


Southern Loop Utility Search Conference™

Background Report

Conference Dates: January 30-31, 2006
Brattleboro Quality Inn & Suites
1380 Putney Road
Brattleboro, VT 05301

Produced for

Central Vermont Public Service (CVPS)

Vermont Electric Power Company (VELCO)

Meeting Design and Facilitation by

STAR Group, LLC

"Background Report Committee"


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Foreword

Central Vermont Public Service (CVPS) and the Vermont Electric Power Company (VELCO) are committed to providing the public with an open discussion about the electric power infrastructure needs in southern Vermont. This document has been prepared to provide the public with an understanding of the reliability issues now confronting southern Vermont and the possible solutions to these issues. Your interest and input are appreciated; we hope this document answers many of the questions you have.

CVPS and VELCO have embarked on an innovative public outreach process. Designed and facilitated by STAR Group, LLC, a nationally renowned meeting facilitation firm, two teams of local residents, business leaders, government officials, utility employees, and public interest groups are engaged in a public process designed to provide recommendations concerning how to solve growing reliability issues on southern Vermont's electrical system. The first team is known as the "Leadership Team," which is chartered with overseeing and coordinating our public involvement. Reporting to the Leadership Team is the "Background Report Committee," which is chartered to oversee the development of a report for the public that provides a fair and balanced look at the electricity reliability issues facing southern Vermont. This report, which has been assembled by UtiliPoint International (www.utilipoint.com) at the request of STAR Group, is intended to be used in preparation for the Utility Search Conference™ scheduled for January 30-31, 2006. The format for that conference will be an intensive 2-day discussion of local issues and the future of electricity supply in the region. The Leadership Team has selected over 50 people to represent various interests and to actively participate at the Utility Search Conference™.

The Leadership Team has developed the following problem statement for consideration at the 2-day conference:

> ***"Southern Vermont electrical transmission facilities have limited ability to support increased electrical demand and are unable to withstand failures of, or to have preventive maintenance conducted on, key components at present demand levels. The reliability of the regional bulk transmission system that connects southern Vermont, southwestern New Hampshire and northwest Massachusetts is at risk at existing demand levels, with increasing reliability risk as regional electrical demand levels increase."***

The goal of the Utility Search Conference is for the community to examine and make recommendations on the potential solutions to the Problem Statement for consideration by CVPS and VELCO. In the months immediately following the conference, a Community Working Group (CWG) of approximately 20 people will be formed to further study and to work with CVPS and VELCO to refine the potential solutions. Ultimately, CVPS and VELCO have a legal responsibility to propose solutions they believe best meet the electrical system's needs. The results of this public process will serve as the foundation for the necessary regulatory filings that may be required of CVPS and/or VELCO in order to implement their proposed solution(s).

If this report leaves questions unanswered or leads to any confusion, please feel free to contact CVPS for further clarification. Please direct any questions you have to:

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1. Overview

Electric energy is a key block in the foundation of our economy, our quality of life, and our community. We use electricity in our households to run our refrigerators, lights, TV, computers, phone systems, water wells, and for some to run life-saving equipment like home oxygen systems. Local industries use electricity to run ski lifts, to produce lumber, and to run precision processes to build electronic circuits. Hospitals need electricity for everything from mundane uses such as lighting and HVAC (heating, ventilating, and air conditioning), to the highly sophisticated and delicate equipment that are at the heart of today's modern medical care facilities. Communities rely on electricity to operate everything from traffic signals to sewage treatment plants. Electricity is so critical to certain facilities, like hospitals, that they sometimes have backup generators or battery systems to run their most critical equipment when there is a power outage.

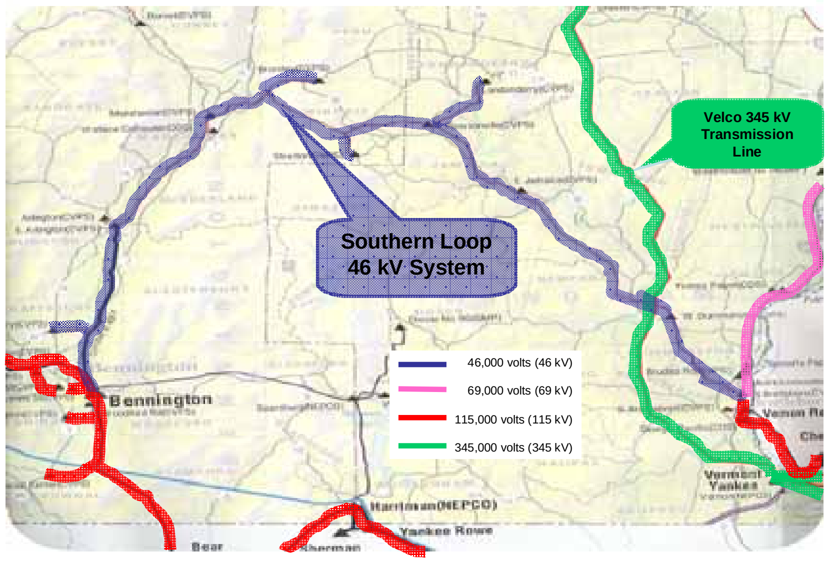
Since electricity plays a critical role in our daily lives, the utilities that supply the power are expected to build and maintain systems that are highly reliable. Even though it is invisible to most people, there is a complex, multi-layered system delivering the electricity to the plugs on our walls. Power systems have been called the most complex machines in the world because the electricity generated must be in perfect balance with the electricity demand at all times. Teams of system operators, computer models, and control systems are at work during all hours of the year monitoring and managing power plants and transmission systems to ensure reliability.

Power plants form the heart of the power system. The main arteries connecting the electricity generated by these power plants to our communities are high-voltage transmission lines. The power plants and associated high-voltage transmission systems are designed to provide high reliability because if this part of the power system fails, it can cause tens to hundreds of thousands of customers to lose power.

Transmission is responsible for 5 to 10 percent of the average electric bill, yet its potential impact on the overall reliability of the power system is much larger than that percentage might suggest. If the transmission system fails, large geographic regions can experience a blackout. For this, among other reasons, the transmission system is planned, designed, and operated to the highest standards of reliability. Achieving this high standard requires the system to have many redundant features and excess capacity so that there is flexibility to reroute power when equipment failures occur, or when a lightning strike or ice storm causes a problem on the system.

This report provides background information to interested parties on a portion of the Vermont and New England electrical system known as the "Southern Loop", which is illustrated in Figure 1-1. Although this electric system operates at "only" 46,000 volts, and is therefore considered a "sub-transmission" line, its reliability is of utmost importance because it serves 40,000 customers.

Figure 1-1. Southern Vermont Transmission.



The Southern Loop spans 66 miles from Bennington to Brattleboro and is used to transport the power needed to serve southern Vermont communities. In electric utility parlance, a "loop" is a system that normally receives power from two different sources. The west end of the Southern Loop in Bennington plugs into the power plant and higher voltage transmission system of New York and Massachusetts. At the eastern end, in Brattleboro, the Loop is connected to Vermont Yankee and New Hampshire's power plant and transmission system.

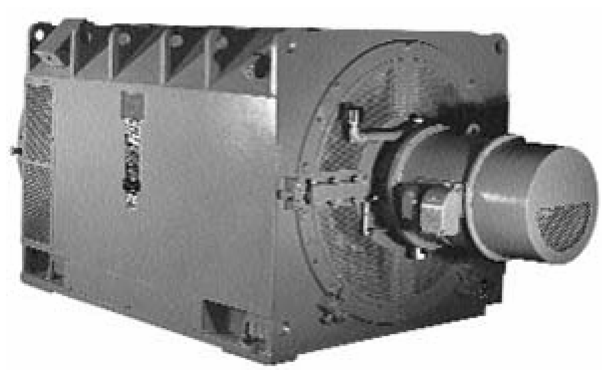
On a normal day most, if not all, of the power for southern Vermont is imported from both the Bennington and Brattleboro connections. Normally a "loop" would be designed so that either end could supply the power needs of the system if necessary. But because the electric demand on the Southern Loop has increased over time, in 60 percent of the hours in the year if either the Bennington or Brattleboro connection is lost, CVPS would be unable to provide power to some or all customers. During these hours the electric demand would exceed the physical ability of the transmission system to maintain acceptable voltages when delivering power solely from either the east or west ends of the Loop.

The event of September 27, 2005 is an example of the kind of vulnerabilities found in the Southern Loop. On that day, CVPS was performing planned maintenance near Brattleboro that required the 46 kV loop to be disconnected from the rest of the transmission system in the Brattleboro area. The electric demand on that day was low enough to be served only from the Bennington connection. During this maintenance, however, a short circuit occurred in Bennington that was caused by an electric equipment failure. The result was that all 40,000 customers on the Southern Loop were without power until a connection could be restored. Had the same equipment failure occurred during a peak electric demand day in the middle of winter or summer, even with the Brattleboro connection in place (no maintenance being performed), the result would have been the same.

The Southern Loop is also quickly losing the ability to serve all customers at times of peak electric demand periods even when both ends of the Loop are connected. CVPS engineering models indicate that if no additional investments are made to improve the Southern Loop, as little as 5 percent growth in electric demand may exceed the physical capability of the Southern Loop transmission line to deliver power to all customers during times of peak electric demand. Because of aggressive energy conservation and other measures already taken to curb demand in the area, the peak electric demand has only grown an average of 0.5 percent per year in the area which is about half the rate of growth across the state of Vermont. But even if this low growth rate continues, sometime within the next 3 to 10 years the Southern Loop will be unable to deliver power to all customers on a peak demand day if no action is taken to improve the existing system.

The potential solutions to the Southern Loop reliability problems are complex and costly. CVPS Is considering making a $10 million investment in a device called a *synchronous condenser* that would be located in the Stratton area. This device would improve the capability of the existing transmission system to deliver more power. If chosen as part of the solution, the device and associated facilities could be installed within the next one to two years, and would look like a typical substation.

Figure 1-2. Synchronous Condenser.



Even with the synchronous condenser in place, the Southern Loop would need additional investments to ensure the future reliability of the system. Traditionally, utilities would upgrade the transmission system to expand the system's ability to transport power to the region. One type of upgrade would be to add another transmission line to act as another way to route power into the area. Such an investment is certainly an option here.

Other options include installing new electric generators in critical locations on the Southern Loop. Another possibility is to actively attempt to reduce the electric demand through energy conservation and what the industry calls *demand response* (DR) and *demand side management* (DSM) programs. For residences, the type of programs used to reduce the electric demand include: improving home insulation, putting electric water heaters on timers or converting them to propane or natural gas, and charging customers different prices during different times of the day to encourage customers to focus their use of electricity during off-peak hours, and use less electricity during on-peak hours. Similar type programs are offered to commercial and industrial customers to reduce their electric usage and demand during peak times.

Given that the companies are engaged in a public input process and are seeking comments and recommendation on how best to solve these issues, it is difficult to put a definitive cost estimate on the potential solutions. Based on the analysis conducted to date, CVPS estimates that the investment needed to resolve the Southern Loop reliability problems will likely range from $100 million to in excess of $160 million. Some of the possible solutions are combinations of the above-mentioned options. And for certain solutions up to 95 percent of the cost may actually be picked up by other New England utilities because these solutions would also provide reliability benefits beyond the southern Vermont region. Cost estimates throughout this document have been provided to allow a current comparison of likely expenses related to various options, but actual costs could vary significantly. In recent years, all facets of the energy market, from fuel and power costs to construction costs, have been highly volatile, so refinement of these estimates will be necessary to account for the passage of time and resulting changes in the market.

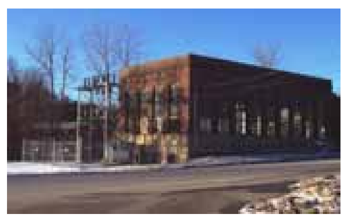
This report explains the basics of power system design, operation, and planning criteria. More specifics are then provided concerning the existing design of the Southern Loop and the reliability risks that face southern Vermont if no investments are made and demand continues to grow. The various options for addressing the problem are then examined in more detail.

2. Power System Basics

Every day we use electricity to power our appliances, light our homes, businesses, hospitals and schools. Yet how electricity is generated, transmitted, and distributed is a mystery to most. Nearly all electricity is generated by large power plants. These power plants can be fueled by a variety of energy sources, most commonly water (also known as hydro-electric facilities), fossil fuels (including coal, oil, and natural gas), or uranium (nuclear). Other means for generating electricity, such as wind, are also becoming a factor in certain parts of the United States. About 73 percent of electricity generated in Vermont comes from nuclear power, 20 percent is from hydro, and the remaining 7 percent is from other sources, such as burning waste wood products or cow methane. While 73 percent of the electricity generated in the state is from nuclear power, over half that electricity is exported out of state.

Figure 2-1. Power plant photos.

Burlington, VT
Wood Plant
McNeil Station
Credit: Electric Dept.

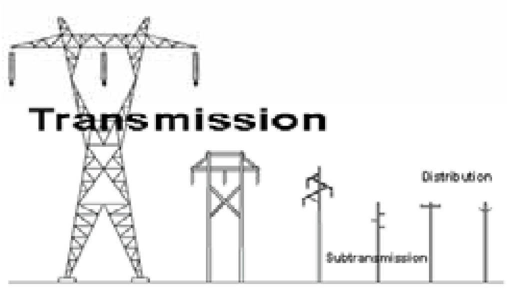


Rutland, VT
Hydro Plant

Credit: CVPS

Brattleboro, VT
Nuclear Plant
Vermont Yankee
Credit: CVPS

Figure 2-2. Transmission structure sizes.



Credit: US Department of Labor (DOL)

Transmission lines normally run tens to hundreds of miles and are used to bring electricity from distant power plants to our communities. These power lines in Vermont operate at voltages ranging from 34,500 volts to 345,000 volts. Lower voltage transmission lines, such as those that operate at 46,000 volts, are typically labeled as "sub-transmission". Utility engineers use the letter "k" as shorthand for the word "thousand" and the capital letter "V" as shorthand for the word "volts". So the term 46,000 volts is also commonly written as 46 kV, for example.

Transmission lines are held in place by transmission structures, which come in many different designs. Transmission structures can be made from different types of materials including wood, steel, and concrete. The size of the transmission structure will depend on the type of material used as well as the voltage that the line is designed to carry

Figure 2-3. Examples of transmission construction.

