



VERMONT'S ENERGY FUTURE

**A Deliberative Polling[®] Event
November 3-4, 2007
Burlington, VT**

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Welcome to Vermont's Energy Future!

My name is David O'Brien and I am the Commissioner of the Vermont Department of Public Service. I am writing to ask your help with some very important decisions we face with our energy future. In 2012, contracts providing two-thirds of the state's electric power begin to expire. This leaves the future source of Vermont's electricity open for discussion and examination. Choices about the future will have to be made and we will have to weigh trade-offs among cost, reliability, environmental impact, large and small scale generation, and in versus out-of-state sources. Vermont needs your help in shaping the future mix of electricity sources for the state.

We understand that giving up a weekend is a significant commitment of time, and we thank you for your participation in this discussion about how Vermont should obtain its future supplies of electricity. At no time in our history has the topic of energy been more important to the future of Vermont and to the future of the United States. It is difficult to pick up a newspaper or watch television news without seeing an article concerning energy. Energy issues affect our budgets, the economy, the environment, and national security. It likely won't surprise you that Vermont has its own particular approach to energy and electricity issues. Vermont currently imports about half of its electricity.

On the other hand, Vermont has been a leader in biomass-produced electricity for over twenty years and spends more per capita on energy efficiency than any other state. Vermont has the distinction of having the lowest carbon footprint in the nation as a result of many things including the electricity mix currently used by the consumers of Vermont. The Vermont electricity mix may change in the future. Two-thirds of the electricity we consume comes from either the Vermont Yankee Nuclear Plant or from Hydro-Québec. The contracts for the nuclear power will expire in 2012. The hydro contracts decrease substantially in 2015. It is time to begin planning for the future.

We will be using a process called Deliberative Polling, which has been used elsewhere for energy planning decisions. This will be the first application in Vermont and the first in New England. We think you will find the process thought provoking, enjoyable, and informative. After you have a chance to read and think about Vermont's electricity future and to discuss the issues in small groups and then ask questions of experts from all viewpoints, we will seek your opinions. We will listen carefully to what you have to say and the judgments you provide will form an important input to our planning process as we move forward.

Again, let me thank you for agreeing to participate.

Sincerely,

David O'Brien

David O'Brien
Commissioner, Public Service Department

This Is What Happens at a Deliberative Poll

You are one of more than 200 Vermonters from all walks of life—all ages, incomes, and occupations—who have been invited to participate in this Deliberative Polling event to be held in Burlington, Vermont in early November.

The Deliberative Poll is being conducted for the Vermont Department of Public Service by the Center for Deliberative Opinion Research of the University of Texas at Austin.

Citizen involvement in electricity planning is important, because it is customers like you who ultimately pay the bills and live with the results of the decisions. Thus, it is very important to hear what you think after you have had the chance to learn, think, and talk about the issues relating to Vermont's electricity future.

We believe you'll find the experience interesting, worthwhile, and enjoyable.

You may not think about electric generation from day to day, and you may not think of yourself as an expert on energy; but we are not looking for experts. What's important to us is that you are a representative member of the public.

You were selected as a member of a random sample chosen to represent all Vermonters. Collectively, the sample's opinions will provide a reasonable prediction of what Vermonters as a whole would say if it were possible to invite the whole State to the same event.

The Deliberative Polling process allows you to gather information, discuss the options with fellow Vermonters in small groups, meet with the whole sample to ask questions of competing experts and policymakers with diverse viewpoints, and then give back your considered opinions about what you think should be done.

The small groups and the sessions with the experts and policy makers are led by professional moderators, trained to be neutral, to keep the process moving and punctual, and to see that everyone gets a chance to participate.

The energy supply choices being discussed do not have right or wrong answers. Different options have advantages and disadvantages. You may come to favor some options, other participants to favor others.

We seek no group decision or consensus; we only want to know what you individually think after discussing and considering these issues.

We look forward to seeing you in Burlington on November 3rd and 4th, when the scientifically selected sample will come together for deliberation.

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Notes

1. The preparation of these materials was supervised by an Advisory Committee and a Resource Panel made up of diverse interests and viewpoints. Together they spent many hours in review and discussion. The goal was to prepare materials that expose Vermonters to all sides of the issues concerning planning for Vermont's Electricity Future. Given the diversity of views, not all of the advisors would agree about what Vermont's energy future should be, but all would concur that Vermonters should have the benefit of hearing from a variety of perspectives.
2. The Vermont Council on Rural Development published a report called the *Vermont Energy Digest* in April, 2007. The report, authored by Brenda Hausauer, is an inventory of renewable energy and efficiency projects and programs in Vermont and was quoted extensively in Chapter Two on Renewables.
3. The Vermont Department of Public Service published *Utility Facts* in 2006 and updated it in August 2007. This document is the source of most of the tables and graphics found in the Background Section of this document.

Background Information

INTRODUCTION: VERMONT NEEDS TO MAKE DECISIONS ABOUT FUTURE SUPPLIES OF ELECTRICITY

Thank you for taking part in this Vermont Department of Public Service effort to gain public involvement in planning for Vermont's electricity future.

This process was authorized in 2006 by the Legislature (Act 208) and has been endorsed by the Governor and the Joint Energy Committee. The goal of this outreach effort is for Vermonters to examine and make recommendations on how to meet Vermont's future electricity needs over the next 5-10 years.

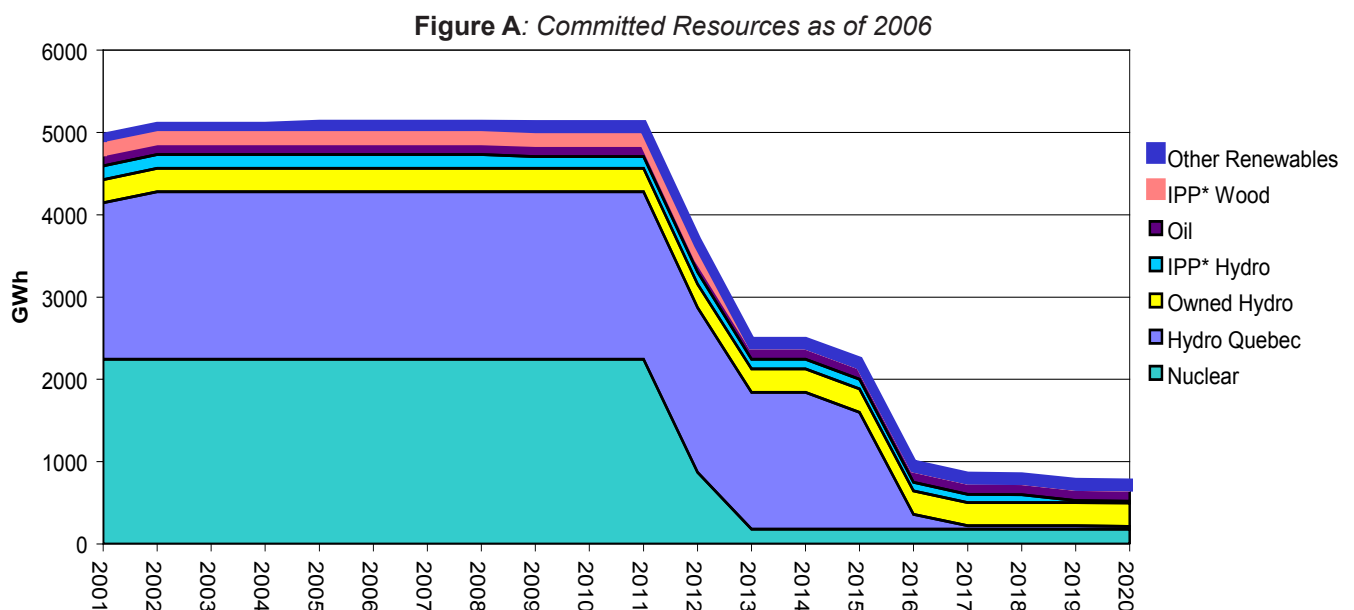
Vermont's electric utilities, ultimately, have the responsibility to procure electricity to meet their customers' needs. Your input will help all parties—the Governor, Legislature, Department of Public Service, Public Service Board, and the utilities—understand Vermonter concerns and priorities as they consider the best mix of energy supplies to serve Vermont in the coming years.

Over two-thirds of Vermont's electricity comes from two large contracts—contracts that are expiring soon. Contracts with Entergy, owner of the Vermont Yankee Nuclear Plant, expire in 2012, and contracts with Hydro-Québec in Canada begin to expire in 2012.

Additionally, a number of contracts with Independent Power Producers for in-state hydro-electric and woodchip plants expire in the same timeframe. But the lights will stay on—electric utilities in Vermont operate under a common system and are part of the New England Grid, enabling them to buy electricity on an as-needed basis called *system power*.

The expiration of these contracts, however, enables Vermont to evaluate its electricity future and to weigh options in energy contracts and sources, which vary widely in cost, price stability, and economic and environmental impact. It is an opportunity for Vermonters to express a preference for where their energy dollars should go.

Figure A shows the changes as contracts expire:



It would be a significant challenge for any state to replace this portion of its electricity load.

Both the Vermont Yankee and Hydro-Québec contracts are relatively inexpensive by today's standards, costing 4-7¢ per kilowatt-hour compared to current market prices of about 8¢ per kilowatt-hour.

Additionally, nuclear and hydro power produce little to no greenhouse gases, unlike natural gas, oil, or coal.

As you can see, the decisions we face on the future of our electric supply are very important.

SOME HELPFUL INFORMATION ABOUT ELECTRIC GENERATION, TRANSMISSION, AND RESOURCE PLANNING IN VERMONT

Electric Utilities

Twenty separate electric companies provide electricity to homes and business in Vermont. They are one of three types of entities:

- **Investor-Owned Companies** - *Central Vermont Public Service, Green Mountain Power, and Vermont Marble*
- **Municipal Electric Departments** - Such as *Burlington Electric Department* and the *Village of Ludlow* (there are fifteen of these)
- **Electric Cooperatives** - Including *Vermont Electric Cooperative* and *Washington Electric Cooperative*

Figure B shows service territories served by Vermont electric utilities.

Figure C shows relative size of the different electric utilities in Vermont in both electricity sold and in dollars of revenue.

Electric utilities are responsible for the following:

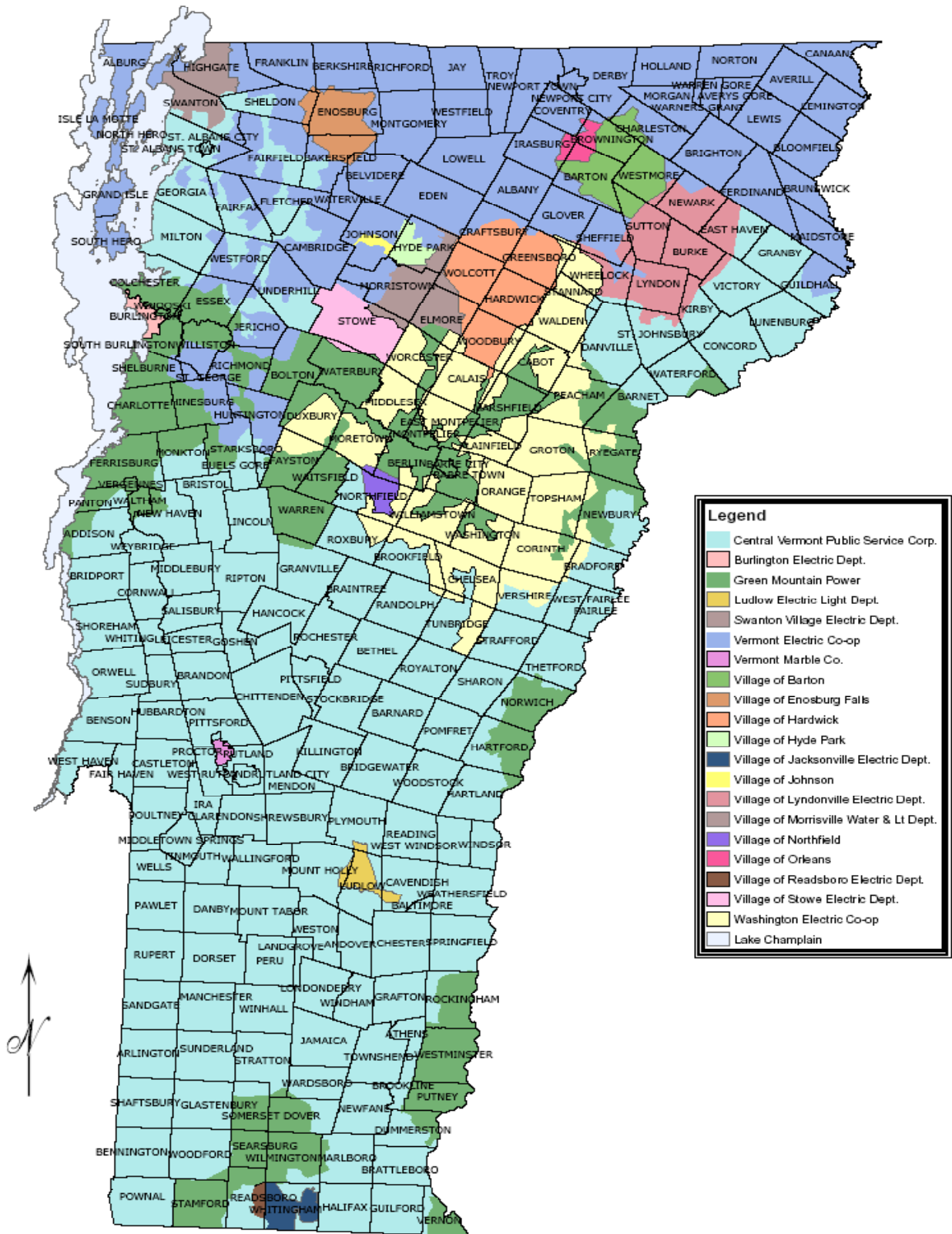
- **Procuring Power** (one-half of Vermont's electricity is purchased from generation sources located out of state.)
- **Building and Maintaining Generation Sources** (on a limited scale)
- **Building and Maintaining Transmission and Distribution Lines**
- **Conducting Long-Term Planning**
- **Managing Local System Reliability**
- **Metering and Billing for Retail Sales**
- **Collecting Funds to Support Demand Side Management (DSM) Programs**

Utilities differ in *governance* (who makes the decisions) and *ownership* (who puts up the investment capital, takes the risk, and earns the returns).

A municipal electric utility may have more flexibility to develop a localized generation mix but may have fewer customers to share research costs in new or experimental technologies.

Rates for all utilities are approved by the Vermont Public Service Board.

Figure B: Electric Utilities Franchise Areas



Source: VTDPs

Figure C: Vermont Utility Sales and Revenue - 2006

	Sales (kWh)	Utility Rate Revenue (\$)	Residential (kWh)	Commercial (kWh)	Industrial (kWh)
BARTON	14,988,177	\$2,182,860	10,859,276	3,127,864	0
BURLINGTON	359,268,266	\$42,827,675	91,153,308	193,418,077	71,031,453
CVPS	2,284,465,000	\$264,771,621	959,455,000	888,537,000	430,348,000
ENOSBURG FALLS	22,733,653	\$2,975,821	12,525,459	1,662,651	6,920,754
GMP	1,961,042,000	\$200,441,290	582,284,000	706,093,000	668,522,000
HARDWICK	31,730,312	\$5,254,274	23,294,443	4,081,488	4,163,704
HYDE PARK	11,572,065	\$1,556,267	8,325,220	2,649,187	0
JACKSONVILLE	5,228,600	\$701,100	3,482,256	653,567	1,092,777
JOHNSON	15,007,078	\$1,766,820	5,171,756	1,257,592	8,220,639
LUDLOW	48,681,015	\$6,139,816	15,536,540	19,738,046	12,935,436
LYNDONVILLE	70,993,531	\$9,381,017	31,635,229	11,493,964	27,342,440
MORRISVILLE	45,565,424	\$6,122,869	20,732,865	24,609,628	0
NORTHFIELD	28,472,344	\$3,315,668	10,639,348	2,760,302	12,914,230
ORLEANS	13,209,071	\$1,442,425	4,145,931	1,635,035	6,868,800
READSBORO	2,298,034	\$247,024	1,645,766	286,358	281,406
ROCHESTER	4,242,565	\$621,013	2,971,683	1,014,821	0
STOWE	66,927,566	\$9,167,740	20,989,708	26,420,114	11,970,585
SWANTON	51,312,511	\$5,368,475	25,162,263	3,752,380	20,841,642
VEC	468,476,165	\$61,495,422	242,369,765	114,005,964	103,873,624
VT.MARBLE	219,234,256	\$16,937,290	6,297,222	4,893,698	207,944,936
WEC	68,545,345	\$10,760,340	61,792,613	3,353,396	3,391,236
Totals	*5,793,992,978	\$653,476,827	2,140,469,651	2,015,444,132	1,598,663,662

*Total includes "Public Street and Highway" (17,668,229 kWh) and "Other and Public Authorities" (21,747,304 kWh) sales.

Source: VTDPDS

Electric Generation in Vermont

Vermont purchases about half of its electricity from generation sources in other states or Canada. Other than the Vermont Yankee Nuclear Plant, the electricity generated in Vermont is mostly hydro or wood-fired, though some hydro stations in Vermont are owned by non-Vermont firms.

Electricity usage in Vermont averages 700-750 MW and peaks at around 1,100 MW in the summer, 46 % of which is imported.

While there are advantages and disadvantages to importing energy, one question is whether this level of imports concerns you as customers.

Vermont also exports energy—55% of power from the Vermont Yankee Nuclear Plant is sold to other New England customers.

Electricity Consumption in Vermont

A good way to think about electricity consumption is in terms of fuel type. Different fuels have advantages and disadvantages, differing in cost, environmental impact, and other factors.

Figure D shows fuel types used to generate the electricity consumed in Vermont. The wedge labeled *System A* represent purchases from New England's power market.

The wedge labeled *System B* represent power purchased from the New England market in which the renewable energy attributes were sold.

For comparative purposes, *Figure E* shows electric use by source in New England and the U.S.

Figure D: Vermont Consumption by Source - 2006

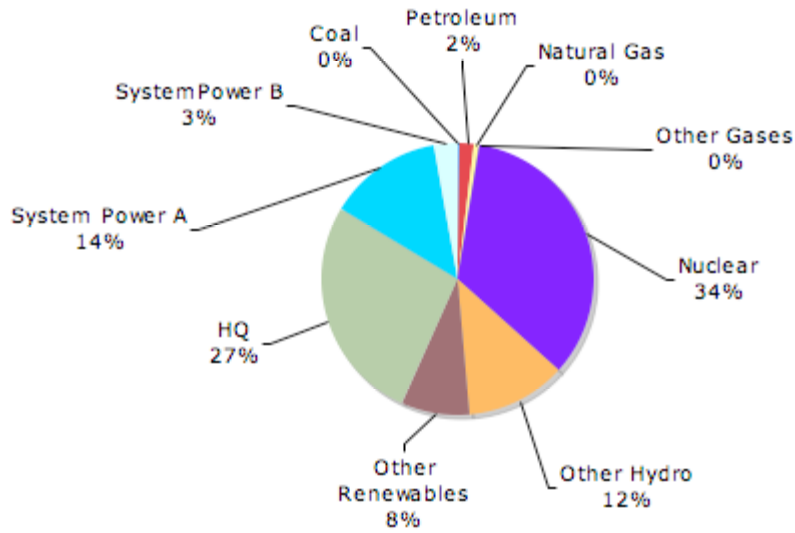
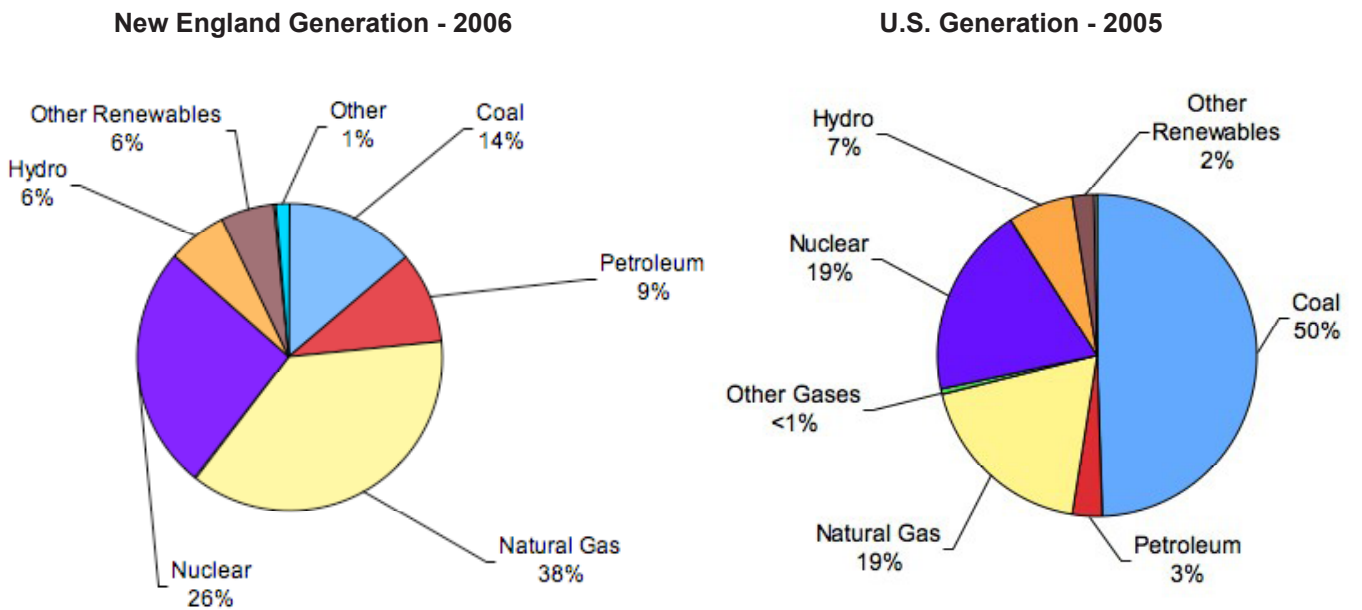


Figure E: New England vs. U.S. Generation by Source



One factor not reflected in these charts is that Vermont has one of the most aggressive energy efficiency programs in the U.S. (based on expenditures and savings per customer).

