safety applications, and further ENVY management must be willing to dedicate sufficient resources for these inspections.

Both of these significant operational shortcomings - the transformer fire and the cooling tower failures - could have been avoided. The common elements in the causes of both events are 1) inadequate inspections; 2) inadequate use of operating experience and 3) their occurrence in nonsafety systems. While we agree with the NSA team's recommendation to strengthen

[32] In its approval of power uprate, the PSB recognized that decreases in reliability were likely in the short term as a result of power uprate modifications. The PSB instituted a ratepayer protection plan that required ENVY to protect customers from decreases in reliability during the first three years after power uprate modifications. As a result of the ratepayer protection plan, customers were compensated from the effects of the transformer fire. Nevertheless, the transformer fire was a significant operational shortcoming that could have been prevented.

contractor oversight, the root cause analysis interviews also contain indications that cost and schedule pressures may have played a role in these inadequate inspections in nonsafety systems. ENVY's assessment of operating experience needs to improve.

3.4.4 Effectiveness of Self Assessments, Corrective Actions and Improvement Plans (Act 189, Section 2(4))

Section 2(4) of Act 189 defined a goal of the comprehensive vertical assessment to be an evaluation of the effectiveness of ENVY's self-assessments, corrective action programs, and improvement plans. To satisfy this goal, section 4(13) of the Act required the inquiries into the six systems identified for the NSA team to examine the corrective actions associated with those systems.

Plant owners are required by federal regulation (Appendix B to Part 50 of Title 10 in the Code of Federal Regulations) to have corrective action programs that identify and correct problems in a timely manner. As discussed below in Section 4.2, corrective action program breakdowns have contributed to year-plus outages at dozens of nuclear reactors. Thus, effective corrective action programs are integral components of reliable reactor operation.

NSA Assessment Findings and Conclusions

The NSA team evaluated the effectiveness of self-assessments, corrective actions, and improvement plans through several tasks. For example, as explicitly required by Act 189, the audit team evaluated corrective actions during examinations of six systems. In addition, the NSA team probed ENVY's root cause evaluations and associated corrective actions for the 2004 transformer fire and the 2007/2008 cooling tower problems. And the NSA team evaluated these areas during its assessments of topical areas such as electrical cable separation and flow-accelerated corrosion.

The NSA team identified human performance as a challenge to future reliability of Vermont Yankee's operations. The team concluded that while ENVY's corrective action process provides for human performance error reviews, such reviews are seldom performed. NSA identified a number of problems involving human performance problems in areas such as procedure use and compliance, Occupational Safety and Health Act reportable events, and foreign material exclusion and concluded that recurring problems in such areas does not meet ENVY's 'Good to Great' human performance goal.

The NSA team identified the spare main transformer as an area of concern for continued reliability. The current spare main transformer was formerly the main transformer. ENVY replaced it with a new transformer designed for the higher output of the plant with power uprate. The old transformer had experienced a degradation of transformer windings that has not been fully resolved. In addition, the spare transformer can only handle about 80 percent of Vermont Yankee's licensed generating capacity.

Section 1.2.5 of the NSA Reliability Assessment Report answered questions posed in Section 4(13) of Act 189 regarding corrective action programs. The team concluded that significant emphasis is placed on timely completion of corrective actions and that deferrals of corrective action measures are both uncommon and controlled. The NSA team further concluded that analyses of problem causes are critical and generally effective, that corrective actions are generally comprehensive and lasting, and that trend analyses are generally effective at identifying emerging trends from a number of related problems. The NSA team identified a bad practice involving corrective actions being closed based on work orders being written to perform the necessary tasks. The standard industry practice is to hold corrective actions open until all required tasks are completed, not merely planned.

The audit team "concluded that ENVY's self-assessment process, Corrective Action Program, and associated improvement plans meet industry standards."

Public Oversight Panel Conclusions

The Panel shares the NSA team's concern as to how human performance issues are handled within ENVY's corrective action program, and specifically that ENVY's corrective action program seldom invokes human performance error reviews. ENVY must resolve this shortcoming expeditiously to prevent undue challenges to plant reliability.

The Panel agrees with the NSA team that ENVY's closure of corrective actions (e.g., condition reports) based on outstanding work orders is a bad practice that should be discontinued. This practice impairs the value of trending studies and unnecessarily creates seams for problems to fall into. ENVY has stated a disagreement on this topic. The Panel reaches the same conclusion as NSA and strongly recommends that VY reconsider its position.

The Panel also agrees with the NSA team regarding the spare main transformer. ENVY has an ongoing effort underway to address the winding degradation issue.

The NSA team's efforts were thorough enough to provide accurate insight as to the effectiveness of ENVY's self-assessment process, corrective action program, and improvement plans, and the audit team's findings and conclusions were reasonable.

3.4.5 Reliability Assessment Goals and Objectives (Act 189, Section 2(3))

Section 2(3) of Act 189 defined a goal of the reliability assessment to assess VY's operational performance, and VY's reliability for continued power production, giving risk perspectives where appropriate. To satisfy this goal as to operational performance, the Act included Operation [Section 4(4)], Maintenance [Section 4(7)], Repairs [Section 4(8)], Modifications [Section 4(9)] and Redesign [Section 4(10)] as inquiry subjects for the six systems identified for the audit team to examine. These aspects specifically relate to the operational performance of

the plant. For assessing future reliability, all of the audit inquiry items from Section 4 of the Act are pertinent. In addition, the management review requested by the Panel was important for assessing future reliability.

NSA Assessment Findings and Conclusions

The NSA team's overall conclusion is that VY is operated reliably and that current levels of reliability can be maintained through an extended operating period, provided that that the areas identified by the NSA report are effectively addressed.[33] Management action, oversight and follow-through are needed to ensure that these issues are addressed and resolved if ENVY is to improve its performance to top industry levels.[34]

The NSA Report identified specific challenges to plant reliability. These challenges are identified as principal conclusions, and include five management areas and three equipment items:

Management Areas

Procedure Quality - The NSA team found that the composition, presentation, and formatting of the majority of VY's procedures do not meet industry standards. VY procedures do not support common practices such as place keeping and data collection on each page. Procedures have indeterminate statements, leaving actions open to interpretation and judgment by workers. The procedure problem is exacerbated by VY's current less-experienced workforce, as opposed to the stable workforce it has had previously. The NSA team concluded that procedure quality must be improved.

Management Emphasis on Worker Performance - The NSA team found weaknesses in management's emphasis of its expectations for worker performance. Examples were a) instances where procedures were not used adequately, b) a high worker accident or injury level in comparison with other plants, and c) lower-than-desirable plant cleanliness practices. NSA also found that assessment of worker errors was infrequently performed in the corrective action process. NSA concluded that management emphasis on expected worker performance must be improved.

Adoption of Industry Equipment Reliability Best Practices - The NSA team identified three industry best practices that ENVY has been slow to adopt. First, the industry has created a Reliability Index to monitor equipment reliability. ENVY has only recently adopted this index. ENVY ranks in the bottom quartile of the U.S. nuclear industry. Second, ENVY has high turnover in the system and component engineering group, leaving some engineers with up to six

[33] In addition to these principal conclusions, NSA identified other findings and recommendations throughout its Report. The Panel expects all of these findings to be addressed by ENVY.

[34] NSA Report, p. 2.

systems, compared to the industry average of two to four systems. Finally, ENVY manages with a matrix approach. NSA believes it will be more difficult for ENVY to ensure reliability with the matrix approach as workforce turnover and retirements impact experience levels. The NSA team recommends single point accountability for the most reliable operation.

Use of Change Management Methods - NSA found that Entergy and ENVY have not used the fleet change management process effectively to implement some major change initiatives. The change management process is a guide for developing a comprehensive plan to identify why the change is being made, what needs to be accomplished, who is responsible for actions, performance indicators to track and measure progress, and dates for completion. One example of ineffective change management is the program to standardize procedures. Various changes are being made as part of VY becoming a part of Entergy's fleet, and this change management process is necessary to accomplish these changes in an effective and timely manner.

Contractor Oversight - NSA found shortcomings in contractor oversight with regard to the structural collapse of the cooling tower. The team identified organizational difficulties contributing to this problem. Cooling tower contractor oversight was provided by Engineering Project Management during outages and by Maintenance during non-outage periods. Maintenance does not have a program, procedure, or specific training for individuals responsible for contractor oversight. NSA found this area needed to be strengthened.

Equipment Items

Condensers and Condensate Demineralizers - The condenser uses cooling water from the Connecticut River or the cooling towers to remove heat from the steam coming from the turbines, changing the steam into condensate/feedwater so that it may be pumped to the reactor again. This condensate/feedwater is passed through condensate demineralizers, which remove impurities from the water. The flow of steam through the condenser has increased as a result of power uprate, causing additional erosion of condenser tubes. Also, as a result of the increased flow, all condensate demineralizers are necessary at 100% power - previously one was available as a spare.