46 kV transmission lines
Location unknown
Credit: CVPS

115 kV transmission line
West Rutland, VT
Credit: VELCO

345 kV transmission line
Coolidge area, VT
Credit: VELCO

Utility transmission systems are normally interconnected with other utility transmission systems, creating large regional transmission grids, also known as “bulk transmission” because they move bulk quantities of power between regions and utilities. By connecting to these other systems, a utility can more efficiently operate its power system and can also draw upon resources from other places to ensure a more reliable system. Vermont’s transmission system is interconnected to New York, Massachusetts, New Hampshire, as well as to Canada. These neighboring transmission and power plant systems are also connected to their neighbors, and so on. In fact the electric transmission system to which Vermont is connected extends as far west as the Colorado state border.

Transmission lines connect to the distribution lines that serve our communities through a facility known as a distribution substation. Substations contain devices called transformers that are used to convert electricity from transmission level voltages to the lower distribution voltage levels that are typically in the range of 4,000 volts (4 kV) to 12,500 volts (12.5 kV), although they can be as high as

34.5 kV. The distribution voltage continues its journey to your home by exiting the distribution substation on either overhead wires, or underground cables. The majority of the wires you see being held up by wooden poles are at distribution voltages. Many people call them “telephone poles” although they are in reality electric power poles. Telephone lines, if there are any, are the lines found about midway down the pole. Distribution lines carry electricity to our houses, but before getting to our house, the voltage is once again reduced to 120 volts using another transformer that is typically mounted on a distribution pole. These distribution transformers look about the size of a large trash can.

Figure 2-4. Substation and distribution system.

Distribution Substation
Credit: US DOL

Distribution Substation
Transformer
Credit: US DOL

Distribution Pole with transformer
and telephone lines
Credit: US DOL

2.1. Utility Measurements

Measurements are used every day to describe our world. Temperature is measured in “degrees”; the distance to the next highway exit in “miles”; and our height in “inches” and “feet”. The electric utility business has several measurements it routinely uses to gauge the power system:

- “Volts” (V) measure the power system “pressure”. Just like our blood pressure, the voltage in the power system must be kept within very tight design parameters or catastrophes will result. Inadequate voltage will lead to what many people call “brownouts” or in severe cases, “blackouts”. The shorthand for volts is the letter “V”.

- “Watts” (W) measure the power capacity of a device and the “flow rate” of electricity. A 100-watt light bulb draws 100 watts of power when it is on. The shorthand for watts is the letter “W”.

- “Watt-Hour” (Wh) measures the amount of electric energy consumed over a period of time. If a 100-watt light bulb is left on for 10 hours, it will consume 1,000 watt-hours of electricity. The bulb consumes 1,000 watt-hours of electricity because in each of the 10 hours the “flow rate” is 100 watts of electricity. The shorthand for watt-hours is “Wh”.

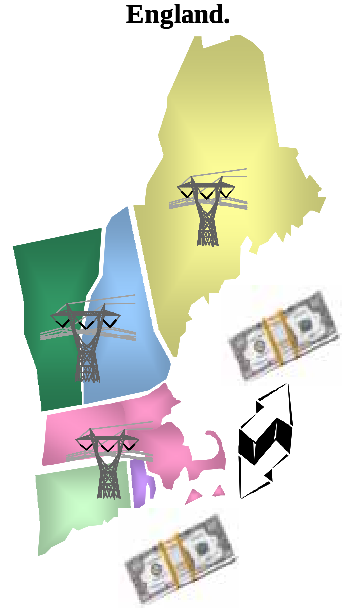
- "Kilo" (k) means one thousand and the letter "k" is used as the shorthand for kilo. The average electricity rate for CVPS is 11.9 cents per kilo-watt-hour (¢/kWh). A 100-watt light bulb that was left on for 10 hours would consume 1,000 watt-hours (1 kWh) and therefore would cost the consumer 11.9 cents at CVPS's average electricity rate.

- "Mega" (M) means one million and the letter "M" is used as shorthand for mega. Vermont Yankee is a 506-mega-watt (MW) nuclear power plant. The annual peak electric demand in Vermont is about 1,100 MW.

2.2. Transmission Operations

Power systems have been called the most complex machines in the world because the electricity generated must be in perfect balance with the electricity demand at all times. Teams of system operators, computer models, and control systems are at work during all hours of the year, monitoring and managing power plants and transmission systems to ensure reliability. CVPS owns and operates 46,000-volt and 69,000-volt "sub-transmission" systems in southern Vermont. That sub-transmission system connects to the 115 kV and 345 kV "bulk" transmission system in Vermont that is owned and operated by VELCO. Overseeing and coordinating all this activity in the New England region is an independent system operator (ISO) known as ISO New England (ISO-NE).

Figure 2-5. ISO New England.

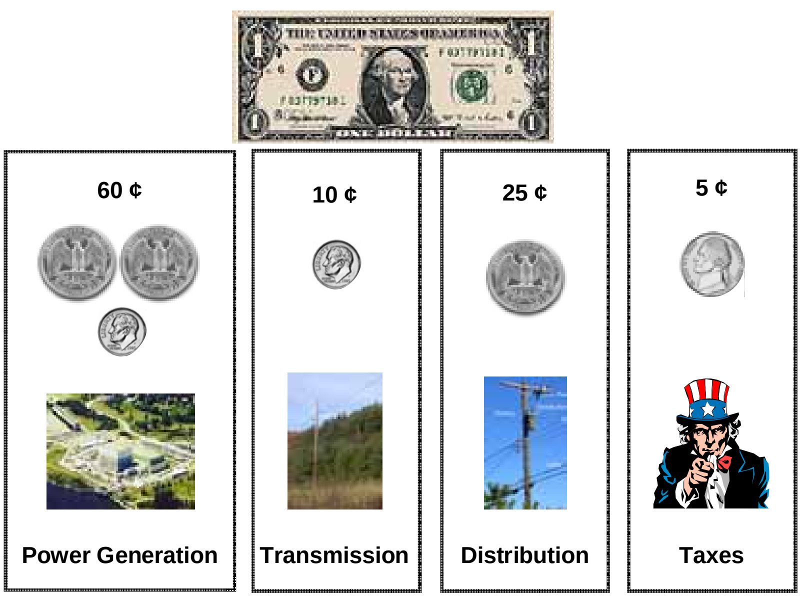


The ISO-NE has many responsibilities. First and foremost ISO-NE is tasked with ensuring that individual utility companies plan for and operate the New England transmission system (also referred to as the transmission "grid") in a way that assures the reliability of the entire New England system. The ISO-NE also acts as the traffic cop for the New England transmission grid by managing the flow of power and trades of electricity in the region to ensure a safe and economic power system. The ISO-NE is also one of the agencies involved in approving New England transmission projects, generally those projects that will operate at voltages of 115 kV and higher. Significantly, if a transmission project is deemed to provide reliability or economic benefit to all of New England, then the cost of that project may be shared throughout the New England states using a funding mechanism called Pool Transmission Facilities ("PTF") funding. Several of the 115 kV transmission investment options for the Southern Loop discussed below would likely be deemed by ISO-NE as benefiting all of New England. Since Vermont represents a very small portion of ISO-NE, its customers would only be asked to pay for 5 percent of the 115 kV transmission related investments that are viewed by ISO-NE as benefiting New England. Conversely, Vermonters also pay money into the ISO-NE cost-share pool to pay for transmission upgrades done by other utilities that benefit New England.

2.3. Utility and Transmission Economics

Nationally and for CVPS, typically around 60 cents of every dollar of an average electric bill goes to paying for power generation costs. Large power plants make up the bulk of these costs because they can cost hundreds of millions to billions of dollars to construct. In addition, the annual operating and fuel costs for running a power plant can be tens to hundreds of millions of dollars. Transmission, by contrast, typically makes up only 5 to 10 cents for every dollar on the utility bill, with distribution and local/state taxes taking up the remainder of a bill.

Figure 2-6. What a dollar on the utility bill pays for.



While electric transmission is a relatively small portion of the cost in the electric business, a new transmission project can cost tens, even hundreds, of millions of dollars. To minimize the impact on rates, the cost of utility investments are financed and spread out over a large period of time. Homeowners do something similar when they buy a house and finance it over 30 years by taking out a mortgage.

By financing utility investments in this way, even these large-scale transmission projects have only a modest potential impact on utility bill. CVPS's electric rates currently average 11.9 cents per kilo-watt (¢/kWh). Roughly 0.06 ¢/kWh, or 0.5 percent of the average electric rate, is needed to generate enough revenue to cover the cost of a $10 million transmission investment. By extension, even a very large transmission investment, such as a $100 million project completely funded by CVPS customers, will have a modest impact on utility costs, not even one-half cent per kWh, or about 5 percent of an average customer's rate. Such large scale transmission projects would typically have benefits that extend beyond CVPS customers and to New England in general. Projects of this type would receive a cost-sharing mechanism whereby 95 percent of the cost of a transmission project benefiting the region would be spread over New England, leaving Vermonters to finance only 5 percent of such project costs. CVPS customers represent about 50 percent of Vermonters, thus CVPS customers would be roughly charged only $2.5 million for a $100 million transmission project that benefits New England. The impact on CVPS costs would therefore be about 0.015 ¢/kWh, or about 0.13 percent of the average electric rate for such a $100 million investment.

Investment Cost Impact Illustrative Example

Every $10 million financed equals approximately 0.06 ¢ per kWh

In 2004, CVPS had a total of $267 million and 2.24 billion kilo-watt hours (kWh) of electricity sales, for an average price of electricity of 11.9 cents per kWh. When a utility makes an investment, it needs to finance that investment similar to taking out a mortgage on a house or borrowing money to buy a car. In the case of a utility, it can borrow money that in house mortgage terms would be about a 30-year, 13 percent interest rate loan. The annual mortgage payment on a $10 million investment works out to be $1.33 million. In other words, every $10 million CVPS borrows to build new transmission adds about $1.33 million of annual costs to their business. A $1.33 million payment spread over 2.24 billion kWh in annual sales is about 0.06 cents per kWh.

The capital cost of a project is just one element for analyzing the overall economics of a utility project. Utility planners are tasked with developing the "least cost plan" which includes not only the upfront investment (capital) costs but also accounts for benefit and cost impacts on other utility operating expenses and society. Societal benefits and costs are commonly referred to in the industry as "externalities" because they do not directly impact the utility. For example, an investment to lower electric usage, such as putting in a more efficient refrigerator, can reduce power plant emissions because less power is being generated. In this case, the lower emissions would create benefits to the environment and therefore society as a whole.

Future benefits and costs can be put into today's dollars by doing what is called a present value analysis. Generally speaking, the lower the net present value (PV) of a project the more attractive the economics. For instance, if Project 1 has a PV of $10 million and Project 2 has a PV of -$20 million (negative $20 million) then Project 2 would generally be considered a lower cost plan than Project 1 because its present value is lower than Project 1.

2.4. Transmission System Design Criteria

Transmission's potential impact on the overall reliability of the power system is much larger than the 5 to 10 percent impact on a customer's bill might suggest. If the transmission system fails, then large regions of the power system can experience a blackout. Due to this, among other reasons, the transmission system is planned, designed, and operated to the highest standards of reliability. Achieving this high standard of design requires the system to have many redundant features and excess capacity so that there is flexibility to reroute power when equipment failures occur or when a lightning strike or storm causes a problem on the system.

The voltage level at which a transmission system is designed to operate will also greatly impact the amount of electricity that can flow over the transmission line. The higher the voltage, the more power the transmission system is capable of transmitting. For example, a 69 kV line might be capable of carrying 100 MW of electricity, but a 345 kV line might carry over 1,000 MW of electricity.

In the water industry there is a similar concept. The higher the pressure (the equivalent of voltage) the more water will flow in a given pipe. But there are consequences to higher pressures. In the water business, the higher the pressure the thicker the pipe needed to withstand the pressure. In the electric business, the higher the voltage, the taller the structures tend to be, and the greater the need for insulation in electrical equipment. All of the upgrades in height, spacing, and protection have costs associated with them. Transmission designers need to carefully balance the added costs of higher voltage with the benefits of being able to carry more power. Similarly, the costs of maintaining redundant systems, loops capable of receiving power from two sources, and other means for engineering excess capacity into the transmission system must be analyzed for the benefits these additional investments create.

Utility planners and operators commonly examine two types of scenarios when planning and managing the transmission system. The first scenario is known as "N-0" (N minus zero) where the transmission system must be capable of serving the electric demands under normal operating conditions. Of course there is no such thing as a perfect system. Electric systems contain thousands of pieces of critical equipment, such as transformers, that will occasionally fail. A transmission line can get hit by lightening, or wires (also called conductors) can break in an ice storm. To provide another layer of protection, utility planners will look at adding redundancy where physically and economically practical to cover what are called "single contingency situations" like the ones just mentioned. The general philosophy is that where practical, no single piece of equipment failure on the power plant and transmission system will cause a large number of customers to lose power. These so-called single contingency scenarios are known as "N-1" (N minus one).

By using these scenarios to plan and design a transmission system, it is extremely rare that a customer loses power because of a problem in the power plant and transmission system. Most customer outages are caused by a local problem on the distribution system.

3. The Existing Southern Vermont Power System

The focus of this report is the 66-mile sub-transmission line that runs from Brattleboro to Bennington that is called the "Southern Loop". The Loop is owned and operated by the local utility, CVPS, but does also serve to provide electricity to another utility, Vermont Electric Co-operative (VEC) that serves several small communities in south-central Vermont including parts of Jamaica, Newfane, Townshend, Windham, Wardsboro, and Londonderry.

