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An Independent Assessment of the Environmental and Economic Impacts Associated with the Closing of the Vermont Yankee Nuclear Plant

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Executive Summary

The Vermont Energy Partnership (VTEP) has retained Energy Strategies, Inc. to assess independently the environmental and economic impacts associated with the continued operation of the Vermont Yankee Nuclear Plant. The State of Vermont ranks among the "cleanest" regions in the United States in terms of lowest levels of airborne emissions. Vermont's electric power plants emit the lowest or second lowest levels of sulfur dioxide, nitric oxide and carbon dioxide, the three major atmospheric pollutants, when compared to the other 47 continental states.

With more than 98 percent of its electric generation fueled by non-hydrocarbon sources, Vermont is the "greenest" state. Because Vermont consumes about one-third of the Vermont Yankee output, utilities in the state must supplement purchases with electricity procured on the New England wholesale electric markets managed by the New England Independent System Operator (ISO-NE). As illustrated in Figure 1, more than 80 percent of electricity consumed in Vermont is derived from non-polluting sources. Vermont Yankee is a 620 megawatt (MW)[1], base load[2] power plant fueled by nuclear power. During 2004–06, the plant operated more than 98 percent of the time generating 15.7 billion kWh[3]. Put in perspective, the Vermont Yankee

1 A megawatt is the measure of electric power typically used to define the size of an electrical power plant or the instantaneous amount of electricity being used. For example, a typical light bulb draws about 100 watts. The Vermont Yankee plant produces enough electricity to energize more than six million light bulbs. (1000 watts = 1 kilowatt, a million watts is one megawatt.).

2 Electric generation typically operates in one of three modes: peaking – the plant is run only when the peak demand rises rapidly; midrange – the plant is run mostly during weekdays, and base load – the plant is run nearly all the time. Vermont Yankee runs almost 95% of the time.

3 A kilowatt-hour is the amount of electric energy either produced or consumed over a period of time. One kilowatt-hour (kWh) of electricity is equivalent to a 1 kw load running for one hour. A 100-watt light bulb consumes 100 watts per hour.

plant alone could have produced all of the electricity required by Vermont's 250,000 households without contributing any greenhouse gas emissions or other form of air pollution.[4]

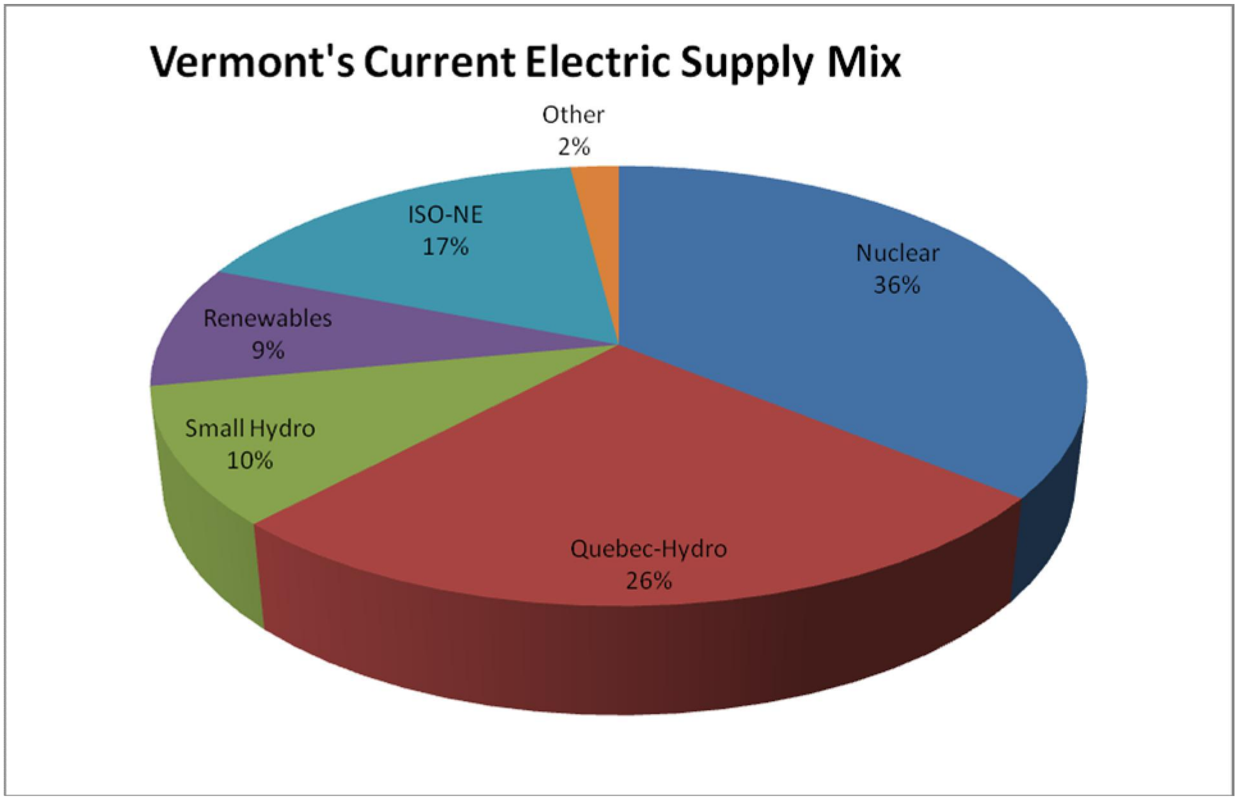

Figure 1: 2005 Electricity Markets in Vermont: Source Vermont Comprehensive Energy Plan 2009[5]

Vermont Yankee is owned and operated by a subsidiary of Entergy Corporation. As with all nuclear power plants, the operating license is regulated by the U.S. Nuclear Regulatory Commission (NRC), which is currently reviewing Entergy's application to extend the Vermont Yankee operating license another 20 years. Otherwise, the Vermont Yankee plant would be forced to retire by March 2012.

[4] Nuclear power plants release no sulfur dioxide, nitric oxide, particulates or carbon dioxide, the most common form of air pollutants from fossil based electric generation.

[5] See Figure II-10 Vermont Energy Supply 2005 (% of Total Energy Consumed), page II-30 http://publicservice.vermont.gov/planning/2009%20-%20CEP%20PUBLIC%20REVIEW%20DRAFT%20r1point2.pdf

The Vermont Energy Partnership is a diverse group of more than 90 business organizations, labor groups, community leaders and independent energy experts committed to finding clear, low-cost and reliable electricity solutions. VTEP is concerned that if Vermont Yankee is retired in 2012, the economic and environmental consequences would be significant. **This report confirms these concerns. Statewide average retail electric prices could increase, likely by as much as 19.3 percent and greenhouse gases from all sources of electricity generation in the state by a hundredfold. If Vermont Yankee were instead replaced by a combination of energy conservation and renewable resources with replacement costs exceeding $200/MWH, the average cost of electricity could rise by the equivalent of 39 percent.**[6]

Opponents to the continued operation of Vermont Yankee past 2012 argue that other forms of renewable resources added to a more aggressive conservation program could supplant the need for Vermont Yankee. However, it is likely that even with an added renewable resource, namely wind generation or wood based biofuel, and a more aggressive statewide conservation program, such actions barely will keep up with the expected growth in electrical demand with Vermont Yankee remaining on-line.[7]

There is no question that wind energy and other renewable resources will play a vital role in meeting Vermont's growing energy needs. However, it is highly unrealistic to assume that between the end of 2009, when the NRC is expected to rule on the Vermont Yankee relicensing application, and 2012, when the original operating license expires, Vermont could add the necessary magnitude of renewable generation. At this time, Vermont has only six MW of operating wind generation, with another 120 MW in the planning or permitting stage. To replace Vermont Yankee, which produces 620 MW 95 percent of the time, with an equivalent number of wind-derived electricity would require the installation of more than 1,500 wind generators.[8] Given that the largest wind farms install only a few hundred generators, the addition of 1,500

[6] Electricity prices would not actually increase by 39% as much of the cost increases to consumers would be in the form of added expenses for conservation investments which would be offset by reduced electricity usage.
[7] Source: Biennial Report to the Vermont General Assembly by the Vermont Public Service Board, December 2007.
[8] A typical commercial sized wind generator is about 1.5 MW and operates about 25% of the time. To achieve parity, more than 1,500 1.5 MW wind generators would be required, assuming such diversity that the electricity production is spread evenly throughout the day.

generators with the associated transmission lines needed to connect to the Vermont network, 2012 is an unrealistic completion date. Of course, there are other forms of renewable resources, including solar and biomass, for which Vermont has an abundant supply of wood materials[9]. However, none of these alternatives is a practical solution to replace Vermont Yankee for two basic reasons:

1. It will take far more than three years to plan for, design and then install 620 MW of wind, solar and/or biomass. Even the most aggressive plans for renewable resource development in Vermont call for a fraction of the electric energy produced by Vermont Yankee.

2. The land resources needed to be committed to solar, wind and biofuels is substantial and would necessitate years of regulatory and siting review. To illustrate:

    a. A 620 MW wood chip plant would require the harvesting of over 200,000 acres of forestry or roughly 5 percent of Vermont – over the 20 year life extension sought for Vermont Yankee nearly all of Vermont's forests would have to be harvested and replaced.

    b. For solar, at a typical 15 watts of electricity per square foot of solar panel, another 2,000 acres of land would need to be cleared – and even this would only account for roughly one fifth of the electricity produced by Vermont Yankee.