Vermont has created a unique *Energy Efficiency Utility* for efficiency programs instead of requiring distribution utilities to do so, as is more typical in the U.S. Additionally, the Burlington Electric Department has administered its own efficiency programs.

Vermont has spent over \$100 million on energy efficiency measures over the last decade, which have saved the state approximately 5% of its total electricity between 2000-2006. These efficiency investments are paid for by customers in a monthly efficiency charge that is part of their electric bill.

Efficiency as a resource, new investments in energy efficiency, and how efficiency helps to control demand will be topics central to the discussions and these materials.

Electric Transmission and Distribution in Vermont

The ability to move electric power from the generation source to the point of consumption is critical in electric resource planning.

The transmission system in Vermont is operated by Vermont Electric Power Company (VELCO), which is responsible for moving electricity in bulk over large power lines.

The smaller power lines, or *distribution lines*, are owned by your local electric utility.

VELCO was formed 50 years ago as the nation's first *transmission only* company—a company that transports but does not generate electricity—a concept that has spread to many other states.

VELCO is controlled by fourteen of the state's utilities with CVPS and Green Mountain Power owning 86%.

Since Vermont is a large importer of electricity, it is important to ensure there is enough capacity in its transmission system to import from New England, New York, and Canada.

There are many factors that impact transmission capacity, including the type of generation source, its distance from customers and existing transmission lines, and whether the source is out of state.

When transmission lines meet their maximum capacity, an increase in transfer limits or new lines may be required—although it is difficult to get permission to build new transmission lines in Vermont.

Strain on the transmission system, however, can be eased if a generation source is located close to its customers and through various efficiency programs such as *peak shaving* (reducing peak load).

You may want to consider the impacts on the transmission system (and the impacts of the system) as you think about the different options to meet consumer demand for electricity.

Types of Customers

Another challenge in electric resource planning is to consider the impact of options on different customers. The basic customer types include:

- **Residential**
- **Commercial**
- **Industrial**

A typical residential household in Vermont uses 600 kilowatt hours (kwh) per month and pays an average bill of \$80 per month.

A typical commercial customer, such as a small restaurant, might use 3600 kwh and pay \$400 per month.

An average industrial customer, however, is difficult to describe, as usage varies greatly and industrial customers pay on a different scale.

Take a large industrial customer such as IBM. IBM uses approximately 24% of the electricity sold by Green Mountain Power and 8% of the total electricity sold in Vermont.

For some companies, electricity can be a significant portion of their annual costs. Because of their size, the average industrial user pays just over 8¢ per kWh compared to the residential rate of just over 13¢.

Different Customers and Customer Types May Seek Different Values

One of the issues that interests Vermont decision-makers is whether you would pay more for certain electricity generation options, including cleaner and healthier options, or whether you would pay premiums to control future price changes.

Customers who normally pay \$100 per month may be willing to pay an additional 10%, or \$10, per month for these options, valuing their potential benefits.

Such a rate increase, however, may have different implications for a business, an industrial customer, or an entity such as a school than for a residential customer. Whether required by law or by the realities of competition, paying additional costs will likely be a tougher choice for some customers.

Customer willingness to pay more for valued options is the central question of this trade-off process.

Energy choices are not always straightforward. With new investments in efficiency programs and technologies, rates may rise to cover fixed costs. However, because you use less energy with these efficiencies, your overall bill should decrease.

To make a trade-off, customers will weigh their feelings on renewables with the risk involved.

Usage By Customer Type

Figure F provides background on electricity usage by customer type. The chart compares usage in Vermont, New England, and the U.S. for residential, commercial, and industrial customers.

Figure G shows residential use per customer in Vermont is less than New England and the U.S. as a whole.

Figure F: Percentage of Retail Electricity Sales by End-use Sector 2006

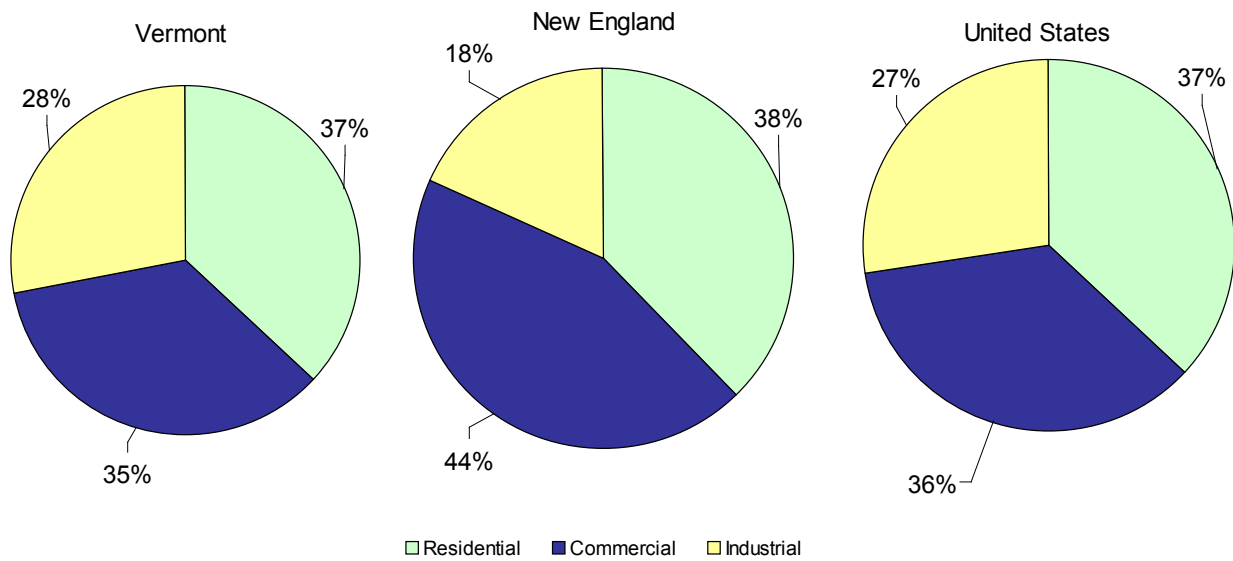
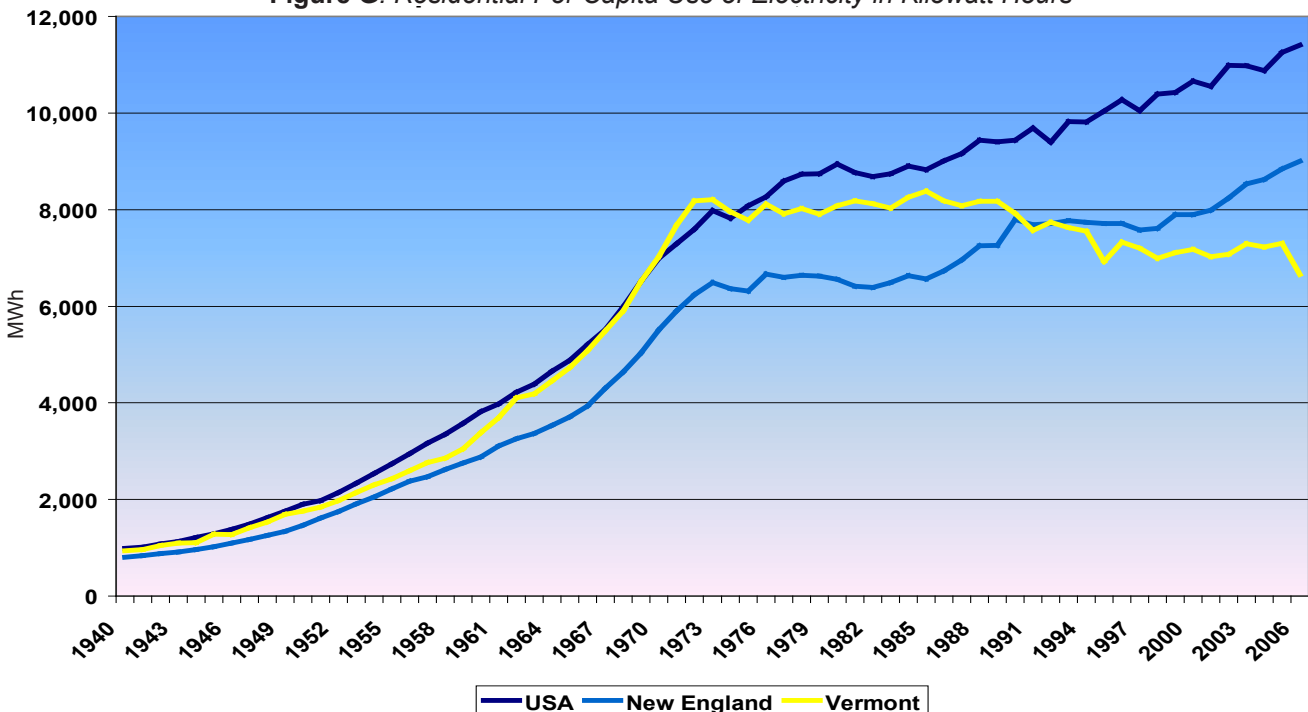


Figure G: Residential Per Capita Use of Electricity in Kilowatt Hours



Understanding Units of Electrical Energy

The following units of electricity may be thought of in terms of the amount of electricity needed for a specific use and duration, such as powering a light:

- **Watt** – The lowest common unit of power, such as a 100-watt bulb (or a 20-watt CFL - *Compact Fluorescent Light*).
- **Kilowatt (kW)** – 1,000 watts. It is the power, or generating *capacity*, necessary to light ten traditional 100-watt light bulbs (or 50 20-watt CFLs).
- **Megawatt (MW)** – 1,000 kilowatts. This measure of electricity is used to discuss resource needs. For example, a typical electrical generating plant burning natural gas would be sized to provide 50 to 250 MW of capacity. Vermont uses 1100 MW electrical power at the time of the peak demand and consumes 700-750 MW on average. Utilities keep about 15% as a reserve margin to ensure reliability in the event that power is unavailable.
- **Kilowatt-hour (kWh)** – The electric *energy* consumed to light ten 100-watt light bulbs (or 50 20-watt CFLs) for one hour. A typical home in Vermont averages about 600 kilowatt-hours of electricity per month, and you can find your monthly usage expressed in kWh on your electric bill.
- **Megawatt-hour (MWh)** – The energy in one megawatt of power consumed for one hour or the energy consumed when 10,000 100-watt light bulbs are lit for one hour.
- **Capacity** – The ability to generate electricity. Capacity is usually discussed in relation to the ability to provide enough electricity for peak times. The measurement for capacity is

either kilowatts or megawatts. Costs for constructing capacity are usually thought of as *fixed* costs, such as construction costs. New generating plants being discussed will have a capacity rating that indicates the amount of electricity they could produce at full output.

- **Energy** – The amount of power generated and consumed over a period of time. Energy has a time element and is measured in kilowatt-hours or megawatt-hours. Energy production costs are usually thought of as *variable* costs, as in the cost to start up and shut down plants and the fuel required to generate electricity.

Operation of the Regional Power Market and the New England Grid

That electricity cannot be stored presents additional challenges in energy planning. At any given time, the amount of electricity generated and the amount used must match exactly. If not, voltage can fluctuate, breakers trip, and the power can go out. We have grown accustomed to a highly reliable electricity supply in the U.S., having learned that larger electrical systems are easier to balance.

Electric utilities initially formed small mutual reliance grids, and these grids have evolved and merged into an interconnected system called the New England Power Pool (NEPOOL) operated by ISO New England.

The *ISO* (Independent System Operator) is overseen by federal regulators with state input. The ISO monitors electricity demand and instructs generators to start, stop, and ramp up or down to meet needs exactly—a process called *dispatching*.

The ISO uses a complex computer program to dispatch that considers many of the same attributes you will think about when considering generation options.

The attributes include price, fuel costs, response time, and how quickly the generator can *ramp* (operate at various levels). As you will see, natural gas and certain hydro generators ramp well, while nuclear, wind, and other hydro generators do not.

The ISO also operates the electricity markets, which closely relate to the dispatching process. Each electric utility is responsible to generate or contract for enough electricity to meet demand. There are two ways to purchase electricity—through a *bilateral contract* or from the *spot market*.

In a bilateral contract, a utility contracts with a generator or a wholesale market seller to provide a set amount of energy for a certain period. Bilateral contracts make up 80-90% of the electricity that retail electric utilities and the New England grid obtains through contract.

Both contracts with Hydro-Québec and Vermont Yankee are bilateral contracts.

Since demand for electricity is constantly changing based on factors such as the weather and the amount of outside light, there must be a market that balances the difference.

The *spot market*, or the short-term market, makes up the other 10-20% of the electricity market. In the spot market, utilities meet demand by paying for energy on an hourly option based on market prices.

The prices of the spot market are more volatile, since electric utilities do not have time to smooth out highs and lows, being subject to fuel availability and transportation risks.

At times, spot market electricity is more expensive than long-term contracts, other times cheaper; so electric utilities vary the amount of spot market purchases in their portfolio based on price risks, playing the market.

Theoretically, it would be possible for local electric companies to rely mostly on the spot market, but this is rare due to the price risks. At times, prices can grow so high that a utility relying heavily on the spot market would not be able to pay its bills without an emergency rate increase to its customers.

This is an outcome most utilities would avoid despite the opportunity to under price the market at other times—it would be a risk comparable to day-trading in the stock market with borrowed money.

When utilities bid on energy in the spot market, the ISO *stacks* the bids, or ranks them, by price and dispatches electricity starting with the lowest-priced bids until demand is met. The price at which demand is met and the auction clears is called the *clearing price*.

All accepted bids receive the clearing price, even those cheaper bids stacked below it.

This may seem like an unusual way to accept bids, but most power markets operate in the same way. Research has shown this system produces lower prices overall and stimulates more active bidding over time.

In fact, most other commodity markets operate in this manner, including the corn market, where producers of similar products are paid the same price regardless of their production costs.

In New England, this clearing price (also known as the *marginal price* or *spot market price*) most often is determined by a natural gas-fired electric generating plant. The amount of electricity your utility obtains from the spot market greatly impacts overall electricity prices, as most bilateral energy contracts use forecasted spot prices as the basis for a contract price.

Understanding Peak Load

Electric systems are designed to meet *peak load*, the moment when power demand is highest.

In order to participate in the ISO power market, utilities are required to have or to contract for the capacity to meet their expected peak demands plus an additional 15% for unexpected generation outages and severe weather.

Generators are primarily classified as one of three types of units:

- **Base Load Units** - Operate year-round except for maintenance. Some base load units, except for nuclear, can change output to handle daily load swings but are not cycled on and off. These units tend to have higher *fixed costs* (construction costs) and lower *variable costs* (fuel and operating costs) and produce large amounts of power.

They are fueled by low or no-cost fuels such as coal, large scale hydro, wood, or nuclear fuel.

- **Intermediate Load Units** – Operate in times of increased seasonal demand, typically in summer and winter when base load units alone cannot meet demand. Mostly fueled by natural gas, they tend to have moderate fixed costs and higher variable costs than base load units. Hydro plants, to the extent their output can be controlled, are considered a mix of base load and intermediate load.
- **Peaking Load Units** – Operate in times of highest demand, such as mid-afternoon on an extremely hot day. They are dispatched *only* at peak times when base load and intermediate load units cannot meet demand—typically less than 5-10% of the year. Fueled by oil or natural gas, they have lower fixed costs but high variable costs. Generally, they are the most expensive to operate.

Other types do not fit these categories, such as *run of the river* hydro, solar, and wind-powered generators. These generate power only when the energy source is available and are not *dispatchable*. However, they displace other forms of generation on the grid—generally, fossil-fueled units. For this reason, most renewable-fueled plants benefit a power grid with other variable sources, such as natural gas or wood-fired generators.

The following charts (*Figure H* and *Figure I*) provide a picture of demand in Vermont on a yearly basis and on peak days.

Figure H: Peak Load over the Course of a Year - 2005

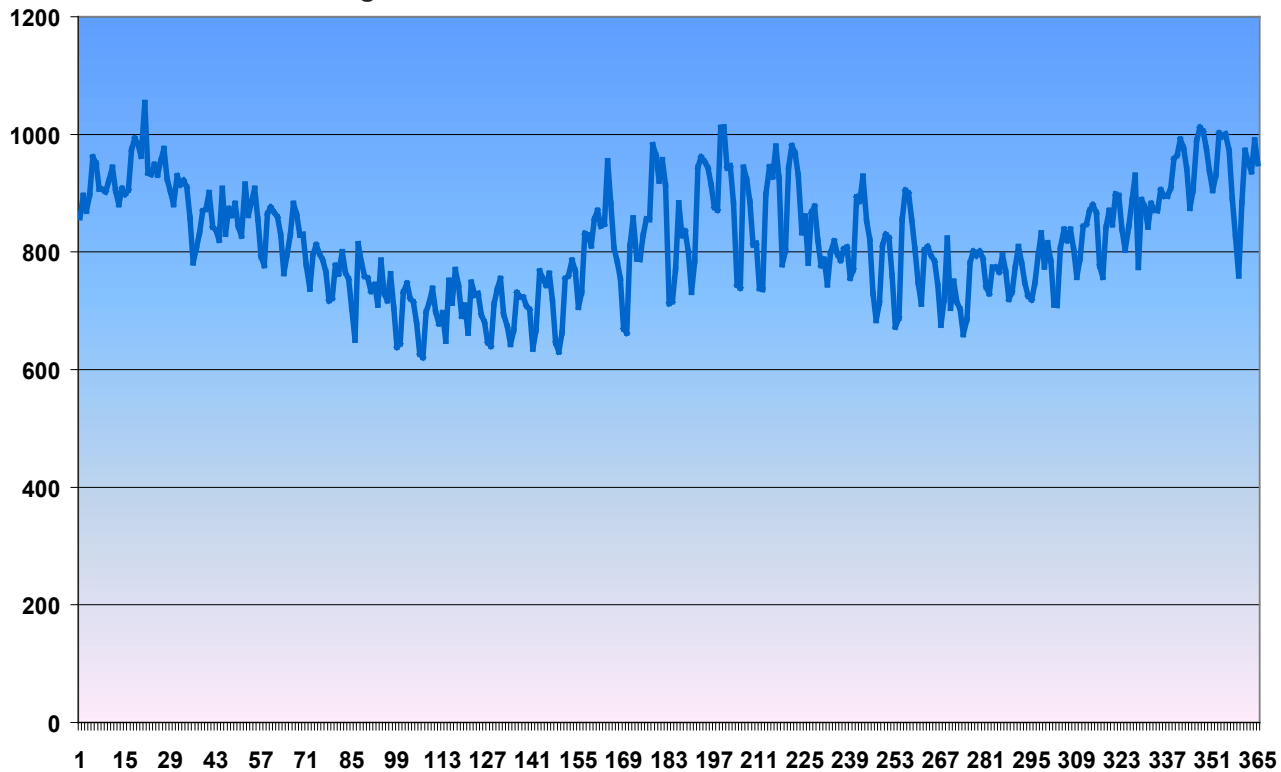
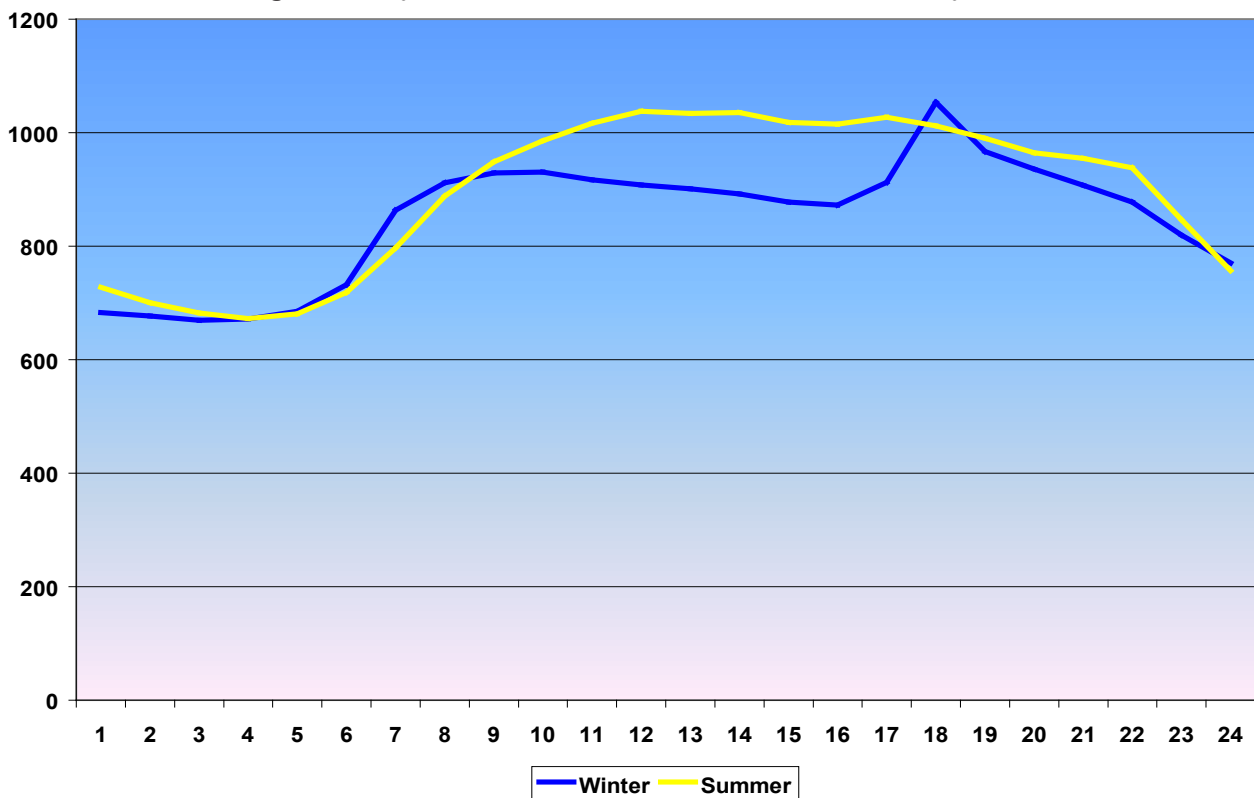


Figure I: Daily Load Curve for Summer and Winter Peak Days - 2005



Efficiency can serve as an alternative to such generation sources. Available at all times, efficiency helps to reduce demand.