ENVY monitors the purity of the reactor water with a chemistry index. This chemistry index is higher than desirable due to increased flow and erosion from power uprate.

The NSA team found condenser erosion and high chemistry index to be both a near-term and long-term reliability challenge.[35]

[35] ENVY stated to the Panel that it has upgraded the condensate demineralizers such that the chemistry index is now within normal operating range. ENVY has budgeted to re-tube or replace the condenser. However, this commitment of resources is on hold until permission to operate beyond 2012 is granted.

Cooling Towers – NSA determined that the cooling tower is a challenge to future plant reliability. Following the cooling tower collapse in 2007, ENVY developed a repair and upgrade plan for the towers. The team stated that a re-evaluation of inspection methods and the repair schedule should be performed because the current plan is based on conditions that are now known to be degraded beyond initial assumptions.

Spare Main Transformer - In 2002, ENVY replaced its main transformer for two reasons. The existing transformer was overheating due to degraded windings. In addition, the existing transformer did not have sufficient capacity for the planned power uprate. After the new transformer was installed, the previous transformer was retained onsite for use if problems developed with the new transformer. The NSA team found two issues with this usage as a spare. First, with power uprate, the old transformer has the capacity for only 83% of the current power output. Secondly, the degraded windings have not been corrected. The NSA team stated that a more comprehensive plan should be implemented for maintaining and upgrading the spare transformer.

Public Oversight Panel Conclusions

The Panel's overall conclusions regarding the reliability of VY for operation beyond 2012 are presented in Section 4.6. As amplified below, the Panel agrees with the conclusions of the NSA audit team.

Management Issues - The Panel finds that Entergy and ENVY management needs to do a more effective job of leading the VY organization in improvement changes and in effectively and consistently applying procedures and processes. Each of the principal conclusions of the audit team identify that management must devote attention and resources to maintain reliable performance. Management needs to assure that procedures are upgraded to industry standards and consistently adhered to, especially with regard to the cooling tower modifications and repairs.

Equipment Reliability Index - NSA identified that ENVY places in the bottom quartile when this index is compared to other US nuclear plants. The Panel asked for, but did not receive any information correlating this index with power production performance. This index may be a sensitive tool to focus management attention, but it may not be an indicator of how well plants produce power. On the other hand, the equipment reliability index contains certain predictive elements. ENVY's low standing may indicates that the plant will not continue its good performance. This index is troubling to the Panel.

Condenser - Documents reviewed by NSA indicate that the condenser is near the end of its useful life and might not be able to operate reliably through 2012 without some remedial actions. The team identified condenser problems including thinning tubes. ENVY has been aware of its condenser problems and has made the economic decision to wait until license renewal is approved to repair or replace it. Condenser replacement or retubing is currently scheduled for the refueling outages in 2013 and 2014.

Main Steam Isolation Valves - The Panel reviewed documents associated with the main steam isolation valves (MSIVs). The purpose of these valves is to stop steam from flowing outside of the containment in case of an accident. There are two MSIVs in each of the four steam lines, one inside containment and one outside. The MSIVs are tested to established leakage limits during each refueling outage. Measured leakage during the 2008 refueling outage was markedly higher than previous outages. These higher leakage levels may indicate problems associated with increased flow from power uprate and need for specific attention to maintenance of these valves to maintain reliability levels.

Preventative Maintenance (PM) Process - The NSA team determined that a significant number of components have deferred maintenance as compared to plants that are considered good performers in terms of reliability. The NSA team observed that high performing plants frequently have less than three and often no "items deferred" maintenance lists. The team also found that "The quality of PM deferrals and the processing of deferrals do not meet industry standard practices." The Panel concurs with NSA's assessment and recommendation that programs and procedures must be put in place to reduce ENVY's higher-than-expected preventive maintenance backlog.

Staffing Turnover Issues - According to NSA, ENVY has about forty vacant positions in its existing organization, or about an 8 percent shortfall. This staff shortfall is further compounded by turnover and attrition of experienced personnel. For example, the Component/Programs engineering group had a 40 percent turnover last year alone. In addition, a significant number of employees are approaching retirement age. Due to the twelve vacancies in the Engineering Department, some system engineers are responsible for six systems while the norm in the industry is for a System Engineer to have oversight responsibility for an average of two to four engineering systems. High turnover also means that many staff members in key areas are relatively new ENVY employees. According to the NSA team's assessment, 85 percent of the auxiliary operators, 86 percent of the instrumentation and control engineers, and 57 percent of the Electrical staff have worked at ENVY for three years or less. The team also observed that more than 16 percent of ENVY engineers have less than 3 years at the VY nuclear plant. The NSA team observed that "based on interviews with system engineers, it was concluded that due to station challenges and personnel turnover, the ability to develop and maintain current monitoring plans was often a challenge." The Panel concludes that staffing turnover creating a less experienced staff makes the other recommendations in this Report all the more important.

Use of Operating Experience - The NSA team indicated a need for improvements in the use of operational experience from other organizations as well as more in-depth inquiry as to events at VY as part of the corrective action program. Inadequate use of operating experience was part of the causes for both the transformer fire and the cooling tower collapse.

ENVY's assessment of operating experience must improve. ENVY management must be willing to allocate adequate resources and use operating experience more pro-actively, specifically in the non-safety area, to maintain reliable performance.

Flow Accelerated Corrosion - The Panel had questions regarding flow accelerated corrosion that were not fully answered by the NSA audit team. The NSA team was not provided information in this area from ENVY due to an ongoing NRC review of an allegation.

Specific Procedure Comments - The Panel notes two procedural items identified by the NSA audit team that should be corrected. First, ENVY used an "at-risk" design change process in modifying the cooling tower structural columns. The attachments to these columns subsequently were insufficient to support the horizontal supports, resulting in a misalignment of the cooling tower piping. The Panel concludes that to reduce the likelihood of additional reliability surprises, ENVY should revise its design change process to better manage "at risk" changes. Secondly, the NSA team identified that ENVY's practice allows closure of corrective actions (e.g., condition reports) based on outstanding work orders. The Panel agrees with the NSA audit team that this is a bad practice that should be discontinued. This practice impairs the value of trending studies and unnecessarily creates seams for problems to fall into.

4. PANEL CONCLUSIONS FOR THE LEGISLATURE

In this section, the Panel first identifies four areas associated with future reliability at VY that were not considered in the NSA assessment: the proposed reorganization under ENEXUS; the possibility of a long-duration outage; the expectation of benefit from any extended operations, and governance and reliability. Then the Panel presents its conclusions regarding reliability and future operation.

4.1 The Proposed Reorganization under ENEXUS

Entergy has proposed spinning off its merchant plant fleet - the Northern and Midwest plants - into a new corporate entity, ENEXUS. This entity would only have access to the assets of the merchant plants, and not the full resources of Entergy Corporation. Currently, this proposal is on hold, a result of the national economic crisis. The Panel takes no position regarding this proposal. However, the corporate commitments reviewed by the NSA team would likely be modified in this transaction, and organizational relationships would be changed. The reorganization would most certainly modify budget structures, and could result in resource impacts for programs reviewed by NSA. The Panel identifies that reorganization into ENEXUS has the possibility of negatively affecting reliability.

4.2 The Possibility of Long Duration Outages

The NSA team did not comment on the possibility of long duration outages. The reliability of an electrical generating plant is clearly reduced if it must shut down for an extended period of time. Forty-one of the 130 nuclear power reactors licensed to operate by the NRC and its predecessor, the Atomic Energy Commission, have experienced outages lasting longer than one year.[36] Ten reactors experienced two separate year-plus outages. To illustrate the abnormality of an outage lasting longer than one year, the average duration of a nuclear power reactor refueling outage in 2005 was 38 days, with some outages completed in less than 20 days. VY's most recent refueling outage was completed in November 2008 in slightly over 22 days.

The first year-plus reactor outage began in October 1966 when the Fermi Unit 1 reactor in Michigan experienced partial meltdown of its reactor core. The most recent year-plus outage ended in March 2004 when the Davis-Besse reactor in Ohio restarted following more than two years of repairs. The unit 1 reactor at the Donald C. Cook nuclear plant in Michigan shut down in September 2008 after suffering catastrophic damage to its main turbine. Its owner announced that repairs will likely keep the reactor shut down over a year.

[36] Several U.S. units closed in the 1990s, some because the expenses of necessary modifications did not seem justified. A number of the closed units would have reached the 40 year mark by now. No U.S. nuclear plants have closed in the last ten years.