[9] However, solar electric systems remain extremely expensive in the Northeast with capital costs exceeding $9,000 per kW and only operate 20 – 30 percent of the time. This compares to approximately $6,000 per kW for a Greenfield nuclear plant that would operate more than 90 percent of the time. Recent cost estimates for a New England-based wood chip bio-fueled power plant have also exceeded $6,000 per kW.

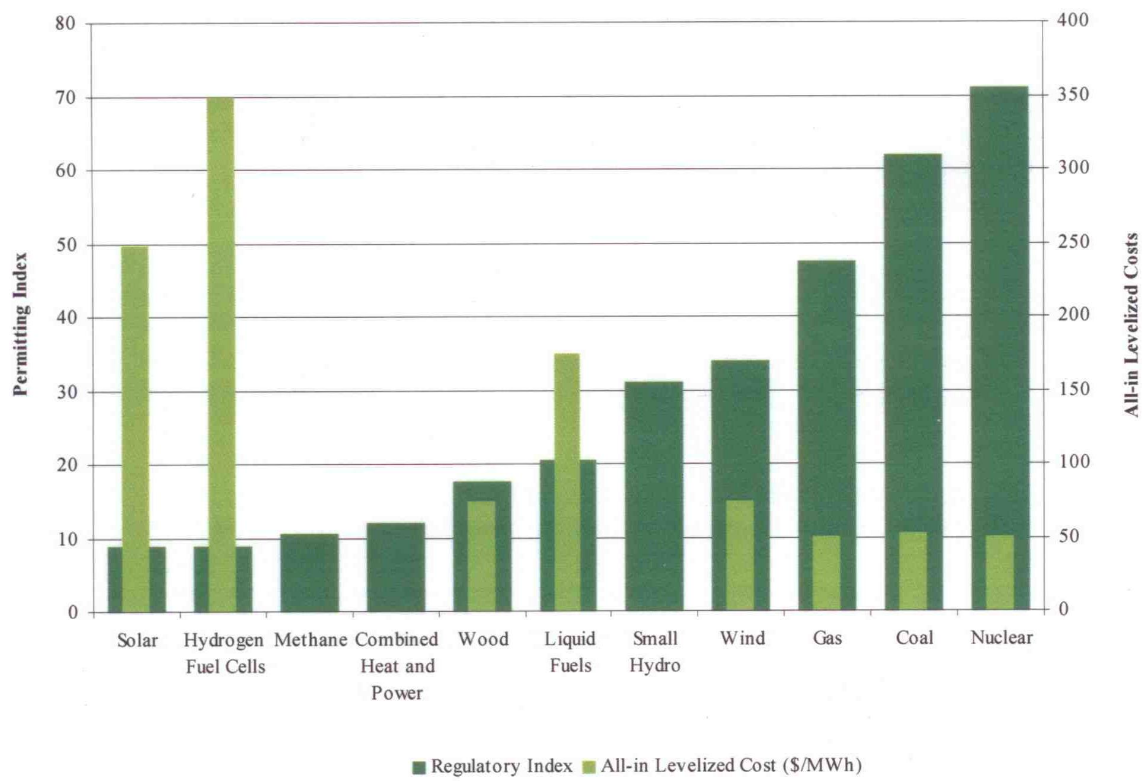

Figure 2: Characteristics of Generation Technologies[10]

Vermont's Clean Energy Development Fund was established by the Vermont General Assembly and funded by Entergy Nuclear at a cost of $4-7 million a year to promote the development and deployment of cost effective and environmentally sustainable electric production resources. Yet, even with this measure there are formidable difficulties in expanding the use of renewable power sources. The cost of such alternative technologies is very expensive relative to the economic value of power produced, as illustrated in the above bar graph (Figure 2), especially when compared to more conventional forms of electric generation.

[10] Vermont Comprehensive Energy Plan – May 2008.

There is one alternative to Vermont Yankee that might meet the tight time schedule, namely the installation of 620 MW of combined cycle gas turbines (CCGT). CCGTs are highly efficient relative to other forms of conventional fossil-based generation, can be installed in a very short construction cycle and are comparatively inexpensive to build. Unfortunately, CCGTs require large volumes of natural gas and will produce significantly more nitric oxide and carbon dioxide, the latter a major source of global warming. From a cost perspective, a new CCGT will be twice as expensive and significantly more uncertain as the price of natural gas represents more than 70 percent of a CCGT's operating costs.

The Vermont Comprehensive Energy Plan 2009, prepared by the Vermont Department of Public Service, clearly points out that Vermont's competitive advantage of having the lowest cost electricity in New England coupled with its negligible carbon footprint is in jeopardy. With both the Vermont Yankee and Hydro-Québec contracts expiring within the next several years and without the renewal of either or both, energy prices will rise rapidly and Vermont's position as one of the cleanest states will fall. With Vermont Yankee's relicensing, utilities in Vermont will at least have the opportunity to negotiate a reliable source of electricity. Furthermore, even if such a contract could not be consummated, Vermont's consumers would at least reap the benefits of the Revenue Sharing Mechanism that calls for Vermont Yankee to share 50/50 any surplus revenues above $61/MWH sold in the wholesale market, assuming the license renewal is approved by the federal Nuclear Regulatory Commission.

Study Scope

The 620 MW Vermont Yankee Nuclear plant has an operating license to March 2012. Nuclear Regulatory Commission approval of Entergy's application for a 20-year license extension would permit operation of the plant through 2032. Opponents contend that Vermont Yankee should be retired by 2012, if not sooner, and claim that conservation and renewable resources can replace the electricity generated by the Vermont Yankee plant.

The purpose for this study, sponsored by the Vermont Energy Partnership, is to evaluate and assess the environmental and economic impacts associated with the operation and non-operation of the Vermont Yankee plant. This study does not attempt to justify the continued operation of Vermont Yankee per se, but to assess the environmental and economic consequences of a variety of Vermont Yankee operating or non-operating scenarios. For example, while Vermont Yankee generates 620 MW, only 273 MW[11] are dedicated to Vermont users. The remainder is allocated to other users throughout New England. As a result, Vermont Yankee's closure would only result in a loss of 273 MW from Vermont's generation mix. However, in the converse, the approximately 45 percent of the Vermont Yankee output consumed in Vermont could theoretically be increased to 60 or 75 percent, thus retaining Vermont's minimal environmental footprint even as electric load grows over time.

As the current Vermont Yankee license expires in 2012, Vermont also faces the expiration of the Hydro-Québec contract for 310 MW of hydroelectric power by 2015.[12] These two sources supply nearly two-thirds of Vermont's electrical needs. If Vermont Yankee were retired in 2012, not only would Vermont utilities be faced with a loss of nearly half of their base load capacity, their negotiating position with Hydro-Québec would be seriously undermined.

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[11] Vermont's current peak electrical load is approximately 500MW.

[12] Source: Biennial Report to the Vermont General Assembly by the Vermont Public Service Board, December 2007.

To assess the environmental and economic impact of Vermont Yankee, four operating scenarios were evaluated:

- Vermont Yankee retirement in 2012
- Vermont Yankee license extension through 2032 with 45% output sold to Vermont
- Vermont Yankee license extension through 2032 with 60% output sold to Vermont
- Vermont Yankee license extension through 2032 with 75% output sold to Vermont

The Vermont Energy Partnership is very concerned with the environmental impact of closing Vermont Yankee. While Vermont Yankee does not release sulfur dioxide, nitric oxide or carbon dioxide, the most common forms of air pollutants, any replacement that is fossil based will. Because more than 98 percent of Vermont's electrical generation is non-polluting, the State of Vermont has among the lowest levels of airborne emissions of any state in the continental U.S. While some opponents to the Vermont Yankee license extension contend that energy conservation and renewable resources could replace Vermont Yankee, this is unrealistic by 2012. To suggest that hundreds or even thousands of wind generators could be added to the Vermont electric network within four years is impractical.

In the long run, there will be renewable technologies such as solar, biomass and combined heat and power units (CHP) that will supplement Vermont's electric resource portfolio with both economical and environmentally sustainable alternatives. Vermont has an abundance of wood waste materials that would be an ideal fuel source for highly efficient CHP. Photovoltaic solar (PV) is another opportunity that is being considered especially as a supplement to residential and commercial building energy requirements. However, large scale applications for either biofuel or PV have yet to be proven practical. For example, the wood and waste wood materials needed to produce the same amounts of electricity as from Vermont Yankee would exceed 2 million tons of bone-dry wood per year. Based on an estimated ten tons of burnable wood product per acre[13], a Vermont Yankee biofuel replacement would require over 200,000 acres of woodlands to be cultivated each year, which represents nearly 5 percent of Vermont total geographic space. A twenty year Vermont Yankee license extension would equate to the burning and replacement of all of Vermont's forest wastes over this time frame. For solar, a state of the art PV system can produce about 15 watts per square foot of photovoltaic solar panels. The Vermont Yankee nuclear plant is 620 megawatts or 620 million watts. The equivalent number of solar collectors would require over 2,000 acres of dedicated space just for the solar collectors. To maximize exposure to the sun, an untold amount of land will have to be cleared in order to capture as much sun energy as possible.