In *demand response programs*, for instance, customers can respond to periods of high demand by reducing the use of air conditioners or pumps.

Typical Electric Rates in Vermont

Electric rates in Vermont are regulated and approved by the Vermont Public Service Board. Most surrounding states have competitive energy markets, and consumers can choose their electric utility.

In Vermont, each electric utility has a geographically defined service territory and is required to supply power to anyone located in that territory.

Figures J and K compare rates in New England for 2005 and 2006.

Electric bills are a product of the applicable rate and the amount used. While the rate is set by the state, consumers can control the amount of electricity they use through efficient appliances and wise use.

Vermont is a national leader in energy efficiency, and one issue under consideration is how much Vermont should invest in efficiency to meet demand.

Currently, efficiency funds are collected through a *system benefit charge* and spent on a wide-range of cost-effective programs throughout all customer sectors.

Power Supply Contracts Versus Investments in Power Plants

Essentially, there are three ways utilities obtain the electricity delivered to customers. A utility can: 1. *Build and operate a power plant that generates electricity* 2. *Enter into a contract to purchase the electricity from another utility* or 3. *Buy the electricity on the market as it is consumed—“pay as you go.”*

Almost all Vermont utilities do some combination of these.

The differences between them is less related to the particular fuel source than to the future price certainty desired, as well as the ability of the utility to borrow, invest, or put up security for long-term contracts.

Some utilities in Vermont do not have the financial strength (the credit rating or investment capital) to consider all options. Some electric utilities can only sign short term contracts and others may be unwilling to enter into long-term construction programs due to the risks inherent in such a venture.

We will return to this subject in later sections of these materials.

Vermont and Climate Change

The combustion of hydrocarbon-based fuels—including gasoline, natural gas, oil, and coal—is causing a global climate change. The combustion of these fuels releases greenhouse gases, trapping heat in the atmosphere and causing temperatures to rise.

Figure J: Average Rates VT vs. New England through January 2007

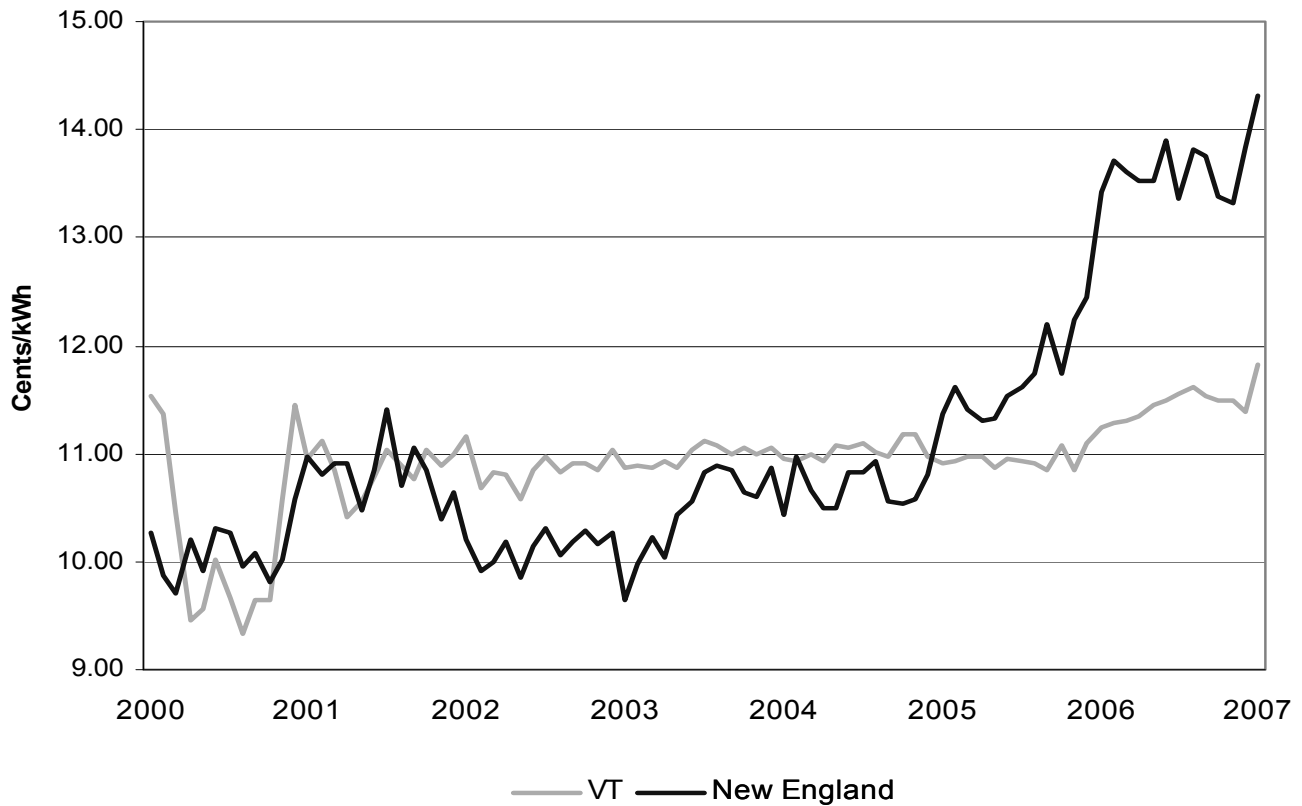


Figure K: Average Retail Price of Electricity to Ultimate Customers by End-Use Sector - 2005 and 2006 (Cents per kWh)

	<u>Residential</u>		<u>Commercial</u>		<u>Industrial</u>		<u>All Sectors</u>	
	2006	2005	2006	2005	2006	2005	2006	2005
New England	16.22	13.44	14.58	11.94	11.06	9.10	14.52	11.95
Connecticut	16.79	13.64	13.82	11.53	11.96	9.40	14.74	12.06
Maine	14.47	13.23	12.39	10.63	8.90	7.28	12.24	10.57
Massachusetts	17.01	13.44	15.82	12.42	11.38	9.22	15.40	12.18
New Hampshire	14.85	13.51	13.79	12.06	12.16	11.48	13.90	12.53
Rhode Island	15.09	13.04	13.52	11.71	12.04	10.01	13.90	11.97
Vermont	13.54	12.96	11.7	11.33	8.34	7.77	11.43	10.95

Source: EIA

Global impacts of climate change could include the raising of sea levels, species extinction, and extreme weather events.

Those in favor of aggressive climate change action plans say that if preventative measures are not taken, global warming could impact the landscape and economy of Vermont—from the number of skiing days to the habitat of the sugar maples.

They point out that a number of energy sources—solar, wind, geothermal, efficiency, and nuclear generation—do not create greenhouse gases or contribute to climate change.

While two-thirds of the electricity in Vermont comes from nuclear and hydro power and its vast quantity of trees help Vermont to offset its greenhouse gases, a number of actions to stabilize global climate change are also underway in the region.

In 2001, New England Governors and Eastern Canadian Premiers signed an agreement to reduce greenhouse gas emissions in the region to 1990 levels by 2010, 10% below 1990 levels by 2020, and eventually by 75%. These reductions will occur in all sectors—transportation, electricity, agriculture, and industry.

In 2005, Governor Douglas issued Executive Order 07-05 establishing a *Governor's Commission on Climate Change* (GCCC), a broad-based group of six Vermont leaders developing a comprehensive *Vermont Climate Change Action Plan* by Fall 2007.

The GCCC was to oversee a public effort to examine climate change impacts on the state. This includes securing input from all sectors regarding existing, planned, and potential

ways to reduce greenhouse gas emissions, helping to educate the public about such opportunities, and considering ways to save money, conserve energy, and bolster Vermont's economy, natural resources, and public health.

Ten Northeastern and Mid-Atlantic States including Vermont have entered into an agreement known as the *Regional Greenhouse Gas Initiative* (RGGI) to establish a regional cap on greenhouse gas emissions from electricity generation.

Beginning in 2009, carbon dioxide (CO₂) emissions from fossil fuel-fired power plants in participating states will be capped at average emission levels from 2000-2004 until 2015. Participating states will then reduce emissions incrementally over a four-year period to achieve a 10% reduction of CO₂ emissions by 2019.

RGGI will reduce emissions through a *cap-and-trade* program, in which power plants in participating states must pay to pollute. In a cap-and-trade program, the state will sell "allowances" to power plants.

One allowance corresponds to one ton of CO₂ emissions emitted by a power plant. Each power plant is required to acquire allowances to cover its emissions.

While plants may buy or sell allowances, there are a limited number of allowances sold by the state—each state will have an emissions cap. Allowances will be allocated to each state and auctioned annually, and the proceeds generated through the program will be used to build cleaner generation sources, invest in energy efficiency, or reduce rates.

Coal-fired, oil-fired, and gas-fired electric generating units with a capacity of 25 megawatts or more will be included in the program. Debate on similar programs is taking place at the national level in Congress.

Depending on your point of view, climate change action plans either complicate electricity planning or create a market-based approach to reducing emissions.

Decisions on this issue will have an impact on generation sources in the future. We are interested to know what you think.

Renewable Portfolio Standards and System Benefit Charges

A *Renewable Portfolio Standard* (RPS) is a requirement, usually implemented through legislation, for utilities to obtain a percentage of their energy from renewable sources.

Utilities unable to secure sufficient supplies must pay default charges into a renewable energy development fund. All New England states have an RPS, except for Vermont.

However, Vermont does have *System Benefit Charges*, which collect money through utility rates to fund the efficiency program. These programs are a way to collect money through utility rates to fund a common societal goal.

Federal Level Support for Different Types of Generation

Support for various types of generation has been provided at the federal level, because Congress believes it advances public interests.

Federal support includes research and development, tax credits for production,

favorable tax treatment in the form of accelerated depreciation, serving as an insurer, and taking responsibility for issues that cross state lines. As examples:

- Nuclear power has received federal support for research and development, federal insurance, and the federal level is responsible for the long-term solution for spent nuclear fuel
- Wind power has received support from research and development and receives tax credits for each kW produced
- The production of oil and gas receives accelerated depreciation
- Energy production from landfill gas has received tax credits for production

Federal energy legislation passed by Congress extended some of these programs, including tax credits for wind, and created some new programs to encourage new nuclear plants.

Additionally, there is pending legislation in Congress that would continue support to various kinds of generation as an indication of the importance of energy development to national security, economic, and environmental goals.

Also under consideration is a national renewable portfolio standard similar to what several states have passed.

Putting the Need in Context—How Much Power (Buy or Build) Do We Need to Plan For?

You can now begin to apply some of the terms and concepts this section has introduced.

Vermont relies on contract and purchased power, and its needs are often stated in terms

of *megawatt-hours* (MWh). Electric sales in Vermont totaled 5.8 million MWh in 2005. Vermont Yankee provided 35% of this, and Hydro-Québec provided an additional 28%.

State-negotiated contracts with Independent Power Producers (consisting of several small hydro and wood facilities) provided another 8%. As each of these contracts expire, a total of 3.9 million MWh (out of 5.8 million MWh) needs to be replaced, mostly during the 2012–2015 timeframe.

This can be done by any one or a combination of the following: 1. *Renewing existing contracts with updated terms* 2. *Signing new contracts* 3. *Building new generation facilities* 4. *Reducing demand through energy efficiency* or 5. *Purchasing power on the spot market.*

Demand in Vermont is projected to peak at 1,274 MW (megawatts) in 2012. If new generation sources are built, Vermont would still need around 700 MW. While energy need grows an additional 20-30 MW per year, efficiency programs and demand reduction are projected to more than offset such growth.

It is likely Vermont will meet its needs through some mix of contracts, energy efficiency, and building new generation sources. As you will see in the next chapters, all options have benefits and drawbacks.

Factors to Consider: Attributes for each Resource Type

Unfortunately, there are no perfect options, and it may be helpful to think of resources in terms of their tradeoffs. Resources with certain attributes may lack others—a resource may be renewable, for example, but not dispatchable.

This section of the materials provides some attributes of resources you may wish to consider.

If you have bought a car recently, researching on the internet, a consumer rating service, or a magazine, this will be a familiar exercise. In buying a car, you often weigh price, gas mileage, headroom, resale value, financing options, incentives, or other considerations.

The following attributes consider both new generation options and contract possibilities, but not all attributes are applicable to every option. You can pick and choose attributes based upon what is important to you.

Cost

- **Cost to Build or Install** – Vary across options. Natural gas options tend to be cheaper to build than coal or wind generation.
- **Cost to Operate** – Are most often fuel. Natural gas is more expensive than coal, both are more expensive than wind, which is essentially a free fuel.
- **Total Cost per kwh** – The annual capital costs (mortgage), fixed costs (property taxes), and variable costs (fuel) divided by the expected annual production from the plant. Electricity on the wholesale market might typically cost 6-8¢ per kwh (or \$60-\$80 per MWh). Retail prices can double after transmission, distribution, and overhead costs. Energy efficiency can also be calculated on a total cost per kwh basis and is generally less expensive than generation options.
- **Cost Over Time** – is difficult to predict. Fossil fuels may become scarce (in the case of natural gas or oil) or burdened with new pollution control or green house gas requirements.

Size

- **Generation Output** – The typical size of a generation option. Nuclear plants and coal-based plants tend to be the largest (500-1000 MW). Natural gas plants tend to be in the mid-range (50-250 MW). Wind and hydro, as might be feasible in Vermont, tend to be smaller (1-50 MW). Efficiency programs tend to be very small but add up when many customers participate.
- **Footprint** – The amount of space consumed by the option, either *local* or *global*. The *local footprint* is the land area occupied or impacted by the option—the power plant or wind farm. The *global footprint* includes other considerations—the mine where fuel originates, the refinery where it is prepared, or the transportation of fuel to the power plant.

Environmental and Health Impacts

- **Air Quality Impacts** – There are four major air pollutants to consider when weighing options:
 - *Sulfur Dioxide (SO_x)* – The major component in acid rain
 - *Oxides of Nitrogen (NO_x)* – A major component of smog and haze
 - *Particulates* – A component of haze and contributor to breathing problems
 - *Mercury* – A pollutant from coal-based sources that builds up in organisms. It causes health problems including developmental and reproductive disorders
- **Climate Change and CO₂ Levels** - The impact climate change from emissions of carbon dioxide and methane.

- **Water Use** - Usually for cooling purposes when combustion is involved or to divert for hydro resources.
- **Other Environmental Impacts**
 - Nuclear waste disposal and transportation
 - Transportation of fuel sources
 - Interruption of the flows of rivers
 - Visual impact—wind turbines or transmission lines

Economic Attributes

- **Jobs Created (Construction or Operation)** – Vary considerably and are difficult to quantify and compare on a MW or MWH basis. Efficiency projects may be some of the most labor intensive, while wood fuel sources can benefit the entire timber industry.
- **Tax Benefits** - Projects with large investments create more taxable assets. New tax revenues potentially lower property tax burdens and provide additional services.
- **Disposable Income Effect** - Less expensive energy choices keep more money for other goods and services in Vermonters' pockets, creating additional economic benefits.

Other Characteristics and Attributes

- **Dispatchability** - The ability to start and stop the resource. Natural gas and many forms of hydro are dispatchable resources, as they can be started and stopped easily. Wind is not, nor are nuclear plants.
- **Contribution to the Load Curve** - Whether the resource runs when demand is highest (the *peak portion* of the load curve), moderate (the *shoulder*

or *mid-range*), or lowest (the *baseload*). One is no more desirable than another—it depends on the portfolio being assembled.

- **Risk Factors** – A broad range of characteristics, such as the volatility of fuel prices or supply interruptions due to political or environmental factors. Risk can also include political elements, such as an additional carbon tax or contractual risks including one party defaulting on its obligations.
- **Construction Time** – The time to permit, approve, and build the facility. A coal plant may take 5-7 years, gas 2-3, wind less than a year to build but several years to permit and study. The planning and construction of a nuclear plant is estimated at 10 years.
- **Impact on the Transmission System** – Whether the resource requires a new transmission system or relieves congestion on the current system. Impact can depend where a generator is built instead of what kind is built.
- **Lifespan of the Option** – The longevity of the source. Conventional sources usually have lifetimes of 25-30 years. Efficiency options vary—appliances have shorter lifespans, while insulation can last 50 years or more. The lifespan of a contract is specified by the parties.
- **Resource Availability** – The probability that the resource will be available when needed (similar to dispatchability). Whereas wind and small hydro vary with natural conditions, efficiency measures can depend upon customer behavior. Some imported purchased power contracts are subject to transmission congestion or interruption.

Point of View – Not Everyone Thinks the Same Things are Important

Resource planning is also a challenge because not everyone thinks the same things are important.

One reason we have asked you here is to gain more insight into this issue. This section focuses on value and tradeoffs with energy resources and is similar to the section on attributes for generation options. When you look at the attributes of each, how do you make a choice?

While there are many possible values that can inform your decision, important ones include:

- **Lowest Cost** – Some participants may prefer the option costing least. They may be on a fixed income or own a business and lack the ability to sustain cost increases. They may work for a large employer who competes globally, or they may be fiscally conservative.
- **Predictable Bills** – Others may prefer having a consistent electric bill. This group might prefer a long-term contract with a fixed escalation rate to a contract subject to market prices for fuel. Attitudes toward predictable bills can reflect a person's comfort with risk.
- **Greatest Reliability** – Some customers may prefer reliability. They may be less interested in options that depend on natural or weather-related events, preferring contracts with utilities that are well-funded with excellent credit ratings. They might be willing to pay more to assure that fuel supplies are under fixed-price long-term contracts. They may wish to avoid imported power or fuels.

- **Least Environmental Impact** – Some may prefer the options with the least environmental impact, whether in terms of emissions, climate change, radioactive waste, or visual impact. Some may be opposed to transmission line construction and favor localized or distributed generation options. They may be willing to trade cost for this value.
- **Independence and Self-Reliance** – Some participants may prefer self-reliance and to be free of foreign fuel. For some, this may mean generating power in Vermont, for others, somewhere in New England, Canada, or nearby. Others might say that electric grids are highly interconnected and power flows freely within the U.S. and Canada.

Chapter 1:

Natural Gas, Coal, Nuclear, and Oil

This section of the materials discusses four options for electric generation. The options differ largely on fuel type and each option has advantages and disadvantages.

NATURAL GAS

Brief

Natural gas as an electric generation fuel has great flexibility and burns cleaner and the technology is more efficient than either coal or oil. It is economical both as a peaking fuel (simple cycle) and as an intermediate and base load fuel (combined cycle).