The 51 year-plus reactor outages to date have three primary causes:

1. Roughly 8 percent involved repairs of extensive damage from events such as the 1975 fire at the Browns Ferry nuclear plant in Alabama and the December 1993 turbine failure at Fermi Unit 2 in Michigan.

2. About 22 percent involved replacement of large components such as the steam generators in 1981 at Turkey Point Unit 3 in Florida and the recirculation piping in 1984 at Pilgrim in Massachusetts.

3. Nearly 70 percent involved resolution of numerous smaller problems that accumulated beyond acceptable numbers such as at the Millstone nuclear plant in Connecticut during 1996 and the Clinton nuclear plant in Illinois during 1997.

The most recent year-plus outage at Davis-Besse is best known for the replacement of its reactor vessel head due to degradation from boric acid. Its owner acquired a replacement head from a canceled nuclear plant in Michigan and could have restarted the reactor in about 8 months had it not been for numerous other problems that took 17 additional months to resolve.

VY has not had an outage lasting one year or longer.[37] About half (46.7 percent) of the boiling water reactors licensed to operate in the U.S. have had one or more year-plus outages.

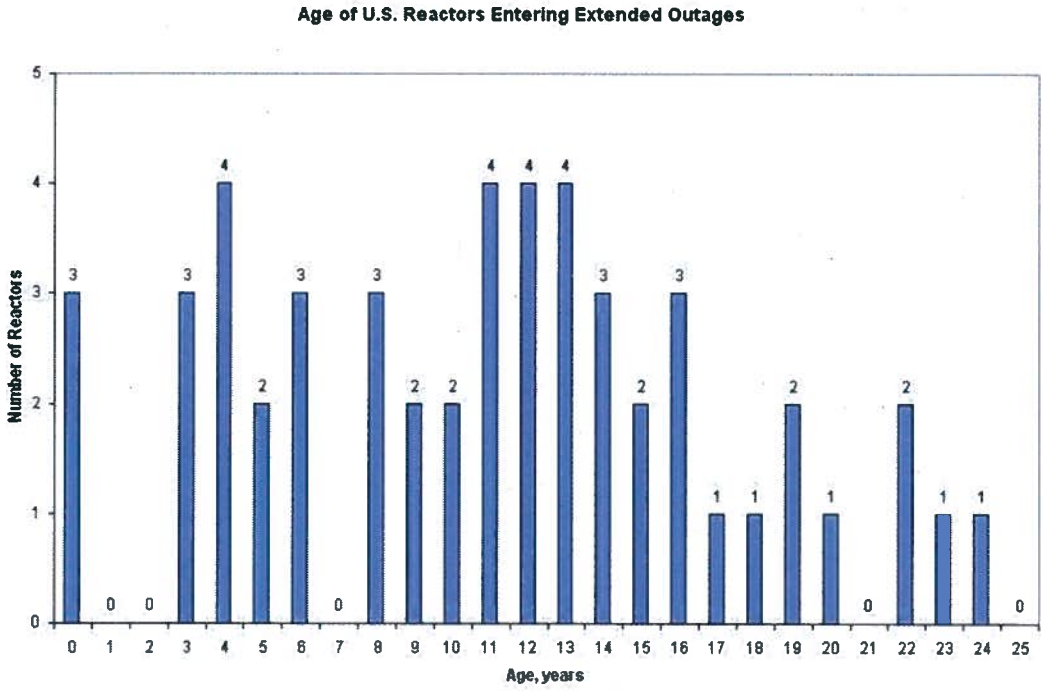
It is not impossible that VY could experience a long outage from either of the two causes - a degraded culture that allows numerous unresolved problems or an event or equipment problem requiring an extended repair or replacement period. Regarding the first cause, VY's history in the last 20 years does not suggest a degraded culture allowing numerous unresolved problems. However, the recurring theme from year-plus outages is that corrective action programs (i.e., the processes used to find and fix problems at nuclear power reactors) are vitally important.[38]

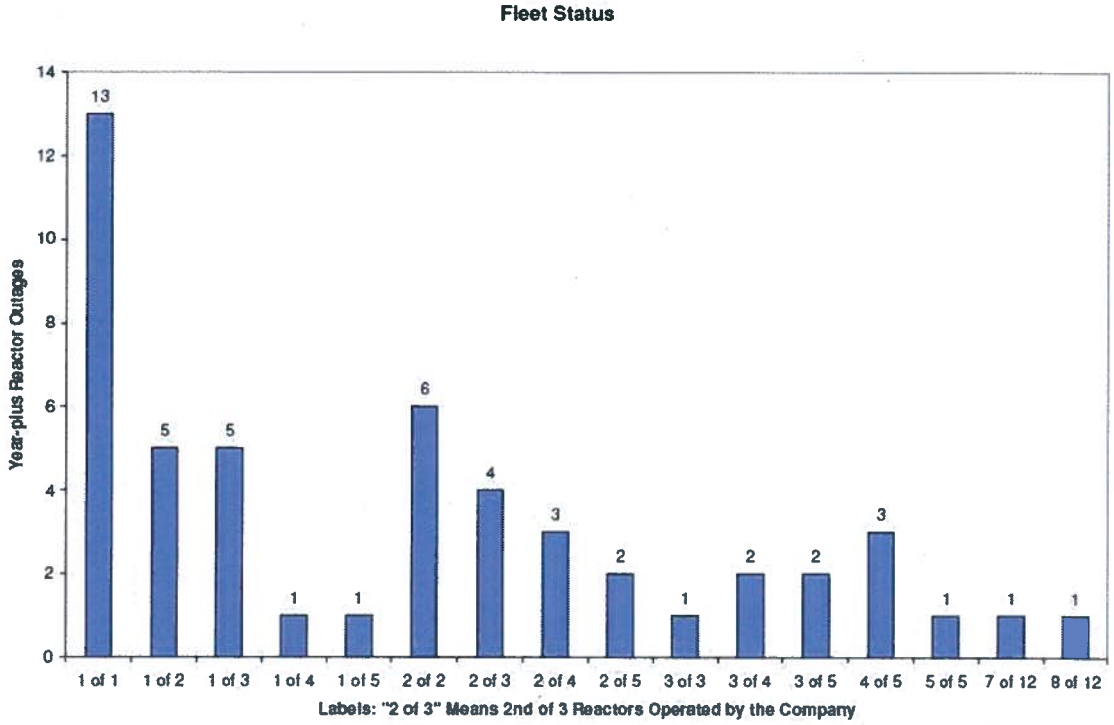
[37] VY's longest outage occurred in 1986-87, a 9-month outage to replace recirculation piping.

[38] Evidence existed among the 51 year-plus outages to reveal future problems and take steps to stem the declining performance, but this evidence was not acted on until it was too late. For example, the 1975 fire at Browns Ferry was presaged by several smaller fires of the same cause, yet the owner failed to address the recurring cause until after the major fire. And the 1993 catastrophic turbine failure at Fermi Unit 2 was preceded by management's decision to run for one more cycle with turbine parts known to be degraded.

The corrective action programs at a nuclear power reactor are like the human body's immune system. The immune system identifies and neutralizes pathogens and tumor cells to maintain a healthy body. The corrective action programs identify and resolve non-conforming equipment and process conditions to maintain a reliable plant. Failure to identify problems and/or failure to properly respond to identified problems results in lower levels of health. Effective corrective action programs that identify non-conforming conditions as early as possible and resolve them in a timely manner afford the absolute best protection against reliability reductions caused by protracted reactor outages. VY must continue to maintain an effective corrective action program.

The second cause of long outages is events or equipment problems requiring extended repair or replacement times. These occurrences are most often unexpected and unpredicted. Unexpected turbine failures have caused some long outages. The recent outage at D.C. Cook was initiated by the failure of its turbine. Compliance with evolving industry standards for predictive and preventive maintenance, along with provision of spare equipment like VY's spare transformer or feedwater pump, can prevent some of these types of problems. But as nuclear plants age beyond the 40 year mark, the unexpected can occur, and VY is not immune.





Source: Lochbaum, David, *Walking a Nuclear Tightrope: Unlearned Lessons of year-plus Reactor Outages*. Washington, DC: Union of Concerned Scientists. September 2006.

4.3 The Expectation of a Benefit from Any Extended Operation

There is a general expectation of benefit to Vermonters from the operation of VY in the extended period. As stated in 30 V.S.A. §248(e)(2), the General Assembly must determine that operation will promote the general welfare for the plant to operate beyond 2012. The PSB, in granting a certificate of public good, must find, under 30 V.S.A. §248(b)(4), that operation beyond 2012 "will result in an economic benefit to the state and its residents."