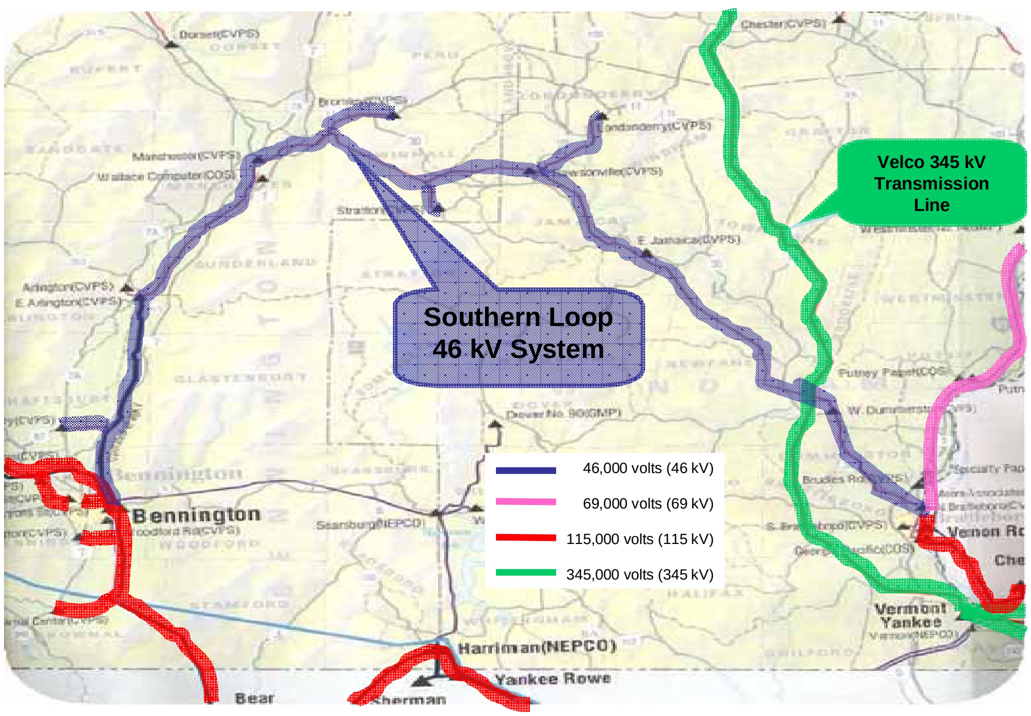
CVPS was organized on August 20, 1929, by the consolidation of eight electric companies including those serving Bradford, Claremont (NH), Middlebury, Rutland and Windsor. The small local utilities that served Bennington, Brattleboro, and the rest of what is now the Southern Loop, were brought into CVPS in subsequent years. Back in those days electricity was mainly used to run basic necessities like lights. Much of Vermont's early industrial base such as machine tool manufacturers, lumber and wood products relied on water power to run its equipment. Subsequently, many of these small mill dams were converted to producing electricity/hydro power. Vermont's industry and economy changed as electricity became more available in the region. For instance, electricity made milking machines and bulk-tank refrigeration possible which expanded the dairy business.

During the 1960s and 1970s, growth in the region and the expansion of its resort industry led to a rapidly growing electric demand. This growth occurred in residential and commercial developments as well as facilities owned by the ski resorts such as ski lifts, snowmaking machines, and condominiums. Supporting the ski industry were other facilities in need of electricity like ski shops, hotels, restaurants, vacation homes, and the homes of people working in the resort industry.

As the area gradually became more dependent upon electrical utilities for a reliable source of power, a transmission system was developed to link it to larger, more distant power plants. The Southern Loop was conceived, designed and constructed from 1943 through 1973, to serve the communities along its path. The construction of the Loop pre-dated the envisioning and development of the ski resort, tourist, and second home industry that constitutes a major share of the load that currently exists along the Loop.

The Loop consists of two primary sections, the main 46 kV line that runs from Bennington to Brattleboro, and a 69 kV spur line that runs from south of Brattleboro up to the major industrial areas north and south of town, as well as parts of Brattleboro itself. The ends of the Southern Loop are connections to 115 kV transmission lines, with major transformation/switching substations, to reduce the voltage from the higher voltage to the lower. These connection points are where electricity is imported from power plants, such as the relatively local Vermont Yankee plant in Vernon, or the distant power plants in New York and Massachusetts. Figure 3-1 shows the major transmission facilities in southern Vermont.

Figure 3-1. Southern Vermont's major transmission facilities.



The Southern Loop provides electricity to more than 40,000 customers in 30 towns; of which 35,000 are residential households, 5,000 are commercial locations, 60 are industrial sites, and 14 are ski-related businesses such as ski resorts. Most of these customers are served by CVPS, although some are served by Vermont Electric Cooperative.

To serve these 40,000 customers, the power system must be capable of delivering at least 120 mega-watts (120 MW) of electricity at peak times (for example, on a cold winter day). Residential customers represent about 46 MW of this peak demand, commercial 38 MW, industrial 20 MW, and ski-resorts about 16 MW. This 120 MW of demand includes approximately 25 MW each in the Bennington and Brattleboro areas and 70 MW distributed along the 46 kV portion of the Southern Loop itself. On a typical peak demand day about 50 MW of power is imported from the 115 kV connection at the west end (Bennington) and 70 MW from the eastern connection in Brattleboro.

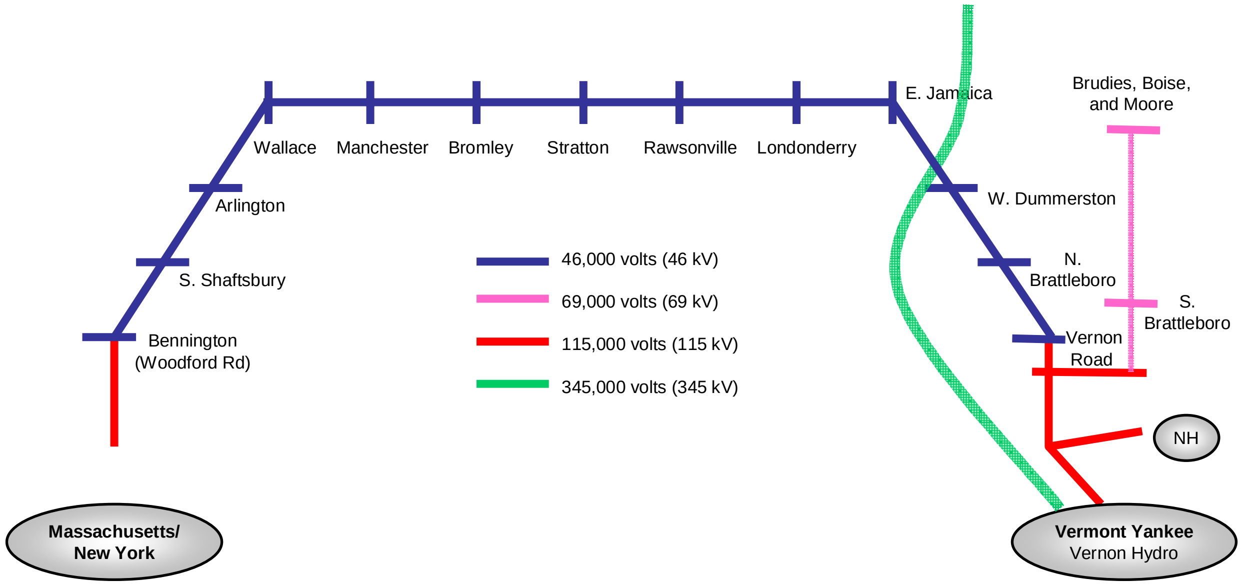
Figure 3-2. Southern Vermont CVPS customer characteristics.

	# of Customers	%	Annual Energy Use (MWh)	%	Peak Demand (MW)	%
Residential	34,681	87%	222,546	39%	46	38%
Commercial	5,207	13%	197,959	34%	38	32%
Industrial	58	0%	135,119	23%	20	17%
Ski	14	0%	20,372	4%	16	13%
Total	39,960		575,996	MWh	120	MW

In the last 20 years, the peak electric demand in the southern Vermont area has grown from 80 MW to today's 120 MW, which represents an average growth rate of about 2 MW per year. In recent years, the peak electric demand in the 46 kV Southern Loop has only grown at an average rate of 0.5 percent per year because of successful and aggressive efforts to curb peak electric demand growth in the region. Much of the recent electric growth on the Southern Loop has occurred near the middle of the 46 kV sub-transmission line, in the Stratton and Bromley area, which is the weakest part of the system. Some growth has also occurred in the nearby communities of Manchester and Dummerston. A significant portion of new electric usage on the Southern Loop has been devoted to new electric-intensive appliances.

Figure 3-3 illustrates the southern Vermont transmission system in graphical way. The red lines show the 115 kV transmission connections with the 46 kV Southern Loop sub-transmission system, which is shown in blue. These 115 kV connections are critically important because they are the connections from electric supply sources into the Southern Loop area. In other words they are the big electric plugs for the power that is delivered to Southern Vermont. Distribution substations, used to reduce the voltage and to provide power to local communities, are represented by short blue lines crossing the Southern Loop.

Figure 3-3. Southern Vermont's major power lines.



The only power plant of significant size in southern Vermont is the Vermont Yankee nuclear plant. There is a scarcity of other local generation resource because there are no significant water sources for hydro plants, as in other parts of Vermont. Moreover, there is no natural gas distribution system in place and there are stringent environmental laws which have historically made diesel or oil burning generators only economic for special purposes such as backup generation. There have been some initiatives involving wind power, but these are still in the early stages of development.

4. Southern Vermont Reliability Concerns

The need for reliable electric service is important for both households and the businesses of southern Vermont. Some people have life-sustaining machines in their residences that run on electricity and most heating systems will not operate without electricity. If the power is out for more than a few hours, food can begin to spoil and those who depend on well water may begin getting uncomfortable. Safety is a concern when electric street lights, traffic signals, and emergency systems lose power. Electricity is also important to the overall economy of southern Vermont, which is quite diverse. There is a large variety of commercial locations that depend on electricity including hospitals, retail stores, schools, colleges, grocery stores, restaurants, and lodging facilities. The industries in the area are electric intensive and include the Stratton and Bromley ski resorts as well as lumber, plastics, concrete, electronic circuits, and rubber-related businesses.

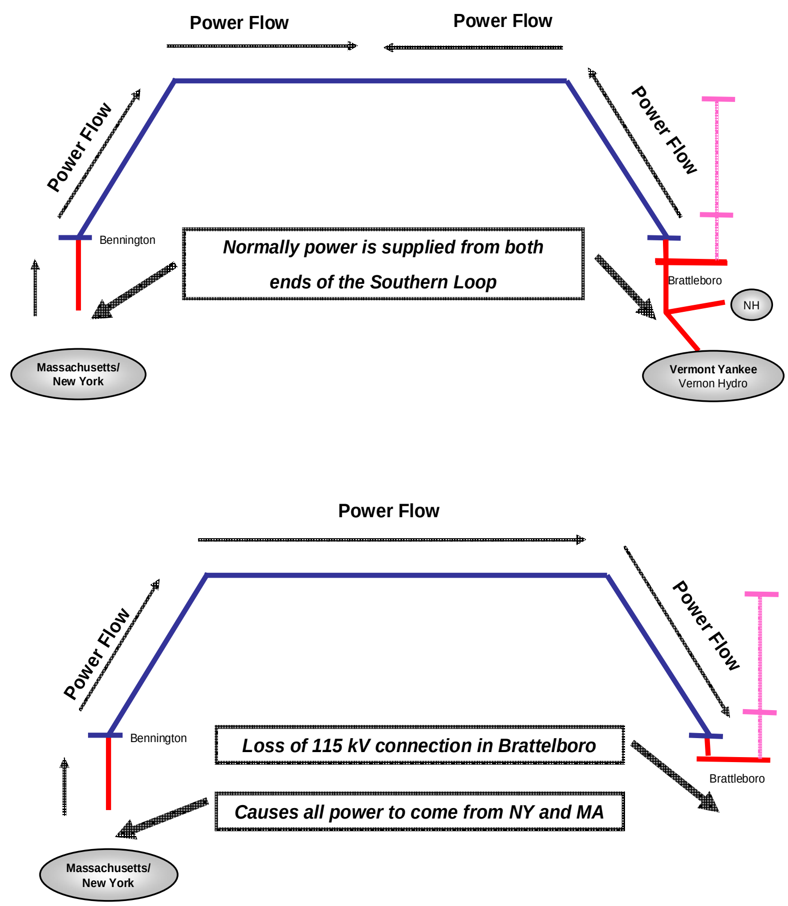
As the electric demand in southern Vermont has grown, the ability for the Southern Loop to deliver power to all customers in all hours of the year has increasingly become compromised. The system is coming close to exceeding its capacity to deliver power during times of peak demand, even under normal operating conditions (N-0) where both the Bennington and Brattleboro connections are in place. In 60 percent of the hours in the year there is no longer sufficient redundancy to adequately cope with a single contingency (N-1) such as the loss of the Brattleboro connection.

The first major concern is that CVPS computer models indicate that if the peak demand on the 46 kV system grows by just 3 to 5 MW, the physical capacity of the Southern Loop will be exceeded. There would simply be too much power being drawn through the system for proper voltage levels to be maintained under normal operation conditions (N-0). 3 MW is about the peak demand of a major hospital. If the area electric demand continues to grow at about 0.5 percent per year and allowing for year-to-year fluctuations due to weather or other random events, it is likely 3 to 5 MW of new demand will be added to the system sometime within the next 3 to 10 years.

The second concern is that in about 60 percent of the hours in a year, the Loop must be connected at both ends to provide electricity of acceptable quality to all customers. Lose the connection at or near either end of the Loop and some or all customers will be without power.

One of the worst failures on the 46 kV loop itself would be to lose the connection at one of its two ends, which leaves most of the electric demand being fed by a long, single, 46 kV electric line. Another worst case scenario would be losing the 115 kV connection to New Hampshire, which would also cause the loss of connection to Vermont Yankee. Under this scenario, the system would be very weak because the 69 kV line feeding part of Brattleboro would then need to be supplied from the 46 kV loop, rather than the 115 kV connection from New Hampshire.

Figure 4-1. Southern Loop power flows under normal conditions and after the loss of the Brattleboro connection.



Long single electric lines tend to have more voltage problems than short lines because the voltage gradually drops along the length of the line, like the drop in water pressure in a long hose. However, because much of the Southern Loop load is concentrated in the center, line failures occurring anywhere along its length may cause unacceptably low voltages since line failures generally lead to a long single power-line supporting all the demand in the region. Simply said, the existing Southern Loop electric "hose" is not big enough to handle all the power that wants to flow through the hose when a connection on either end of the system is lost either for routine maintenance or due to an equipment failure.