It should not be misconstrued, solar, wind and biofuels can and should all contribute to Vermont's portfolio of energy resources, but to assume that 620 MW of Vermont Yankee power can be replaced by 2013 is unrealistic. In combination with an aggressive demand side management program, for which Vermont is already recognized as a national leader, it is very likely that Vermont can significantly offset the need for new electric generation to meet future electric load growth whether conventional or renewable. However, the cost is going to be expensive. To illustrate, both the Energy Efficiency Utility (EEU) and the Burlington Electric Department successfully promoted energy efficiency in homes and businesses. During the last two years, Vermont's electric consumption remained flat versus previous annual growth rates of 1-2 percent. However, the cost was substantial: from 2000 to 2006 more than 340,000 MWh were saved, but at an investment cost of between $213 and $270/MWh. The Vermont Comprehensive Energy Plan (2009) forecasts the maximum achievable cost effective electric energy efficiency potential of 1.3 million kWh at a cost of $6.6 million or $237/MWh. This compares to about $45/MWh for Vermont Yankee or even $100/MWh for a new high efficient combined cycle gas turbine.

[13] "Where wood works: Strategies for heating with woody biomass" by Flexible Energy Communities Initiative and sponsored by the U.S. Forest Service.

Furthermore, should Vermont Yankee be retired in 2012, utilities outside of Vermont would have to find replacements for the other 327 MW of Vermont Yankee output. It is equally likely that these users will replace Vermont Yankee capacity with substantially fossil-fired generation that would increase airborne emissions.

The current price for Vermont Yankee generated electricity is not market-based[14] but set at about $45/MWh via a rate formula contained in the Vermont Yankee sales agreement with Entergy Nuclear Vermont Yankee. This agreement also stipulated that should Vermont Yankee continue to operate after 2012 and the price of energy sold from Vermont Yankee exceeded $61/MWh starting in 2012 and escalated thereafter, those revenues representing the difference between the actual sale price and the $61 threshold would be shared on a 50/50 basis between Entergy and the owners of Vermont Yankee Power Corporation. As a result, even if Vermont consumers were no longer able to purchase Vermont Yankee energy, but instead bought from the Day Ahead Market (D.A.M.), they could reap a substantial benefit.

To illustrate, if the average D.A.M. was $100, then the revenue sharing mechanism would produce a net discount of $19.50/MWH ($100-$61 = $39 times 50% = $19.50) and the ultimate cost would be $81/MWH. Assuming this savings was passed on to Vermont's electricity consumers, with or without a Vermont Yankee contract, electricity prices would be substantially less than they would have been should Vermont Yankee be forced to retire in 2012.

There is little question that wholesale electric prices will rise in Vermont after 2012 whether Vermont Yankee operates or not. Both the Vermont Yankee and Hydro-Québec purchase power agreements expire between 2012 and 2015 freeing up wholesale suppliers to seek higher contract prices. With average ISO-NE D.A.M. prices currently at $100 or more, it would be unrealistic to assume that the stipulated prices in the 2002 agreement, about one

[14] The VY 2002 sales agreement set rates at about $45/MWh which was 13% less than the average Day Ahead Market (D.A.M.) price in 2003 – 2004 and 18% below historical regulated wholesale prices.

half that amount, could be sustained in the future. However, with Vermont Yankee's continued operation, the excess revenue sharing mechanism would help to mitigate future price increases.

From an environmental perspective, the impact of a Vermont Yankee closure would be even more dramatic. With more than 98 percent of Vermont's electric generation "green", replacement of Vermont Yankee would increase airborne emissions of toxic and greenhouse gases, e.g., carbon dioxide (CO_2), sulfur dioxide (SO_2), and nitric oxide (NO_X). The following sections of this report address the likely environmental and economic impacts associated with the retirement of Vermont Yankee in 2012 versus a range of supply options should the Vermont Yankee plant continue to operate until 2032.

Environmental Assessment

Environmental Impact

All electric power plants that burn a fuel derived from carbohydrates, which include coal, oil, natural gas and even wood, emit a range of air pollutants[15]. The three major sources of air pollution include carbon dioxide (CO_2), recognized as the major contributor to global warming, sulfur dioxide (SO_2), a contributor to smog, and nitric oxide (NO_X), which causes the weakening of the earth's ozone layer. Utilities have for many years invested in pollution control technologies and processes that have mitigated the effects of both SO_2 and NO_X emissions. However, effective abatement technologies for CO_2 from both power plants and automobiles, the two primary sources, have yet to emerge with cost-effective solutions. One of the leading strategies to reduce the automobile's contribution to global warming is to convert from the gasoline engine to electric motors. While this may prove effective in lowering one source of CO_2, unless the electricity produced for the electric car comes from non-fossil generation, the ultimate impact on global warming will be compromised.

Nuclear power is one form of electric generation that does not contribute to the air quality emissions discussed above. While the safe disposal of nuclear waste products and the ultimate decommissioning of the facility upon retirement require careful planning and execution, the overall safety history of nuclear power in the United States has been superlative as measured by levels of emissions released to the public and loss of life.[16] Whether one supports nuclear power, it is incontrovertible that the Vermont Yankee nuclear plant does not contribute to the carbon footprint in Vermont, but if the plant is retired in 2012, any replacement that burns a carbon-based fuel, including wood based bio-fuels, will.

[15] See http://www.epa.gov/air/caa/peg/ for more information on air pollution.

[16] The only major nuclear accident in the United States was at the Three Mile Island plant in 1979. The plant's containment system successfully protected the public from any radioactive release.

Electricity Sources

The vast majority of electricity throughout the United States is produced by conventional power plants, specifically:

- Hydroelectric plants
- Coal-fired power plants
- Natural gas (via combined cycle gas turbines)
- Nuclear power

Other sources of electricity include wind and solar generation, cogeneration which burns either natural gas or oil (diesel) and produces both electricity and steam energy used in industrial processes; biomass plants that burn either methane from landfills or waste materials ranging from garbage to woodchips, and small run-of-the-stream hydroelectric plants.

During the last three decades, the focus of environmental management relative to electric generation has been containing such air pollutants as particulates, sulfur dioxide and nitric oxide, all byproducts of burning fossil fuels. Advances in abatement technologies, as well as the shift from petroleum-based fuels to natural gas, have resulted in significant declines in emissions levels. Recently, however, scientists and environmental experts have been refocusing their attention on other environmental impacts, including carbon dioxide associated with global warming and the release of heavy metals such as mercury. Power plants that burn fossil fuels, especially coal, face the greatest challenge to contain these pollutants.

While there are emerging generation technologies that could burn coal, which is in abundant supply, by converting it into a natural gas type product and then capturing any CO_2 emissions, it is unlikely that any such plant would be built in New England within the next two decades. Extremely high capital costs, access to low-cost coal supplies and feasibility of CO_2 sequestration are all factors that would inhibit location in the Northeast, especially New England.

Vermont's Electricity Portfolio

Compared to other states, Vermont is unique because its electricity has been primarily produced by hydroelectric plants and nuclear power. Nearly 98 percent of the electricity consumed in Vermont comes from power plants that do not emit the preceding air contaminants. While the state does have hydroelectric plants, most of the hydro-based electricity is produced in Canada and sold under contract with Hydro-Québec. Vermont receives approximately 310 MW of hydroelectric generation from Hydro-Québec under a contract that will phase out by 2015 unless a new contract can be successfully negotiated.

The other major source of electricity in Vermont is the 273 MW from the Vermont Yankee Nuclear Power Plant owned by Entergy. Vermont Yankee produces 620 MW, which is sold throughout New England. What is most critical, however, is the rapid decline in contracted electrical supplies after 2012 as demonstrated in the following graphic. By 2016, of Vermont's 5,000 gigawatt hours (GWh) requirement, less than 1,000 GWh are known resources.