The exact structure and nature of this benefit is heavily dependent on the power purchase agreement and the customer protection conditions adopted by Vermont. Nothing that the Panel has found in its review forecloses the possibility that protections can be crafted such that, even with reduced reliability, a long duration outage, or premature plant closure, Vermonters would still see some benefit from operation beyond March 12, 2012.

4.4 Governance and Reliability

The future reliability of Vermont Yankee will be affected by government policy in several ways. This topic was not within the NSA mandate. However, it is within the experience of the Panel to the extent of the following observations regarding government policy if operation after 2012 is permitted:

- Continuing or periodic uncertainty as to whether government will permit continued operation deters capital investment and is therefore detrimental to reliability. Subjecting the plant to additional "certificate of public good" requirements at short intervals cannot be reconciled with reliability concerns. Other ways exist to enforce Vermont reliability concerns, and the types of major capital investment commitments essential to reliability (condenser repair or replacement, for example) will not be made if the opportunity to recover those investments is shortened to a few years by factors having little to do with operating proficiency or with normal commercial risks.

- Another way in which governance may affect reliability is through its handling of the contentious discourse with regard to the plant. Vermont offers many attractions as a place to live and build a career. Today's environment of highly charged discourse over the future of the plant isn't one of them.

  It is not our intention to take sides in this discourse. Our point is that the nature of the current discourse has the potential to impede reliability, particularly because it raises barriers to Vermont Yankee's ability to attract the needed skilled workers in a highly competitive nuclear job market.

- In place of frequent certification proceedings, the Legislature might undertake to strengthen institutions capable of instilling the public confidence necessary to offset the need for continuous direct Legislative supervision. Vermont has a long tradition of well respected utility regulation that can be drawn on in designing such institutions.

  The necessary characteristics are high professional competence commensurate with the tasks at hand; domination neither by specific proponents nor by specific opponents of nuclear power; resources adequate to effective performance at ENVY's expense; periodic effective verification with reports available to the public; and the ability for public interaction and recourse through structured, credible and established institutions.

- Some of these characteristics are present within the existing governance arrangements. Based on VY's good historical performance, Vermonters may take a degree of confidence in the institutions Vermont created to provide regulatory oversight of the plant. The DPS has direct, day-to-day contact with the plant and receives a daily status of plant activities. DPS conducts state inspections at the plant and has access to VY documents. Vermonters may contact the DPS to ask questions and receive information regarding VY operations.

State government has also established the PSB to investigate complex issues best suited for an orderly, process-driven investigation. The PSB has managed significant actions involving VY, providing public interaction and information.

In addition, state government has established the Vermont State Nuclear Advisory Panel that has broad responsibilities outlined in 18 V.S.A. Chapter 34, including holding "regular public meetings for the purpose of discussing issues relating to the present and future use of nuclear power and to advise the governor, the general assembly and the agencies of the state thereon."

- In this Report, the Panel makes no specific governance recommendations. We do note that options include strengthening existing institutional capabilities and occasional use of scientific/technical advisory bodies, university faculty, enhanced monitoring and targeted investigation.

With this said Vermont government should achieve credible and public verification that ENVY actively considers and implements or otherwise satisfactorily dispositions these recommendations of the NSA team as well as those of the Panel. Attaining credible assessment and verification of complex technical and management issues such as the recommendations is a difficult matter and should be given serious consideration. We believe that it is important that some periodic means of verification be established regarding the implementation of recommendations for achieving continuing reliable operation of VY. No governance system gives foolproof guarantees. Such effective verification is a critical check against the complacency that can sometimes come between very good past performance and a very good future.

4.5 Reliability and Operation Beyond 2012

In considering its charge to inform the legislature regarding reliability, the Panel has considered three questions:

- Does the NSA Reliability Assessment meet the intent of Act 189?

- Are the transformer fire and cooling tower collapse events indications that VY will not perform reliably in the future?

- What steps must VY take to avoid operational shortcomings like the transformer fire and cooling tower collapse in order to maintain and improve its reliable performance?

4.5.1 Does the NSA Reliability Assessment meet the intent of Act 189?

The assessment, performed by a thirty-person audit team in more than 7,400 hours of assessment, with approximately 1,900 hours of onsite observations, represents a significant inspection effort. In Section 3.2, we state that the methods identified by Sections 4 and 5 of the Act were used effectively for the assessment. In Sections 3.3 we summarize the results of two specific reviews that we requested, the management and corporate review and the sister plant review. In Section 3.4, we identify how the goals from Section 2 of the Act were met. Our conclusion is that the General Assembly's intent to receive a comprehensive vertical assessment of VY's reliability has been met.

Notwithstanding this overall conclusion, we found there were areas in which the NSA team could have improved its work. As stated in Section 3.4.2, the goal to identify deviations, exemptions, and waivers, and to compare with requirements for new plants, was only met in response to Panel questions posed after the NSA report was issued on December 22, 2008.

In Section 3.4.5, we have identified several additional areas not included in the principal conclusions of the audit team. In general, these items are covered by the team in its report, but the Panel feels specific emphasis is desirable.

The NSA team based its conclusion that VY was essentially reliable upon a determination that most of the areas reviewed met *industry standards*. The Panel finds that this rather formulaic determination has a valid basis. Over the past 20 years, the industry as a whole has greatly increased the reliability of nuclear operation through the development of practices called industry standards.

In addition, individual Panel members are aware of documentation that they might have expected the NSA audit team to discover and review, but NSA did not. Examples are documents in the cooling tower and condenser area. While the Panel recognized that this type of audit cannot review every historical document, the Panel would like to have seen NSA's comments on these documents.

4.5.2 Are the transformer fire and cooling tower collapse events indications that VY will not perform reliably in the future?

These events are not precursors of unreliable operation in the future. However, management action is necessary to address items such as procedures, at risk designs, operational experience and needed resources.

At VY, events occasionally occur that result in decreased power production. For example, ENVY had three equipment issues in January 2009 in rapid succession that resulted in a small

decrease in power production.[39] These types of events occur intermittently in all nuclear plants. Even with these types of events, nuclear plants are able to achieve good power production performance.

Nevertheless, the Panel considers the transformer fire and the repetitive cooling tower events to be significant operational shortcomings.

The Panel recognizes VY's good historical performance but questions whether the transformer fire and the repetitive cooling tower failures are indicative of declining performance that will result in unacceptable reliability. As stated in Section 3.4.3, these events could have been avoided. A less-than-desirable management commitment to reliability may have played a role in these events (e.g., schedule pressures deferring the isophase bus duct inspection and/or budget restrictions related to cooling tower inspections and implementation of operating experience). Certain NSA team findings may also suggest a less-than-desirable management commitment. The lack of procedure upgrades, lack of sufficient emphasis on worker performance, slowness in adoption of some industry reliability standards, and incomplete use of change management techniques, are all related to management's willingness to commit resources to accomplish these tasks properly and promptly. The low VY Equipment Reliability Index, in the bottom quartile, may also indicate deficiencies in management commitment.

As elaborated in the next section, the Panel concludes that management must be willing to commit sufficient resources to maintain a high standard of reliable performance.

4.5.3 What steps must VY take to avoid operational shortcomings like the transformer fire and cooling tower collapse in order to maintain and improve its reliable performance?

In order to maintain and improve its reliable performance, Entergy and ENVY management must exhibit a long-term commitment to a high standard of reliable performance. This must be shown by management's implementing and satisfactorily addressing the items in Section 3.4.5, together with all the recommendations in the NSA assessment. Furthermore, an effective method to monitor ENVY's implementation of these recommendations must be put into place. The issues of the findings occurred under ENVY's management. There must be some oversight of this management to see that improvements are accomplished and the commitment to reliability remains high.

[39] January 7 - a leaking valve gasket on 4-inch piping in the reactor building, no power reduction; January 8 - a leak at a welded inspection plug in feed water piping, reduction to 40% power, and; January 12 - reduced gas pressure in a switchyard electrical breaker, reduction to 70% power.

4.6 Overall Panel Conclusions

The NSA Report found that in general VY is reliably operated and maintained with appropriate design, engineering, modification, maintenance, training, operations, staffing, documentation, and management. That said, the NSA Report also indicated too great a reliance on individual experience and relationships, and that behavior on occasion is not driven by programs, processes, and procedure adherence. Thus improvements are needed in management leadership to achieve more consistent and improved performance. This is especially true as the work force is changing and the challenges of a maturing physical plant need to be worked in a more integrated and assured manner to maintain reliability.