In Brattleboro, the Vernon Road Substation is supplied by a lone 115 kV line from Chestnut Substation in New Hampshire. Vernon Road's dependence on this single line means that its loss causes unacceptably low voltage in southern Vermont, including the Southern Loop, even when total electric demand in the area is as low as 55 MW. The electric demand on the southern Vermont area is at least 55 MW in more than two-thirds of the hours in a year, meaning that the Southern Loop is exposed to a possible blackout from this one line failure.

Another concern is that all these constraints on the Southern Vermont system are limiting CVPS's ability to perform maintenance on the system, causing additional reliability concerns. Windows of opportunity to perform maintenance on critical lines, transformers, and other equipment have diminished to the point where CVPS can only remove certain equipment from service during time of low electric usage (typically Spring and Fall), and even then only on weekends. This type of event occurred on September 27, 2005 when power was lost to all 40,000 customers on the Loop after a piece of electric equipment failed in Woodford Road substation in Bennington, disconnecting the Loop from New York and Massachusetts. Because of scheduled maintenance in the Brattleboro area, the Vernon end of the 46 kV Loop was also disconnected at the time of the equipment failure in Bennington. With the loss of the Bennington connection the system had no power source, resulting in a blackout. Although this event occurred while maintenance was being performed, had the same equipment failure occurred during a peak electric demand day in the middle of winter or summer, even with the Brattleboro connection in place (no maintenance being performed), the result would have been the same.

There are many other scenarios where the reliability of the Southern Loop is compromised and a more detailed document describing those scenarios is available from CVPS in its "Supplemental Technical Report".

5. Possible Solutions

As early as the 1980s CVPS became concerned that the 46 kV Southern Loop was reaching its limits to serve all the electric needs on the system. CVPS felt that some form of action was needed 20 years ago to avoid the possibility of low voltages and power outages if either connection at the ends of the Loop was lost during times of high electric demand. In 1983, CVPS filed an application with state regulators to build a new 46 kV line from Chester to Londonderry that would reinforce the middle of the Southern Loop by providing a third option for injecting power. After a thorough hearing process, the Vermont Public Service Board (PSB) denied that request in favor of CVPS pursuing alternatives to the construction of a new sub-transmission line.

Those alternatives included adding new equipment to the Southern Loop to improve its ability to handle more electric demand and an aggressive effort to lower the electric demand through DSM. Capacitors, devices that help raise the voltage on a power system, were added at strategic locations to help keep the voltage on the Southern Loop within acceptable limits. A second transformer was also added at Woodford Road Substation (near Bennington) to share the electric demand with another transformer at that same substation. These transformers are used to convert 115 kV transmission voltage to the 46 kV voltage required by the existing Southern Loop system.

The DSM efforts have taken many forms over the years. Some of the programs involve pricing electricity more expensively during on-peak periods and less expensively during off-peak periods. This encourages customers to use electricity when it is least expensive and has the effect of lowering electric demands during the on-peak times. Other efforts included converting many electric water and space heaters to propane or oil, and improving the insulation in homes. Ski resorts and other industrial customers also agreed to allow CVPS to interrupt their electric service during high-peak situations. Today, many of the DSM measures in Vermont are now conceived, delivered, and administered by a company separate from CVPS known as *Efficiency Vermont*. *Efficiency Vermont* is funded by a charge on customer bills and is the energy efficiency utility that operates under contract to the Vermont Public Service Board to promote the efficient use of electricity.

The capacitor and DSM strategies have proven to be effective over the past 20 years for deferring the need for major investments in new transmission and avoiding blackouts in the region. These strategies, however, are reaching their practical limits. CVPS and VELCO believe that in order for them to fulfill their responsibility to deliver reliable electric power, new investment is now needed to ensure a safe and reliable power system. This investment could take the form of new transmission, generation, other voltage support investments, or efforts to control peak electric demands and energy conservation, or a combination of all of these.

There are many potential solutions for addressing the reliability concerns in the Southern Loop. Coming up with the preferred solutions involves a careful balancing of several issues including cost, reliability, the concerns of the public and customers, and the potential impacts of a recommended solution on the environment and society. The following discussion provides a general overview of the main options under review. More details are available from CVPS in a more comprehensive report on these technical issues should you need further information. Please request the CVPS "Supplemental Technical Report" by contacting Steve Costello at (802) 747-5427 or scostel@cvps.com if you are interested in this report.

Generally speaking, potential solutions for the Southern Loop tend to fall into one or more of the four categories:

- ***Voltage support devices*** such as capacitors and synchronous condensers. These devices are used to adjust voltage to acceptable levels.
- ***Reduce the electric demand and usage***, also referred to as demand side management (DSM).
- ***New Electric Generators*** that involve constructing either a relatively large power plant or dispersing smaller power plants along the Southern Loop.
- ***New Transmission*** to add one or more new lines or substations to the existing transmission system.

We will discuss the possible solutions in more detail and then summarize by comparing and contrasting some of the best potential combinations for solving the reliability problem.

5.1. Voltage Support Devices – Synchronous Condenser

CVPS studies indicate that continuing to add more, relatively inexpensive, capacitors to solve the voltage problems on the Southern Loop is no longer a practical option. Too many capacitors on a power system create unmanageable operational problems and can actually increase the probability of a blackout when there is a major event like the loss of the 115 kV connection near Brattleboro. Capacitors work well when conditions are normal, but because of certain performance characteristics, they can actually worsen the voltage situation when sudden changes in a power system occur, such as the loss of the Brattleboro connection. Under these quickly changing conditions, they can even create excessively high or low voltages, which could cause equipment failures, worsening the situation.

A synchronous condenser is a much more expensive and versatile form of the inexpensive capacitor. One part of a solution could be for CVPS to make a $10 million investment to install a synchronous condenser near Stratton. Based on the engineering and financial analysis performed to date, it appears that the first step in many potential solutions to improve reliability on the Southern Loop may include the installation of the synchronous condenser at Stratton. Installing a synchronous condenser would not preclude any of the other options. In fact, the condenser makes certain alternatives to new transmission more viable because it would expand the functionality of the existing transmission system. This gives more flexibility to implementing other solutions such as DSM or new generation.

If chosen as part of the solution and should CVPS receive approval for the investment, a synchronous condenser could be installed within the next one to two years to immediately increase the operating flexibility of the Southern Loop. It would be located in a facility that would look like a new substation and would not have air emissions or high noise levels where it is located.

<u>Synchronous Condenser Quick Facts</u>

Cost:	Approximately $10 million in capital
Benefits:	Could be installed within 2 years, providing some immediate relief
Negatives:	Only part of the solution
Location:	Stratton area, in a facility that would look like a new substation.

CVPS has not made a formal decision to pursue an investment in the synchronous condenser. However, the synchronous condenser has the best benefit to cost ratio of any single solution component and is compatible with most of the solution alternatives examined to date. Accordingly, CVPS will seek public input as to whether this initial step is reasonable to take in the near term. Even with this device, however, the need for additional investment in other options would remain because the condenser would solve only some of the reliability problems on the system.

5.2. Reducing Demand

The existing demand side management (DSM) programs in the Southern Loop area have been very effective, resulting in a very slow electric growth rate of only 0.5 percent per year in the past 5 years, which is about half the electric growth rate experienced by the entire state of Vermont. As already discussed, even at this low growth rate, the delivery capacity of the power system will likely be exceeded within the next few years, and the ability to manage major problems will continue to decrease.

DSM programs generally fall into the following categories:

1. ***Efficiency*** measures such as replacing standard light bulbs with high-efficiency light bulbs, or adding extra insulation to buildings.
2. ***Utility rates and contracts*** that encourage customers to conserve energy and/or to move their electrical use to those hours when overall electrical demand tends to be lower. Examples include charging a customer a higher electric rate during on-peak hours and a less expensive rate in off-peak hours to encourage the customer to use appliances during off-peak rather than on-peak times, with the prospect of lowering overall costs.
3. ***Control devices*** that disable non-essential customer appliances such as electric hot water heaters during high-demand hours. Devices can also adjust thermostats by a few degrees for a short time, with little inconvenience to a customer, but significant value to the system.
4. ***Fuel switching*** to replace electricity-powered heating, cooking, and drying equipment with fuel-powered equipment, such as replacing electric water heaters with gas heaters.

5. ***Other*** methods for reducing demand that may not get classified as DSM include raising appliance and equipment efficiency standards and improving building codes.

Not only have the DSM programs been effective in curbing peak demands in the Southern Loop, but they have moved much of the electric demand into the “off-peak” times of the day as well. As a result, the Southern Loop system is actually an extremely efficient system by electric industry standards. One measure of the overall system efficiency which many industries use is to calculate a capacity factor (also known as load factor or demand factor). In the airline business, for example, if a plane having 100 seats has, on average, 60 passengers flying on it, that plane would be said to have a 60 percent capacity factor. A 100 percent capacity factor would mean the plane flies completely full on every flight.

In the electric business we have a similar concept. The 46 kV portion of the Southern Loop has a peak demand of about 70 MW on a cold winter day. On the same day its lowest electric demand is about 45 MW and the average demand across all hours in the day is 60 MW. If we think of our electric “plane” as having 70 seats available to fill, on average our Southern Loop plane has 60 of those seats filled on a cold winter day, which is a capacity factor of about 86 percent (60 divided by 70 is 0.86, or 86 percent). So CVPS’s electric “plane” on the Southern Loop is nearly full during most hours on a cold winter day when the electric demand is at its peak.

Figure 5-1 shows how the electric demand changes on the 46 kV Southern Loop throughout a cold winter day. Continuing with the airplane analogy, each shaded block in the drawing represents an occupied “seat” and there are seven rows of seats. Notice that to reduce our maximum electric demand from 70 to 60 MW (to eliminate the 7th row at the top of the graph), the 10 red seats must be moved to the hours of midnight to 5 a.m. Unfortunately, there are only 9 unoccupied “seats” in rows 5 and 6 available in those hours (the unshaded squares on the 50 MW and 60 MW lines)

As Figure 5-2 shows, even if all of our 10 seats were willing to move to other hours, there is not enough space available in those other hours to accommodate all of the passengers who want to fly on this 46 kV “plane” on a cold winter day. In other words, no matter how much we attempt to shift the electric demand further to off-peak hours, we are not likely to reduce the Southern Loop peak demand of 70 MW.

Figure 5-1. Typical hourly electric demand (gray and red) on the 46kv portion of the Southern Loop during a cold winter day.

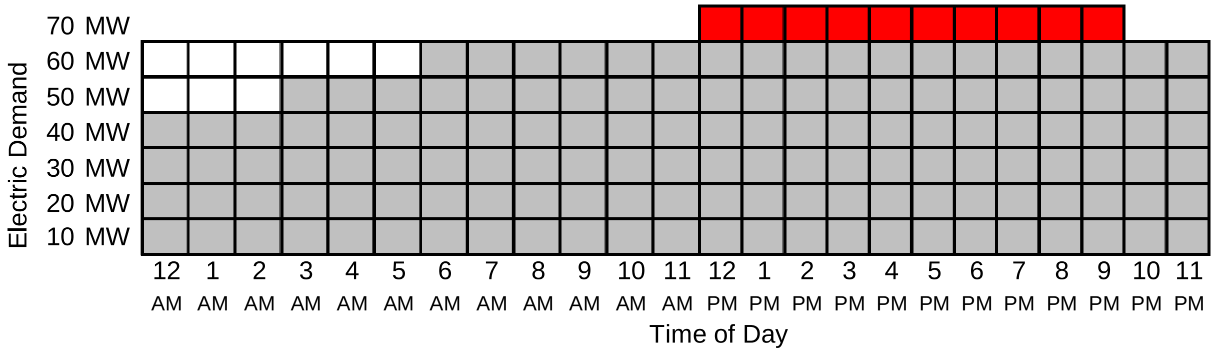
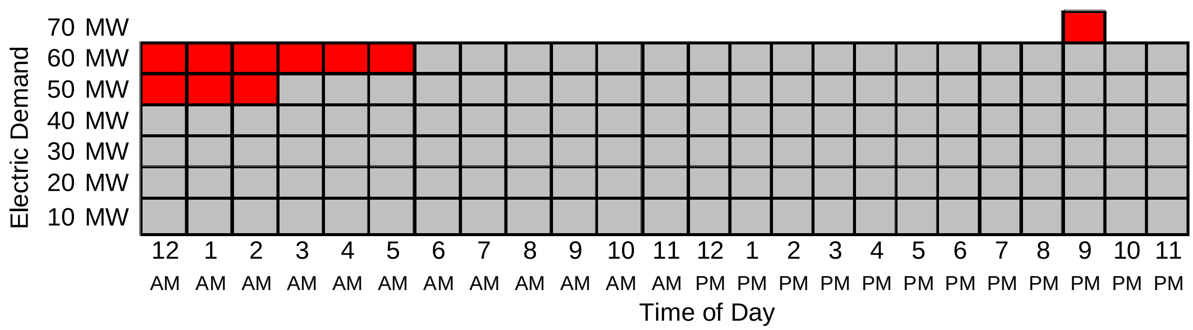


Figure 5-2. Even if we could move much of the electric demand from on-peak (noon to 9:00 PM) to off-peak times (midnight to 5:00 AM), the peak demand would still be around 70 MW during the day.



CVPS continues to explore additional types of DSM programs that will slow future growth in demand, as well as energy efficiency measures that may lower energy usage and demand. Accordingly, CVPS is considering how DSM can be cost-effectively developed as part of the resolution of the Southern Loop's problems. A preliminary screening of the Southern Vermont area shows a potential for approximately 26 MW of DSM along the Southern Loop. Approximately 19 MW of DSM implemented over the next 10 years at a

DSM Quick Facts

Cost: Approximately $78 million to implement 26 MW of demand reduction, but these costs would likely be more than offset by other operational cost savings.

Benefits: Eliminates some power generation costs because electricity demand is lowered, which is expected to offset all, and possibly more, than the cost to implement this program.

Negatives: Actual costs and amount of demand reduction are uncertain.
DSM alone is unlikely to fully address Southern Loop's reliability concerns.
CVPS customers will be responsible for all costs because DSM costs are not shared across New England like regional transmission projects

cost of roughly $57 million would be useful in increasing reliability when combined with other solutions such as distributed generation and transmission investments. The reason that 19 MW is useful in these situations, rather than 26 MW, is because if new transmission is built in the Brattleboro area there would be no additional reliability value associated with reducing demand in that area.