In terms of electricity generated in 2006, 38% of the generation in New England was fueled by gas. The amount of natural gas generation grew in the late 1990s when gas was cheaper (\$2 per MCF) than it is now, and inefficient oil units were replaced.

Gas is now in the \$5-7 per MCF (per thousand cubic feet) range and future prices are difficult to predict. Gas is available in the northwestern portion of Vermont, but there is no natural gas-fired electricity generation in Vermont. The combustion of natural gas contributes to greenhouse gases.

Right now in New England, wholesale market electricity prices are strongly correlated with natural gas prices. While the largest global natural gas reserves are in the Middle East and the former Soviet Union, 80% of New England's natural gas comes from North America, and Vermont's natural gas comes from Canada.

Several terminals to import liquefied natural gas (LNG) are either under construction or

in permitting in the Northeast. Advocates say LNG might stabilize natural gas prices.

Advantages

- Low construction cost
- Flexibility in unit size
- Short construction period
- Fewer emissions than coal or oil
- No need for fuel storage or fuel handling areas like coal or wood; has a smaller footprint (backup fuel is usually oil)
- Dispatchable

Disadvantages

- Contributes to greenhouse gases; has some emissions of NO_x
- Natural gas prices are less predictable than other fuel sources
- Natural gas is imported into the region and thus can be subject to transportation or supply disruptions caused by unforeseen environmental or political actions
- There is a finite supply of gas
- May require water for cooling for larger combined-cycle plants

Natural gas is a flexible fuel. It is readily available in much of the U.S. and transported by pipeline. Natural gas burns cleaner than traditional coal plants (in which coal is pulverized and combusted in a boiler—see coal section for prospective improved technologies).

Over the last ten years, it has increased in efficiency by about 30%. Prior to 2000, there was a boom in the construction of natural gas generation in New England and the U.S. for these reasons.

The boom, however, has since declined because gas has become more expensive.

A major disadvantage of natural gas is the unpredictability of its prices. Gas prices are often stated in the cost of a *thousand cubic feet* (MCF). While gas prices are currently in the range of \$6-\$7 per MCF, over the past decade prices have fluctuated from \$2 per MCF to \$13 per MCF.

Vermont has little control over price swings of this magnitude. Natural gas plants are typically built to be 50-250 MW in size. They are estimated to cost between \$525-\$730 per kW of capacity, with the larger plants having the lowest cost per MW to construct.

There are three types of natural gas technology:

- **Steam Generator/Steam Turbines**
- Typically large units that serve as baseload or intermediate load units.
- **Simple-Cycle Gas Combustion Turbines** - The least expensive to construct but expensive to operate (requires more fuel). They are typically used as peaking units.
- **Combined-Cycle Gas Turbines**
- Recycle exhaust gases from a combustion turbine, producing steam to generate additional electricity in a steam turbine. They are more expensive to build than simple cycle units but are more efficient and have lower fuel costs. They are typically used for intermediate portions of the load curve.

The advances in natural gas efficiency have come largely through improvement in gas turbine technology and the efficient use of recycled exhaust gases. It is interesting to

note that natural gas turbines in smaller sizes are interchangeable with aircraft engines.

The recent improvements in efficiency have made the efficiency differential between peaking plants and intermediate plants less important for natural gas. There have been natural gas units proposed for Vermont in the past—they ran into opposition, and development plans were dropped. As noted earlier, none has been permitted or sited to date.

The nature of the opposition centered around placement of the proposed units and the proposed large size of the units (produced more power than was needed in the area or Vermont). Some opponents stated that Vermont would suffer the disadvantages of power plant location for power that was to be shipped to other states.

Supporters observe Vermont interests could get all the power that they would want from such projects and would benefit from the economies of scale associated with producing more for export. Others believe smaller units, sized for the local Vermont needs, might not suffer the opposition that plagued the earlier proposals.

In the comparative tables found in Chapter 5, we use three gas plants as examples.

The first is a small (25 MW) simple-cycle combustion turbine (CT). This plant is designed for peak load purposes. The second is a larger 50 MW combustion turbine (CT).

The third option is a larger (200 MW) combined-cycle plant (CTCC) that is appropriate for either intermediate load or base load purposes.

Figure L: Vermont Gas Distribution Line and Service Territory - 2006



COAL

Brief

While there is no coal-fired generation in Vermont, the state purchased 14% of its electricity in 2006 from the New England Power Pool, which includes coal generation.

In terms of the electricity generated in 2006, coal made up 14% of the generation in New England. In the U.S., about 50% of the electricity is generated with coal. New technology might make coal a cleaner burning fuel and lower its contribution to greenhouse gases, but this will also increase the cost of using coal.

Advocates say coal must be an element of the U.S. energy solution due to the large amount of new generation required and the impact on national security. Opponents say current pulverized coal technology should be discontinued due to environmental impact, and that the jury is out on the feasibility and performance of new coal technologies.

If coal is selected as an element of the future Vermont electricity portfolio, it would likely be through contract rather than a building a new coal plant in Vermont.

Advantages

- U.S.-based fuel source
- Coal can be stored on-site in large quantities
- Potential for long-term contracts
- Less price volatility than gas
- 200 or more year supply
- Generating plants using coal can be built in large sizes (700-1,000 MW), achieving economies of scale

Disadvantages

- Greater emissions than all other generation types (NO_x, SO_x, particulates, mercury)
- Major contributor to greenhouse gases
- New technology (IGCC) to burn coal cleanly is untested and cost is unclear
- New technology to capture CO₂ is untested and cost is unclear
- Takes longer to build and site (5-7 years) than other options
- Coal plants only come in large sizes
- Transportation costs and available infrastructure to support new transportation are limiting factors

The main advantages of coal are its abundant supply in the U.S., stable prices, and consistency (its technology has been used for over 50 years).

While coal plants are more expensive and take longer to build than natural gas plants, they produce power at a cheaper rate per megawatt hour, due largely to stable fuel prices. States in the U.S. with large amounts of coal generation tend to have cheaper electricity.

The primary disadvantage of coal is emissions. While coal is doing significantly better on air emissions (NO_x, SO_x, and particulates), efforts to control mercury are only now underway and coal still emits far more of these than natural gas.

The overwhelming concern for coal is its contribution to climate change through carbon dioxide emissions.

As a consequence, permitting of new pulverized coal plants has significantly slowed in the U.S. and Canada, as most wait for improved technology.

If coal is to have a significant future as a generation source, then technological changes will likely be required to reduce carbon emissions. Since the coal itself has a fixed amount of carbon, techniques for reducing CO₂ emissions involve either increasing efficiency or capturing the CO₂ before it leaves the exhaust stack.

The most-discussed technology for efficiency improvement is called *Integrated Gasification Combined-Cycle* (IGCC). In a IGCC, a chemical process converts the coal to a gas that is cleaner to combust, enabling the CO₂ to be more easily captured. The coal/gas is then burned in a *combined-cycle plant*, which is an efficient way to burn gas.

The current challenge is to make the two processes work together on a day-in-day-out basis, especially when coal does not have a consistent molecular structure (like gas).

Another consideration with new coal technologies is how to capture the carbon dioxide and what to do with it. Some propose to use it commercially in process manufacturing or enhanced oil field recovery.

Others propose a process called *sequestration*, or storing it long-term in abandoned gas and oil wells or at sea. Several companies say their technology for sequestration is ready for commercial use.

A less dramatic technology employs a conventional boiler combusting pulverized coal to produce ultra supercritical steam and scrubbers to clean the exhaust gas. The

design offers more efficiency in fuel conversion and less pollution than conventional plants. However, it is unclear whether there is any viable solution to removing CO₂ from the emissions of this design.

A few IGCC plants are operating in a demonstration phase, but most experts would agree we lack commercial experience with the technology. Several companies believe their technology is ready for commercial adoption and are proposing IGCC plants. One of these is a 680 MW IGCC plant proposed by NRG (a company specializing in generation) in western New York.

According to news releases, the plant would go into operation in 2013. NRG was the winner of the competition to build an IGCC plant and sell to the New York Power Authority. However, the costs of these new plants is uncertain until we have more experience. Some say the costs of IGCC plants with sequestration will be twice that of a pulverized coal plant, others even more.

Assuming the technological challenges can be resolved, coal has additional advantages. Because it is a domestic resource, coal has implications for energy independence in the U.S.

Coal plants are generally larger (700-1,000 MW) and can achieve economies of scale. Coal is typically transported to plants by rail and barge and can be stored on site, avoiding supply shortages. While the ash produced from burning coal has many chemicals and needs proper disposal, it has found use in the construction industry. About 50% of the electricity produced in the U.S. is from coal.

The disadvantage of coal is its emission profile, especially carbon. Another current disadvantage is the uncertainty over the cost for new technology, such as IGCC. Because of the large size of typical coal plants, coal may be an unlikely option for location in Vermont.

The cost of transportation for coal is a significant variable, and the availability of transportation has experienced limitations in some parts of the country. Coal, especially the IGCC version, has a much larger footprint than does a natural gas plant and takes much longer to build (5-7 years).

The issue then becomes the desirability of coal as a fuel type in a portfolio of purchased power contracts that electric utilities in Vermont may select. Some may say that if the coal plant is in another state, then that is not a Vermont impact, especially if the price is stable and lower than other energy generation contract options.

Others say it depends on which way the wind blows regarding things like acid rain, but that climate change is a global problem regardless of plant location. They say that, in any case, Vermont should be responsible about its emissions profile.

The comparative chart in Chapter 5 looks at three coal options. The first is a traditional pulverized coal plant that would form the basis of advantages and disadvantages for existing coal-based power.

The second option is an IGCC plant (without sequestration). The third option is a *circulating fluidized bed* (CFB) plant that uses an advanced form of combustion to reduce emissions (it also does not include

sequestration of carbon dioxide). The environmental chart in Chapter 5 compares current coal technology with an IGCC plant and includes sequestration.

NUCLEAR POWER

Brief

The Vermont Yankee Nuclear Plant currently provides 35% of the electricity consumed in Vermont, which is about 46% of Vermont Yankee's total output (the other 54% is exported to other states). As a significant portion of our base load power (the other being Hydro-Québec), it often meets as much as 50% of our daily demand for energy.

Vermont Yankee was granted a 40-year license to operate, beginning in 1972, by the U.S. Nuclear Regulatory Commission (NRC). Under consideration now is whether the plant will be given permission to operate for another twenty years following 2012 and, if so, whether Vermont utilities will continue to purchase power from Vermont Yankee. Vermont utilities could also possibly purchase power from other operating nuclear plants in New England if available.

Proponents of nuclear power in the U.S. are advocating new nuclear plants and license extensions at existing plants as a way to combat greenhouse gases, offer stable prices, and increase energy independence.

Opponents of nuclear power say there are other options available. They cite concerns about safety of nuclear plants as they age and the possibility of accidents and point out nuclear plants are considered possible

terrorist targets. Opponents also cite the considerable issue that absence of a national waste disposal site represents.

If the Vermont Yankee plant is not relicensed and new power contracts for Vermont Yankee Power are not negotiated past 2012, alternate measures will be needed to meet Vermont's electricity needs and to meet its greenhouse gas reduction goals.

Advantages

- No greenhouse gases or emissions from power generation, since nuclear plants do not burn fossil fuel
- Reliable base load power, meaning it is part of our every day energy supply
- Potential to negotiate a long-term (up to 20 years) contract for power
- Economic benefits to Vermont in the form of taxes, revenue sharing, and 650 jobs
- The plant already exists along with the needed transmission infrastructure; it is an in-state generation source
- If the plant is re-licensed, a prior regulatory order requires revenue sharing for Vermont customers when prices are above \$61 per MWH
- The plant has a 35-year track record of high reliability and consistent power output
- Over the past five years, the plant has been retrofitted with multiple equipment upgrades and large component replacements

Disadvantages

- There is currently no long-term solution (nationally) for safe storage of nuclear waste.

- There is currently more than one million pounds of high-level nuclear waste being stored at Vermont Yankee in a pool approximately 26 feet wide and 40 feet long. Continued operation creates even more spent fuel stored on-site
- Operation of a nuclear facility always poses some degree of risk for potentially serious accidents
- The plant, like any other mechanical or industrial facility, has experienced mechanical failures
- As a unit-contingent contracted facility, power from Vermont Yankee is predicated on the reliability of a single facility, meaning that a plant shut-down would have a greater impact on customers than would be the case if power were received from multiple resources
- Nuclear fuel is finite; reprocessing nuclear spent fuel is practiced in other countries but is not currently available in the U.S. If nuclear generation expands worldwide, the price of nuclear fuel could go up, with increased demand

The most likely option for nuclear power for Vermont on an ongoing basis primarily revolves around the Vermont Yankee Plant operated by Entergy Nuclear Northeast in the town of Vernon, VT.

Vermont utilities could purchase the output from other nuclear facilities in New England, but Vermont's degree of leverage and long-term relationship is with Vermont Yankee.

Entergy Nuclear is a specialized nuclear plant operator that owns and operates several nuclear plants in the northeast.

The issues are whether the plant will be relicensed by the U.S. Nuclear Regulatory Commission (NRC) for an additional twenty years of operation, receive a Certificate of Public Good (CPG) from the Vermont Public Service Board (both are needed under federal and state laws), and whether additional storage of nuclear fuel waste will be approved by the state Legislature before the current license expires in 2012.

The capacity of the original, water-filled “spent fuel pool” is nearly exhausted. Ongoing operation is being conducted by moving some of the older fuel assemblies from the spent fuel pool into separate concrete and steel canisters, or *dry cask storage*. Even if the plant were to be closed in 2012, additional dry cask storage would be needed in order to empty the reactor and the spent fuel pool.

An additional consideration will be whether suitable contracts for purchase of the power can be negotiated between Entergy and Vermont’s distribution utilities.

The requirement for legislative and regulatory relicensing approvals suggest that a future contract with Vermont utilities could be obtained on favorable terms (e.g. lower price, easier credit requirements, etc.) or other benefits obtained for Vermont.

Vermont Yankee currently provides approximately 35% of the electricity used in Vermont at a fixed price of \$40 per MWh. In comparison, nuclear power provides 14% of the power in New England and 20% of the power in the U.S.

While there is renewed interest in new nuclear plants across the U.S., and the federal government has created a program of

tax incentives for those interested in building new nuclear plants, the option for a new plant anywhere in New England is beyond the 5-10 year timespan we are considering (a new nuclear plant would likely take at least 10 years to permit and build).

Vermont’s major utilities have indicated an interest in discussing the continuation of new power contracts after 2012. Terms and conditions for such an extension are unknown at this time, but preliminary negotiations are expected to begin in the next several months.

Those in favor of relicensing and new power contracts past 2012 say:

- Vermont Yankee is a good in-state source for a large quantity of Vermont’s base load electricity
- The plant already exists, along with existing distribution and transmission needed to move the power; no new construction is required
- The plant’s operation creates no greenhouse gas emission since a nuclear plant is a non-fossil fuel generation source
- Continuing a reliable long-term contract could provide stable, predictable power prices; the contract currently in effect has saved Vermont customers more than \$250 million over the past five years, compared to what the power would have cost at market prices, and has contributed significantly to Vermont having the lowest electric rates in New England
- The plant provides economic benefits to Vermont estimated at about \$200 million per year, including an employee payroll

of 650, significant state and local tax payments, and purchases of goods and services from in-state businesses

- Vermont Yankee produces benefits to the state, whether or not Vermont utilities take the power from the plant

An existing regulatory order requires plant sales after 2012, which are at prices above \$61 per MWH, to be shared with certain Vermont utilities. Depending upon future market prices, these benefits could be tens of millions of dollars annually.

Those in favor say the issue of storing spent nuclear fuel is ultimately the responsibility of the federal government. While limited action has taken place at the federal level, the technology and funding is in place to safely store spent fuel at the Vermont Yankee site until the federal government takes ownership.

Those who oppose the Vermont Yankee nuclear power plant cite ongoing safety concerns about the plant (and nuclear power in general) and concerns about storing spent nuclear fuel. They point out that other nuclear plants in the region have been shut down.

They say the economic benefits of the plant (such as jobs and tax payments) do not offset the potential for an accident. They believe the economic benefits of alternative energy sources are as good or better, especially in job creation.

While the debate continues, analysis of the economic benefits of alternative energy sources (with the exception of biomass) appears to be contained to early construction and, after completion, very limited as compared to the overall workforce.

The issue of storing and disposing of nuclear fuel is of major concern. By law, spent nuclear fuel is the responsibility of the federal government.

The federal government has failed to build an adequate waste disposal site despite more than two decades of research and investment (the fuel is radioactive for many thousand years). Until a national repository is opened, spent nuclear fuel is stored at the nuclear plants.

Nuclear plant operators say the technology for plant storage is safe and reliable until the national issue is resolved.

Opponents of the Vermont Yankee extension are not convinced and say it is irresponsible to continue producing nuclear waste if there is no reliably safe long-term solution currently available.

In the final analysis, it is perhaps overly simplistic to cast the issue of long-term waste disposal in terms of how opponents or proponents see it.

In deciding upon an extended life for Vermont Yankee in Vermont, the state and its citizens will need to balance the very real benefits of reliable base load power at stable prices against the possibility that the spent fuel will be stored in Vermont for an as yet defined period of time. This is the ultimate risk and benefit calculation that we all have to make.

OIL

Brief

Oil has long been an important fuel in New England, but recently has been displaced by natural gas where it is available. It provided 2% of Vermont's in-state generation capacity in 2006 and 9% of the electricity produced in New England.

Oil is also part of the system mix purchased from the New England Power Pool. It is between gas and coal in terms of emissions and greenhouse gases. Oil is flexible, in that it can be delivered by truck, making it a potential fuel source for distributed generation and combined heat and power systems.

Oil can also be used in peaking plants that usually run less than 100 hours per year. Oil prices have more than tripled over the past decade.

Advantages

- Less pollution and greenhouse gases than coal
- Can serve as a backup or replacement to natural gas
- Can be transported by truck to areas where natural gas is not available
- Has good dispatchability; starts quickly and can decide when to run
- Possible fuel source for distributed generation

Disadvantages

- Price can be volatile and tends to be more expensive than gas
- Limited oil supply globally

- Oil consumption is a negative for national security and energy independence
- Contributes to greenhouse gases
- Contributes to other air emissions (SO_x, NO_x, particulates, and mercury)

Oil is an older fuel and, in many cases, has been replaced by natural gas. Oil made up 34% of New England's generative capacity in 2000 and only 24% by 2006.

New oil plants in Vermont would likely serve peak demand. It is a relatively efficient fuel for peak load, and small oil-fired turbines have benefited from the technological advances in natural gas turbines.

Oil can be transported by truck to remote locations that do not have natural gas. However, disadvantages include price volatility (which fluctuate with natural gas and world oil) and its emission levels. Oil is a hydrocarbon and burning oil releases carbon dioxide to the atmosphere at levels above natural gas and below coal.

Those arguing for oil to serve demand point out that peaking units typically operate less than 100 hours per year.

Chapter 2: Biomass, Hydro, Wind, Solar, and Combined Heat and Power

This section considers a broad range of generation options that are smaller in size and typically do not depend on *finite fuels*. Finite fuels are those with limited amounts remaining, including oil, natural gas, coal, and nuclear.

It is estimated there is oil and natural gas for another 20-50 years, coal for 200-plus years, and nuclear for several hundred years. Instead, the options in this chapter tend to rely on *renewable fuels*. The terms *renewable* and *renewable fuels* can have multiple definitions.

As commonly stated, a renewable is a fuel source that is inexhaustible, such as wind, water, geothermal and solar, or one that regenerates at a rate greater than or equal to the rate it is consumed—as in many forms of biomass.

For the purpose of discussion, renewable projects come in two basic sizes: *utility scale* and *smaller scale*.

Utility scale projects share many characteristics with other utility generation. Utility scale projects can include large wind farms, large scale hydro, large scale biomass, and geothermal. 20-50 MW would be a large, utility scale renewable installation for Vermont (such as a large wind farm, or the Burlington wood chip plant). It is also possible to purchase power from large renewable projects located outside Vermont (Hydro-Québec is an example). Utility scale solar is under development in the southwestern U.S. but is several years away from commercial operation.

Smaller scale renewable projects range from several MW to very small projects used to

provide part of a single home's usage. The very small projects are often dedicated to a particular load and are termed, "behind the meter."

If there is more power produced than the load requires, *net metering* is sometimes allowed for small projects. These small projects essentially turn the meter backwards reducing the amount of electricity one needs to buy from their local utility, thus called net-metering. If more electricity is produced than is needed, it can be sold to the electric utility at wholesale prices.

Net metering is a simplified billing method which does not take into account the fact that energy produced at different times is of different values. Net metering is designed to encourage very small, homeowner-sized renewable generation sources.

Many of the options in this section are also eligible for *Renewable Energy Certificates* (RECs), another method used to stimulate small renewable sources (see below).

RENEWABLE ENERGY CERTIFICATES

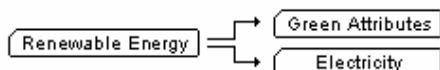
In the U.S., a growing recognition of the importance of renewable energy has resulted in a number of federal, state, and utility initiatives to encourage the growth of the renewables sector and to incorporate more energy from renewable resources into the nation's power grids.