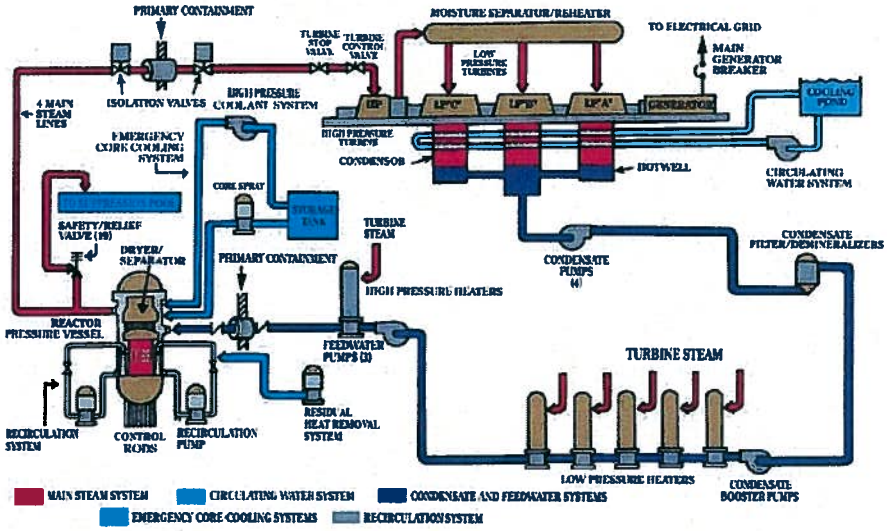
The Panel finds that the NSA recommendations for improvement and for management engagement/leadership are appropriate and needed to provide reasonable assurance of reliable operation for the future and for operation beyond 2012.

A recurring theme associated with significant operational events of the past few years is inadequate consideration of operating experience in identification of potential component degradation in non-safety systems and related improvement of inspection methods and techniques. In some cases interviews appeared to indicate that personnel felt efforts to carry out improved inspections were precluded by resource limitations (either cost or schedule). It was also not clear that engineering personnel were aggressively identifying or communicating to management the need for improvements in inspections which operating experience would indicate. For the transformer fire this might well have produced an improved ability to access portions of the ducts for inspections; for the cooling towers this might well have resulted in better physical inspection of the structural members and the identification of their degrading condition prior to failure. Effective age management programs require improved inspection programs and allocation of resources and schedule to effectively accomplish the inspections. It also requires the work load of the system engineers/managers be such that they can routinely review and consider operational experience to identify risks associated with aging components and structures and consider "what if" scenarios that would not routinely come to mind with newer equipment and materials.

The Panel concludes that reliability of VY for operation beyond 2012 can be reasonably expected if the recommendations of this report and the NSA report are taken. Specifically, there must be an effective verification put in place to assure the recommendations are implemented satisfactorily and in a timely manner. Also, because there are always risks for reliability from changes in management philosophy or from unexpected technical causes, the PSB and General Assembly must assure that an adequate benefit is provided to Vermonters for operation beyond 2012.

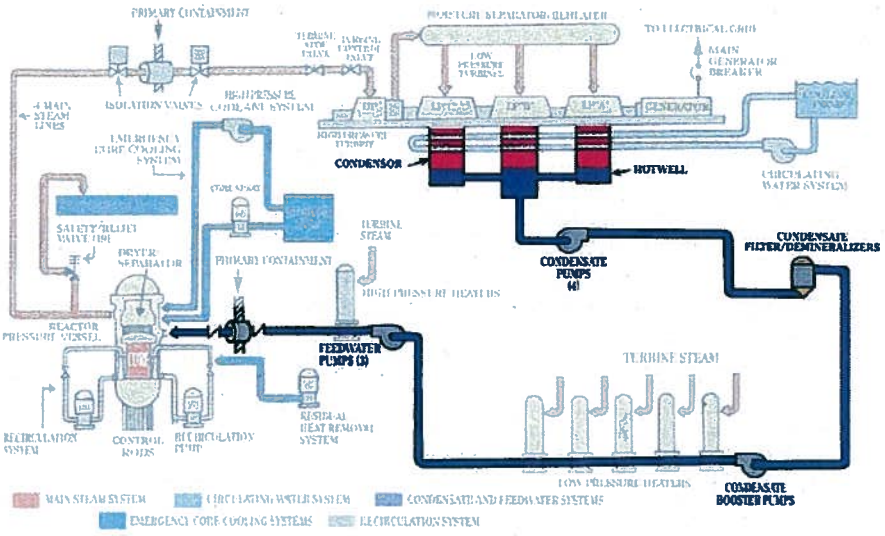
Appendix A – Boiling Water Reactor Schematic

Boiling Water Reactor Schematic

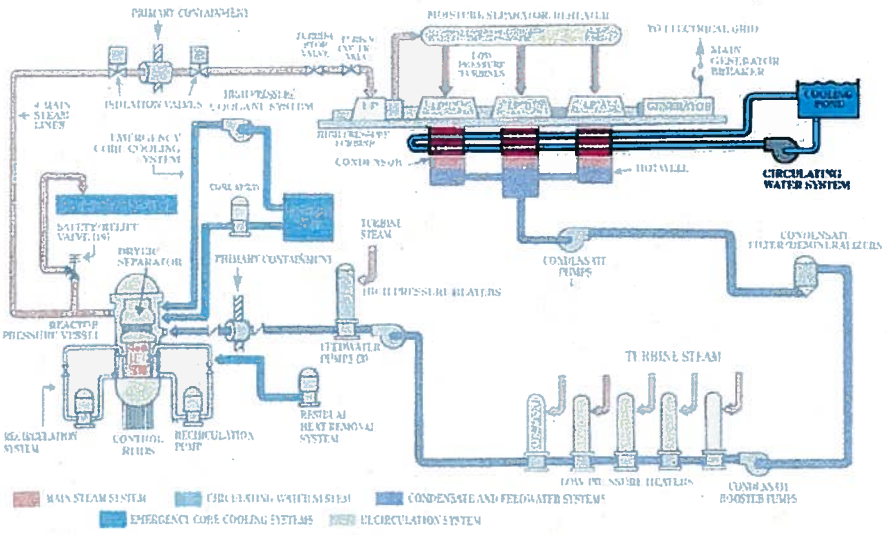


Vermont Yankee is a boiling water reactor. The heat produced by the reactor core boils water. That steam spins a turbine connected to a generator to make electricity. The steam is then condensed back into water form and returned to the reactor pressure vessel for another cycle.

Appendix A – Boiling Water Reactor Schematic

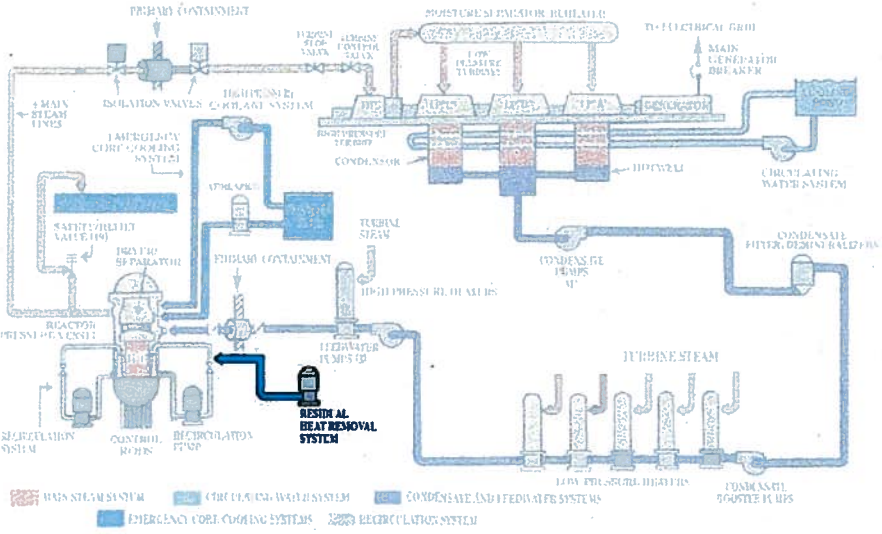


The condensate and feedwater systems take water from the condenser's hotwell, treat it in filter/demineralizer units to remove impurities, pre-warm it via a series of heat exchangers, and supply it at a controlled rate to maintain the desired water level above the core inside the reactor pressure vessel.