While the implementation cost for DSM is high, much if not all of that cost may be offset over the next 20 years by other operational cost savings and other societal benefits associated with using less electricity. Since societal benefits are external to the utility, a utility's rates may actually go up as a result of DSM initiatives but customers may benefit by lower total bills (because they use less electricity) and they may receive other benefits such as an improved environment, the monetary value which does not show up in a utility rate or bill. As a result, when developing an investment plan, utility planners consider these internal and external factors as well as other factors including, but not limited to, resource availability, financial constraints, and financial effects on the utility and its customers.

Assuming the demand could be lowered by 19 MW, this level of demand reduction is not sufficient by itself to remedy the Southern Loop problem, but could significantly contribute to certain other solution combinations. A risk factor to consider when examining DSM is that the actual results may vary from what models predict. For instance a $57 million program could result in less than 19 MW of demand savings.

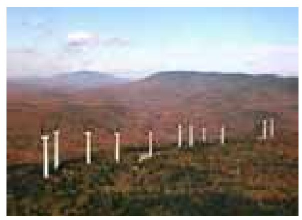
5.3. New Generation

Another way to address the Southern Loop reliability concerns would be to locate new electric generators along the system. New electric generators can reduce the amount of electricity flowing on the transmission system because if they are properly placed nearby or within our communities, rather than in distant places, the electric demand would then be served in part by this local generation resource. These electric generators are typically much smaller than their bigger cousins like nuclear plants. A typical size for these generators would be in the range of 1 to 100 MW. A nuclear plant, by comparison would be 500 to 1000 MW.

There can be a price to pay, however, for these smaller generators. They can be less efficient and therefore cost more to operate than their larger cousins. Many of the technologies run on diesel fuel or oil, which limits the number of hours in a year they can operate because of emission restrictions. In fact, one of the contributions to the growth in electric demand over the past 20 years has been the conversion of snowmaking air compressors from diesel to electric, a conversion required by the State of Vermont for air quality purposes. Other technologies, such as natural gas turbines, can be fairly efficient and clean, but unfortunately there are no natural gas pipelines in southern Vermont. And in certain areas, wood-fired and wind generators can be used to provide local generation.

Figure 5-3. Examples of local generation.

Burlington, VT
Wood Plant
McNeil Station
Credit: Electric Dept.



Searsburg, VT
Wind Plant
Credit: Green Mtn. Power

0.8 MW reciprocating engine
Credit: DOE

In southern Vermont, the type of electric generators used along the Southern Loop would likely be limited to diesel- or oil-fired type technologies and facilities that can utilize both a source of heat and power which are known as "combined heat and power". Biomass generation may have potential, although CVPS has not yet identified a sufficiently sized source of local biomaterial such as woodchips, trash, or livestock waste to solve the Southern Loop problem. Other potential fuel sources in the area either do not exist today, such as natural gas, or are already fully developed, such as hydro dams. Although under investigation, preliminary data available on the wind resource in southern Vermont indicates that the wind does not blow consistently enough during times of high electric demand to be considered an option for addressing the reliability issues in the area.

CVPS engineering models indicate that 80 MW of generation would be needed right now and an additional 25 MW of new electric generation would be required to be locally sited over 10 years along the Southern Loop at a capital cost that is likely to exceed $100 million to fully address the reliability concerns. The new generation would need to be spread across the Southern Loop as follows: 31 MW at Stratton, 9 MW at Bromley, 18 MW at Brattleboro, 21 MW of distributed generation on the 46 kV Loop west of Stratton, and 26 MW of distributed generation on the 46 kV Loop east of Stratton.

Solely relying on generation to solve the Southern Loop concerns would be extremely expensive because there are substantial costs beyond just the upfront capital costs to operate generators, for example fuel costs. A more pragmatic and cost-effective approach would likely be to combine new generation with other efforts such as demand management (DSM), new voltage support devices (synchronous condenser), and/or new transmission. In these combination solutions, 21 to 38 MW of new generation would be required to create a beneficial impact. One possibility for consideration, not involving the construction of new transmission lines, is to install the synchronous condenser in combination with 38 MW of new generation and 26 MW of DSM. The total implementation cost for this "DG, DSM, S" solution would likely exceed $130 million, but this cost is expected to be more than offset by operational cost savings and other societal benefits associated with the DSM programs. When these savings are accounted for, the present value (PV) for this option is -$51 million (negative $51 million).

"DG, DSM, S" Option Quick Facts

Cost:	$131 million in capital but -$51 million in present value (PV). The actual total cost may ultimately become higher than other options because this option does not improve the regional transmission system which may require additional investment to address.
Benefits:	May avoid or defer the need to construct new transmission.
Negatives:	Would likely add to air emissions to the region No PTF cost share from ISO-NE Does not improve the regional 115 kV and 345 kV transmission system, which may lead to substantial additional costs in the future as those concerns get addressed. DSM actual results uncertain Ability to get cost-effective 38 MW of new generation sited along the Loop is uncertain.
Location:	New generators would need to be spread throughout the Southern Loop with a large concentration in the Stratton, Bromley, and Brattleboro areas.

This solution does not, however, help with other regional concerns on the 345 kV and 115 kV transmission systems. When those regional concerns are separately addressed, the combined cost may be more expensive than other options that include the building of new transmission that help both the Southern Loop and other regional transmission issues.

5.4. Transmission

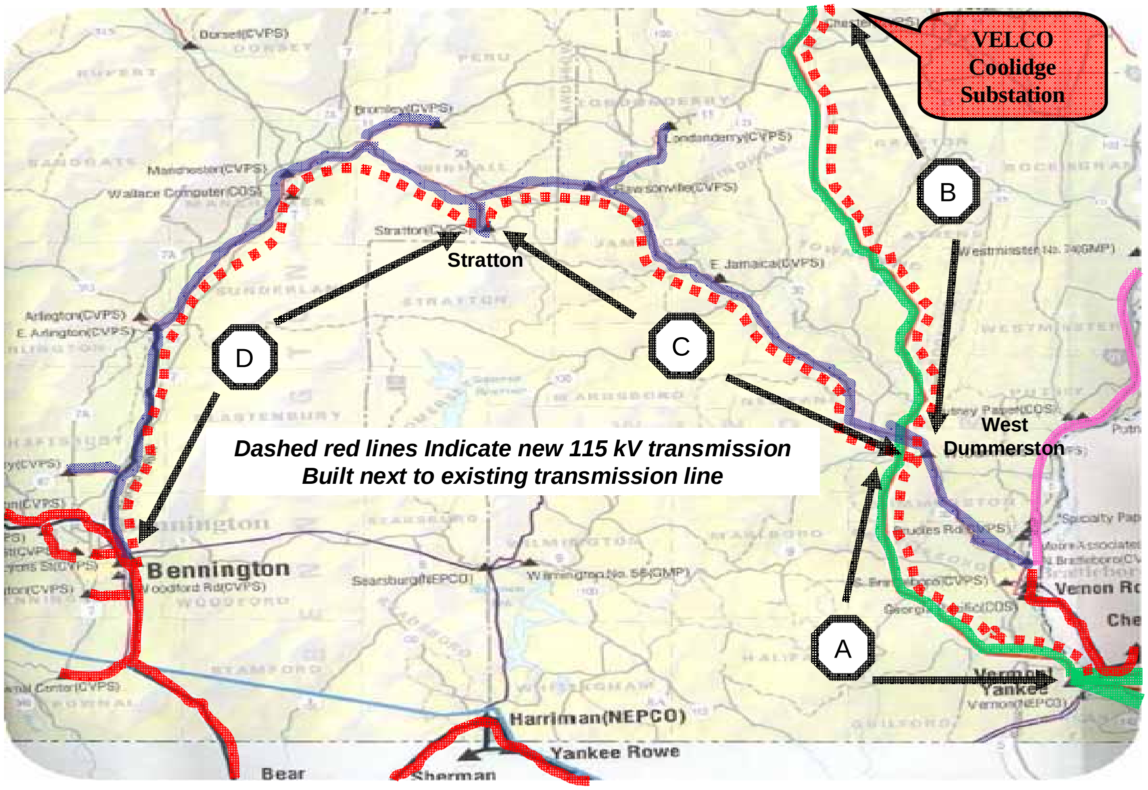
Building new transmission circuits to the Southern Loop is another way to solve the reliability problems in the area. CVPS and VELCO have identified many possible methods to bring new transmission into the area, but for illustration purposes three primary transmission solutions that would provide a comprehensive resolution to the Southern Loop reliability and capacity concerns are examined here. While the companies identified other possible solutions involving new transmission, these three examples will give a sense as to the range of viable transmission options. A more complete treatment of the topic is provided in the CVPS "Supplemental Technical Report" document that is available to you if you wish to explore this issue in greater detail.

5.4.1. Possible New Transmission Line Sections

Figure 5-4 illustrates three possible new transmission line sections that could be constructed in the Southern Loop area. These new transmission line sections could be combined in various ways to solve the Southern Loop reliability concerns.

Section "A" is a new 17-mile 115 kV transmission line that could be built alongside of the existing 345 kV transmission line running from Vermont Yankee to West Dummerston. Figure 5-5 provides a photo of a 115kV transmission line built alongside a 345 kV transmission line. Section "B" is a new 32-mile 115 kV transmission line that could be built alongside the existing 345 kV transmission line running from West Dummerston to the VELCO Coolidge substation located near Cavendish. Section "C" is a new 20-mile 115 kV transmission line that could be built alongside the existing 46 kV Southern Loop sub-transmission line running from West Dummerston to Stratton. Section "D" is a new 28-mile 115 kV transmission line that could be built alongside the existing 46 kV Southern Loop line running from Stratton to the Woodford Road substation located in Bennington.

Figure 5-4. Possible New Transmission Lines.



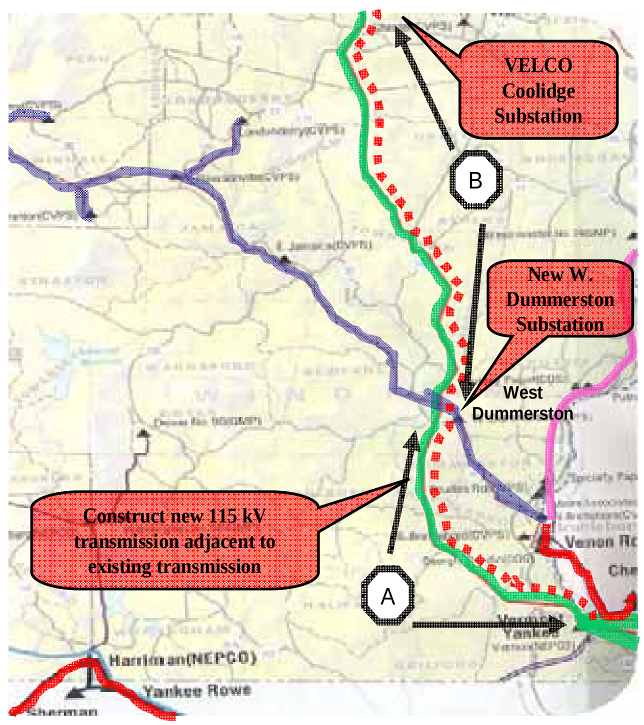
To create new connection points into the 46 kV system, new substations may need to be built in either West Dummerston or Stratton or both to convert from the new 115 kV transmission line to the 46 kV voltage of the Southern Loop. For example, if only the "A" segment were built, then a new substation at West Dummerston would have to be built to create a connection point with the 46 kV system. Likewise, if both sections A and C were constructed, a substation at Stratton and at West Dummerston would both have to be built in order to connect the new lines to the existing 46 kV system.

Figure 5-5. Example of a 345 kV and 115 kV transmission line located side-by-side. [Photo from VELCO]

5.4.2. The "A, B, DG, DSM, S" Option

One potential transmission solution is to build upon the previously mentioned DSM, DG, and synchronous condenser ("DSM, DG, S") option by adding a new point of connection into the 46 kV Southern Loop. This would be done by constructing new transmission sections A and B alongside the existing 345kV transmission line and adding a substation in West Dummerston as shown in Figure 5-6.

Figure 5-6. "A, B, DG, DSM, S" Option. New 115 kV transmission line connecting the VELCO Coolidge substation, the 115 kV system at Vermont Yankee, and a new substations at West Dummerston shown by dashed lines



One advantage of this option is that it improves the regional transmission system by adding a redundant path for power to flow through the area since this system parallels the 345 kV transmission line from Vermont Yankee to

Coolidge substation. The transmission related investments of sections A and B would therefore be subject to regional cost sharing (PTF funding). This solution also has the added benefit of providing the Southern Loop with two new connections to import power from – the 115 kV system near Vermont Yankee and Coolidge substation. Adding some new transmission in the area somewhat lessens the amount of DSM and DG when compared to the "DSM, DG, S" option. If transmission sections A and B were constructed, 19 MW of DSM and 25 MW of distributed generation would be required.

The "A, B, DG, DSM, S" Option Quick Facts

Cost: Approximately $162 million, of which $62 million would be funded by utilities outside of Vermont, leaving Vermonters to fund $100 million. Much of the implementation (capital) cost would be expected to be offset over the next 20 years by operational cost savings and other societal benefits associated with DSM. The project's PV is estimated at $50 million while Vermont's PV is -$2 million.

Benefits: $62 million in PTF contributions from utilities outside of Vermont is possible for transmission sections A and B.
Would be built next to existing transmission lines, minimizing impact to communities and environment.

Negatives: Would take years to complete
New generation would create air emissions
Actual demand reduction result from DSM is uncertain
Transmission requires annual maintenance

Location: New line extending from Brattleboro to West Dummerston.
New substation in West Dummerston.
Generation distributed across the Loop.

The total capital cost for implementing this option is expected to be around $162 million, but Vermonters would be expected to pay only about $100 million because $62 million of the project cost may be funded by utilities outside of Vermont since transmission segments A and B will provide benefits to the New England region. In addition, the savings and society benefits associated with DSM are expected to offset most of the project cost over the next 20 years. The net savings, however, are not as great as the "DG, DSM, S" option because most prominently, among other factors, there will be annual maintenance expenses associated with the new transmission line. The PV will be different for the project as a whole and Vermont itself because of the New England cost sharing. In this case, the total project PV is estimated to be $50 million while Vermont's PV is -$2 million.