Some of these initiatives are voluntary, like green pricing programs, and some are mandatory, like renewable portfolio standards.

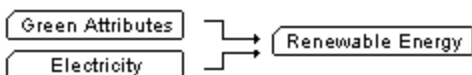
Almost all of these initiatives require the operator of the New England electric system to carefully account for the amount of renewable energy sold to customers. One feature of this accounting is the use of *Renewable Energy Certificates* (RECs).

One REC represents the attributes of one MWh of renewable energy—but not the electricity itself.

Generation from renewable sources can be separated from the commodity electricity to create two products—each of which can be sold separately:



A utility with requirements to meet a certain percentage of its supply with renewable energy is able to demonstrate compliance either by creating RECs with its own resources or by purchasing them from owners of other renewable facilities. When RECs are combined with electricity from any source, it is considered renewable electricity.



For example, if a utility receives 100% of its electricity from a coal plant but combines it with the purchase of an equivalent number of RECs, that electricity would be considered renewable energy for their reporting requirements. Conversely, if a utility chooses to sell the RECs from a renewable project, it no longer can claim that resource as renewable in its portfolio.

A strict rule which prohibits double counting retains the integrity of the system and

ensures that those paying for the renewable attribute get the credit.

For a utility, RECs represent a convenient way to demonstrate compliance with any regulatory requirements regarding quantities of renewable energy. They also ensure customers get what they pay for, since only one REC is issued for each MWh of renewable energy produced.

For an owner of a renewable project, RECs represent an additional source of income to justify the construction of a project and encourage additional projects are built.

For policy makers, RECs inject market forces into the procurement of renewable energy. Competition would suggest that the most cost-effective renewable projects will be built under such a system.

For consumers of electricity, RECs represent a way to ensure that their utility is actually delivering renewable energy to them.

The market price of RECs depends on the relationship between the demand for RECs and the supply of RECs. The demand is a function of the region's various renewable portfolio standard requirements. Most REC requirements will likely increase over the next several years.

The price is also influenced by the demand for voluntary green pricing programs, such as the *Cow Power* program offered by CVPS. The supply is driven by the pace of new construction of projects that qualify. At present, supply is lagging demand in many areas, so prices for RECs from new projects are high.

Referring to the discussion on externalities, the price of RECs internalizes through a combination of policy and markets what used to be thought of as an externality.

Each state defines the type of generation that qualifies as a renewable resource in that state. Generally, RECs are tradeable within the New England region.

EXTERNALITIES

The production of electricity involves many costs—some of which are borne by the consumer and some of which are passed on to society at large.

Costs typically borne by the consumer include the fuel and capital costs of generating electricity. Whereas those costs passed on to society at large include emissions from power plants (particulates and mercury) and the related healthcare costs that follow—these are called *externalities*.

There have been efforts to include a greater portion of externalities in the production costs of electricity. Initial efforts included requiring emitters to clean the sulfur from flue gases with scrubbers or by purchasing lower sulfur fuel. More recently, permits have become required in order to emit various pollutants into the air.

The annual amount of permits issued is limited, thereby reducing the aggregate pollution from a particular generation type. RECs are a similar device, in that the externality costs for cleaner generation are included into the costs we pay for renewable resources.

The requirements for renewable portfolio standards are enacted by elected officials who are concerned about the pollution associated with generating electricity and want to see renewable energy business grow in their state. The additional costs, which are passed on to consumers, represent those societal values as perceived by the various state legislators, and they serve to send a price signal to consumers regarding their use of electricity.

BIOMASS

Brief

Vermont is one of the leading states in the use of biomass to generate electricity—most is from wood by-products. With 78% of the state forested, the rate of consumption is sustainable (less is used than replaced).

In 2006, wood provided 8% of the electricity consumed in Vermont. Wood generation units can range from 50-60 MW down to 1-3 MW. Wood has economic benefits in terms of jobs, but price can also fluctuate based on what is going on in the forest products industry.

Burning wood emits greenhouse gases. However, the CO₂ from biomass is recycled as the next generation of trees mature. Generation from farm-based wastes (such as manure) that have been turned into methane is a new and growing source. While farm methane projects are not economic just for electricity production, the associated benefits of odor and runoff control make the process feasible.

Advantages

- Wood as a fuel in Vermont is renewable
- Landfill gas or methane from a farm is generated from a waste product
- Creates jobs and provides another revenue stream for forest industries and agriculture
- Is neutral to beneficial on greenhouse gases (wood is neutral if sustainably harvested, beneficial if used instead of natural gas; methane fuel sources are beneficial when they prevent methane from escaping to the atmosphere)
- At current natural gas prices, the cost for wood generation is competitive

Disadvantages

- Biomass is usually waste wood from another process and price and supply can fluctuate
- Must be transported from the forest to the plant
- While emissions have improved, there remains some concern over particulates
- Some say wood products should be dedicated to combined heat and power systems (where both electricity and useful heat is generated) rather than used for large-scale generation

Vermont is a leader in the use of electrical energy produced from biomass sources.

The following discussion about advantages and disadvantages of biomass energy is taken largely from the *Vermont Energy Digest* published in April 2007 by the Vermont Council on Rural Development (Brenda Hausauer, author) and from the work of the Biomass Energy Resource Center and their *Vermont Wood Fuel Supply Study*.

Because the range of options in biomass energy is so broad, these materials will concentrate in two areas: 1. *Wood chips* and 2. *Methane gas from farms and landfills*.

The potential for wood chips or wood as a fuel is all around us—about 78% of Vermont's land is forested. Vermont electric utilities have long considered wood as a source of fuel to generate electricity and as a source of energy for combined heat and power systems.

The technology for using wood as a fuel is advancing and is becoming more efficient and cleaner. But the source of wood for large electric generation can be uncertain as it tends to be a by-product produced from other industries. For example, wood availability and price suffers at times because of the close and obvious linkage to the forest products industry. As the forest products business goes through cycles, wood-fueled power is directly impacted.

Wood

According to the Vermont Department of Public Service, wood provided 8% of our electricity supply in 2006. Vermont currently has two wood-fired power plants and one more in a conceptual stage.

The McNeil Generation Station in Burlington is owned by the Burlington Electric Department (50%) and other Vermont utilities. It has a rated capacity of 53 MW and has operated since 1984. McNeil was the largest wood-fired generator in the world when it came on-line.

After the plant opened, its fuel price was not competitive with low oil prices beginning in 1986, and thus it operated at a low capacity of

about 20% for a time. In 1989, McNeil added the capability to fire its boiler using natural gas when wood was not economic. With today's high natural gas and oil prices, McNeil is now fairly competitive and basically burns no oil or gas except for startup purposes.

The McNeil plant provides 39 jobs at the power plant, including four procurement foresters. There are about twice that number of full-time jobs associated with wood harvesting, transportation, etc. It has contributed over \$200 million to the local economy through January 2007 (not including the construction of the plant).

It also uses sawdust, chips and bark from local sawmills, and processed urban wood waste. Local residents contribute between 2,000-3,000 tons per year of yard trimmings and 3,000-4,000 tons per year of pallets (Irving, 2007).

A second wood-fired generation plant in Ryegate came online in 1992, with a capacity of 20 MW. The Ryegate plant is an Independent Power Producer (IPP) selling power through the Vermont purchasing agent, similar to in-state hydroelectric facilities. When Ryegate's contract ends in 2012, the company hopes to sell power through the New England power grid.

There are several new wood-fired generation plants currently under consideration in Vermont, including one that plans to supply heat and power to an existing industrial facility.

Wood chips are a low value product produced from sawmill residue or concurrently with a forestry logging operation. Sawmills generally try to minimize their creation of wood chips. So while demand for wood chips

may increase in the future, the creation of wood chips as a by-product is not likely to increase.

Production of wood chips requires significant investment in a wood chipper for a low value product. This creates a market that is not straightforward, and prices and reliability of supply can change. Developments in the pulp and paper industry impact wood energy prices. Wood chip prices have gone from \$18 per ton in 1984 to \$29 per ton today. This price change is similar in pattern to coal, smaller than the change in other fuels such as gas, but is less volatile.

Vermont has enough wood to increase its use for the large-scale generation of electric energy, but the state may not have enough loggers and equipment. Landowner and harvesting issues also exist. The sizes of land parcels are shrinking, and there is a new generation of landowners purchasing properties. Harvesting wood often has no significant financial advantage to landowners.

Farm-Based Biogas Energy Systems

When Vermont's cows are fed a ration of grain, corn silage, and hay, they extract the energy they need from the feed to provide for their own growth and sustenance and to produce milk. However, because no biological process (including a cow's stomach) is 100% efficient, the manure it excretes contains a significant amount of additional potential energy.

By employing the process of anaerobic digestion, farmers can extract this potential energy in the form of biogas. The biogas can, in turn, be used to create electricity and heat.

Anaerobic Digestion of Biodegradable Wastes

Anaerobic digestion is the bacteriological breakdown of organic (carbon-containing) material in an oxygen-free environment.

Manure-to-energy projects collect manure from the cows into a large airtight concrete tank and hold it there for about three weeks.

Bacteria already present in the excreted manure further digests the manure in virtually the same process as was occurring in the cow's stomach. Biogas, produced by the bacterial breakdown of the manure, builds up in the tank and a pipe delivers it to an internal combustion engine where it is burned to make electricity.

Anaerobic digester systems are unique in that their benefits are a result not only of the renewable nature of the energy produced, but also because they have a significant positive impact on existing farm manure management practices.

The anaerobic digestion process leads to improved water quality, a significant reduction in farm odor emissions, improved farm nutrient management practices, and, perhaps most significant given our current understanding of global climate change, a reduction in total farm methane emissions.

Currently, there are four anaerobic digester systems in operation on Vermont dairy farms with a capacity of 1 MW. Because the feedstock is available 24 hours per day, throughout the entire year, the systems produce power on a nearly continuous basis.

Additional projects are due to come on-line in the coming months. The overall potential for farm methane systems in Vermont is estimated to be fairly small.

Landfill Biogas

Landfill biogas is created when municipal solid waste decomposes. The gas is about 35% methane (much of the rest is carbon dioxide) and has roughly one-half the energy value of natural gas. This landfill biogas can be captured, converted, and used as an energy source.

This not only reduces odors and other local air pollution problems, it also prevents the gas from migrating into the atmosphere and contributing to smog and global warming. (Methane has about 21-times the global warming impact of carbon dioxide.)

Today, only two major landfills operate in Vermont—in Coventry and Brattleboro.

Coventry is Vermont's only operating landfill that has a biogas project. That project currently has 6.4 MW of capacity, and could grow to 8 MW. The current project is expected to produce power for about 25 years.

The Waste System's Moretown landfill has the largest untapped potential for a biogas project. The Moretown landfill has capacity for a 3 MW landfill biogas project. Sewage treatment may offer a source of biomass generated electricity in the next decade.

HYDROELECTRIC

Brief

Hydroelectric power is a large scale energy source in Vermont, second only to nuclear power. The current contract with Hydro-Québec provides 27% of Vermont's electricity. Other hydro sources, mostly in Vermont, provide an additional 12%. Hydro has environmental benefits related to air pollutants because it has low emissions and creates few greenhouse gases.

Hydro built in Vermont can have economic benefits, but by most estimates less than 100 MW of potential new or refurbished hydro sites exist, and most are small. Hydro is expensive to site, permit, and build, but the fuel is free.

The Hydro-Québec contracts begin to expire in 2012, but Hydro-Québec has indicated a willingness to discuss terms of a new contract with a price to be negotiated. Other large scale hydro resources are potentially available from other providers outside of Vermont, both in the U.S. and Canada.

If a new contract is not put in place, Vermont will need to replace this relatively large and inexpensive power source and factor in the loss of this non-greenhouse gas generation source into the Vermont plan to reduce greenhouse gas.

Advantages

- Low emissions; low greenhouse gas; renewable source
- May be able to enter into longer duration contracts more easily than sources with less fuel price predictability
- Stable pricing can be negotiated in long-

term contract (because the fuel price does not fluctuate)

- Contributes to goal of energy independence from oil
- A contract with Hydro-Québec provides system power as a backup, therefore reliable and dispatchable deliveries; transmission infrastructure is in place
- Some hydroelectric is a local resource

Disadvantages

- Small and new hydro projects are expensive to permit and build and can disrupt existing stream flows
- Small hydro power can be intermittent, so needs to be combined with another resource type
- Hydro-Québec contract or other large scale hydro contracts means direct economic benefits don't reside in Vermont; a contract with Hydro-Québec does not produce local economic benefits in the form of tax payments and jobs
- Canada or Québec could change energy export policies
- Contract will likely renew at a multiple (above or below) of then market price forecasts so can be above or below market price in future years
- New hydro projects can significantly harm wildlife habitats and limit stream flows

There are many sizes of hydroelectric facilities. Large hydroelectric facilities, usually owned by utilities, generally impound water behind a dam. The water is controlled and released to turn turbines and run generators when electricity is needed. Facilities with impounded areas are more economically attractive, but they have greater environmental impacts due to the flooding of lands to create lakes and fluctuating water levels.

Small hydroelectric projects often refer to facilities with 1-5 MW capacity. In general, small hydroelectric projects have fewer environmental impacts than large projects due to their use of *run-of-river* design. (Opponents of specific projects, such as the Peterson Dam, might disagree.)

Run-of-river hydroelectric projects generate power as the water flows through the facilities, requiring little or no impoundment. Small hydropower systems have other benefits as well—they do not displace people, the technology is not complex and can be easily transferred to communities, and the technology can provide power for locations that are not connected to larger grids.

Small hydropower sometimes includes the classifications of very small projects, including mini-hydro (less than 1 MW), micro-hydro (less than 100 kW). These smaller projects almost always use run-of-river designs. Some can be installed in farm ponds and water supply pipes. The projects can produce enough power for a single home, a block of homes, a school, or a municipal building.

About 2,321 GWh, or 37%, of Vermont's electricity supply came from hydro sources in 2005. About 28% came through contracts with Hydro-Québec; 8% from Vermont utility-owned and privately-owned Vermont plants; and 1% from New York plants. Starting in 2015, the quantity of contracts Vermont will hold with Hydro-Québec decreases sharply.

In 2005, Vermont had 138 MW of small in-state hydroelectric capacity providing electricity. Utilities owned 84 MW, of which 51 MW came from a run-of-river stations, and 32 MW from facilities that have the ability to store water for use when electricity demand is at its peak. Independent power

producers selling power to utilities owned about twenty hydro stations with a total capacity of 54 MW.

In 2003-2004, the state declined an opportunity to purchase a network of hydroelectric facilities with 567 MW of capacity on the Connecticut River between Vermont and New Hampshire and the Deerfield River in Southern Vermont. Instead, the dams were purchased by TransCanada Corporation for \$505 million, who sold the power into the New England electricity grid, though not directly to Vermont utilities.

There has been a new interest in considering whether nonworking in-state hydro sites can be redeveloped, whether working hydro sites can be repowered (their output levels increased), and whether more micro-hydro and mini-hydro facilities can be built.

Costs, permitting, and environmental constraints are significant barriers to small hydro development in Vermont. Hydro projects that use public waters, even small rivers and brooks, require several permits, including permits from the Vermont Public Service Board, the Agency of Natural Resources, and the Federal Energy Regulatory Commission.

Many of the permits are required to mitigate environmental impacts. Projects can take from 3-5 years to develop and are expensive, making it prohibitive for small projects.

A *pico-hydro-sized* system (less than 5 kW) in Vermont costs around \$20,000 installed (including the grid interconnection) without permitting costs. On a project of under 1 MW, permitting costs add about \$2,000 per kW to the total cost, bringing the total cost of a 5 kW system up to \$30,000.

Studies on the economic potential for small hydro in Vermont show that it can range from 93 MW (Barg, 2007) to 10 to 15 MW at existing dams ranging in size from 500 kW to 2 MW (Warshow, 2007). (Note: the previous section drew from and excerpts from the *Vermont Energy Digest*, Brenda Hausauer, April 2007, Vermont Council on Rural Development.)

Negotiation of a New Long-Term Contract with Hydro-Québec

The Hydro-Québec contract provides 28% of the electric energy used in Vermont. The bulk of the contract is scheduled to decrease sharply beginning in October, 2015. The current Hydro-Québec contract totals 309 MW. It is divided into six schedules with expiration dates as follows.

Each schedule has a 75% annual capacity requirement on energy deliveries. GMP has a resale agreement under which they annually sellback some of their energy to HQ at contract energy prices.

Roughly half of the cost is a fixed capacity payment (minor variation among schedules) and the other half is an energy payment that changes with an inflation-based index. The current energy cost is about 3.1¢ and the average capacity cost is about \$20 per kW a month. Total cost is on average about 6.8¢ per kWh (some variation among schedules).

Schedule B	175 MW	expires 10/31/2015
Schedule C-1	57 MW	expires 10/31/2012 (27MW sellback)
Schedule C-2	28 MW	expires 10/31/2012
Schedule C-3	47 MW	expires 10/31/2015
Schedule C-4a	25 MW	expires 10/31/2016
Schedule C-4b	6 MW	expires 10/31/2020

Hydro-Québec has indicated an interest in negotiating a new long-term contract with the possibility of additional hydro resources. Terms and conditions for such new contract are unknown at this time, but any contract will depend upon regional electric market conditions anticipated at the time.

One would assume at this early point that Vermont might enjoy a small advantage when it comes to price, as alternate purchases of the Hydro-Québec power might require additional transportation costs to reach markets to the south. A new contract brings the benefits of hydropower to the Vermont portfolio such as no emissions, dispatchability (within contract terms), and the potential for a pricing formula that could include stable prices or prices with low variability.

The existing Hydro-Québec contract already demonstrates some of the advantages and disadvantages of long-term pricing. At times, during the current Hydro-Québec contract, prices paid for the power were above market price and at times (more recently) prices charged for the power were below market prices in New England—Vermont consumers benefited.

WIND

Brief

Across the U.S., wind power is the fastest growing source of new generation (annual growth rate of 25%). Successful projects require attractive wind speeds, sites that can be permitted, and access to economically competitive markets for the electricity generated.

Experience with Vermont's only commercial-scale wind power facility, the 6 megawatt Green Mountain Power wind facility in Searsburg, has generally been good. Searsburg verified the feasibility of wind power operating in cold climates.

It has been asserted by wind industry proponents that the technical potential for utility scale wind power could reach 200 MW of rated power, or up to 20% of the state's current electricity peak demand, over the next decade. However, this projection is based largely on the assessment of wind resources, the proximity to the bulk transmission system, and eliminating sites that are part of either state, federal or other conserved lands and may not reflect what amount of commercial wind can ultimately be sited in Vermont.

Vermont's predominant wind sites are along higher elevation ridge lines, thus placing them potentially in higher visible parts of Vermont's communities. Wind power could also be purchased from outside Vermont under contract. Wind power is competitive with other sources of generation.

Implementing new wind-powered generation in New England has been problematic due to siting and permitting concerns.

As beauty is in the eye of the beholder, wind power advocates believe large wind farms are visually attractive and increasing their use will improve air quality by displacing greenhouse gas emissions from fossil fuel-driven electricity. Advocates point out there are clear precedents for mitigation should wildlife impacts exist. They say wind farms provide economic benefits to the regional and local economies.

In contrast, opponents contend that wind

turbines are a significant intrusion on landscapes, that they spoil views, alter Vermont's "Green Mountain State" ridge lines, and could have wildlife impacts at higher elevations.

There are plans being considered by independent developers to install over 100 megawatts of new wind power in Vermont at the present time. So far, the Vermont Public Service Board has approved the Searsburg Wind Power Facility, the region's first utility-scale project with 11 turbines, and, more recently, a 16-turbine project in Sheffield. PPM Energy recently submitted a petition to site a 45-megawatt project with 17 turbines in the towns of Readsboro and Searsburg.

Advantages

- No air emissions
- No greenhouse gases
- Wind is a renewable resource
- Fuel is free, enabling stably-priced contracts
- Vermont-based wind farms would produce local economic benefits in the form of tax payments and installation jobs
- Can be built or expanded in manageable increments of 20-50 megawatts as needed

Disadvantages

- Wind turbines can be an intrusion on the landscape
- Wind farms may cause wildlife or habitat damage from either construction or operation because windy ridgelines are often wild and undeveloped
- Wind power is only available when the wind blows, so is not dispatchable
- Windy locations are often remote from

electric load centers and may require transmission lines to be upgraded or constructed

- Permitting timeframes are uncertain in Vermont (true for all fuels); this can make projects more expensive and, in an active market like wind, encourage wind developers to go elsewhere
- Some may like wind as an option but feel that it is better for wind power to come from outside Vermont (New England, Canada, or New York), where the wind resource may be better, it may be less expensive to develop wind projects, and the projects can achieve economies of scale

Over the past decade, wind turbines have become larger in terms of physical size and power generated. Production size per turbines have gone from less than 1 MW and are now between 1.5-2 MW. Off shore machines are bigger.