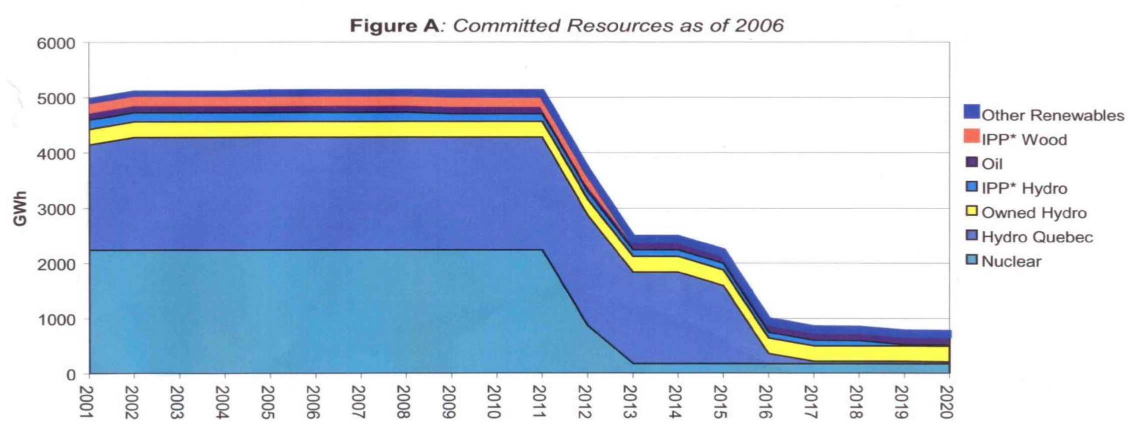

Figure 3: Committed Resources as of 2006

Both the Hydro-Québec and Vermont Yankee sources are base load, which means they produce electricity nearly round the clock. Because hydroelectric and nuclear power emits no SO_2, NO_X or CO_2, <u>closing Vermont Yankee and resorting to other sources of power will increase pollution</u>. As noted in the Vermont Comprehensive Energy Plan:

"Vermont's electric energy comes from a mix of local resources and major utility contracts. Two contracts dominate the Vermont mix, a major purchase power agreement with Hydro Québec (HQ) and a long-term agreement with Entergy for Vermont Yankee power. In large part owing to the existence of these two contracts, Vermont enjoys one of the most stable, low-priced, and environmentally benign (from the standpoint of carbon emissions) portfolios in the Northeast." (xiii)

And,

"Vermont has the smallest carbon footprint of any state in the U.S. and has one of the smallest on the basis of per capita emissions. Despite Vermont's current advantage, the state may be particularly challenged to maintain or improve upon that profile relative to other states. As noted below, Vermont's advantage is due in significant part to the existence of contracts for electricity with Vermont Yankee and Hydro-Québec." (Page I-7)

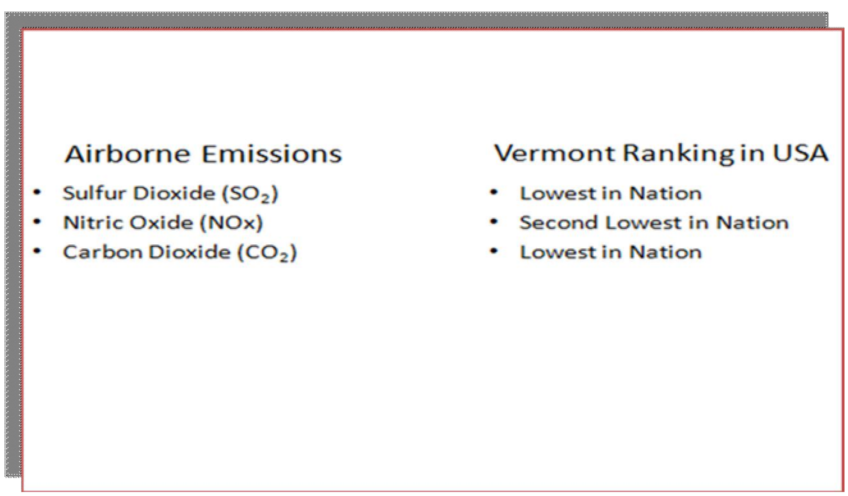

Figure 4

As illustrated in the following table from the U.S. Energy Information Administration's website (Figure 5), CO_2 emissions from electric power plants in Vermont average about 20,000 tons per year. This represents less than 1/100 of a percent of the carbon emitted in New England.

Greenhouse Emissions from electric production in Vermont are negligible when compared to the rest of New England as most of Vermont's electricity is produced by non-fossil generation – Hydroelectric & Nuclear

	Carbon Dioxide Emissions (tons/year)
• U.S Average State	• 50,000,000
Total New England	• 270,000,000
• Massachusetts	• 26,000,000
• Connecticut	• 9,700,000
• New Hampshire	• 5,000,000
• Rhode Island	• 3,200,000
• Vermont	• 20,000

Figure 5

In order to evaluate the impact Vermont Yankee has had on Vermont's environment, an assessment of various Vermont Yankee operating modes was evaluated. First, a baseline forecast of the three primary sources of airborne emissions was derived based on the trending of historical experience.[17] It was assumed that since Vermont Yankee emits no levels of SO_2, NO_X and CO_2, its continued operation would not influence existing trends. As the following three graphics demonstrate, with Vermont Yankee continuing to operate, statewide SO_2 levels are projected to remain nearly constant, NO_X levels will rise, while CO_2 levels decline. Figures 6, 7 and 8 illustrate both historic and trended emissions levels in Vermont.

[17] The source for historical emissions data was the Energy Information Administration's web site: www.eia.doe.gov.