5.4.3. The "A, B, C, S" Option

Another potentially effective transmission system solution would be to provide a new power source and points of connection into the 46 kV Southern Loop by constructing sections A, B, and C, the synchronous condenser (S), as well as new substations in West Dummerston and Stratton. As shown in Figure 5-7, if a 115 kV transmission line were built alongside the existing 345 kV line to VELCO's Coolidge Substation and also extended along the existing 46 kV transmission system running from West Dummerston to Stratton, the 46 kV Southern Loop system would now have four power sources for the region – the existing Bennington connection, the existing Brattleboro connection, the new West Dummerston connection and the new Stratton connection.

"A, B, C, S" Option Quick Facts

Cost: Approximately $107 million, of which $62 million would be funded by utilities outside of Vermont leaving Vermonters to fund $45 million. The project's PV is $147 million while Vermont's PV is $95 million.

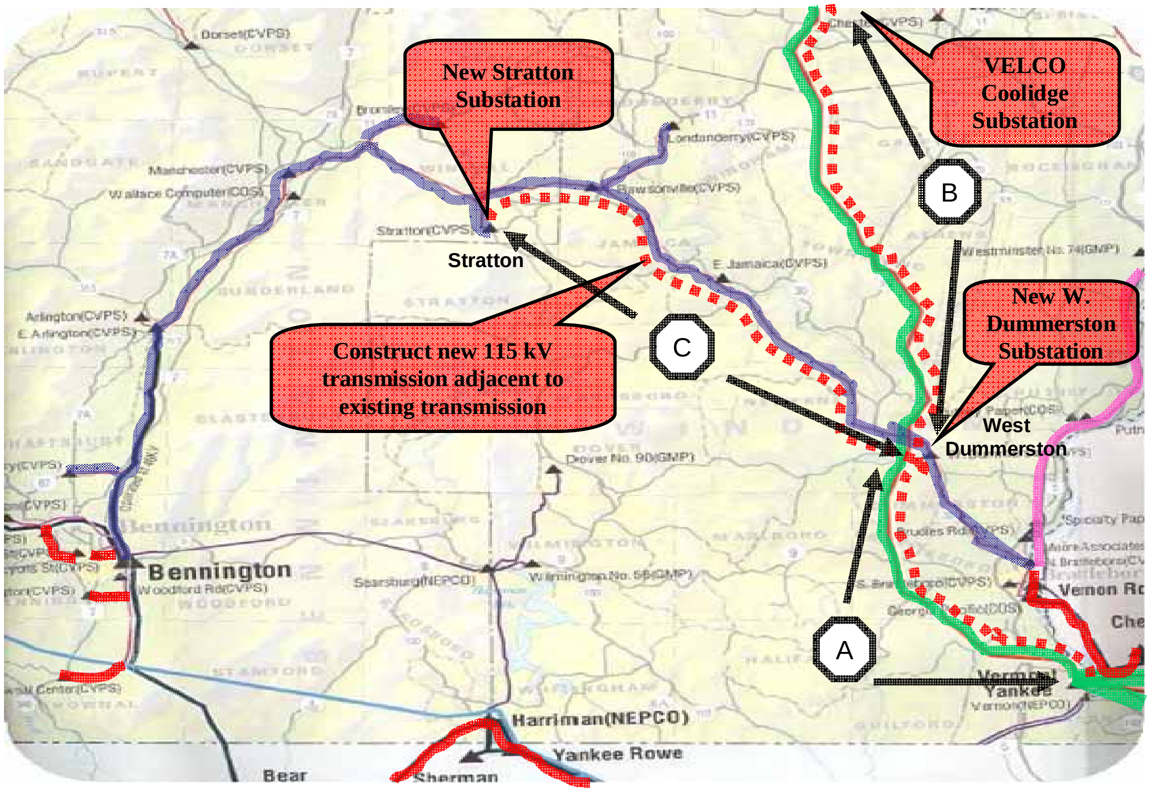
Benefits: $62 million of PTF cost share from non-Vermont utilities possible for transmission sections A and B.
Would be built next to existing transmission lines, minimizing impact to communities and environment.
Results more certain than options that include DSM and/or DG.

Negatives: Would take years to complete
There are annual maintenance costs associated with transmission and there are no appreciable savings as is the case with DSM related options.
One of the most expensive options on a PV basis.

Location: New line extending from Brattleboro to Stratton.
Line would also extend from W. Dummerston north to Cavendish.

To connect the new 115 kV transmission line to the 46 kV system, two new substations would need to be constructed, one in West Dummerston and another in Stratton. This transmission option would cost about $107 million including the cost of the synchronous condenser. The ISO-NE may determine that approximately $62 million of the project cost would be funded from utilities outside of Vermont because the construction of transmission sections A and B would provide benefits to other parts of Vermont and all of New England, not just CVPS customers, by strengthening the regional grid. There are annual maintenance costs associated with transmission and there are no appreciable savings as is the case with DSM related options. The project PV estimate is $147 million while Vermont's PV estimate is $95 million.

Figure 5-7. "A,B,C,S" Solution - New 115,000 volt transmission line connecting to a VELCO substation and new substations at Stratton and West Dummerston shown by dashed lines.



5.4.4. The "A, C, D, S" Option

Another possible transmission solution candidate is to connect Brattleboro to Bennington using a new 115 kV transmission line that would physically be placed right next to the existing 46 kV and 345 kV transmission lines as shown in Figure 5-8. New substations would have to be added at Stratton and West Dummerston to enable power to be injected at these points. Notice that with this solution if either connection on the ends of the Southern Loop is lost, there would be ways to reroute power into the middle points of the 46 kV Southern Loop system through the new substations at Stratton and West Dummerston. CVPS engineers estimate this design would cost $108 million to construct, including the $10 million for the synchronous condenser. The ISO NE may determine that approximately $73 million of the project cost would come from utilities outside Vermont because the construction of transmission sections A, C, and D would provide benefits to all of New England, not just CVPS customers. There are annual maintenance costs associated with transmission and there are no appreciable savings as is the case with DSM related options. The project's PV estimate is $147 million, while Vermont's PV estimate is $86 million.

The "A, C, D, S" Option Quick Facts

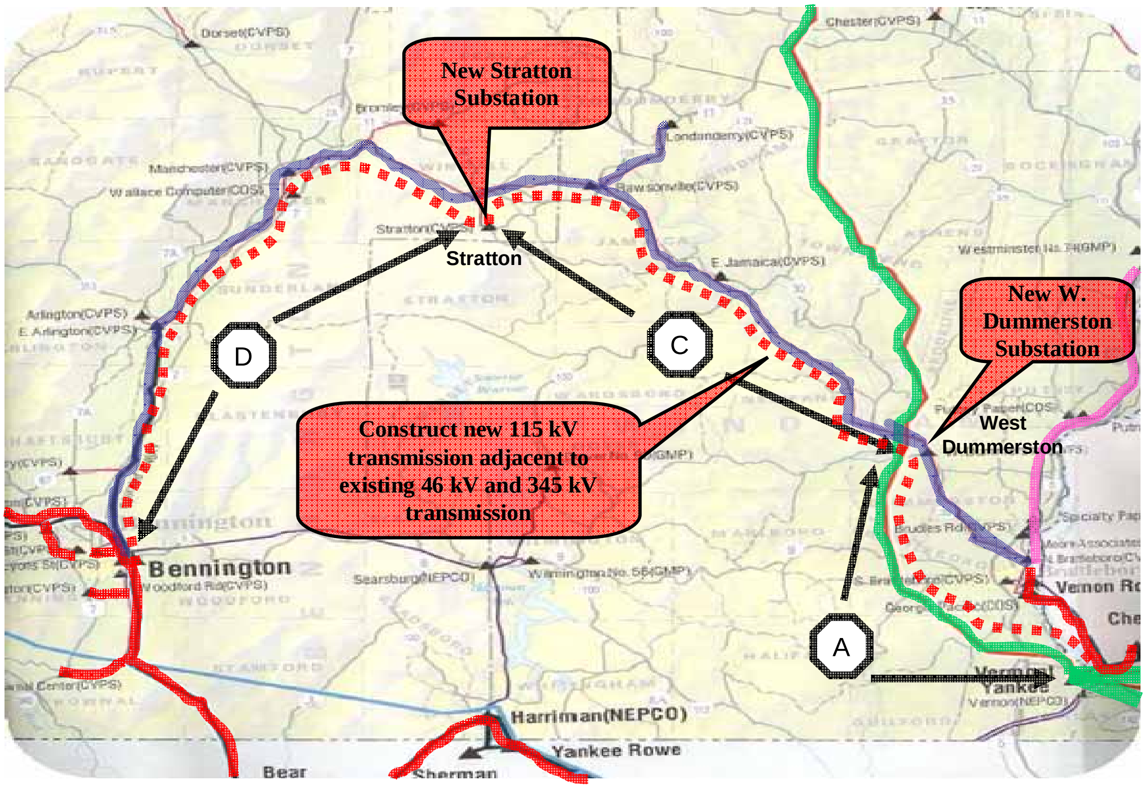
Cost: Approximately $108 million, of which $73 million would be funded by utilities outside of Vermont, leaving Vermonters to fund $35 million. The project's PV is $147 million and Vermont's PV is $86 million.

Benefits: $73 million of PTF cost share from non-Vermont utilities possible for transmission sections A, C, and D.
Would be built next to existing transmission lines, minimizing impact to communities and environment.
Results more certain than options that include DSM and/or DG.

Negatives: Would take years to complete
There are annual maintenance costs associated with transmission and there are no appreciable offsetting costs as is the case with DSM related options.
Regional benefits are fewer than with options that include lines A and B.
One of the most expensive options on a PV basis.

Location: New line extending from Brattleboro to Stratton to Bennington

Figure 5-8. New 115,000 volt transmission line and new substations West Dummerston and Stratton shown by dashed lines.



5.4.5. "A, T4, S, DSM, DG" - New Transformer at Vermont Yankee

One of the most difficult problems that can occur on the Southern Loop is the failure of a 33-year old transformer (called "T4") located at Vermont Yankee, which connects the 345 kV transmission to the 115 kV transmission system. The T4 is a large transformer located at the Vermont Yankee nuclear plant, that connects the 345 kV system to the local 115 kV transmission system, including a crucial transmission line (known as the "N-186" line) from New Hampshire. This transformer (owned and operated by Vermont Yankee's Entergy Corporation) is 33 years old, has no on-site backup, and there is no spare unit within a reasonable distance that has been specifically earmarked as a replacement in the event of a T4 failure.

The "A, T4, S, DSM, DG" Option Quick Facts

Cost:	Approximately $153 million, of which $29 million would be funded by utilities outside of Vermont, leaving Vermonters to fund $124 million. The project's PV is $37 million and Vermont's PV is $13 million.
Benefits:	Minimizes the amount of transmission that needs to be built. DSM savings and societal benefits would offset much, but not all of the implementation (capital costs).
Negatives:	Would take years to complete. One of the most expensive transmission options for upfront costs. New England cost sharing only on T4 portion of investment is possible.
Location:	New 115kV line extending from Vermont Yankee to West Dummerston.

If this transformer fails irreparably, it could take as much as a year to install a new transformer because transformers of this size are not kept in their builder's inventory, and are built only when needed. Loss of T4 weakens the 115 kV transmission system in Brattleboro which increases the potential for blackouts in the Brattleboro area during periods of high electric demand. An even greater concern is if another important electric component on Southern Loop or local 115 kV transmission system fails during the year-long replacement process. This second failure could lead to a widespread blackout, depending on the nature of the failure.

Nuclear Regulatory Commission rules would also force the shutdown of the Vermont Yankee plant if the T4 remained unavailable for more than 7 days. Although the shutdown would have little effect on system reliability, it would necessitate the purchase of replacement power by Vermont utilities, probably at much higher cost. Ultimately this increased cost would be born by Vermont's customers.

A potential solution is to add a redundant transformer at Vermont Yankee along with constructing a new 115 kV transmission line from Vermont Yankee to West Dummerston (the "A" section), installing a 115 kV to 46 kV substation at West Dummerston, adding the synchronous condenser, 19 MW of DSM and 25 MW of new generation. The benefit of this solution is it minimizes the amount of new transmission that needs to be built. One major drawback is it does not contribute much to solving other New England 115 kV and 345 kV regional transmission issues, which is why there is little New England PTF cost sharing under this scenario. The capital cost estimate for this project is $153 million. The project's PV estimate is $37 million and Vermont's PV estimate is $13 million.

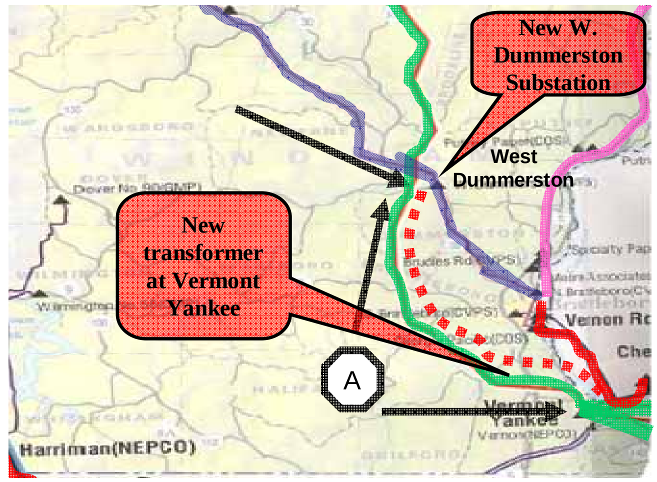


Figure 5-9. Add transformer to Vermont Yankee, build 115 kV transmission from VT Yankee to W. Dummerston.

5.5. *Summary of Possible Solutions*

Five possible solutions that fully address the Southern Loop reliability concerns have been identified and briefly discussed. The following table summarizes the options examined in this report. It is important to note that CVPS and VELCO continue to model and identify other possible solutions to the problem and through discussions with the public other solutions may be identified and analyzed.