Wind turbine towers come in a variety of heights. 262 feet is a common size, and one of the taller sizes is 328 feet. Blades can be 120 feet longer, so the tower and blade would be 260-430 feet (depending on the height of the tower and the position of the blade).

Wind power costs can be competitive relative to other forms of generating electricity. Wind power can be produced for as low as 6-8¢ per kWh. Because the costs of a wind project do not vary year to year, a wind developer is more likely to enter into a stably-priced contract than the owner of a fossil fueled plant.

However, there are often cases where wind generated energy is priced according to the going wholesale market price. If the current

wholesale market price for electricity is in the range of 6¢ (this is a dynamic number effected by a variety of factors, most notably fluctuation in natural gas and other commodity prices), the difference is often made up by the value of the renewable energy certificates wind can attain.

The second factor driving growth is that wind turbine technology has proven to be much more reliable than turbines just a decade ago, allowing the financial community to become comfortable investing in wind.

The third factor is federal and state policy initiatives, including financial incentives that have been implemented over this past decade, encouraging forms of renewable energy development.

Variability of Wind

Because wind generation is a variable resource (similar to small hydro but with much greater short-term variability), wind can only provide a portion of electric system load requirements. 20-25% of a regional system's energy needs may be a practical limit for the technology (some European systems already have higher percentages).

Wind power in New England currently produces less than 1% of our electricity, so this should not present a practical constraint in the near term.

Modern wind farms generate electricity 70-80% of the time, but, due to changing wind speeds, they generate over a year 30-40% of their full, theoretical name-plate capacity (if they were able to run 100% of the time at full output—something no generation source is capable of doing).

Wind power's greatest value will be on electrical systems that have at least an equal amount of variable generation (gas peaking units or storage, such as hydro storage) to fill in when the wind is not blowing.

When paired with another variable generation source, wind acts as a "fuel saver" on the system, preventing the burning of fossil fuels and generation of attendant air emissions. An electrical system with a significant amount of hydro storage or natural gas or oil-fired generation like the New England system is a good match for expanding wind power generation.

Wind power can therefore be readily integrated into the existing regional electric generation system. Geographic diversity provided by multiple wind installations will also serve to dampen the intermittent nature of any single project.

Transmission Issues

Because the best wind locations are often located remote from load centers, transmission of the power can be a significant and sometimes limiting issue for wind development.

The transmission infrastructure near a wind development must be capable of carrying the peak output load of the wind facility. The costs and other impacts of strengthening these wires can, for some sites, be prohibitive.

An active issue in the New England electric system is to determine what portion of these upgrading costs should be shouldered by the developer and what portion should be allocated to all electric users in the region.

The Wind Power Resource in New England

The fact that wind blows the strongest and steadiest at the higher elevations in interior New England is well documented. This effect can be seen visually in the wind map for New England included in this section. (This map was produced by AWS Truewind).

Stronger annual wind speeds are illustrated by the red-hued colors on *Figure L* and show the best resources are concentrated off the coast and at the summit of the higher mountain ranges.

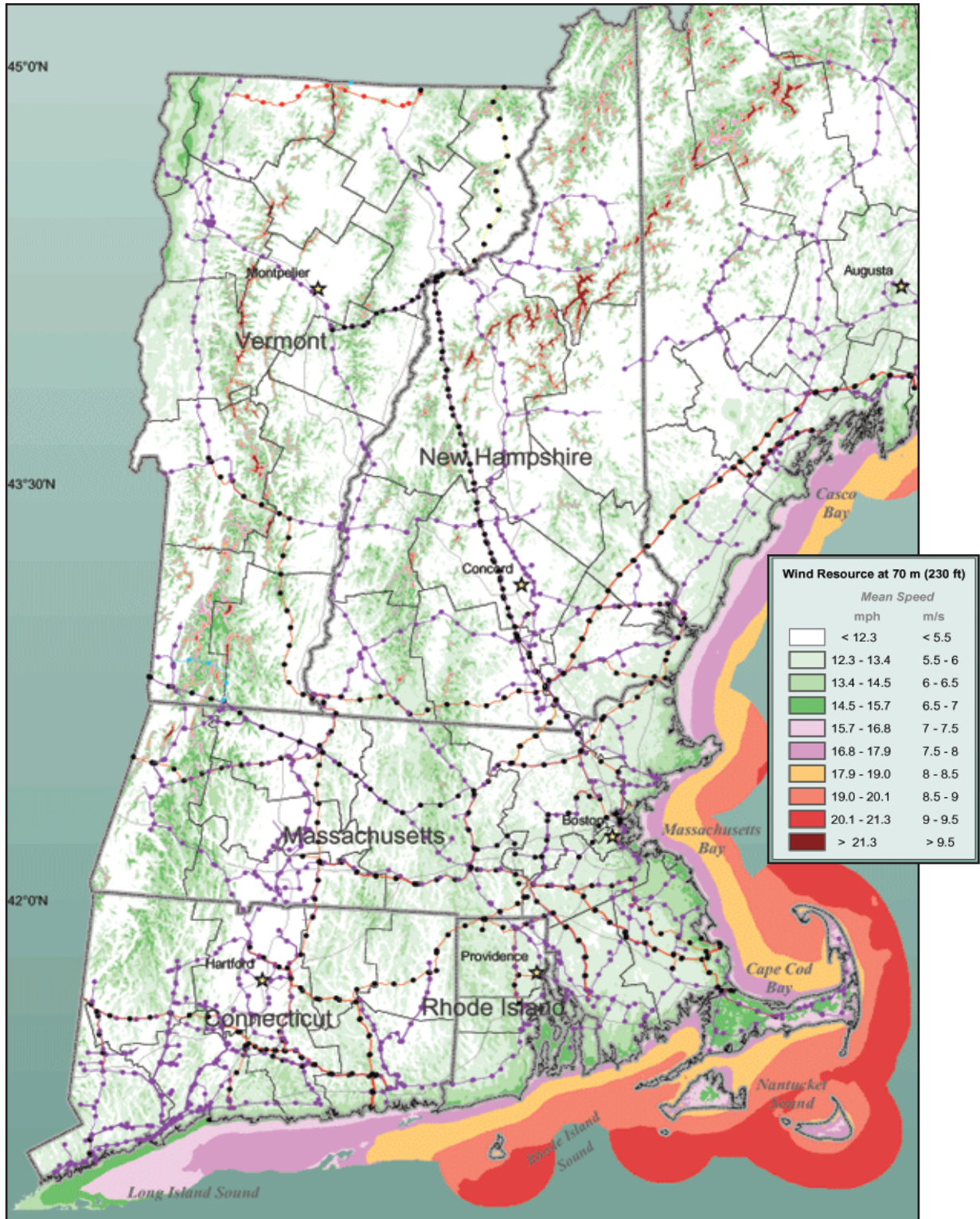
Regardless of the theoretical potential in Vermont, most planners, environmental agencies, and organizations that have looked closely at Vermont's potential for wind power acknowledge that a relatively small percentage of this theoretical resource will be developed due to land use conflicts and economic reasons.

Some say that 250-300 MW could be installed in Vermont over the next decade. If each turbine had rated capacity of 1.5-2.5 MW, this level of development would require between 5-7% of Vermont's ridgelines.

Utility Scale Wind

Most large wind developments have been built by independent, non-utility companies. Typical size across the U.S. and Canada is now around 100 MW, with big projects in the range of 200-300 MW. Projects in New England are smaller, in the range of 20-50 MW.

Figure L: Wind Speed Map of New England with Electric Transmission Lines



Electricity from these large projects is usually sold at wholesale prices, under long-term contracts to electric utility companies, or on regional electricity spot markets. The cost of electricity from these large wind facilities is lower than for smaller local area projects or residential scale projects.

Quantity pricing results in lower turbine prices, and a facility's fixed costs, such as interconnection, permitting, and operation and maintenance, can be spread over many more units of output. These large wind projects require careful siting, especially considering their higher elevations, to mitigate environmental and aesthetic impacts.

Vermont is unique in that its electric utility companies remain vertically integrated businesses. Utility companies, private entities, municipalities, and cooperatives can all invest in generation plants in Vermont. It is possible for Vermont utilities to participate directly in large wind plants by agreeing to finance a portion of the cost of the facility in return for a similar portion of the output of the facility or other returns.

For wind to reach its full potential in Vermont, the price of the electricity produced must be competitive. Like other sources of generation, the contract or spot market prices paid for wind are not related to the amount spent, but rather to prevailing wholesale market conditions on the New England electric system.

Prevailing policy in Vermont has been focused on obtaining stable-priced contracts to take full advantage of wind power not being subject to fuel price fluctuations.

Local Area Wind

These wind facilities involve one or several large modern turbines installed close to where the power is needed. Capital is provided through local investors, banks, or municipal utilities. The electrical output can be supplied as bulk power to the regional grid or can be used on local power systems.

The cost of energy produced by these facilities is higher than utility scale wind because fixed costs are spread among fewer turbines and there are often lower quality wind regimes.

However, municipal electric utilities sometimes have access to low cost tax exempt financing and/or some ability to sell the output at retail prices to offset this cost disadvantage. Presently, there are no such installations in Vermont.

Examples are the town of Hull, Massachusetts (*Figure N*), 8 miles to the southeast of Boston, where a 660 kW turbine was installed in 2001 and a 1.8 MW turbine in 2006.

A privately-owned example is provided by the summer 2007 installation of a 1.5 MW wind turbine at Jiminy Peak Mountain Resort in the Berkshires of western Massachusetts (*Figure O*).

Local area wind development may be constrained in the future due to lack of technical knowledge of the resources, siting, and competition for wind turbines and constructors. There is currently a world-wide shortage of wind turbines, especially for small projects.

Figure M: *Simulation of a Large Wind Project from along Interstate 91 in Sheffield, Vermont in the Northern Part of the State.*



Residential Scale Installations

This scale of development involves small wind turbines, 25-100 kilowatts in size, to meet the needs of an individual home or small business owner or small groups of homes and businesses.

Existing Vermont electric regulations usually permit net billing where small projects sell excess electricity back to the utility company at retail prices (roll the meter backwards).

The cost of energy from this scale of wind turbine is the highest of the three categories (they are over twice as expensive per kilowatt to purchase as large wind turbines and the electrical output is significantly lower per dollar invested because they are generally installed in less windy areas).

For example, it would take as many as 1,400 residential scale turbines in Chittenden County to produce the same amount of power as one large wind turbine on a windy ridge.

These installations are usually financed by the homeowners or small business that use the power themselves. Over the last three years, there have been over 70 Homeowner Scale wind turbines installed across Vermont at farms, homes, and schools.

Many of these have received substantial federal subsidies provided through state agencies. However, because they can offset retail electric prices, which are about twice as high as wholesale prices, some can enjoy economic practicality in the best circumstances.

Figure N: 600 KW Turbine Developed, Financed, and Installed by the Hull Municipal Light Plant in 2001 on the Coastline beside its Elementary School.



Figure O: 1.5 MW Wind Turbine Installed at the Jiminy Peak Resort in Western Massachusetts in July 2007 to Help Provide the Resort's Electric Usage.



SOLAR

Brief

Solar energy can be captured by using *photovoltaics* (PVs) and thermal collectors. PVs convert sunlight into electricity and have many applications. Thermal collectors are used to heat water or air for domestic or commercial use.

As this report focuses on electricity, we will focus our description on PVs. PVs produce electricity any time the sun is shining, but more electricity is produced when the light is more intense and is striking the PV modules directly.

Solar electricity is the most expensive generation technology under consideration in Vermont. Because of the expense, it is currently cost competitive only for specialized and remote applications when compared with large scale options. But photovoltaics are coming down in price as technology and markets advance. (By contrast, using the sun to heat water is already cost competitive.)

Most of the cost for solar systems is upfront (fuel is free) and the systems often need incentives and/or net metering to make the economics more attractive.

The near-term potential to supply electricity for Vermont is enormous. Enough sun hits the average house roof in Vermont to supply 10 times the electricity used by the average homeowner. Current practical limitations, however, will likely keep the contribution of solar power to small levels (estimates are in the range of under 5%). Technological advances and policy driven incentives could change that potential.

Advantages

- No emissions; no greenhouse gas; renewable source
- Fuel is free
- Economic benefits from installation jobs
- Distributed generation
- Solar power works best on hot summer days and cold clear winter days when electricity prices are the highest

Disadvantages

- Solar generation is comparatively expensive and only cost competitive for remote locations (off grid) or specialized applications (offset the cost of running a line)
- All the costs are front-loaded, requiring a multiple year payback

Solar energy as a technology and as an option for generating electricity in Vermont is still evolving. In the comparative charts, solar options have some of the highest prices. Most of the costs are equipment-based, since the fuel is essentially free.

Solar energy will likely generate only a portion of Vermont's electricity, in the 1% or below range, over the next 5-10 years.

Most of the solar activity is in the area of displacing electricity used to heat water. About 37% of the water in Vermont is still heated with electricity.

In the cost comparison chart in Chapter 5, we look at solar for a commercial installation (50 KW to 1 MW). Similar to small wind power systems and small hydro power systems, solar potential in Vermont in the near term will not likely provide bulk electricity supplies to the regional electric grid, but rather provide for part or all of a residence's or small business's electricity needs.

Photovoltaics (PVs) convert sunlight into electricity and have many applications. PVs produce electricity any time the sun is shining, but more electricity is produced when the light is more intense and is striking the PV modules directly. Unlike solar thermal systems, PVs do not use the sun's heat to make energy, but instead produce electricity directly from the electrons freed by the interaction of photons of sunlight with semiconductor materials in the PV cells.

When domestic PV systems are installed on homes that are independent of the utility grid (called *off-grid*), they use battery banks to provide power when the sun is not out; domestic PV systems on homes or businesses connected to the grid can use electricity from the utility when the sun is not shining. The market has largely shifted from remote, off-grid, and consumer products to a majority of grid-connected, distributed power.

Vermont had 240 net-metered solar PV systems, providing 673 kW of capacity, as of March 2007. It is estimated that Vermonters have installed about 300 PV systems not connected to the electricity grid.

In addition, there are an estimated 500 solar water heater systems in the state. There are a few commercial facilities with solar

installations in Vermont, including NRG Systems and groSolar, but this is not a large sector of use currently.

Vermont provides incentives for solar installations. *The Vermont Solar and Small Wind Incentive Program* was established in 2003. Under the program, individuals and businesses can receive \$1.75 per watt for approved solar PV projects, with a maximum of \$8,750 or 5 kW. *The Clean Energy Development Fund* has provided support for larger projects.

While some solar systems are cost-effective over the long run, about 95% of their lifecycle cost is up front, making them difficult to afford for many people.

For example, residential solar water heaters, with or without current Vermont incentives, are less expensive than electric or propane water heaters over their 25-year lifetime (\$13,500 for solar with incentives on a typical residential system, compared to about \$21,000 or more for electric or propane).

But the up-front capital cost is considerably higher (about \$6,250 for a solar system with incentives and propane backup, compared to \$750 for a propane or electric system).

Some states such as New Jersey have decided to dramatically encourage solar systems and have created special solar RECs.

Some have decided to target the flat roofs typical of commercial or industrial buildings and are working with chain stores owned by companies looking to make a difference in climate change.

COMBINED HEAT AND POWER (CHP) SYSTEMS

Brief

Combined heat and power systems (also known as co-generation) are a growing source of electric generation in Vermont with the added benefit of offsetting other energy needed for heating buildings. A CHP system is one where the waste heat from a combustion-type generator is used to provide space heat or process heat for a building.

An example of this system would be an internal combustion engine where the heat from the radiator provides space heat to a building or steam in industrial applications. The advantage of CHP is greater efficiency than if the electric generation and heating were done separately. Vermont is estimated to have 21 MW of electric generation from CHP with more growth potential, depending on the site.

Advantages

- Greater efficiency means lower fuel use, fewer emissions and less greenhouse gases
- Vermont-based resource
- Can create local jobs and economic benefits
- Distributed generation; can benefit transmission system
- Can use biomass from Vermont's woods and farms

Disadvantages

- Combustion is still required so there are environmental impacts
- Systems are small
- Upfront costs may require incentives or ways to spread out cost recovery and payback

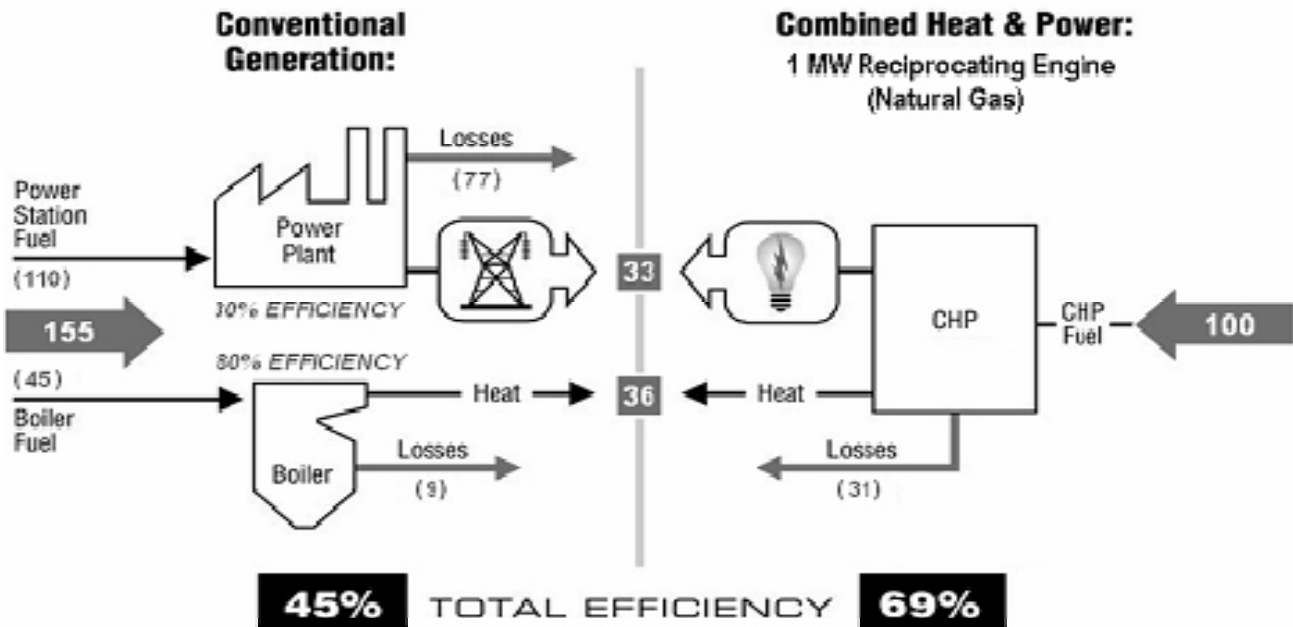
Vermont has several Combined Heat and Power (CHP) applications operating in the state. The Department of Public Service estimates approximately 21 megawatts of CHP capacity is installed in Vermont.

The definition of CHP is the sequential or simultaneous generation of multiple forms of useful energy, usually in the form of electric and thermal. Another name for CHP is co-generation. Normally, for CHP to be a viable option, it requires a host site that has the need for both electrical and thermal energy concurrently, which typically is an industrial site or large commercial building.

CHP is a specific form of *distributed generation* (DG); DG refers to locating electrical generating units in or near a facility to supply or augment the onsite electrical needs of the facility. DG offers the host site many advantages, such as energy security, improved energy reliability, and cost savings.

But CHP goes a step further than DG by giving the host site the simultaneous production of electric power and useful thermal output which greatly increases overall system efficiency (see *Figure P*).

Figure P: Efficiency of Conventional vs. Combined Heat and Power Generation



The advantages of the CHP systems over a traditional set up of electric energy received from the utility and on site thermal systems are greater efficiencies and potential cost savings.

CHP technology could benefit any customer that has the requirement of both electrical and thermal loads, such as schools, hospitals, apartment buildings, commercial buildings, universities, industrial buildings, health clubs, laundries, nursing homes, etc.

A typical CHP system will include three major components: the *prime mover*, the *electric generator*, and the *heat recovery system*. The prime movers for CHP systems can be gas turbines, micro turbines, steam turbines, reciprocating engines, and fuel cells.

The CHP system can be designed to use a variety of fuels, such as natural gas, propane, fuel oil, and biomass. An example of a typical CHP system may consist of a reciprocating engine running on natural gas. The engine

powers a generator to produce electricity, and the waste heat from the engine is recovered through a heat exchanger to produce useful thermal energy.

This thermal energy output can be in the form of steam or hot water and can be used for a host of different applications depending on the needs of the site, such as heating, domestic hot water, laundries, or process use like drying. The thermal energy can also be used for cooling needs by using a absorption chiller.

In a electric generator set up using a fossil fueled boiler and a steam turbine, the efficiency would be approximately 30-35% just to generate the electric power.

If none of the waste heat is captured, that means that 65-70% is wasted. But in a CHP set up, this waste heat is captured and turned into useful thermal output, which can double the efficiency of the process.

The benefits of this improved efficiency is that the host site saves money, conserves fuel, and has less air-polluting emissions.