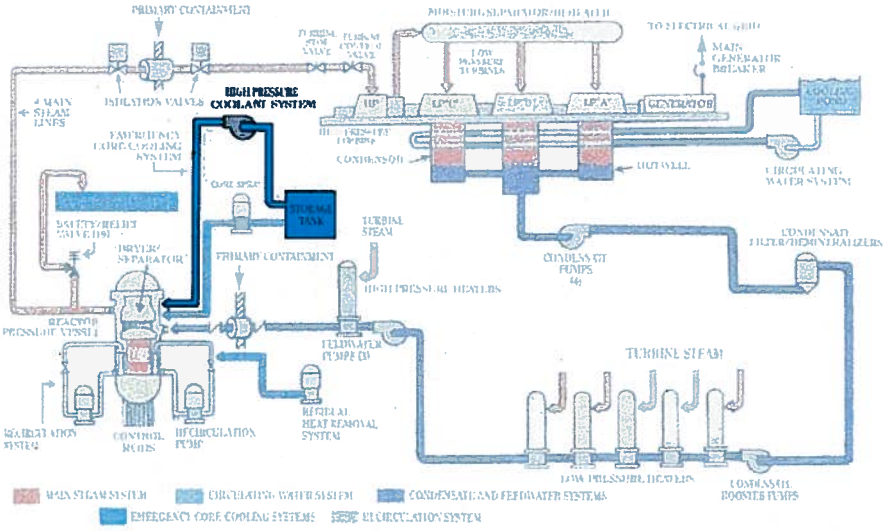


The circulating water system condenses the steam leaving the turbine. Water taken from the Connecticut River and/or the cooling tower basin passes through thousands of metal tubes inside the condenser. The steam outside the tubes is cooled and converted back into water.

Appendix A – Boiling Water Reactor Schematic



The residual heat removal system performs several functions. Its primary function is to supply makeup water to the reactor pressure vessel in event of an accident, such as a broken pipe that drains cooling water. The RHR system is normally in standby mode, starting automatically or manually when needed.



In event of an accident, the high pressure coolant system uses steam produced by the reactor core to spin a turbine connected to a pump. That pump transfers water from a large storage tank, or the suppression pool (torus), to the reactor pressure vessel to cool the reactor core.

Appendix B – Panel Resumes

Peter A. Bradford

Peter Bradford is an adjunct professor at Vermont Law School, where he teaches Nuclear Power and Public Policy. He was a Commissioner on the U.S. Nuclear Regulatory Commission (1977-82) and chair of the New York State Public Service Commission (1987-95) and the Maine Public Utilities Commission (1982-1987). He has participated in a National Academy of Sciences Panel on alternatives to the Indian Point nuclear power plants in New York, the 2007 Keystone Center fact finding project with regard to U.S. nuclear power, a 1998 European Bank for Reconstruction and Development review of ways to replace the Chernobyl nuclear station in Ukraine, a 1999 walkdown of the Mochovce nuclear power plant in Slovakia, and a 1993 U.S. Office of Technology Assessment study on aging nuclear power plants.

Arnold Gundersen

A former nuclear industry senior vice-president and whistleblower, Mr. Gundersen currently teaches math at the Community College of Vermont. He earned his Bachelor's and Master's Degrees in Nuclear Engineering cum laude from Rensselaer and was a licensed reactor operator during his career in the nuclear industry. As a Senior Vice President, Mr. Gundersen's business responsibilities encompassed about 400 technical and engineering employees at nuclear plants throughout the country. He was responsible for projects at 70 nuclear plants, including providing nuclear fuel racks for Vermont Yankee in the 1980's. He holds one patent for an "Energy Absorbing Turbine Missile Shield" for nuclear power plants. As an independent nuclear engineer and expert witness, Mr. Gundersen reviewed more than 200,000 pages regarding Vermont Yankee's uprate application, decommissioning fund, and life extension. In testimony to the VT PSB, he predicted the VY cooling tower collapse, as well as predicting aging management issues, inspection problems similar to those that led to the VY transformer fire, and the shortfall in the Decommissioning Fund. As an expert witness, he was frequently called upon to testify to the NRC, Congressional and State Officials on nuclear power operations and has also testified to the Czech Republic's Senate. He was an expert witness in the cases involving Three Mile Island, Western Atlas, Peach Bottom, and Florida Power and Light. Mr. Gundersen was a co-author of the initial DOE Decommissioning Handbook (1982), co-author of the Fairewinds Associates white papers on the ENVY Decommissioning Shortfall (2006), and is presently writing two scientific papers regarding Strontium 90 releases from early Boiling Water Reactors and on the radiation releases from Three Mile Island.

Appendix B – Panel Resumes

David Lochbaum

Until February 13, 2009, David Lochbaum was the Director of the Nuclear Safety Project for the Union of Concerned Scientists. Mr. Lochbaum led UCS's efforts to ensure the safety of nuclear power in the United States by monitoring licensed commercial nuclear plants to identify and publicize safety risks.

David Lochbaum has more than seventeen years of experience in commercial nuclear power plant start-up testing, operations, licensing, software development, training, and design engineering. He has worked on safety issues at the Hope Creek and Salem (New Jersey), Brunswick (North Carolina), Perry (Ohio), Limerick and Susquehanna (Pennsylvania), Wolf Creek (Kansas), Haddam Neck (Connecticut), Fitzpatrick and Indian Point 3 (New York), Grand Gulf (Mississippi), Browns Ferry (Alabama), and Hatch (Georgia) nuclear plants. In 1992, he and a colleague identified deficiencies in the design for spent fuel pool cooling at the Susquehanna plant and reported their concerns to the plant owner, to the Nuclear Regulatory Commission, and then to Congress. Their efforts resulted in safety improvements at Susquehanna and at other nuclear plants with similar problems.

Prior to joining UCS in October 1996, Mr. Lochbaum served as a Senior Engineer for Enercon Services, Inc., System Engineer for General Technical Services, Reactor Engineer/Shift Technical Advisor for the Tennessee Valley Authority, BWR Instructor for General Electric, and Junior Engineer for Georgia Power.

Mr. Lochbaum received a Bachelor of Science in Nuclear Engineering from the University of Tennessee in 1979. He has been a member of the American Nuclear Society since 1978. Mr. Lochbaum has written numerous articles on various aspects of nuclear safety and published books entitled *Nuclear Waste Disposal Crisis* and *Fission Stories.*

Appendix B – Panel Resumes

C. Frederick (Fred) Sears

Dr. C. Frederick Sears is a nuclear safety and management consultant with over 47 years of experience in the nuclear industry. He recently retired from The Pennsylvania State University where he served as Director of their Radiation Science and Engineering Center. Prior to working at Penn State Dr. Sears had retired as a Vice-President at Northeast Utilities (NU) where he had been responsible for corporate environmental activities. Prior to that he had been the NU VP responsible for Nuclear Engineering including safety and nuclear analysis, PRA, QA/QC, nuclear training, generation facilities licensing, nuclear services support (including radiological protection, emergency preparedness, chemistry support, materials management, and event analysis), nuclear fuel supply, safety review committees, and environmental services. He served as the corporate nuclear emergency director and spokesperson. He was also responsible for the management of the annual corporate generation facility (nuclear and fossil) budgets. Prior to working at NU he was employed by Combustion Engineering (CE) in roles ranging from Chief Test Engineer for startup and testing of CE supplied NSSSs, to Assistant Project Manager to Manager, Product Development. He also served on active duty in the U.S.Army Reactor Group where he was the Assistant Chief, Nuclear Branch responsible for reload design, safety analysis and testing of Army nuclear power plants; during this service he qualifies as Officer-in-Charge (equivalent of station director). In addition to his Army reactor qualification he has held four NRC/AEC reactor or senior reactor licenses.

Sears has served on numerous nuclear industry committees including: DOE's Advisory Committee on Nuclear Facility Safety; Wisconsin Energy Board's Nuclear Oversight Committee; National Academy of Science's Bilateral Exchange with USSR on Reactor Safety; Industry Degraded Core Committee (IDCOR) – Vice Chair; Industry committees on Chernobyl and TMI; and Executive Committees for GE Boiling Water Reactors Owners Group; Test, Research & Training Reactor Group; American Nuclear Society-Nuclear Installation Safety Division - Chair; EPRI Advanced Light Water Reactors – Chair; and Industry Radioactive Waste Management Committee (EEI-UWASTE) – Chair. He has also worked with the companies managing the DOE complexes at Hanford and Savannah River regarding design basis reconstruction and reactor operations.

Sears hold's bachelors and masters degrees in physics and nuclear science & engineering from the Virginia Polytechnic Institute and State University and a doctorate in nuclear engineering from the Pennsylvania State University. He also has completed the Executive Management Program of the Edison Electric Institute and the Advanced Management Program of the Harvard School of Business.