Preliminary economic analysis suggest that a combination of distributed generation (DG), demand side management (DSM), and a synchronous condenser (S) would lead to what is called the least cost plan because there would be operational cost savings and societal benefits associated with DSM type investments that are expected to more than offset the implementation (capital) costs. There are, however, risks associated with this project. This option does not help address other 115 kV and 345 kV transmission concerns in the area which means when those broader regional issues are addressed separately the expected net savings may not materialize when compared to other options. Additionally, the cost to achieve 38 MW of new generation and 26 MW of DSM are uncertain and the ability to achieve this level of new resources is also uncertain.

To address some of these risks, the option of building a new transmission line adjacent to the existing 345 kV line running from Vermont Yankee to West Dummerston and then on to Cavendish (Coolidge Substation) was added for consideration. This option provides the added benefit of increasing the ability to transport power into the Southern Loop from an additional strong source at West Dummerston. This option also addresses broader regional 115 kV and 345 kV transmission system issues. Three other distinctly different options to solve the Southern Loop concerns are also provided, although preliminary economic analyses indicate that these options are somewhat more expensive than the other two. Many other solutions are being considered by CVPS and VELCO but they typically contain one or more elements of the 5 options examined in this report.

Possible Solution	**Description**	**Total Cost**	**Cost to Vermont customers**
DG, DSM, S	▪ Synchronous condenser installed at Stratton ▪ 38 MW of new generation ▪ 26 MW of DSM ▪ Substantial additional costs likely in the future because does not address 115 kV or 345 kV regional transmission issues	$131 million to implement, -$51 million present value. The actual total cost may ultimately become higher than other options because this option does not improve the regional transmission system which may require additional investment to address.	$131 million to implement, -$51 million present value. The actual total cost may ultimately become higher than other options because this option does not improve the regional transmission system which may require additional investment to address.

Possible Solution	Description	Total Cost	Cost to Vermont customers
A, B, DG, DSM, S	▪ New 115 kV transmission line connecting Vermont Yankee, VELCO's Coolidge substation, West Dummerston. ▪ Synchronous condenser installed at Stratton ▪ 25 MW of new generation ▪ 19 MW of DSM ▪ Addresses regional 115 kV/345 kV transmission issues so PTF funding (New England cost sharing) is available	$162 million to implement, $50 million present value.	$100 million because the cost of constructing transmission (A and B segments) would be shared with others in New England. The Vermont-only PV for this option is -$2 million.
A,B,C,S	▪ New 115 kV transmission line connecting Vermont Yankee, VELCO's Coolidge substation, West Dummerston, and Stratton. ▪ New substations at West Dummerston and Stratton ▪ Synchronous condenser installed at Stratton	$107 million to implement, $147 million present value.	$45 million to implement because the cost of constructing the A and B segments of transmission would be shared with others in New England. The Vermont-only PV for this option is $95 million.
A,C,D,S	▪ New 115kV transmission line connecting Vermont Yankee, West Dummerston, Stratton, and Woodford Road substation in Bennington. ▪ New substations at W. Dummerston and Stratton ▪ Synchronous condenser installed at Stratton	$108 million to implement, $147 million present value.	$35 million because the cost of constructing transmission (A, C, and D segments) would be shared with others in New England. The Vermont-only PV for this option is $86 million.
A, T4, S, DSM, DG	▪ New 115kV transmission line connecting Vermont Yankee to West Dummerston ▪ New substation at West Dummerston ▪ New transformer (T4) at Vermont Yankee ▪ 19 MW of DSM ▪ 25 MW of distributed generation	$153 million to implement. $37 million present value.	$123 million implement. The Vermont-only PV for this option is $13 million.

6. The Regulatory and Community Approval Process

It takes years to study, plan and receive the necessary approvals to construct any major new electric facility in the state of Vermont. The public process for solving the Southern Loop reliability concerns started in 2003. Once CVPS commits to a solution based on a public and technical assessment of various options, it will then likely take an additional year to get the necessary approvals to move forward with the project. The Vermont Public Service Board (PSB) will hold hearings on the matter after a petition is filed to issue a "certificate of public good". The overall solution to the Southern Loop concerns may be divided into two or more projects that are submitted separately for approval, one that solves both the near-term reliability and longer-term capacity limitations, or multiple projects that first solve the reliability problem and then the capacity issues.

The public process for addressing the Southern Loop reliability started in full swing in early 2003 after the Vermont Public Service Board (PSB) in docket 6290 approved an agreement by CVPS with other parties on how to proceed with the process. That agreement requires, among other things, the following:

- A complete distributed utility planning (DUP) study of potential solutions including new transmission and alternatives such as more demand response (DSM) and/or locating new generation facilities (known as "distributed generation") along the Southern Loop region.
- The formation of an "Area-Specific Collaborative" (ASC) to oversee the DUP study. The ASC members are the parties to the agreement including CVPS, the Vermont Department of Public Service (DPS) and other interested parties. The ASC is responsible for coordinating information, and the DUP analysis.
- The ASC is then required to select the preferred solution to address the Southern Loop reliability concerns.
- The PSB opened Docket 6805 to formally begin the DUP process. Under that Docket, the ASC is required to file quarterly progress reports with the PSB.

The ASC held numerous meetings over the past 2 years to examine the Southern Loop reliability issue. During the summer of 2005, it was decided by CVPS and VELCO to seek input from the public on the alternative solutions using a public outreach process administered by an independent company certified in public process management, the STAR Group.

Two teams of local residents, business leaders, government officials, utility employees, and public interest groups are engaged in this public process designed to provide recommendations on how to solve growing reliability issues on southern Vermont's electrical system. The first team is known as the "Leadership Team," which is chartered with overseeing and coordinating our public involvement. Reporting to the Leadership Team is the "Background Report Committee," which is chartered to oversee the development of this report for the public, to provide a fair and balanced look at the electricity reliability issues facing Southern Vermont. This report, which has been assembled by UtiliPoint International (www.utilipoint.com) at the request of STAR Group, is intended to be used in preparation for the Utility Search Conference™ scheduled for January 30-31, 2006. The format for that conference will be an intensive two-day discussion of local issues and the future of electricity supply in the region. The Leadership Team has selected over 50 people to represent various interests and to actively participate at the Utility Search Conference™.

The goal of the Utility Search Conference is for the community to examine, provide input on, and recommend potential solutions to the Problem Statement for consideration by CVPS and VELCO. In the months immediately following the conference, a Community Working Group (CWG) of approximately 20 people will be formed to further study and to work with CVPS and VELCO to refine the potential solutions. Ultimately, CVPS and VELCO have a legal responsibility to propose solutions they believe best meet the electrical system's needs. The results of this public process will serve as the foundation for the necessary regulatory filings that may be required of CVPS and/or VELCO in order to implement their proposed solution(s).

This public outreach process is an important part of a broader planning process. If the chosen solution or combination of solutions involves the construction of new transmission or generation facilities, a filing for issuance of "certificate of public good" will need to be made with PSB. If the solution involves the construction of 115 kV transmission lines, then it is likely CVPS and VELCO would need to also have the design of that project reviewed with the New England Independent System Operator (ISO-NE).

The process for obtaining a "certificate of public good" that allows a utility to move forward with a project is defined in Section 248 of Title 30 of Vermont Statutes Annotated. Section 248 requires a utility to take the following steps when seeking a certificate of public good:

- Develop a petition package explaining the need and justification for the project.
- The construction plans must be provided to municipal and regional planning commissions at least 45 days prior to filing at the Vermont Public Service Board (PSB).
- The municipal and regional planning commissions must provide its initial input to the utility and PSB at least 7 days prior to when the utility plans to file the petition with the PSB.
- The petition is then filed with the PSB to prove the need and to address other substantive criteria in the section. These filings are called "248 filings" because they are required by Section 248 of Title 30 of the Vermont Statutes Annotated. Copies of Section 248 are available from CVPS by contacting Steve Costello at (802) 747-5427 or scostel@cvps.com.
- The PSB will hold hearings in which they take testimony and input from the utility and expert witnesses. All evidence that the PSB receives in these hearings is subject to discovery (questions in advance of hearing) and live cross-examination. Anyone can petition the PSB to provide input on the petition. Normally the PSB will grant these requests where it can be shown that the sponsors have an interest at stake in the proceeding or can provide information or help in the effort. Anyone can also request to be put in a list of interested persons, enabling them to receive what becomes a voluminous amount of information from all the parties through out the case.
- The PSB is required to hold a pubic hearing in all counties where the construction of a facility will take place.
- After holding hearings and taking testimony, including a rebuttal phase in which the parties get a chance to rebut evidence that emerged during the case that was not already addressed in their direct case, the PSB will issue a ruling denying or granting the "certificate of public good". There may be some iterative process, in which the PSB makes a ruling, but requires more evidence to get the details right. The amount of time it takes the PSB to make a ruling varies widely, but in a recent transmission project the process took over a year to complete from the time the utility filed its petition with the PSB.

A realistic timeline for an effective process of selecting a solution to the Southern Loop and then getting the necessary approval from the PSB is two years, and as long as three years. During that time, the public will have at least two opportunities to provide input. The first opportunity is the "Utility Search Conference™" for which this document was prepared. There will be other meetings in the coming year to explore the Southern Loop issue further. Once a filing is made with the PSB, individuals can once again provide input if you desire by soliciting the PSB to submit testimony at their hearings. It is likely the PSB will also hold at least one public hearing in your county, where you will be afforded another opportunity to provide input.

Should the chosen solution involve the development of additional DSM, specific program designs will need to be developed and filed with the PSB, who is authorized to approve such programs. If the DSM alternatives involve establishing new pricing structures for service provided by CVPS, the new pricing structures would also need to be approved. A filing for approval of DSM programs and pricing strategies could be combined with a request for a certificate of public good.

7. Questions and Answers

In this section we try to anticipate questions that may have come to mind, and provide clear answers. Several of these Questions and Answers were made available to UtiliPoint by CVPS and/or VELCO.

If building a 46 kV line between Chester and Londonderry was the favored solution in the 1980s, why is it no longer included on the list of potential strategic solutions?
In 2004, CVPS reassessed the cost-effectiveness of this older plan. It was found to be more costly and less effective than other newer solution options that were then under consideration. Subsequently, these newer solution options have been further refined and improved, meaning that the Chester-Londonderry approach is now significantly inferior to many other solution options. Moreover, it would require the procurement of considerable *new* 46 kV right-of-way where no lines now exist.

Can wind power help Southern Vermont's electric system problems?
Based on the wind data available, CVPS did not find that the wind blows consistently or reliably enough in the hours when demands are highest for wind generation to provide a meaningful contribution to solving the Southern Loop reliability concerns.

Would any of the proposed solutions help to promote the development of wind power for economic reasons instead of reliability reasons?
Yes. Every one of the strategic solution options would improve the ability of the Southern Loop to support wind-powered generators, although this is not the motivation for Southern Loop improvements. The intention is to restore adequate strength to the transmission and sub-transmission systems, in order to reduce the risk of blackouts.

Why are the transmission and sub-transmission systems important to me?
Transmission delivers the power to our local communities from distant power plants. Transmission system failures can cause large regional blackouts. To prevent large-scale blackouts, utilities use multiple strategies to ensure the transmission system has high reliability. As a result, nearly all of the power interruptions we experience are related to the local distribution system.

How does the Vermont Yankee generating plant factor into this discussion? Does its operation affect the need for system improvements in Southern Vermont?
The presence of the Vermont Yankee plant has almost no impact on the strengths and weaknesses of the 46 kV and 69 kV systems in this area. Although Vermont Yankee's T4 transformer *is*

involved in these issues, it would remain in operation as part of the transmission system even if the plant itself closed or is not operating.

Is the effort to improve Southern Vermont's electric system somehow involved with the pending Vermont Yankee power increase or with the effort to extend its operating license?
No, although strengthening the 115 kV transmission system at Vermont Yankee can indirectly benefit the power plant. Vermont Yankee relies on a nearby 115 kV line as its source of "off-site power", as required by the Nuclear Regulatory Commission. If Vermont Yankee's 345/115 kV "T4" transformer failed in a way that removed it from service for many months, the local 115 kV transmission line voltage would be too weak to supply Vermont Yankee's off-site power. This would force the plant to shut down, creating a serious financial setback for its owners (Entergy Corporation) and Vermont ratepayers. This financial pain would be felt by Vermont's customers because some of the utilities that serve Vermont customers purchase power from Vermont Yankee at very favorable rates through existing long-term contracts. Most of the transmission solution options presented in this report will improve the voltage strength of the existing 115 kV line, which benefits Vermont customers not only from a reliability perspective, but also from a financial perspective.

Is the effort to improve Southern Vermont's electric system really just to help the ski resorts and related industries?
The Southern Loop is arguably the most vulnerable sub-transmission facility in the state of Vermont and is in serious need of investment for the good of all the customers it serves.
The ski resorts and related electric users are utility customers, deserving of reliable electric service like any customer. However, there is no intention to provide the ski resorts with a better system than that provided to any other customers.

But, is the need for this investment being caused by the ski resorts?
The growth in electric demand at the ski resorts is *part* of the reason that the Southern Vermont system needs to be upgraded. But many other non-resort customers have connected to this system or have added to their existing demand over the past 20 years.

Besides VELCO, what other utilities are involved with or connected to the Southern Vermont systems in question?
Only Vermont Electric Cooperative has a direct connection to the facilities in question and only on several of the lower-voltage distribution systems fed by the 46 kV loop.

Could a special contract be offered to the ski areas, giving them a better rate in exchange for the right to automatically shed their demand during system problems, thereby fixing those problems without the need for new investment in DG, DSM, or transmission?

Such a contract could be offered. However, recent engineering analysis by CVPS has demonstrated that shedding all of the Stratton and Bromley "ski operations" demand would not restore acceptable system performance following an outage of the 115kV line in Brattleboro during peak demand. Moreover, additional analyses suggest that even if this approach was augmented with several dispersed synchronous condensers to leverage its benefit, it still would not perform acceptably. Therefore, a special contract to shed the demand of even the largest and most strategically-located customers would be ineffective, at least for some failure at some demand levels.

If nothing is done, what will happen?

As became apparent on Sept. 27, 2005, the Southern Vermont system is exposed to extensive periods when various transmission line or equipment failures could result in widespread outages involving tens of thousands of customers, including residences, resorts, industrial facilities, and commercial facilities. CVPS calculates that the likelihood of an outage of at least some customers is slightly higher than 50 percent within a period of three years. Such an outage would be more likely to occur at times of system stress, either during extremely cold weather or (less likely) during extremely hot weather. Over time, additional growth in the electric demand will increase the likelihood and scope of such outages. Additionally, after only 3 to 5 MW of additional load growth on the 46 kV Southern Loop, adequate voltage could not be maintained even under normal operating conditions. When this happens, there could be rolling blackouts during high-demand periods that would impact thousands of customers.