In 2000, The Department of Energy completed a study to estimate the market and technical potential for CHP systems in the United States. This study estimated a technical potential of 179 megawatts of CHP capacity in Vermont.

It is important to note that this number is *technical potential*, meaning that there is enough industrial and commercial sites to support 179 megawatts of capacity. This does not mean 179 megawatts of CHP capacity could be installed that is cost effective and economically viable for the host site.

The economics of the CHP systems revolve around cost of the fuel and price of the electricity which is being displaced and avoided, operating and maintenance costs, and any financing costs that were required to purchase and construct the system.

The host site must weigh the costs and benefits of a CHP system versus a more traditional set up before deciding to move forward on a CHP project. The host site would normally only install a CHP system if it was economical to do so. In addition, large upfront capital costs have also been a barrier to CHP project development.

Some sites that have CHP systems installed in Vermont are the Brattleboro Kiln Dry Company, Green Mountain Coffee Roasters, and North Country Hospital.

The Brattleboro Kiln Dry company system was installed in 1989. The system uses boilers fired by wood waste from the site. The steam from the boilers powers a steam turbine generator rated at 380 KW, and waste heat from the turbine is used in their kiln drying process.

Green Mountain Coffee Roasters installed a 280 KW CHP system in 2003. The CHP system uses a Waukesha engine running on propane. The heat recovered from the engine is used for heat and hot water for their building.

The CHP system at North Country Hospital was installed in 2005. The CHP system consists of a wood chip fired boiler and a 274 KW steam turbine generator. Waste heat from the steam turbine serves a variety of the hospital's heating needs.

Chapter 3:

Energy Efficiency and Demand Reduction

Brief

Energy efficiency can be considered as a resource option comparable to traditional generation resources like coal, nuclear, natural gas, and renewables. It is relatively inexpensive and clean compared to generation options.

It also is considered an alternative resource in transmission and distribution (T&D) planning. In the past decade, utility ratepayer investments in energy efficiency resources have reduced overall electric consumption in New England by about 3-5% and in Vermont by over 5%.

Since 2000, energy efficiency services have been provided in Vermont by the nation's first energy efficiency utility¹. A 2006 study done for the Department of Public Service concluded that nearly 15% of Vermont's electricity needs in 2015 can be met through cost-effective efficiency programs (it would be 20% if fuel switching occurs).

Advocates say efficiency should be the first choice for meeting Vermont's electricity needs due to its low cost and associated environmental and economic development benefits. There is little opposition to efficiency as a concept.

However, some are concerned about increased rates and costs on near-term bills (especially for non-participants) and ensuring the accountability and cost-effectiveness of the delivery mechanisms.

¹Efficiency Vermont ("EVT") provides energy efficiency services statewide, with the exception that the Burlington Electric Department ("BED") provides these services in its service territory. Both EVT and BED are part of the Energy Efficiency Utility ("EEU") structure that is currently funded through the Energy Efficiency Charge ("EEC").

Advantages

- Significantly lower cost than other resource options
- Lowers everyone's power costs by displacing the most expensive resource at any given time
- Large quantity of both energy (kwh) and capacity (kw) available from energy efficiency in Vermont
- Improved electric sector reliability
- Can defer or avoid costs to upgrade electric transmission and distribution system
- Can be deployed or scaled back relatively quickly
- No significant greenhouse gas emissions or other pollutants
- Job creation and local economic development impacts
- Improves the value, public health, and comfort of Vermont's homes and buildings.
- Reduces our dependence upon foreign energy sources
- Reduces natural gas price volatility

Disadvantages

- Requires coordination among many to be most effective
- Can initially raise rates and bills for non-participants if costs are not spread over the period of benefits
- The effects of efficiency on overall energy use can be difficult to quantify
- Requires an infrastructure of knowledgeable and skilled efficiency service and product providers

Energy efficiency includes: 1. *Using less energy by making buildings and the energy-using devices in them more efficient (their design, lighting, motors, appliances, etc.)* 2. *Using energy-consuming devices less (conservation)* and 3. *Reducing the peak demand for electricity (through load shifting, self-generation, or interruption).*

It may be helpful to think of cars and highways as a way to understand these strategies. Just as certain cars get more miles per gallon, buildings and devices can be made more efficient. Driving less would be an example of conservation, and rush-hour traffic the equivalent of peak demand.

Energy efficiency can be as simple as installing additional insulation in buildings and switching incandescent lights with fluorescents. Or it can be as complex as installing computerized energy management systems in commercial buildings.

Energy efficiency programs are primarily paid for by customers through their electric rates or as a surcharge on their electric bills. Vermont is a national leader in the development and delivery of efficiency programs for residential, commercial, and industrial electricity customers.

Efficiency efforts in Vermont began with programs run by Vermont's electric utilities in the 1980s and 90s and were continued by *Efficiency Vermont*, the nation's first energy efficiency utility, and the Burlington Electric Department (BED).

Electricity Savings To-Date

Over the last decade in Vermont, savings from efficiency programs and investments have helped to reduce the growth rate of electricity requirements. Efficiency savings along with changing economic conditions have cut the rate of electric demand growth from 2% to 1% (see *Figure Q*).

Figure Q: Efficiency Savings in Vermont since 1999

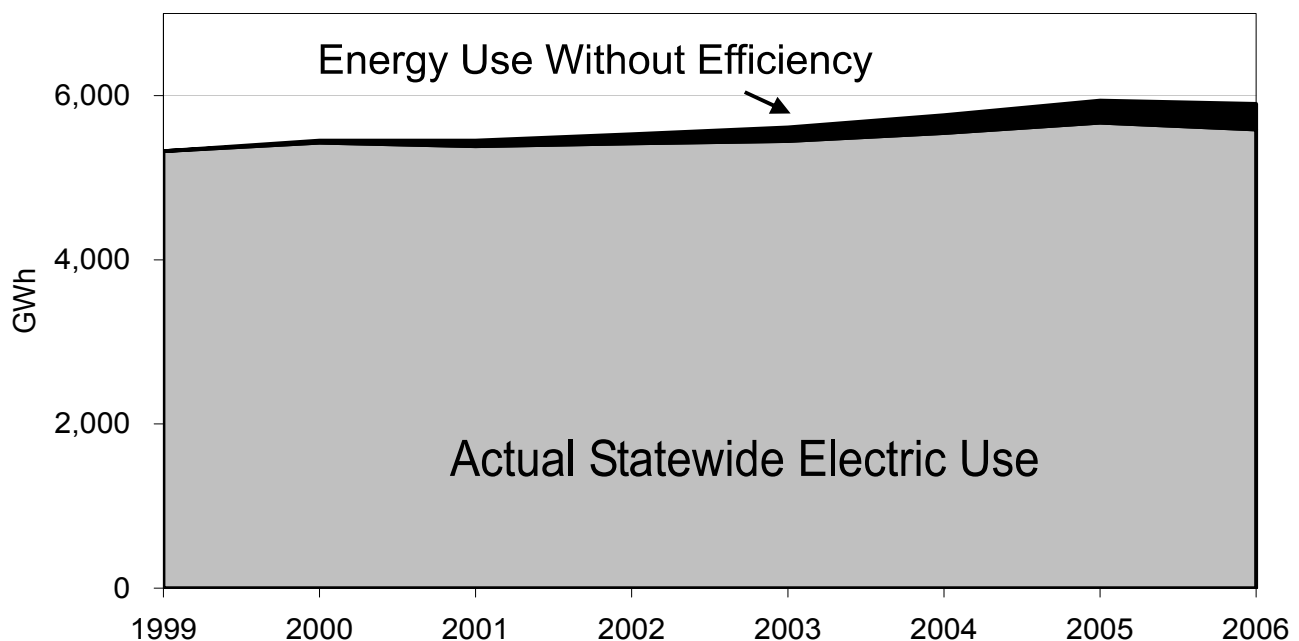
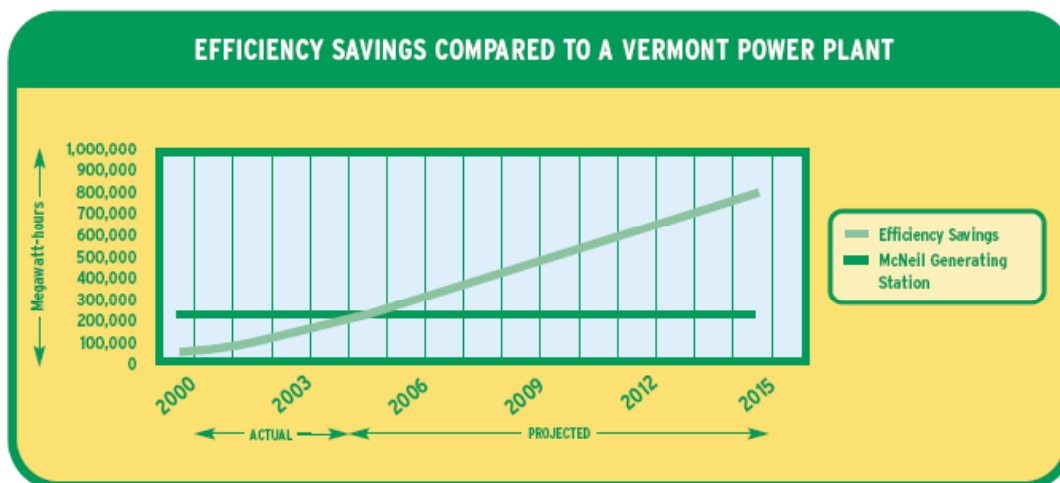


Figure R:



Vermont businesses and homeowners who worked with Efficiency Vermont from 2000-2006 to make cost-effective efficiency investments saved almost 315 million kilowatt hours (kWh) in annual electric energy (approximately 5% of total sales).

Households and businesses are expected to see savings continue for at least a decade—the average life of the efficiency measures.

The effect of investing in energy efficiency is cumulative and, over the years, can contribute significantly to offset energy and demand. Comparing efficiency to an electric plant generator, such as Burlington Electric's McNeil Generating Plant, demonstrates the savings each year (*Figure R*).

Efficiency Savings Potential

Vermont recently completed studies of electric energy efficiency potential and concluded that, with an increase in investment, electricity

demand could be reduced by nearly 20% by 2015 and 30% by 2028 (*Figure S*).

Cost and Benefits of Efficiency Investments

In 2004, Vermont electric customers spent around \$15 million on efficiency programs to save electricity, leading the nation with an investment of \$25 per person. After extensive review of its potential, the Vermont Public Service Board significantly increased the efficiency investment.

By 2008, customer expenditures on energy efficiency should be approximately \$30 million per year, or approximately \$49 per person.

The Board largely targeted this increased funding toward geographically constrained areas of the state in an effort to avoid or defer costly investments in transmission facilities.

Figure S: Achievable Cost Effective Electric Energy Efficiency Potential by 2015 in Vermont

Sector	Achievable Cost Effective kWh Savings by 2015 from Electric Energy Efficiency Measures/Programs for Vermont (Cost Effective According to Societal Test)	2015 kWh Sales Forecast for This Sector	Percent of Sector 2015 kWh Sales Forecast
Residential Sector	567,511,161	2,659,831,768	21.3%
Commercial Sector	450,383,577	2,115,167,148	21.3%
Industrial Sector	268,928,672	1,851,792,067	14.5%
Total	1,286,823,410	6,626,790,983	19.4%

Vermont Electric Efficiency Program Expenditures

Year	Amount (in millions)
2000	\$9
2001	\$10
2002	\$12
2003	\$14
2004	\$15
2005	\$16
2006	\$16
2007	\$24 (budgeted)
2008	\$31 (budgeted)

Source: VT DPS (EVT and BED expenditures)

In 2006, investments made by Efficiency Vermont cost approximately 3.5¢ per kWh. This includes money contributed by state ratepayers and additional amounts paid by Efficiency Vermont customers and reflects the savings in water, maintenance, and other costs resulting from measure installation. This combined expenditure reduces Vermont’s annual need for electricity generation by 52,950 MWh and 7.8 MW at summer peak demand and 7.2 MW at winter peak demand.

One challenge related to utility-funded energy efficiency programs is that, although they reduce average electricity *bills*, they

can increase *rates* in the short run. This is because existing costs are spread over fewer kilowatt hour sales. This can doubly impact non-participants, who do not reduce use and whose rates increase.

Rates can increase in the short term because efficiency costs are paid as they are incurred. In traditional utility investments, like power stations or transmission lines, costs are spread out. One issue under consideration is whether efficiency investments should be funded with a similar, longer-term approach.

Benefits from efficiency include:

- Reduces greenhouse gas emissions and local air pollution
- Comes in small units and can be accelerated or decelerated quickly
- Can act as an alternative to the costs or visual impacts of transmission systems
- Creates in-state jobs and economic development opportunities
- Improves the value, public health, and comfort of the state’s homes and buildings
- Can enhance physical infrastructure and worker productivity (i.e, through better lighting)
- Provides short and long-term savings to building owners

There is little opposition to efficiency as a concept. Some are concerned, however, about increased rates and costs on near-term bills (especially for non-participants), and the need to ensure the accountability and cost-effectiveness.

Demand Reduction

Reducing energy use, especially during peak hours, is important, as the costs to generate electricity are highest at those times and the electricity system has the greatest potential for outages.

To the extent that energy efficiency reduces consumption during peak periods, it is an important demand reduction tool.

Demand reduction can also occur by shifting consumption from peak to off-peak periods, such as an industry moving its production schedule from a summer afternoon to the evening, a home using a timer to run its dishwasher in the middle of the night, or businesses running generators during peak periods to reduce the demand on the electricity system.

One method that states are considering to reduce energy use at peak periods is called *dynamic pricing*. Although there are numerous ways to implement dynamic pricing, customers would pay more for electricity use during peak periods and less during off-peak periods.

Currently, most Vermont customers pay the same price for electricity at every hour. Dynamic pricing is similar to phone plans that charge less for nights and weekends when demand is lower.

These schemes generally include some form of advanced metering that can register not only *how much* electricity is consumed, but *when* it is consumed.

Dynamic pricing schemes could be simple, such as charging residential customers a higher price from noon to 6 p.m. every day, with prices set annually or by season.

Or they could be more complex, with customers having a real-time price that differs every hour of the year based on the current cost to produce electricity in New England.

Chapter 4:

Cross Cutting Issues

In previous sections of these materials, we looked at specific options for providing electricity in Vermont. To the extent possible, the options were compared side by side based upon a series of attributes such as cost, time to build, footprint, typical size, environmental impact, potential to create jobs, etc.

In this section of the materials, we look at some of the issues that are common to many of the options. In that regard, the issues discussed in this section cut across the spectrum of options.

The Buy versus Build Decision: Power Supply Contracts versus Investments in Power Plants

Vermont utilities are responsible for procuring power resources to meet the electrical needs (including reserves for reliability) of their service territories. Regardless of the fuel source, power supply may be obtained by contracting with the owners of a generation source or by investing in power plants.

The principal differences between contracting and building are: 1. *The degree of future price certainty of a power supply* and 2. *The effect of each option on utility credit ratings and access to capital*. There is also concern regarding the ability of a utility to effectively manage ownership of power generation.

Price Certainty and Contracted Power

Price certainty represents the predictability of future power supply costs. For example, if your utility company entered into a long-term contract to buy energy for 8¢ per kilowatt hour for twenty years, you would know

exactly what you are paying for that power for the duration of the contract.

Market prices could rise to 10 or 15¢ per kilowatt hour, but you would still pay 8¢ until the expiration of the contract. Alternately, market prices can go down. If prices were to fall to 2¢, you would pay more than four times the market price.

For utility investments, price certainty with regard to future costs can also be obtained from utility investment (ownership) of those fuel sources that have no or relatively low fuel costs or fuel costs with little or no correlation to fossil fuel commodities, such as wind, hydro or, to a lesser extent, nuclear power. Most of the costs for these facilities are for the initial permitting and construction.

Utilities would collect these costs from customers over the life of the plant. Future rate changes arising from these investments would be very low, whether future market costs of power declined or rose. Of course, if wholesale market power supply prices declined substantially, then the power produced from these plants could end up being well above market prices.

Cost volatility in gas/oil plants tend to be greater because the price of fuel represents a significantly higher percentage of these plants' total costs. Fossil fuel prices have, at least on a near-term basis, experienced substantial volatility.

But since any price change would reflect underlying fuel costs, there is much less risk that wholesale market prices would be substantially different from the price of output from these plants.

Financial Effects of Contracts

Consumers may see little difference in rates whether a utility owns a plant or whether it enters into a twenty year (or longer) fixed price contract. On the other hand, because of the way credit rating agencies view long-term contracts, utilities that invest in a plant will generally enjoy better credit treatment.

Rating agencies sometimes look at long-term power supply contracts as debt obligations—this can potentially increase the cost of borrowing for utilities, who pass that cost to consumers. Additionally, if the utility has a poor credit rating, it may not even be able to obtain long-term power supply contracts.

Termination of Contracts

When a contract ends, other costs and benefits become apparent. For instance, had the utility invested in a plant rather than contracting, it would likely own the site. It could potentially extend the life of the plant or undertake other plant development.

However, ownership would entail its own burdens, such as assuming any liability risks of owning the plant/site, including plant removal at the end of the plant's life. In a contract, by contrast, there are no such obligations on either party at the conclusion of a contract.

Ability of Vermont Utilities to Develop Investment Opportunities

Opportunities for Vermont utilities to invest in plants are limited due to their size (Vermont utilities are among the smallest utilities in the nation). Therefore, the number of investment opportunities and the nature of those opportunities are likely to be limited. Due to

economies of scale, smaller scale plants are typically more expensive to construct.

The efficiency (output) of larger plants tends to grow as the size of the plant increases. There may be opportunities for Vermont utilities to obtain a small ownership share of a large scale investment, but only if owners of that facility are seeking investors. Should this opportunity arise, the larger scale investments are likely to be out of state.

Types of Contracts

Power supply contracts can be *firm power delivery* (meaning it can come from any plant) or *unit contingent*. *Unit contingent* means that the utility and its customers only pay for the power that is produced by that particular power plant. If something unexpected occurs that takes the plant out of service, customers would be exposed to market prices during the time the plant is not operating.

Market power contracts are not based on a specific source and require all energy purchased to be delivered regardless of the performance of the seller's plants. Therefore, unit contingent power is less valuable than system power and should be priced lower.

Of course, when a utility invests in a power plant, the power derived from that plant is completely dependent on that plant operating at optimum levels. Plants with more predictable production are therefore worth more than contracts or investments in units with less predictable output.

Term of Contracts

The length of a power contract is important if customers value price certainty above the lost opportunity of riding the market when

energy prices decline. A longer duration contract along with a fixed price obtains price certainty. Shorter-term fixed price contracts would generally result in prices closer to the average market price than would longer-term contracts.

Price Terms of Contracts

Power supply contracts do not always have fixed prices. They can be tied (entirely or in part) to the market price in energy, capacity, or even *Renwable Energy Certificates* (RECs). They can contain both fixed and variable components. For example, a contract could move with market prices within a certain range, but stay at a predetermined price outside of that range (or vice versa).

Utility investment in plants can have similar features. For example, utilities can buy future gas supplies for a gas plant investment or let the price float with the market.

Summary – Price Certainty

A look at current Vermont power supplies indicates a strong preference for price certainty.

The contract with Hydro-Québec includes price terms that were set at the beginning of the contract and are completely disconnected from fossil fuels. The contract with Entergy Vermont Yankee is also a stable price with no fossil fuel connection. In addition, Vermont utilities obtain a significant amount of power from local hydro and biomass sources that have had stable prices disconnected from fossil fuels.

These outcomes, however, have not come about by chance. Regulators, utilities, and political leaders of prior decades have

voiced a preference for Vermont to manage risk by locking in price terms or minimizing correlation with fossil fuels, even if it means paying a more at some times. We will be interested to see if you agree.

In-State versus Out-of-State

A second issue related to the theme of cross cutting has to do with whether a generation resource (either built or purchased under contract) is located in Vermont or out-of-state is of concern to Vermonters.

The issue of in-state versus out-of-state has a different impact on the various resource options. For some resources, the answer is clear cut and based upon previous decisions or the nature of the resource. For example, the Vermont Yankee Plant is already in Vermont and that in-state location has its own advantages and disadvantages.

If a new nuclear plant were built, it would more likely be outside of Vermont. If large-scale hydro were selected as a resource, it would likely come from outside Vermont, most likely from Canada. If the energy efficiency or demand control resources were favored, those resources would likely come from inside Vermont (although it may be possible to contract for energy efficiency or demand response resources from outside the state—it would not be typical).

Coal-based resources would likely come from plants outside Vermont because coal plants tend to come in sizes that surpass the demand in Vermont. In addition, siting coal in Vermont would likely be more difficult than it would in other states. Generalizing across the set of resources, there are several ways to think about the in-state versus out-of-state issue.

Economic Impact

If a generation resource or contract has positive economic impacts such as tax revenues or creation of jobs, then one might argue for an in-state location. Biomass resources would be a good example, as would nuclear projects, or smaller oil or gas peaking plants. Energy efficiency also adds local economic value.