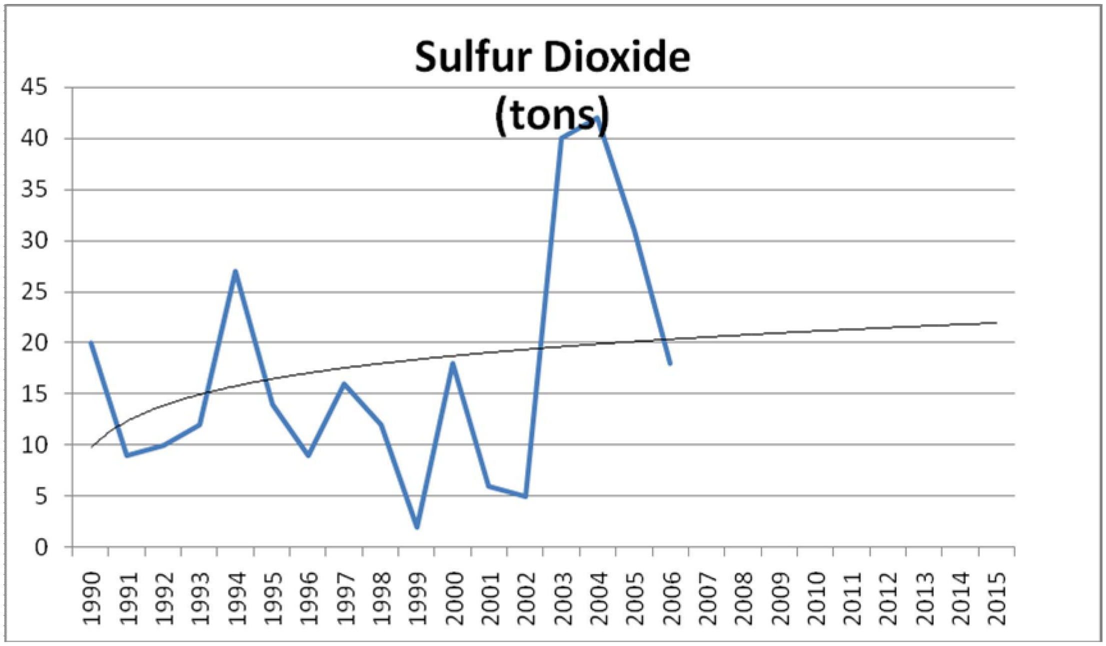

Figure 6: Historical and Projected levels of SO_2 emissions in Vermont

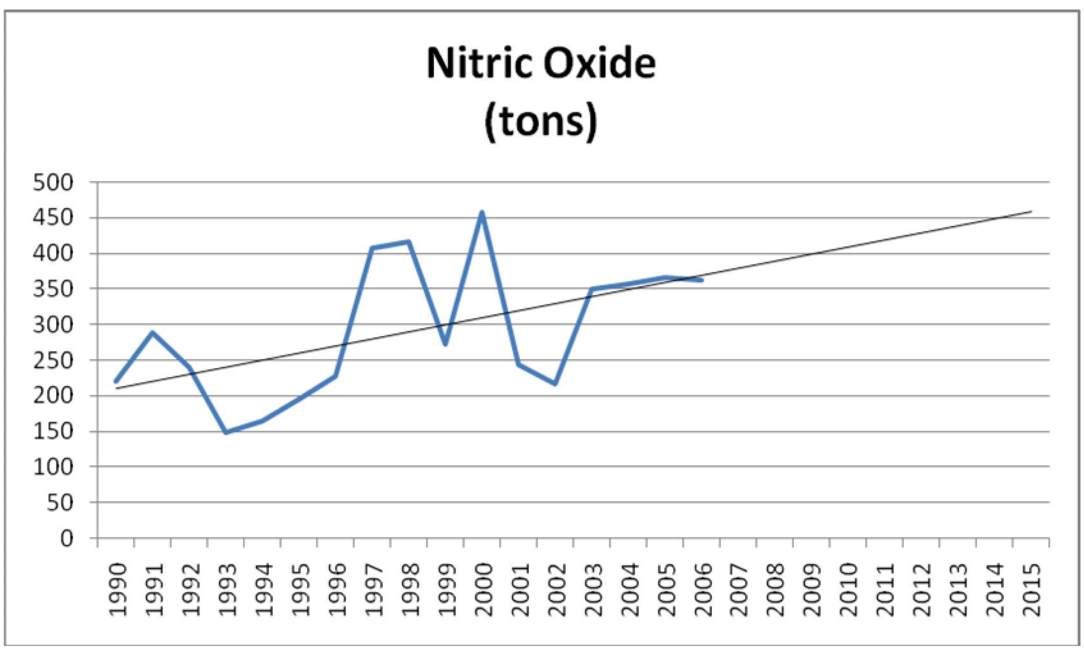

Figure 7: Historical and Projected levels of NO_x emissions in Vermont

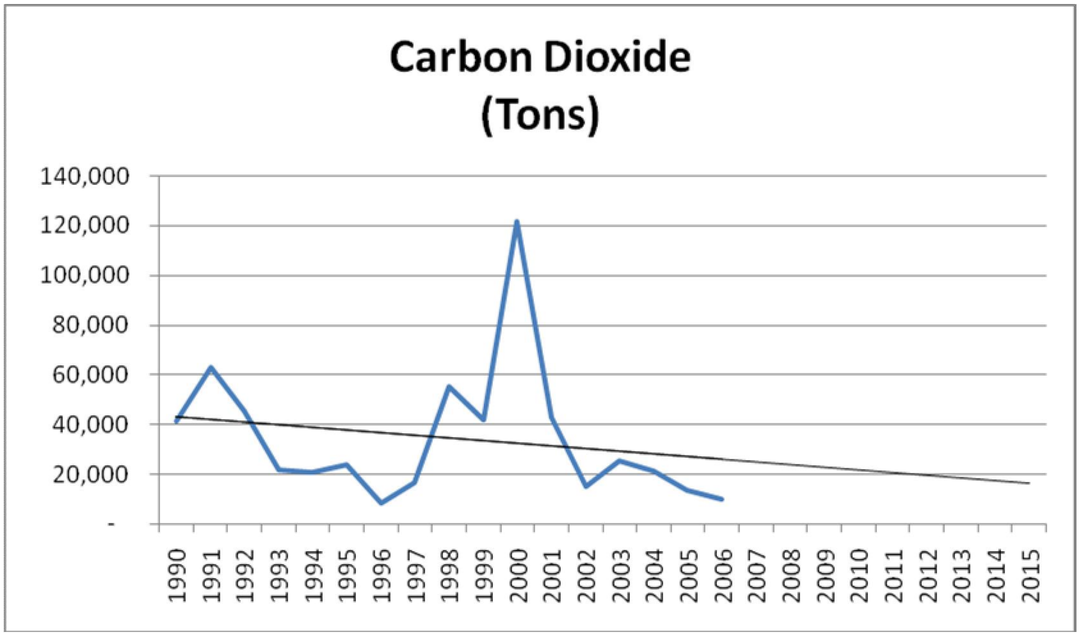

Figure 8: Historical and Projected levels of CO_2 emissions in Vermont

If, however, Vermont Yankee were retired in 2012, it was assumed that the replacement electricity would come from a new combined cycle gas turbine that burns natural gas while emitting no SO_2 and one-third the CO_2 of a conventional coal plant. While Vermont currently only receives 273 MW from Vermont Yankee, the plant produces 620 MW, which would all have to be reproduced should this plant close. Buyers of Vermont Yankee power would either have to acquire replacement energy from the wholesale market or other alternatives. As addressed earlier, the only feasible replacement for the base load capacity of Vermont Yankee would be a combined cycle gas turbine.

Renewable resources such as solar and wind are interim resources that produce only when certain conditions exist, namely, when the sun and/or wind are available. As will be discussed later in the economic section, the least cost alternative, still twice as expensive as Vermont Yankee, is a new combined cycle gas turbine. On an expedited schedule, 620 MW of new capacity could be installed within five years.

A typical combined cycle gas turbine (CCGT) emits .213 lbs of NO_X per MWh generated and .4 tons of CO_2 per MWh. Assuming the same level of operating performance, in a typical year the CCGT would have to generate about five million MWh. This would be an increase of approximately two million tons of CO_2, a hundredfold increase from the current amounts produced by electricity generation in Vermont. The following CO_2 bar chart (Figure 9) illustrates the significant difference in CO_2 levels.

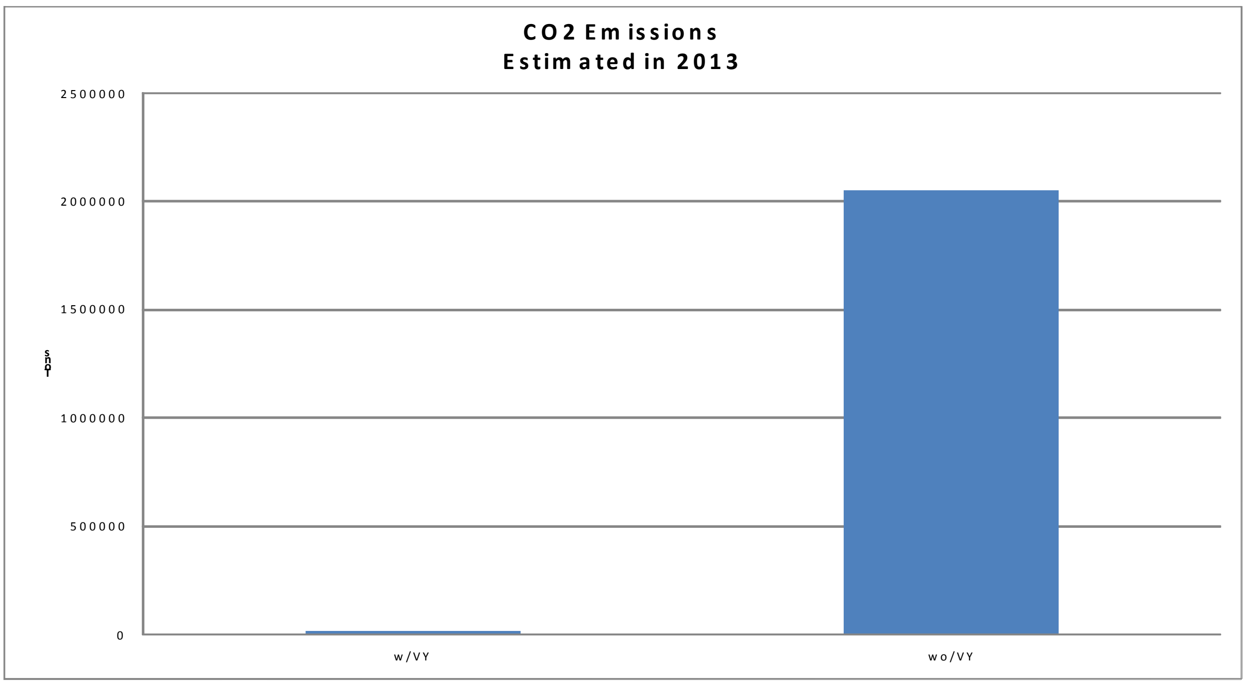

Figure 9: Increase in CO_2 emissions should a CCGT replace Vermont Yankee

NO_X emissions will increase by 550 tons, a twofold increase from current levels. The NO_X bar chart (Figure 10) illustrates the impact on NO_X emissions.

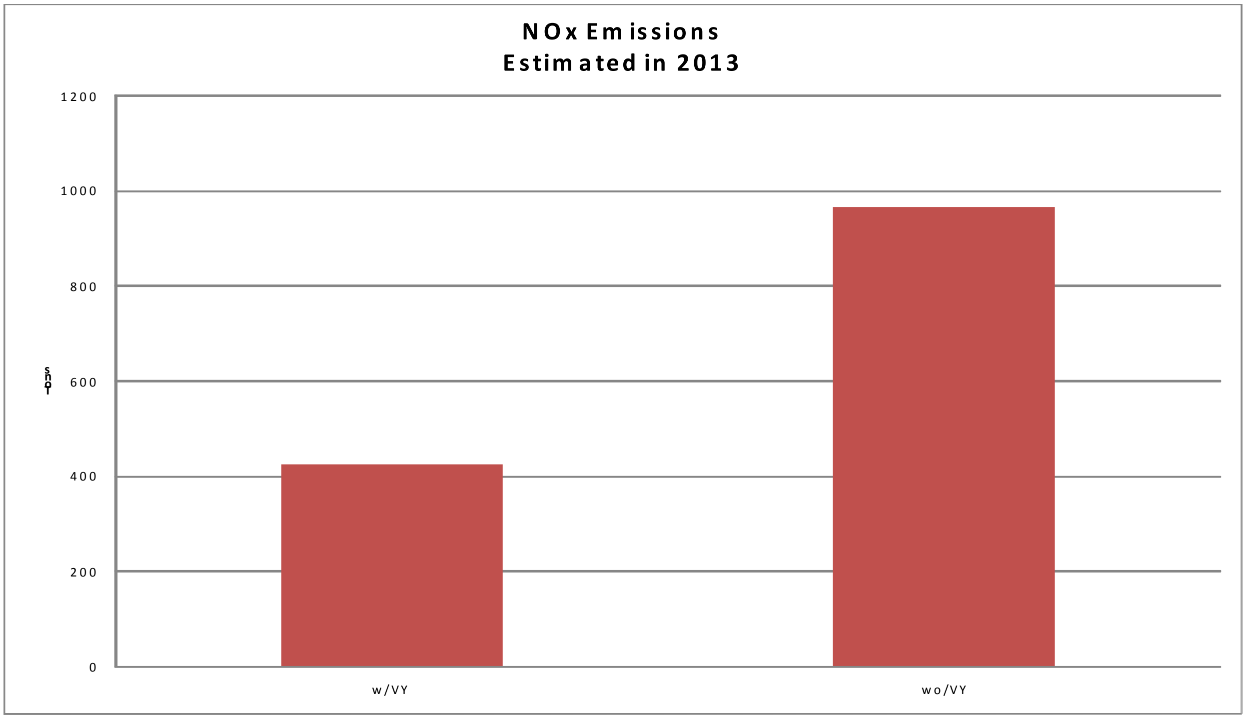

Figure 10: Increase in NO_X emissions should a CCGT replace Vermont Yankee

The above environmental assessment calculates the CO_2 and NO_X impacts based on the full output of Vermont Yankee. If Vermont Yankee were retired in 2012, only 273 MW or 45 percent of Vermont Yankee would actually have to be replaced in order to meet Vermont's current capacity needs. The environmental impacts associated with this level of Vermont Yankee replacement would be proportionate.