Appendix B – Panel Resumes

William K. Sherman

William Sherman was Vermont State Nuclear Engineer from 1988 until 2007. He served as lead expert witness in numerous cases before the Vermont Public Service Board involving nuclear power and Vermont Yankee, including the sale of Vermont Yankee to AmerGen, the sale of Vermont Yankee to Entergy, the increase in power output by 20% (power uprate), and the implementation of dry cask storage of used nuclear fuel. He was the primary policy advisor for nuclear power to four Vermont administrations. He testified regularly before committees of the Vermont General Assembly on nuclear matters, and served as expert witness in Federal Energy Regulatory Commission (FERC) cases involving nuclear decommissioning. Mr. Sherman was a prime negotiator of the Texas Low-level Radioactive Waste Disposal Compact, and Vermont's member for the Compact. He was Chairman of the Northeast High-Level Radioactive Waste Transportation Task Force. He was also Vermont's representative on the Nuclear Waste Strategy Coalition, a coalition of state public utility commission, attorney general and nuclear utility representatives, acting to affect a solution for the disposal of nuclear high-level radioactive waste. During the period as State Nuclear Engineer, he maintained cognizance of the daily status of operation of the Vermont Yankee Nuclear Plant and conducted periodic inspections at Vermont Yankee. He was Vermont's liaison with the Nuclear Regulatory Commission. Earlier, Mr. Sherman had a fourteen-year engineering career with an architect/engineering firm, where he was responsible for technical and administrative activities associated with the licensing, engineering and construction of various nuclear power plants. Mr. Sherman is a registered professional engineer in three states.

Appendix C – Scope for NSA Reliability Assessment

PUBLIC OVERSIGHT PANEL
(In accordance with Act 189)
C/O Arnie Gundersen
376 Appletree Point Road
Burlington, VT 05408

Peter Bradford
Arnie Gundersen
David Lochbaum
Fred Sears
William Sherman

October 28, 2008

David O'Brien, Commissioner
Vermont Department of Public Service
112 State Street, Drawer 20
Montpelier, VT 05620-2601

Dear Commissioner O'Brien:

Over the past weeks, the Act 189 Public Oversight Panel has been in discussion with the Department of Public Service regarding the scope of the comprehensive reliability assessment ("audit") that will be conducted by the Act 189 audit inspection team.

The scope of the audit is set out in Act 189: section 2 of Act 189 lists the goals and objectives of the audit; section 3 lists the specific systems to be assessed in the audit; and section 4 lists specific inquiries for each system analyzed as part of the audit.

Section 3(b) of Act 189 authorizes the Public Oversight Panel to select, in consultation with the Department, additional systems for inclusion in the audit. Section 5(a) requires the Department to conduct a vertical investigation of each system unless, in consultation with the Panel, the Department determines that such methodology would be "inefficient or ineffective."

With due considerations to the requirements of Act 189, the Panel, at our meeting of October 3, 2008, determined that the scope of work for the audit and inspection, described in the attached matrix dated October 28, 2008, will satisfy the intent of the Legislation. It is our understanding that the Department of Public Service is in agreement with, and will implement, this scope of work.

Please contact the Public Oversight Panel if you have questions regarding the interpretation of our matrix.

Sincerely,

William Sherman, for the Panel
Interim Chair of the Public Oversight Panel

Enclosure
Cc: Members of the Act 189 Public Oversight Panel
Peter Shumlin, President Pro Tempore of the Vermont Senate
Gaye Symington, Speaker of the Vermont House of Representatives

Appendix C – Scope for NSA Reliability Assessment

ACT 189 - PUBLIC OVERSIGHT PANEL
Recommendations for Implementation of the Comprehensive Reliability Assessment

	Section 3(a)(1): Electrical System: Back-up or stand-by electrical system				Section 3(a)(2): An Emergency System: the Emergency Core Cooling System	
	Diesel Generators	Batteries	Vernon dam tie	All associated electrical connections and controls	High pressure coolant injection system (HPCI)	Low Pressure Injection System
Vertical Audit						
4(1) Initial conditions	• Was loading an issue in 1992? • Why was loading missed in 1992 EDSFI? • Look at corrective actions identified in 1992 EDSFI and subsequent inspections. How were the corrective actions implemented? • Look at findings in CDBIs and corrective actions; relate back to EDSFI. • Look at license event reports (LERs) for these areas and how they were resolved.		N/A	• Look at corrective actions identified in 1992 EDSFI. • How were those corrective actions implemented?	yes	Done in 3(a)(4) - RHR
4(2) Procurement			N/A		yes	Done in 3(a)(4) - RHR
4(3) Installation			N/A		yes	Done in 3(a)(4) - RHR
4(4) Operation			• Look at corrective actions identified in NRC IR-2004008 and in other inspections. • How were those corrective actions implemented?		yes	Done in 3(a)(4) - RHR
4(5) Testing					yes	Done in 3(a)(4) - RHR
4(6) Inspection					yes	Done in 3(a)(4) - RHR
4(7) Maintenance					yes	Done in 3(a)(4) - RHR
4(8) Repairs					yes	Done in 3(a)(4) - RHR
4(9) Modifications					yes	Done in 3(a)(4) - RHR
4(10) Redesign					yes	Done in 3(a)(4) - RHR
4(11) Seismic Analysis (See Note 1)					yes	Done in 3(a)(4) - RHR
4(12) Training					yes	Done in 3(a)(4) - RHR
4(13) CAPs					yes	Done in 3(a)(4) - RHR
5(a)(2) Horizontal	If required	If required	If required	If required	If required	If required
5(a) Notes on methodology	See above	See above	See above	See above	Baseline: • HPCI Report (2000) • CDBI (2006)	
5(b) Add'l Inquiries						
Notes	Note 1: Seismic analysis applies to those systems for which a full review is being performed. Review existing bases for seismic analysis to assure that loads are within the initial design envelope. Modifications should also be verified for seismic adequacy.					

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Appendix C – Scope for NSA Reliability Assessment

ACT 189 - PUBLIC OVERSIGHT PANEL
Recommendations for Implementation of the Comprehensive Reliability Assessment

	Section 3(a)(3): A Mechanical System: The condensate/ feed water system		Section 3(a)(4): The primary containment system					
	Condensate/ Feed Water System	Condenser	Dry well shell	Torus supports	Residual Heat Removal System (RHR)	Isolation valves	Containment Spray	Adequate Suction
Vertical Audit								
4(1) Initial conditions	yes	yes	• Coating • Thickness • Weld inspections • Type A, B, C tests (review adequacy of these tests including trends determined in isolation valve testing)	• Fitzpatrick	yes	• Type C Tests (review adequacy of programs)	Done in 3(a)(4) - RHR	
4(2) Procurement	yes	yes			yes		Done in 3(a)(4) - RHR	
4(3) Installation	yes	yes			yes		Done in 3(a)(4) - RHR	
4(4) Operation	yes	yes			yes		Done in 3(a)(4) - RHR	
4(5) Testing	yes	yes			yes		Done in 3(a)(4) - RHR	
4(6) Inspection	yes	yes			yes		Done in 3(a)(4) - RHR	
4(7) Maintenance	yes	yes			yes		Done in 3(a)(4) - RHR	
4(8) Repairs	yes	yes			yes		Done in 3(a)(4) - RHR	
4(9) Modifications	yes	yes			yes		Done in 3(a)(4) - RHR	
4(10) Redesign	yes	yes			yes		Done in 3(a)(4) - RHR	
4(11) Seismic Analysis (See Note 1)	yes	yes			yes		Done in 3(a)(4) - RHR	
4(12) Training	yes	yes			yes		Done in 3(a)(4) - RHR	
4(13) CAPs	yes	yes			yes		Done in 3(a)(4) - RHR	
5(a)(2) Horizontal	If required	If required			If required		If required	
5(a) Notes on methodology	• Report (2004) • Checkworks Testimony	• Report (2004) • Checkworks						
5(b) Add'l Inquiries								
Notes								

Appendix C – Scope for NSA Reliability Assessment

ACT 189 - PUBLIC OVERSIGHT PANEL
Recommendations for Implementation of the Comprehensive Reliability Assessment