Environmental Impact

Environmental impacts on Vermont's air quality, land use, water use, and visuals could be lessened by purchasing electricity generated out of state. However, buying electricity from facilities outside of Vermont will not reduce the impact of emissions, but merely put them in someone else's backyard. Moreover, the location of generating facilities has no global impact in terms of greenhouse gas emissions.

Other Local Impacts

A second way to think about the in-state versus out-of-state issue is to consider local impact. On the negative side, many of the local impacts are environmental. Pollutants, land use, water use, and visual impact are examples.

There can also be positive local impacts. An example might be the positive side effects of extending a natural gas line to fuel a peaking plant. With the natural gas peaking unit as the anchor tenant, natural gas is then available to customers along the way.

A combined heat and power project built in Vermont can have positive local impact in the form of lower rates and overall energy costs. An example of a local combined heat

and power project might be a local university or school district.

Control Over the Resource - Self-Sufficiency

The issue can also be considered in terms of control and self-sufficiency. Many are proud that Vermont does things its own way, and they would like to ensure that the priorities of other states do not interfere with their own. They would argue that the way for Vermont to control its energy supply is to build and retain generation sources within the state. Others would argue, however, that control and self-sufficiency are elusive and that contracts provide security.

Generation Ownership

The question in the third cross cutting issue is whether the type of entity that owns the generation sources matters to Vermonters. The first way to think about the issue is public ownership (state, municipal, or special purpose entity) versus investor-based, private ownership. Some practical and philosophical questions can include:

- What type of entity has the management capacity to oversee the project?
- What type of entity can raise the investment capital at the least expensive rate?
- What type of entity is better able to assume risk?
- What types of activities are best handled in the private sector versus the public sector?

Some options, such as local area or residential scale wind, tend to be community-based and work well under public ownership.

Other options are larger than a particular community can handle. Investor-based ownership can have advantages in terms of risk. If a generation plant has problems in a regulated setting, regulators can assign the risk and cost to the shareholders. New technologies, such as coal IGCC, are good examples. If the owners are independent power producers, such as out-of-state entities specializing in generation ownership, assigning risk is even easier—it is assumed by the market.

Impact on Transmission

Impact on the transmission system is another cross cutting issue impacting the various resource options to a greater or lesser extent. Resources built in remote areas tend to require new transmission.

Large-scale resources tend to require either new transmission, or transmission upgrades. The two existing large-scale contracts, Hydro-Québec and Vermont Yankee, already have transmission systems in place. New large-scale contracts for the import of additional power could require new transmission or additional electric import capacity. Generation resources built near the load, as in distributed generation, often relieve strain on a transmission system.

Efficiency programs and Demand Response programs generally defer the need for additional transmission facilities. Generation built away from load centers, even in modest quantities, may require significant transmission to deliver the power to the grid. Some wind sites have this characteristic.

New transmission raises significant financial and environmental issues and has a negative bias. For these reasons, new transmission

requires a *Certificate of Public Good* before it can be constructed. Community concerns about transmission systems can include their route, visual aesthetics, impact on property values, and potential health effects from herbicides and electro-magnetic fields (EMF).

Because of these complexities, Vermont has instituted a new *least cost transmission planning process*. Before a new transmission line can be authorized, those involved must evaluate alternatives such as efficiency, demand response programs, or distributed generation that might allow for the deferral or down-sizing of the transmission line.

Distributed versus Centralized Generation Sources

As generation plants have grown larger to achieve economies of scale, the tendency in the U.S. has been to move towards *centralized generation*. Vermont, however, is an example of a different trend.

Other than the obvious example of Vermont Yankee, much of the generation in Vermont is small-scale, and there are a number of cases of *distributed generation* built close to the load. These include small hydro and biomass projects.

While centralized generation has certain attributes, such as economies of scale (and therefore relatively lower costs), distributed generation has a different set of advantages.

Those advantages include less impact on the transmission system, more local control, localized economic benefit, and less risk, since each increment of generation is of a smaller size.

When a large, centralized resource fails (i.e. an 1100 MW generator or a heavily loaded power line), the impact can be widespread. When a small, decentralized generation resource fails, the impact tends to be limited to the local area and is more quickly and routinely managed.

The centralized versus decentralized issue cuts across the entire spectrum of resources because each of the generation options tends to fall in one of the two groups (e.g. nuclear and coal are used in centralized generation, and solar, wind, CHP and biomass tend to be more decentralized).

Favoring centralized or decentralized can be a factor in the generation source one recommends.

Renewable Energy Certificates (RECs)

Earlier in the renewable energy chapter, we discussed renewable energy certificates (RECs). RECs are a way to influence generation choices by placing a value on the benefits of renewable sources. Since many of the renewable benefits are shared by all, RECs create a market value for those benefits and spread the costs.

The REC program enables societal benefits and the value of energy to be sold separately. For example, the energy output from wind power in Vermont can be sold to the New England grid at the same price as electricity from any other source.

The resulting RECs can be sold separately to entities needing to meet renewable energy portfolio requirements. This includes entities in states where the REC value can be higher, such as Massachusetts. Purchasing a renewable credit is how a utility proves

renewable purchases. Since RECs can provide revenue beyond the spot market sale price, the development of renewable resources in Vermont is stimulated.

The cross cutting issue is that environmental benefits and energy value can be traded separately. So a utility can either use the money from the sale of RECs to lower its costs or claim the environmental benefits of the renewable generation, but not both.

If Vermont were required, through state or federal action, to obtain 20% of its portfolio from renewable sources, it could either: *1. Build enough renewable generation to provide that amount or 2. Purchase enough renewable energy certificates to represent 20% of its portfolio.*

How Vermonters feel about satisfying renewable requirements with RECs and how they feel about Vermont's RECs being sold in other states where their value is higher are important considerations. Many feel that in buying renewables, the resource should be within transmission distance.

Others insist that the impact of renewables on the system as a whole is more important—they are satisfied if the renewable power enters the system and less concerned who uses the electrons.

Another issue facing Vermont is what to do with its *qualifying facilities* (QFs). Qualifying facilities are hydro and wood plants built under previous federal legislation, designed to stimulate more efficient generation.

The contracts expire in the 2012-2015 timeframe. It is possible that many of these will not survive in a pure power market without the beneficial contracts, which utilize elements similar to RECs. If Vermonters care about the circumstances surrounding these 20 facilities, which total 70 MW, a test could be developed to determine if these projects require RECs to continue.

Summary on Cross Cutting Issues

There are differences as you look down the list of options to meet the need for generation. We have called those *attributes* or *advantages and disadvantages*.

There are also multiple ways to implement each of the options—long-term versus short-term, build versus contract, in-state versus out-of-state, etc. These multiple ways to implement are the cross cutting issues in this chapter. In the next and final chapter, we begin to put it all together and start the process of asking you to make recommendations.

Chapter 5: Putting It All Together and Making Recommendations

INTRODUCTION

We need to know how you would decide which tradeoffs should be a part of planning for Vermont's energy future. We will ask you a series of questions to collect your opinions. There are no right or wrong answers—we only want to know what is important to you as an individual.

COMPARING ATTRIBUTES OF THE OPTIONS

Each of the options we have discussed has different characteristics—or *attributes*. The following charts are an attempt to summarize some of those attributes across the options.

Figure T deals with costs for a new generating plant. The chart uses 2007 as a way to use consistent dollars, but several of the options have long lead times. For example, a coal plant might have a lead time of 5-7 years, and a nuclear plant of 10-15 years. The 2007 costs shown in the table would be subject to inflation in those later years. This cost structure impacts either a generation plant built by a Vermont utility or the cost of a contract for the plant's output. The types of plants covered are:

1. *Coal-Circulating Fluidized Bed (CFB)* - This is a more advanced form of combustion.
2. *Coal-Pulverized* - This is current technology of most coal plants and is less expensive than CFB.
3. *Natural Gas Combustion Turbine (CT)* - This is the standard design for gas peaking units. Two sizes are shown—25 MW and 50 MW. Both are relatively small.
4. *Natural Gas Combustion Turbine Combined Cycle (CTCC)* - This is a more efficient natural gas generator. It captures waste heat to generate more electricity. It costs more to build but uses less fuel.
5. *Fuel Cell* - This is an advanced technology that is still in development stages. Most fuel cells use natural gas as a feedstock. They are a good candidate for distributed generation but, as you can see, are the second (to solar) most expensive option.
6. *Coal-Integrated Gasification Combined Cycle (IGCC)* - This is the new technology being discussed for using coal. The coal is gasified and then put through a combined cycle turbine. These numbers do not include sequestration, which would approximately double the costs shown.
7. *Nuclear* - These costs would be for a new nuclear unit.
8. *Solar* - This is for a photovoltaic system. They are currently the most expensive option considered but are used in specialized applications where they offset an even higher cost, such as a transmission or distribution line.
9. *Wind* - This is for a utility scale wind project. Small projects are considerably more expensive.
10. *Wood-Circulating Fluidized Bed (CFB)* - As with coal (CFB), this is a more advanced form of combustion. It is more expensive but with lower emissions.
11. *Wood-Stoker* - This is more typical wood combustion.

Figure T:

Summary Results for a plant that would come on line in 2007

Real levelized 2007 dollars/MWh

	Total Plant Investment - No AFUDC (\$/kW) - 2007\$\$	Real Levelized capacity cost (including AFUDC) (\$/MWh) - 2007\$\$	Real Levelized energy cost (\$/MWh) - 2007\$\$	Real Levelized all in cost (\$/MWh) - 2007\$\$	Real Levelized REC value (\$/MWh) - 2007\$\$	Real Levelized emissions costs (included in all in) (\$/MWh) - 2007\$\$
Coal (CFB)	2426	35.95	40.92	76.87	0	5.37
Coal (Pulverized)	1936	29.56	33.35	62.91	0	5.02
CT (25MW)	662	79.89	84.79	164.67	0	3.38
CT (50MW)	524	65.92	84.79	150.71	0	3.38
CTCC	730	10.19	55.35	65.55	0	2.04
Fuel Cell	5820	198.08	225.25	423.33	0.00	1.82
IGCC	2058	35.78	31.16	66.94	0	4.25
Nuclear	2633	42.23	17.81	60.04	0	0.00
Solar	6040	296.27	0.00	296.27	25.03	0.00
Wind	2059	88.83	0.00	88.83	25.03	0.00
Wood (CFB)	2518	37.15	47.66	84.82	25.03	0.36
Wood (Stoker)	2385	37.08	53.34	90.43	25.03	0.71
DSM (w-non-electric savings)				29.28	0	0
DSM (w/o-non-electric savings)				66.97	0	0
Hydro 2 MW	2500	63.79	19.00	82.79	25.03	0
Hydro 500 kW	4000	102.06	19.00	121.06	25.03	0

A new nuclear plant has not been proposed or built in the US in 15 years. The ability of a utility or developer to finance such a large project and to cost effectively manage the construction of a plant would be a challenge. Because of this, the nuclear cost estimate is subject to additional uncertainty.

12. *DSM (with non-electric savings)* - This option includes both electric savings and collateral savings from associated resources such as water and other fuels, as well as a reduction in costs for operation, maintenance, and replacement.

13. *DSM (without non-electric savings)* - This option looks strictly at electricity savings.

14. *Hydro* - This option shows costs for two sizes of small hydro that might be built in Vermont.

Each of the options is evaluated on a series of cost comparisons. They are:

- A. *Total Plant Investment (without a return to the utility during construction or AFUDC)* - This cost is measured in dollars per kW. The figure shown is what it costs to build a kW of generating capacity for each option.
- B. *Real Levelized Capacity Cost with AFUDC* - This column looks at what it costs per MWh and assumes the utility is allowed to earn a return on its investment during construction. This way of viewing the cost allows contracts for power and building plants to be compared. These are the costs to construct or capacity costs.
- C. *Real Levelized Energy Costs* - These are the costs per MWh to operate the plant—most are either fuel or operations and maintenance.
- D. *Real Levelized All-In Cost* - This is combined dollars per MWh to build and operate or cost for both capacity and energy.
- E. *Real Levelized REC Value* - This is the estimated value for renewable energy credits.
- F. *Real Levelized Emissions Costs (included in all-in costs)* - This column

shows the cost for emission allowances that were included in the *all-in* column.

Figure U compares relative environmental impacts for each of the options. Impacts are not cradle (e.g., mining) to grave (e.g., disposal) but associated with the generation or saving of electricity only.

Impacts can vary within a particular fuel type based on technology, design, specific fuel used (e.g., type of biomass or coal), and location.

WHICH ATTRIBUTES ARE MOST IMPORTANT TO YOU

Cost

Think about the upfront costs and operating costs of each option. For example, coal-based options cost more to build than gas or oil-based options, but have cheaper fuel. Nuclear has cheap fuel, but long-term waste disposal costs. Fuel is free for wind and solar, but not always available, so these are often paired with other generation options. Contracts for energy will likely have no upfront costs but obligate the utility to pay in the future.

Risk

Resources come with varying amounts of risk. Risk can often be managed through practices such as *diversification*, spreading out investments and contracts. Potentially, diversification could mean committing less to a source than would be attractive. To what extent should diversification be a priority in future resource investment?

Figure U: Relative Environmental Impacts by Resource Type
(per comparable unit of energy)

	Sulfur dioxide (SO ₂)	Nitrogen oxide (NO ₂)	Carbon dioxide (CO ₂)	Particulate matter (PM)	Mercury (Hg)	Water Quality Impacts	Habitat impacts	Solid waste	Nuclear waste
Biomass	○	◐		◐	○		○	○	
Coal	●	●	●	●	●	◐	◐	◐	
Coal gasification with CO ₂ capture	◐	◐	○	○	○	○	◐	◐	
Energy efficiency									
Hydro-dam with reservoir			○			●	●		
Hydro-run-of-river						○	○		
Natural gas	○	◐	◐	○		○	○		
Nuclear						○	○		●
Oil	◐	◐	◐	◐	○	○	◐	○	
Solar									
Wind							○		

● High Impact ◐ Medium Impact ○ Low Impact ○ No Significant Impact (blank)

Notes

1. Impacts are not cradle (e.g., mining) to grave (e.g., disposal) but associated with generation or saving of electricity only.
2. Impacts can vary within a particular fuel type based on technology, design, specific fuel used (e.g., type of biomass or coal) and location.
3. Biomass is assumed to be sustainably harvested, resulting in no net CO₂ emissions.

Predictable Bills

In recent years, gas costs have been unpredictable. Oil also shares that unpredictability. While long-term contracts for either fuel or power as a combined product can provide more predictability, they often come at a premium when sellers demand some of the upside. The price of wood, even as a byproduct, varies based upon conditions in the forest products industry.

Least Consumption of Finite Resources

The sustainability of a resource can also be a consideration. While the debate continues over how much gas and oil remain in the world, these resources will eventually expire.

Both coal and nuclear fuels will likely be available beyond our lifetimes, but they are still finite resources. Solar and wind, on the other hand, are renewable resources. Some will say that our consumption will have implications for future generations, others will argue that Vermont is so small that its impact will not make a difference.

Greatest Reliability

Reliability can signify the stability of a particular technology, whether it needs frequent maintenance, or if a fuel source is regularly available (in the case of wind, solar, and water). It can also signify the impact to the grid in the event of a failure—the larger the resource, the greater the impact tends to be. For a contract, reliability can signify the credit worthiness of the other party and the quality of their portfolio.

Vermont-Based Energy Resources

Some people value a resource that is Vermont-based. Their opinion could be a desire for control, a belief that self-sufficiency is important, or a view that some technologies provide Vermont with economic benefits.

Others discuss this issue in terms of “doing our part.” Is it right for Vermont to lean heavily on surrounding states and provinces for a large share, shifting to them the burdens of generation siting? The counter view would say, if other places are better generator sites, that’s OK. It is an ethical versus practical dilemma.

Least Local Environmental Impact

Local environmental impacts range from emissions of particulates, nitrogen oxide and sulphur dioxide, visual impacts from wind turbines and transmission lines, to waste management. Larger generation plants have greater footprints, and some plants require water for cooling.

Plants located in other states or Canada obviously have little visual or land impacts on Vermont but can still impact the air quality of the state if upwind. A contract often has no particular fuel or power source associated with it and therefore has no clear emissions impact. Preferred attributes, however, can be purchased in the market for a premium.

Least Impact on Climate Change

Any option involving the combustion and release of carbon dioxide can impact climate change. Natural Gas plants have less impact than coal, but much more than wind or hydro. Coal plants with new technologies are predicted to have much less impact than traditional plants, but are considerably more expensive.

Wood burning plants operated in a sustainable manner can offset carbon dioxide with the carbon absorbing properties of trees. Contract power, once again, may or may not be associated with a fuel type.

For some, climate change considerations have become the primary concern. As carbon controls are implemented with increasing intensity, this consideration may increasingly merge with cost.

More Control over my Energy Future

Like many of the attributes discussed in the section, control can mean different things. Control can signify smaller, community-based resources or public ownership in which users have input. It can signify an energy source local to Vermont or predictable prices and bills. For some utilities, control signifies surviving a blackout with their own resources.

Most Economic Benefit to my Area or to Vermont

Economic benefits in electricity resources arise from building and operating a generating facility and the manufacturing and installation of energy efficiency equipment. This includes the local jobs and the goods and services

needed to support these activities, as well as local tax revenues.

Also, when Vermonters choose less expensive resources, they have more disposable income to spend on other goods and services.

Efficiency programs are both labor intensive and less expensive than most alternatives. Vermont Yankee Plant also sustains a large number of local jobs and pays significant local taxes. And Burlington's biomass plant supports local jobs while consuming wood to help sustain the Vermont forest industry.

Long-term contracts from out of state tend to have less direct economic benefits for Vermont. When these contracts provide cheaper electricity, however, they can free up disposable income for Vermonters.

OTHER FACTORS THAT MAY BE IMPORTANT TO YOU

There are a number of additional ways to think about electricity resources that may be of importance in your recommendations.

Impact on Large Volume Users

Some generation options—such as environmentally favorable options—can cause electricity bills to increase. Often, customers impacted most by price increases are those who use large volumes of power. A price increase that is digestible for a family may be beyond the range of a manufacturer in a competitive market. Additionally, the shared costs of transmission line construction greatly impact those who use large volumes of power.

Impact on Low and Fixed Income Users

While some families may be willing to pay more for certain attributes, price increases are more challenging for those with low or fixed incomes. Low or fixed income families may find the attribute of lowest cost more important.

Impact on Energy Independence, Self-reliance, and National Security

Some Vermonters may prefer options not reliant on imported oil or gas, believing them to improve national security. Some may prefer renewable and efficiency options for their contribution to energy independence and sustainability. Still others may support Vermont-based options that encourage self-reliance.

Moving Toward Distributed Generation

Some may prefer the benefits of *distributed generation*—producing power in smaller amounts closer to delivery points—over traditional, centralized generation. They would prefer options such combined heat and power systems, small hydro, small gas or oil peakers, and community scale wind installations, all of which are candidates for distributed generation. In some cases, smaller scale resources come at a higher price.

Impact on Future Generations

Certain options can impact future generations by leaving nuclear waste, consuming finite resources, or emitting pollutants that accumulate in the environment, such as greenhouse gases or mercury.

Moving Toward Market-Based Pricing and Solutions

Some believe energy decisions are better based upon market signals than government policy. Advocates for market-based systems would argue that retail prices adequately balance consumption and the need for new generation sources. They would say the marketplace reinforces consumer values, citing long-term contracts stabilizing prices as an example.

Market-based solutions would advocate for *green choice programs*, where only those customers desiring renewables would pay for them and, in turn, receive them. Central Vermont Public Service's *Cow Power Program* is one such green choice program.

Others would argue, however, that markets do not include all policy objectives and that there are unintended consequences to overly relying on them. Market barriers, for instance, often require government action—such as net metering, statewide energy efficiency programs, or renewable portfolio standards.

Making It Easier to Site, Build, and Invest in Vermont

Some argue it is too difficult to build new generation sources in Vermont and that *siting* processes create uncertainty and long delays. Certain wind developments in Vermont could be examples of this. Energy developments and their economic benefits, they would say, go instead to other states, where it is easier to build.

Others would argue that the lifestyles and scenic beauty in Vermont need protection, and that the high standards of the siting process reflect these values.

Role of the Local Utility and Ownership Structure

Some argue that local utilities (especially those owned by investors) are in a better position to absorb risks from large-scale projects and make decisions based on market economics.

Others argue that government-owned or community-based electric utilities have a better ability to match local preferences and lifestyles with energy choices.

It differs from time to time which type of entity can obtain the lowest cost investment funds.

CREATING A MIX OF OPTIONS OR PORTFOLIOS

Vermont currently operates with a mix of energy resources in the form of a portfolio, which will likely continue in the future. In the current portfolio, two-thirds of the energy consumed comes from either Vermont Yankee or Hydro-Québec.

Because both contracts expire in the near future, there is both a need to replace that power and an opportunity to adjust the portfolio. The amount of power built in Vermont versus the amount obtained through contract can be adjusted, as well as the types of resources.

The recommendations you make on the portfolio will depend upon which attributes you believe are most important.