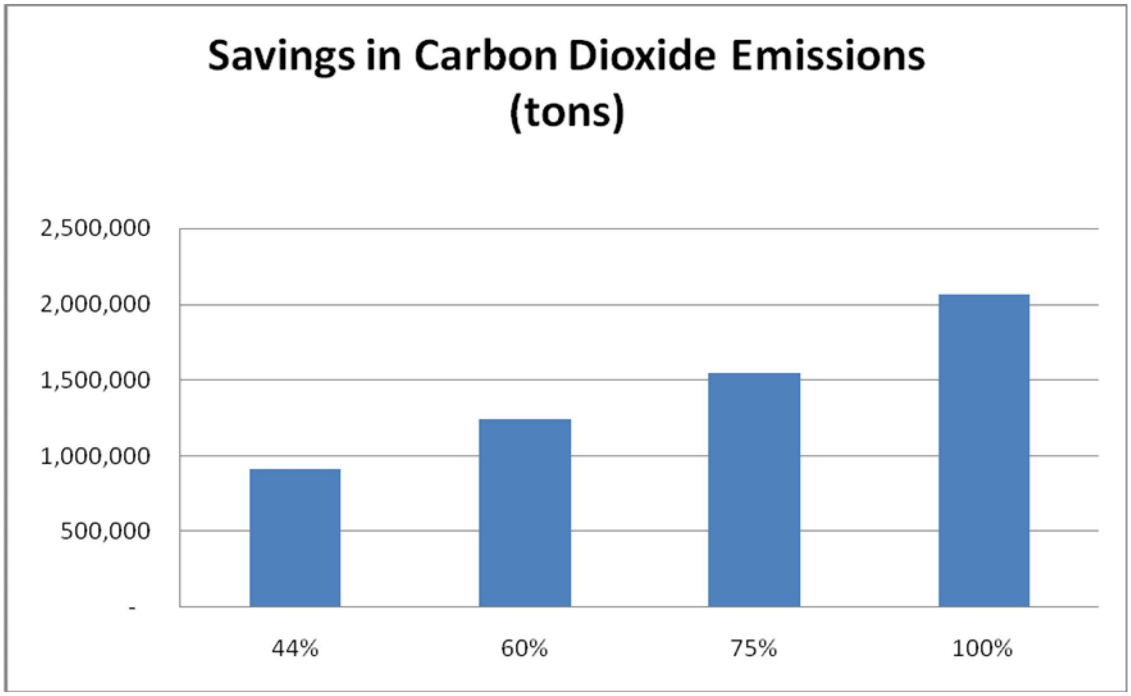

Figure 11: Impact of Vermont Yankee on Vermont's Carbon Footprint

Two other scenarios representing slightly greater Vermont Yankee supply for Vermont were evaluated assuming some portion of Vermont's future load growth can also be supplied by Vermont Yankee – a very realistic scenario given the potential loss of Hydro-Québec power.

- Approximately 373 MW or 60% of Vermont Yankee – adding 100 MW
- Approximately 412 MW or 75% of Vermont Yankee – adding 185 MW.

If only 273 MW of the Vermont Yankee capacity were replaced in Vermont with a CCGT, then CO_2 emissions would rise by about 900,000 tons and NOx would rise by about 240 tons. As the percentage of Vermont Yankee replacement rises from the current 45% to 100% replacement, the levels of CO_2 and NOx emissions incurred – or saved if Vermont Yankee were to continue to operate – would proportionally increase to up to 2 million tons of CO_2 and 550 tons of NOx. (see Figure 12)

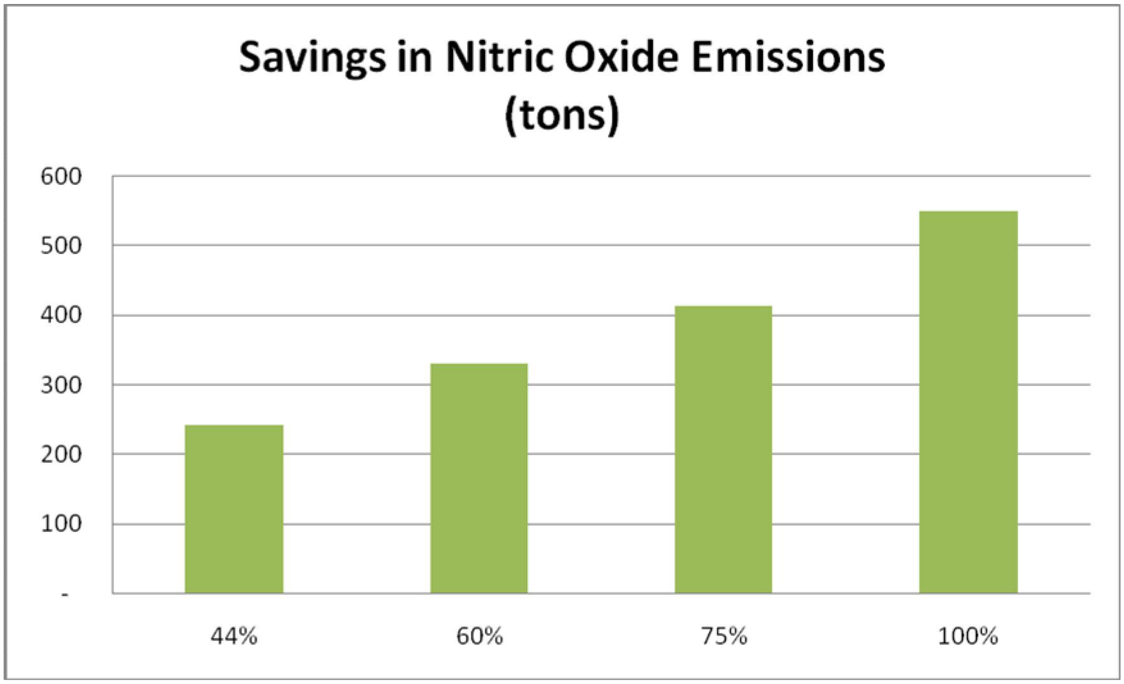

Figure 12: Savings in NO_X emissions relative to Vermont Yankee usage

While the next section of this report will address the likely electric prices associated with a Vermont Yankee closure in 2012, there also are potential incremental environmental costs as well. Although there is considerable uncertainty associated with the value of SO_2, NO_X and CO_2 allowance trading markets[18], the **potential costs associated with additional CO_2 emissions could exceed $60 million a year and $3 million for NO_X.**

As a final observation, in Vermont the current level of greenhouse gas emissions from electric production is about 20,000 tons per year. This equals the CO_2 released from just 3,500 automobiles, which emit roughly six tons of CO_2 apiece per year.[19] Should Vermont Yankee be retired in 2012, the potential increase in greenhouse gases would be two million tons or the

[18] On July 11, 2008, the U.S. Court of Appeals for the D.C. Circuit had vacated EPA's Clean Air Interstate Rule ("CAIR") which has undermined the SO_2 and NOx allowance markets at the present time. However, the high values for SO_2 had reached $1,226/short ton and $5,000/short ton for NOx allowances. A cap and trade program for CO2 emissions has yet to be implemented. Prices in the European markets have exceeded $30/ton.
[19] Source: U.S. EPA.

equivalent of more than 330,000 additional cars in Vermont, more than doubling the number of automobiles on the road[20] today.

This raises a related issue. The Vermont Comprehensive Energy Plan has identified Six Policy Directions that can make a difference:

1. Establish well-formed regional and national carbon constraints
2. **Transform the passenger car – improving fuel economy, electrification and fuel diversity**
3. Improving energy efficiency in buildings and homes
4. Improving diversity of regional generation sources through effective regional cooperation
5. Establishing sound replacements to existing major electric power contracts
6. Constructing local and distributed generation: traditional peaking units, smaller base-load biomass, and combined heat and power units (CHP)

Policy Directive Two specifically calls for the electrification of automobiles, which account for 46 percent of the state's carbon footprint. This is almost twice the national average of 25 percent.[21] With the 2010 introduction of General Motor's Volt, an advanced hybrid-electric vehicle, and competitive entries by Toyota and Honda, Vermont's utilities will also have to plan for increased demand for electricity.

[20] Vermont currently has approximately 269,000 automobiles and 238,000 trucks and buses.
[21] The Vermont Comprehensive Energy Plan, page I-7 – I-8.