	Section 3(a)(5): A heat removal system			Section 3(a)(6): Cooling system dependent upon Connecticut River water		Section 3(a)(7): An underground piping system that carries radionuclides
	Normal cooling towers	Emergency-related cooling towers	Alternate cooling system	Alternate cooling system	Emergency service water	
Vertical Audit						See Note 3
4(1) Initial conditions	yes	yes	done in 3(b) (SWS)	done in 3(b) (SWS)	yes	
4(2) Procurement	yes	yes	done in 3(b) (SWS)	done in 3(b) (SWS)	yes	
4(3) Installation	yes	yes	done in 3(b) (SWS)	done in 3(b) (SWS)	yes	
4(4) Operation	yes	yes	done in 3(b) (SWS)	done in 3(b) (SWS)	yes	
4(5) Testing	yes	yes	done in 3(b) (SWS)	done in 3(b) (SWS)	yes	
4(6) Inspection	yes	yes	done in 3(b) (SWS)	done in 3(b) (SWS)	yes	
4(7) Maintenance	yes	yes	done in 3(b) (SWS)	done in 3(b) (SWS)	yes	
4(8) Repairs	yes	yes	done in 3(b) (SWS)	done in 3(b) (SWS)	yes	
4(9) Modifications	See note 2	yes	done in 3(b) (SWS)	done in 3(b) (SWS)	yes	
4(10) Redesign	yes	yes	done in 3(b) (SWS)	done in 3(b) (SWS)	yes	
4(11) Seismic Analysis (See Note 1)	yes	yes	done in 3(b) (SWS)	done in 3(b) (SWS)	yes	
4(12) Training	yes	yes	done in 3(b) (SWS)	done in 3(b) (SWS)	yes	
4(13) CAPs	yes	yes	done in 3(b) (SWS)	done in 3(b) (SWS)	yes	
5(a)(2) Horizontal	If required	If required	If required	If required	If required	
5(a) Notes on methodology						
5(b) Add'l Inquiries	Root cause report on cooling towers					
Notes	Note 2: Tower modifications to be examined include (1) whether 1987 replacement of fill in seismic tower is sufficient and (2) whether new 2006 fiberglass beams in West Tower may plug suction.					Note 3: The panel is informed that there are no underground piping systems carrying radioactivity at Vermont Yankee.

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Appendix C – Scope for NSA Reliability Assessment

ACT 189 - PUBLIC OVERSIGHT PANEL
Recommendations for Implementation of the Comprehensive Reliability Assessment

	Section 3(b): Additional Systems				Section 3(c): Generic Systems Issue: Cable separation - Separation of safety systems		Section 2(2): Deviations, exemptions or waivers from new reactor regulatory requirements
	Main Transformer	Service Water System (SWS)	Management and Corporate Review	Sister Plant Review	Physical Separation	Electrical Separation	
Vertical Audit		See Note 4	NSA Scope of Work, dated 10/14/08	NSA Scope of Work, dated 10/14/08	NSA Scope of Work, dated 10/22/08	NSA Scope of Work, dated 10/22/08	Two systems shall be chosen for which vertical slices inspections are being performed. The current Standard Review Plans applicable to those systems shall be reviewed and compared with the Vermont Yankee Design Basis Documents for those systems. Differences from current requirements shall be identified, and an assessment of these differences on reliability shall be rendered.
4(1) Initial conditions	yes	yes					
4(2) Procurement	yes	yes					
4(3) Installation	yes	yes					
4(4) Operation	yes	yes					
4(5) Testing	yes	yes					
4(6) Inspection	yes	yes					
4(7) Maintenance	yes	yes					
4(8) Repairs	yes	yes					
4(9) Modifications	yes	yes					
4(10) Redesign	yes	yes					
4(11) Seismic Analysis (See Note 1)	yes	yes					
4(12) Training	yes	yes					
4(13) CAPs	yes	yes					
5(a)(2) Horizontal	If required	If required					
5(a) Notes on methodology							
5(b) Add'l Inquiries	Root cause report on transformer fire	Tank Inspection Program (BPTIP)					
Notes	Note 4: Since the panel is informed there are no undergroundpiping systems carrying radioactivity, the Panel designates the Service Water System, which has buried piping, to be evaluated. The Buried Pipe and Tank Inspection Program (BPTIP) will be evaluated as part of the review of SWS.						

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Appendix D – Documents Relied On by the Panel Members

This Appendix lists documents relied on by the Panel in its deliberations.*

1. *Reliability Assessment of the Vermont Yankee Nuclear Facility*, Nuclear Safety Associates, December 22, 2008, Redacted Public Version: Redaction as of January 15, 2009.

2. *Appendix G: Evaluation of Vermont Yankee Root Cause Analyses performed on The Electrical Fault/Fire (2004) and The Cooling Tower Events (2007-2008)*, Nuclear Safety Associates, undated (redaction as of January 15, 2009).

3. Exhibit DPS – Panel-2, *Technical Information Addendum*, Vermont Yankee Reliability Assessment Report, Nuclear Safety Associates, Filed with DPS Prefiled Direct Testimony in PSB Docket No. 7440, February 12, 2009.

4. Exhibit DPS – Panel-3, *Response to Oversight Panel Questions*, Vermont Yankee Reliability Assessment Report, Nuclear Safety Associates, Filed with DPS Prefiled Direct Testimony in PSB Docket No. 7440, February 12, 2009.

5. Exhibit DPS – Panel-4, *Reliability Assessment Errata Sheet*, Vermont Yankee Reliability Assessment Report, Nuclear Safety Associates, Filed with DPS Prefiled Direct Testimony in PSB Docket No. 7440, February 12, 2009.

6. Exhibit DPS – Panel-5, *Search Results for ENVY Regulatory Exemptions, Deviations and Waivers*, Vermont Yankee Reliability Assessment Report, Nuclear Safety Associates, Filed with DPS Prefiled Direct Testimony in PSB Docket No. 7440, February 12, 2009.

7. *Generic Aging Lessons Learned (GALL) Report*, NUREG-1801, Vol. 1, Rev. 1

8. *Generic Aging Lessons Learned (GALL) Report*, NUREG-1801, Vol. 2, Rev. 1

9. NRC Standard Review Plan 3.5.1.3, *Turbine Missiles,* NUREG-0800, Rev. 3, March 2007

* Redacted Versions of References 1 and 2 are listed. The Panel did not rely on confidential information for its Findings and Conclusions.

Appendix D – Documents Relied On by the Panel Members

10. NRC Standard Review Plan 6.3.3, *Emergency Core Cooling Systems*, NUREG-0800, Rev. 3, March 2007

11. NRC Standard Review Plan 9.2.1, *Station Service Water System,* NUREG-0800, Rev. 5, March 2007

12. NRC Standard Review Plan 9.2.5, *Ultimate Heat Sink,* NUREG-0800, Rev. 3, March 2007

13. *U.S. capacity factors: Another small gain, another new peak*, E. Michael Blake, Nuclear News, May 2008, pp. 28-34

14. Email D. McElwee, ENVY, to U. Vanags, DPS, VY Cap Factor, attaching table of VY historical capacity factors, February 17, 2009

15. Email D. McElwee, ENVY, to U. Vanags, DPS, FW: MSIV History.xls, December 9, 2008

16. Summary List of NRC Team Inspections at Vermont Yankee, 1986 – 2008.

17. Root Cause Analysis Report, Electrical Fault/Fire, ENVY, CR 04-2015, Rev. 2, 4-26-2005

18. Root Cause Analysis Report, Electrical Fault/Fire, ENVY, CR 04-2015, Rev. 2, 7-27-2004, p. 23 of 33

19. Root Cause Analysis Report, Structural Failure of CT 2-4, ENVY, CR-VTY-2007-03243, 9-21-2007, pp. 7, 8, and 9 of 22

20. Root Cause Analysis Report, Structural Failure of CT 2-4, ENVY, CR-VTY-2007-03243, 9-21-2007, Attachment H – Interview Notes

21. CR-VTY-2004-02183, Inadequate OE Response with Surge Arrester and Electrical Bus Flexible Connector Inspection and Preventive Maintenance/Testing, 7-4-2004

22. Direct testimony, Arnold Gundersen, May 15,2003, Docket 6812

23. Letter to DPS, August 12, 2003

24. Prefiled Surrebutal Testimony, Arnold Gundersen, August 19, 2003, Docket 6812

Appendix D – Documents Relied On by the Panel Members

25. Prefiled Surrebuttal Testimony, Arnold Gundersen, October 3, 2003, Docket 6812
26. Prefiled Surrebuttal Testimony, Arnold Gundersen, December 11, 2003, Docket 6812
27. Prefiled Surrebuttal Testimony, Arnold Gundersen, January 2, 2004, Docket 6812
28. Direct Testimony, Arnold Gundersen, June 29, 2004, Docket 6812
29. Supplement and Amendment to Testimony, Arnold Gundersen, July 6, 2004, Docket 6812
30. Affidavit of Arnold Gundersen, March 8, 2006, Docket 6812
31. Declaration of Arnold Gundersen, NRC Docket 50-271-LR, ASLB No. 06-849-03-LR
32. Affidavit for Motion for Summary Dismissal and Remand, State of Vermont Environmental Court, Docket 89-4-06
33. *Walking a Nuclear Tightrope: Unlearned Lessons of year-plus Reactor Outages*, David Lochbaum, Union of Concerned Scientists, September 2006
34. Email J. Marshall, for ENVY, to R. Ellis, for the Panel, NSA Report, page 18 - Allegedly Confidential Information, January 23, 2009