Economic Assessment

The Vermont Yankee Nuclear Plant provides 620 MW of electricity nearly round-the-clock. At 95 percent capacity, the plant generates more than five million MWh, which can meet the electricity needs of 500,000 homes[22]. Although only 287 MW of Vermont Yankee is dedicated to Vermont customers, its total output provides nearly 90 percent of the state's total electricity usage.

Projecting the price of electricity in Vermont with or without Vermont Yankee after 2012 is very difficult because a purchase power agreement (PPA) between Entergy and the former Vermont Yankee owners provides for a price based on a fixed formula that is well below the current wholesale market price for electricity in New England. This contract expires in 2012. The PPA which was negotiated as part of the Vermont Yankee sales agreement with Entergy has a base price of $45/MWh.

When the contract was signed in 2002, the average regulated rate was about $55/MWh, an 18 percent savings for consumers, although the ISO-New England day ahead market prices did average about $52/MWh during 2003 and 2004 that resulted in a 13 percent savings. During recent years, however, D.A.M. prices have averaged about $75/MWh, producing even more significant savings for Vermont consumers.

Cost Estimates, Post 2012

When the PPA expires in 2012, the Vermont Yankee owners will be free to renegotiate higher prices or possibly sell all of Vermont Yankee output on the D.A.M. Clearly, the more energy sold on the real time markets creates greater and greater price uncertainty and risk exposure that Entergy may not wish to assume. It is therefore likely that a portfolio-based sales strategy will be pursued and include a range of sales initiatives:

- Day ahead market

[22] Based on 1,000 kWh per month usage.

- Short-term sales agreements – less than two years
- Long-term sales agreements – two to twenty years.

For this analysis a forward-looking, all-inclusive cost assessment of Vermont Yankee was performed that projected costs associated with operation, maintenance, capital additions and return on equity. For each variable, a probability distribution was developed representing the range and likelihood of future costs. A Monte Carlo model was then used to calculate the annual price per MWh, which was also measured in terms of a probability distribution.

RISK ANALYSIS OVERVIEW- WHAT IS MONTE CARLO SIMULATION?[23]

What do we mean by "simulation?"

When we use the word ***simulation***, we refer to any analytical method meant to imitate a real-life system, especially when other analyses are too mathematically complex or too difficult to reproduce.

Without the aid of simulation, a spreadsheet model will only reveal a single outcome, generally the most likely or average scenario. Spreadsheet risk analysis uses both a spreadsheet model and simulation to automatically analyze the effect of varying inputs on outputs of the modeled system.

> One type of spreadsheet simulation is **Monte Carlo simulation**, which randomly generates values for uncertain variables over and over to simulate a model.

How did Monte Carlo simulation get its name?

Monte Carlo simulation was named for Monte Carlo, Monaco, where the primary attractions are casinos containing games of chance. Games of chance such as roulette wheels, dice, and slot machines, exhibit random behavior.

The random behavior in games of chance is similar to how Monte Carlo simulation selects variable values at random to simulate a model. When you roll a die, you know that either a 1, 2, 3, 4, 5, or 6 will come up, but you don't know which for any particular roll. It's the same with the variables that have a known range of values but an uncertain value for any particular time or event (e.g. interest rates, staffing needs, stock prices, inventory, phone calls per minute).

[23] Definition of Monte Carlo Simulation provided by Oracle (http://www.decisioneering.com/monte-carlo-simulation.html).

From this assessment, a price range within a given degree of confidence (in this case 90 percent confidence) was derived. Because the actual costs associated with this plant's operation are not publicly available, this analysis provides a ballpark estimate of prices that might be charged, assuming the strategy was to recover all costs plus an appropriate return on investment.

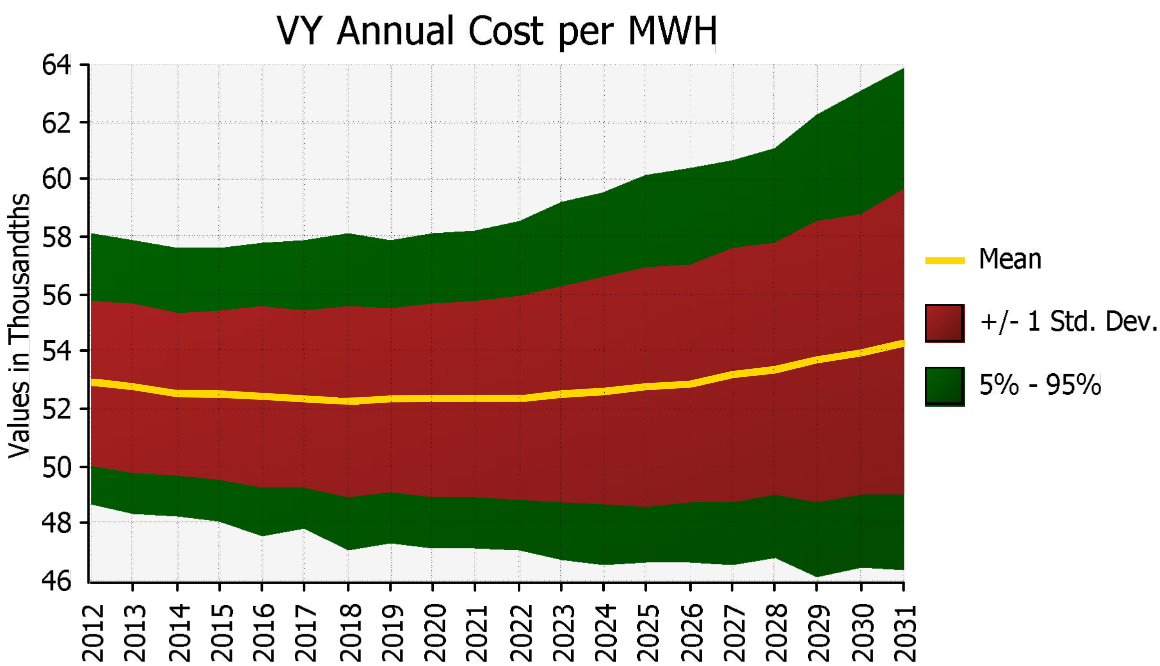

Figure 13: Projected cost of Vermont Yankee

Figure 13 presents the range of average annual costs per MWh with a 90 percent degree of confidence. The cost to operate Vermont Yankee increases from $49 to $58/MWh in 2012 to $47 to $64/MWh[24] in 2031 with rising prices offsetting declining depreciation.

After 2012, assuming Vermont Yankee is granted a license extension, the PPA provides a surplus revenue sharing mechanism that rebates half the difference between the actual sales price and $61/MWh[25]. As a result, Entergy and the former owners of Vermont Yankee will share revenues that exceed the Vermont Yankee cost of service, which includes a fair return on

[24] Note: This is not an inflation adjusted forecast, but actual dollars. Because such a high percent of VY's costs are fixed, inflationary pressure is limited.
[25] Adjusted each year for price escalation.

investment. Unfortunately, it is impossible to know the future sales strategy. However, as a worst case, if consumers bought off the NE-ISO D.A.M. at, say, \$100/MWH, they would receive a \$19.50/MWh rebate with a net cost of \$80.50/MWh.[26]

As a best case, Vermont could buy all of its electrical needs from Vermont Yankee for \$52.60/MWh, the mid-range of the Vermont Yankee levelized cost analysis.

If, however, Vermont Yankee were retired in 2012 and its capacity replaced by a CCGT of equivalent size, then the replacement costs, as illustrated in the following probability distribution graphic (Figure 14), would be twice as expensive as Vermont Yankee. While the expected cost (mean value) for Vermont Yankee was calculated to be \$52.60/MWh, the expected levelized price for a new CCGT was \$111.29/MWh.

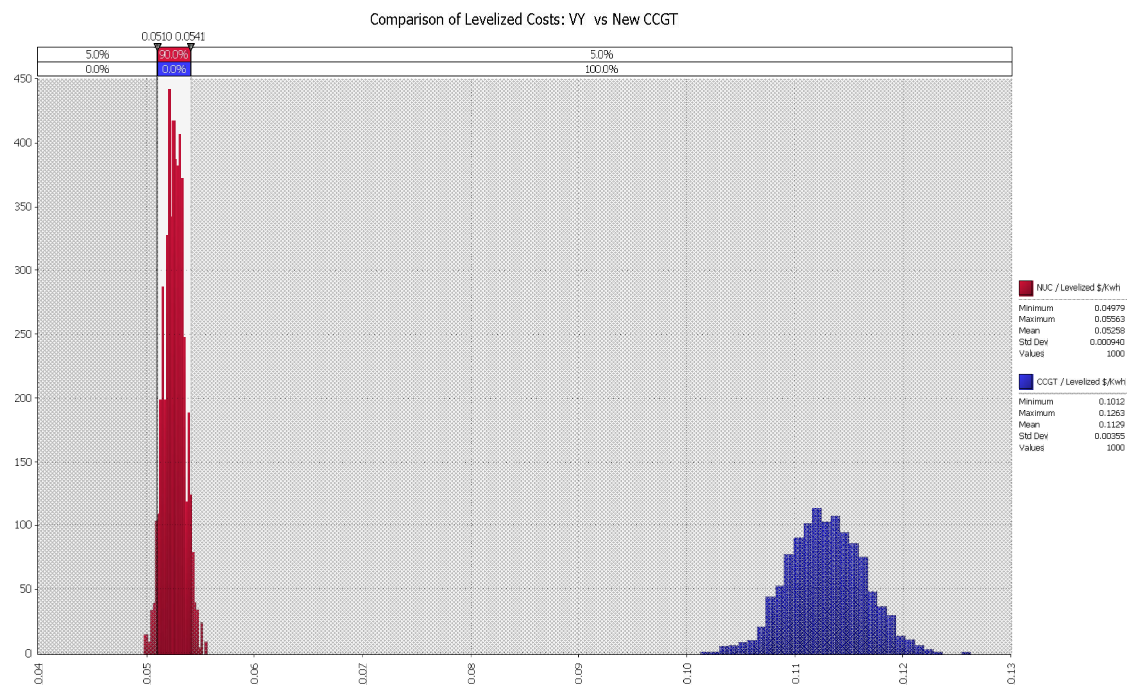

Figure 14: Comparative cost of Vermont Yankee to a new CCGT

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[26] Using the revenue sharing mechanism: \$100 - \$61 = \$39, divided by 2 = \$19.50 credit.

The retail price of electricity in Vermont consistently has been the lowest among the other New England States. Since 2006, however, electric prices have risen dramatically as illustrated on Figure 15. To demonstrate the potential impact on average rates, an analysis of Central Vermont Public Service's cost of service was performed. In 2007, the company's total revenues were about $329 million with about $161 million for purchased power. Nearly half of all revenues collected from retail consumers is spent on purchased power with approximately $102 million[27] going to Vermont Yankee. If Vermont Yankee were replaced by a CCGT at $110/MWh, it would increase the purchase power expenses by $64 million, increasing total annual revenues up to $393 million, a 19.3 percent rate increase.

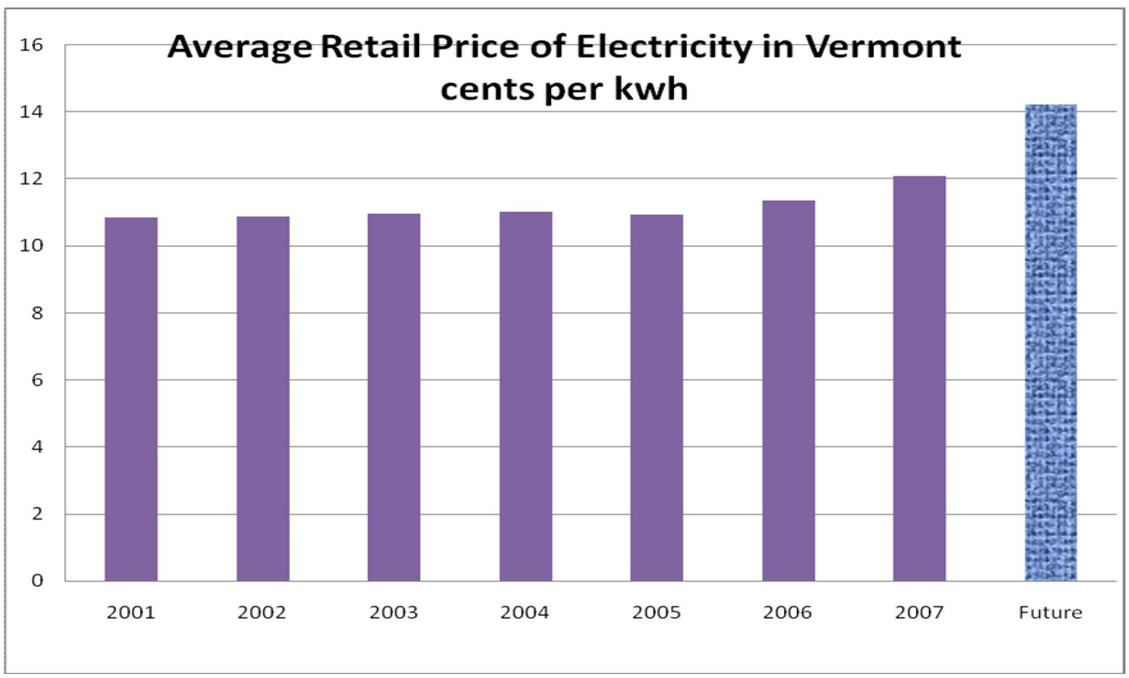

Figure 15: Retail Electric Prices in Vermont with Projected Price with Vermont Yankee replaced by a CCGT

[27] CVPSC's Annual Report and its FERC Form 1 report were used to identify 2007 revenues and expenses. The VY charges were derived using the following assumptions: 43% of the 278 MW dedicated to Vermont was sold to CVPSC, a 95% capacity factor and $45/MWh cost.

Currently, Vermont's retail electric rates are the lowest in New England. The average cost of electricity in New England is 14.91 cents, with Connecticut the highest at 16.27. (see Figure 16)

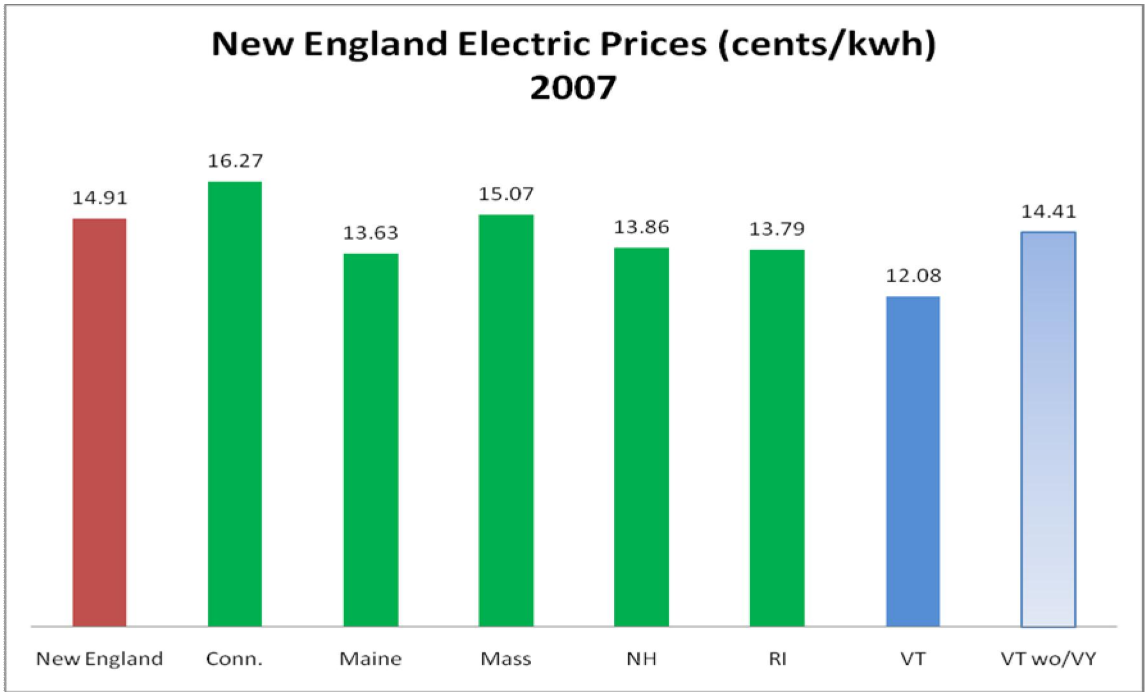

Figure 16: Comparison of Retail Electricity Prices in New England

Without Vermont Yankee, the estimated retail price of electricity in Vermont would rise from 12.08 cents/kWh to 14.41 cents/kWh, making it the third most costly state in New England. If Vermont Yankee were instead replaced by a combination of energy conservation and renewable resources with replacement costs exceeding $200/MWh, the average cost of electricity could rise by the equavalent of 39 percent.[28]

[28] Electricity prices would not actually increase by 39% as much of the cost increases to consumers would be in the form of added expenses for conservation investments, which would be offset by reduced electricity usage. The equivalent electric price would be 16.8 cents per kWh.

About Energy Strategies, Inc.

Energy Strategies, Inc., headquartered in Albany, N.Y. with a satellite office in Atlanta, is a management consulting firm serving the energy sector. The firm opened in 1995 and has served more than 50 clients, including investor-owned electric, gas and telecommunications utilities, municipal electric systems, state and federal regulatory agencies, independent power producers and large commercial customers. Energy Strategies, Inc. has performed a similar study relating to the continued operation of Indian Point 2 & 3 nuclear plants for Westchester Business Alliance. Neither Energy Strategies Inc. nor any of its employees have been retained by Entergy or any of its subsidiaries. For more information on Energy Strategies, Inc. visit www.energystrategiesinc.com.

Howard J. Axelrod is president and founder of Energy Strategies, Inc. Dr. Axelrod has been a management consultant for over 25 years and has been engaged by a wide range of energy clients including investor-owned and municipal electric systems, state and federal regulatory agencies, independent power suppliers and large industrial users. Earlier in his career, he served as the Director of Utility Intervention for the NYS Consumer Protection Board, a senior staff member of the NYS Public Service Commission and Chief Economist for the Shoreham Commission.

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