8. Glossary

Please note that ***bold italicized text*** refer to terms that are defined elsewhere in the Glossary**.**

248 application process - The 248 application process is a regulatory process based on the Vermont law known as Section 248 (30 V.S.A. 248). It is administered by the Vermont Public Service Board (***PSB***) to consider proposed projects by utilities serving Vermont, and to determine whether they are in the public interest. Successful applicants are granted a ***CPG*** (Certificate of Public Good) which is essentially a license to build and operate the proposed project. The 248 process allows interested parties that qualify by statute and by procedure, to have a say in the hearing process and to influence the decision by the PSB to issue a CPG, a conditional CPG or a notice of denial.

ANR (Agency of Natural Resources) - ANR is the Vermont state agency in charge of protecting air, water, and soil quality, as well as wildlife. ANR is a party in all 248 application processes.

ASC (Area Specific Collaborative) - The ASC is an association of interested parties organized under ***PSB*** Docket No. 6805 to jointly develop an integrated, least-cost solution to the Southern Loop's problems. It includes representatives from Vermont's ***DPS***, the Stratton and Bromley ski resorts, and ***CVPS***.

Blackout – A total loss of power over an area; usually caused by the failure of major generating equipment or transmission facilities. Utilities sometimes used a "controlled blackout" to isolate a relatively small area when there is an electric problem to keep that problem from cascading to other areas which could otherwise cause a large regional loss of power.

Breaker - See the definition of *circuit breaker* below.

Brownout - Abnormally low voltage that causes voltage sensitive equipment such as computers, motors, and certain types of lighting to be degraded in performance

Capacitor - A capacitor is a device located in a ***substation*** that supports ***voltage*** within a local area. It has no moving parts and is relatively inexpensive. Capacitors are often added to ***transmission*** and ***distribution*** systems to keep the voltage acceptably high as electric ***demand*** grows over time. Over-reliance on this strategy may lead to a system that has high enough voltage, but with poor stability, meaning that its voltage is too easily changed by the daily cycle of ***deman***d ramping up and down. This forces utility personnel to constantly re-adjust which capacitors are on and which are off, and makes the system vulnerable to a blackout.

Capacity or capability – For a transmission system electrical component, capacity is the maximum ***demand*** that an electrical component or system can carry without overheating.

Circuit breaker - A circuit breaker is a large switch that turns utility equipment on or off. It may be operated manually in order to safely perform preventative maintenance on equipment, or it may operate automatically to turn off equipment that is malfunctioning (see also the definition of ***fault*** below).

Conductor – A conductor is the part of a ***transmission*** line that actually carries the electricity, in other words, the wire itself. The wire or conductor is just one part of a transmission line; other parts include the poles and the insulators from which the conductor is hung. A conductor must have enough ***capacity*** to carry the highest ***demand*** that it will experience, or it could overheat and fail.

Contingency - A contingency is an unplanned outage of a critical system component such as a ***transmission*** line, ***transformer***, or ***generator***. The time prior to the contingency is referred to as *pre-contingency* and the time after it has begun is referred to as *post-contingency*.

CPG (Certificate of Public Good) - A CPG is a document that may be granted by the Vermont ***PSB*** at the conclusion of a Section ***248 application process***. It is essentially a license to build a proposed project that has been applied for (such as a new ***transmission*** line or ***substation***) and signifies the PSB's conclusion that the project is in the best interests of the public.

CVPS (Central Vermont Public Service) - CVPS is an investor-owned and state-regulated electric company responsible for the purchase or ***generation*** of electricity and its delivery to customers within its Vermont franchise area.

Demand - Demand is the amount of electricity being used at any given moment by a single customer, or by a group of customers. The *total* demand on a given system is the sum of all of the individual demands on that system occurring at the same moment. The *peak* demand is the highest demand occurring within a given span of time, usually a season or a year. The total peak demand that a ***transmission*** or ***distribution*** system must carry sets the minimum requirement for its ***capacity*** (see also the definition for ***energy***).

Demand factor - Demand factor is the average ***demand*** of a customer or system, divided by the highest (i.e. "peak") demand of that same customer or system. The peak demand determines how much infrastructure is needed; the demand factor shows how fully that infrastructure is being utilized over time.

DG (Distributed Generation) - Distributed generators are relatively small, dispersed electric generators that are intended to serve local electrical ***demand***. They have come into greater use in recent years to satisfy gradual growth in demand, without the need to periodically build expensive ***transmission*** lines. They may be owned and operated by the local utility or by individual customers. Typically, they are driven by gasoline or diesel engines, or by ***renewable power sources*** such as solar, biomass, wind, and running water. Depending on their size, they may be connected to a transmission system or to a ***distribution*** system.

Dispatch - Dispatch is the act of turning on or turning off system resources that are needed in varying amounts over time, such as ***generators*** and ***capacitors***. Such resources are said to be "dispatchable".

Distribution - Distribution lines and distribution ***substations*** operate at lower ***voltage*** than the ***transmission*** systems that feed them. They carry relatively small amounts of electricity to local customers. Distribution lines use shorter poles, have shorter wire spans between poles, and are usually found alongside streets and roads, or buried beneath them. Typical distribution *voltages* include 12.5 ***kV*** and 4 kV.

DPS (Department of Public Service) - The DPS is Vermont's public advocate in legal proceedings and other forums that involve utility regulation, statutes, and related issues, including all 248 application processes.

DSM (Demand Side Management) - Demand side management, like ***DG*** (distributed generation), is intended to satisfy local growth in electrical ***demand*** without the need to build new ***transmission*** lines. However, it differs from DG in that it strives to reduce the demand itself rather than to increase the supply.

DUP (Distributed Utility Planning) – DUP is a planning method that seeks to find the lowest cost of providing reliable ***energy*** delivery through traditional means such as ***transmission***, as well as newer approaches such as distributed generation (***DG***) and demand side management (***DSM***). Often, these various strategies are used in combination.

Efficiency Vermont - Efficiency Vermont is Vermont's energy efficiency utility and administers programs under contract with the ***PSB*** that conserve ***energy*** by utilizing it more efficiently (see also the definition of *DSM* above).

Energy – Energy is the amount of power consumed over a period of time. Energy comes in many forms (electrical, chemical, ***thermal***, mechanical, etc). It is measurable in common units, regardless of which form it is in. The rate at which energy is made, used, transformed, or transferred is called ***power*** or ***demand***. Energy is expensive to produce and should therefore not be wasted.

Fault - A fault is the failure of a line, ***transformer***, or other electrical component. Once such a component has failed (due to overheating, short-circuiting, physical breakage, or other trauma) it is automatically taken out of operation by a ***circuit breaker*** that quickly turns the component off. Once it has been "tripped off" it no longer poses a threat to human safety, but its loss may present a difficult burden to the remaining system (see also the definition of ***redundant*** below).

Generation or Generator - A mechanical generator is a device that converts mechanical ***power*** from an engine, a water wheel, a windmill, or other source, into electrical power. Generators have internal parts that spin as they make electricity, similar to an electric motor.

Hydro - Hydro is electric ***generation*** driven by running water such as streams or rivers.

Island or Islanding - An "island" in utility parlance, means an area of the electrical system that is electrically cut off from the main system by switches or by disabled equipment, but that is able to serve its own demand by means of ***generation*** located within its own boundaries. This requires that the generation have special controls to match its output to the island's ever-changing demand, and also requires that there be enough generation to satisfy the island's total demand. "Islanding" is the process of disconnecting from the main system and re-establishing service using these specialized generators.

ISO New England Inc. - ISO New England Inc. is the "independent system operator" for all of New England, and is responsible for the coordinated planning, ***PTF*** funding, and operation of the ***transmission*** system, as well as reliability oversight of ***generators*** and other electrical facilities. ISO-NE is also responsible for the administration of New England's ***power*** supply markets (in which utilities make bids or exercise contracts for other companies' generation to meet their own customers' demand).

kV (kilovolt) - A kilovolt is a thousand volts. Volts and kilovolts are measures of ***voltage***. As an example, the "Southern Loop" ***sub-transmission*** line that runs from Bennington to Brattleboro operates at 46 kV or 46,000 volts.

Load - Load is the same thing as ***demand***.

Load factor - Load factor is the same thing as ***demand factor***.

Losses - Losses are wasted electrical ***energy***. All components and systems that carry electricity waste some amount of its energy. This wasted energy is given off as heat to the surrounding air. Losses cost money, but can be minimized by sound engineering practices.

MW (Megawatt) - A megawatt is one million watts. Watts and megawatts are measures of ***demand***. To put this in perspective, the peak demand for the state of Vermont is approximately 1,100 MW or 1,100,000,000 watts.

N-0 or **N-1** or **N-2 -** The term N minus zero (or one or two) refers to the failure of important equipment. Although these terms sound complex, they are actually quite simple. "N" is the total number of components that the system relies on to operate properly. Only rarely does anyone try to calculate its actual value; it is simply a generic term to describe all the components of a given system. The number subtracted from N is the number of components that may fail in a given scenario, although more information is needed to denote just what component or components are assumed to have failed. Therefore, N-0 means that no components have failed and the system is in a normal condition. N-1 means that only one component has failed. N-2 means that two components have failed at the same time, which is generally worse than having only one fail (see also the definition of *contingency* above).

Network - A network line is one that is capable of carrying ***power*** in either direction, similar to a two-way street. Most ***transmission*** lines are network lines, while most ***distribution*** lines are not (see also the definition of *radial* below).

Peaking Generation - Peaking generation is ***generation*** that is designed to run only a limited number of hours per year, during periods of high ***demand***.

Power - Power is the same thing as ***demand***.

PSB (Public Service Board) - The PSB is Vermont's quasi-judicial authority in legal proceedings that involve utility regulation, statutes, and related issues. It consists of three members (appointed by Vermont's governor) and supporting staff. The PSB presides over ***248 application processes***.

PTF (Pool Transmission Facility) - The precise definition of a pool ***transmission*** facility is beyond the scope of this document but, generally speaking, it is any transmission facility operating at 69 ***kV*** or higher and that is ***networked*** (not ***radial***). PTF falls under the authority of ***ISO New England***. The construction of new PTF facilities is funded by the ISO on a pro-rata basis among its member utilities. Vermont's responsibility for such costs is about 5 percent of the total.

Radial - A radial line is one that is capable of carrying ***power*** in only one direction, similar to a one-way street. Most ***distribution*** lines are radial lines, while most ***transmission*** lines are not (see also the definition of *network* above).

Redundant - Facilities that have backups or alternate ways of operating are said to be redundant, that is, their function can be sufficiently provided even after they suffer a breakdown or failure. The more crucial a component or system, the greater the need for it to be redundant.

Renewable power source - A renewable power source is any power source that does not rely on a *finite* fuel resource to keep it running, such as coal, oil, or natural gas, which will eventually run out. Renewable power sources include solar, wind, and ***hydro*** generators, because sunlight, wind, and running water will not run out. Generators that burn replaceable fuels also qualify as renewable power sources. Examples include bio-diesel generators that run on crop-derived fuels, and wood-burning generators.

Rolling blackout - The deliberate cutting off of electric service to a limited number of customers during emergency conditions. These blackouts are targeted at different groups of customers, first one and then the next, and continuing this way in a cyclical pattern in order to "spread the pain" as evenly and fairly as possible until the emergency problem is fixed.

ROW (Right-of-Way) - A right-of-way is the long but narrow strip of property on which a ***transmission*** line is built. It may be owned by the associated utility or it may be owned privately, with the utility exercising its state-mandated right to use this private property for the public good.

Substation - A substation is a fenced-in area where several ***transmission*** and/or ***distribution*** lines come together and are connected by various other equipment for purposes of switching, metering, or manipulating ***voltage***. Often they contain ***transformers***.

Sub-transmission – Sub-transmission systems are very similar to ***transmission*** systems (see also the definition of *transmission* below) and differ only in that they operate at somewhat lower ***voltage*** and carry smaller amounts of ***power***. Typical sub-transmission voltages include 46 ***kV*** and 34.5 kV.

Synchronous Condenser - A synchronous condenser is a device, located in a ***substation***, that supports voltage on electric ***transmission*** or ***distribution*** systems, much like a ***capacitor***. But unlike a capacitor, a synchronous condenser has moving parts, that is, it spins like a motor, and its outward appearance is very similar to that of a large motor. Synchronous condensers tend to be more effective than capacitors but also much more expensive. They run for very long periods of time, but do not burn fuel and therefore do not release emissions into the atmosphere.

Thermal - This term is related to the terms ***capacity*** or ***capability***. Thermal refers to heat or temperature, which are of concern when electrical equipment is carrying a high ***demand***. Electrical components that exceed their capacity or capability are said to be "thermally overloaded," meaning that they are carrying too much demand, are growing too hot, and could fail as a result.

Transformer – A transformer is a device that connects high-***voltage*** equipment to lower-voltage equipment and allows ***power*** to flow from one to the other. Different voltages are used because higher voltages are better for *moving* electricity over a long distance, but lower voltages are better for *using* electricity in machinery and appliances. Transformers are commonly described by the two (or more) voltages that they connect, such as "115/46 kV", signifying a connection between 115 kV and 46 kV equipment.

Transmission - Transmission lines and transmission ***substatio***ns operate at high ***voltage*** and carry large amounts of electricity from centralized ***generation*** plants to lower voltage ***distribution*** lines and substations that supply small towns and localities. A few transmission lines or even one may be capable of supplying an entire region or metro area. Transmission lines use poles or structures, have long wire spans between poles, and usually traverse fairly straight paths across large distances. They do not tend to follow roads. Typical transmission ***voltages*** include 345 ***kV***, 115 kV, and 69 kV.

VELCO (Vermont Electric Power Company) - VELCO is a ***transmission*** company wholly owned by Vermont's ***distribution*** companies, and responsible for the planning, construction, and operation of Vermont's transmission system.

Voltage - Voltage in an electric ***transmission*** or ***distribution*** system is much like water pressure in a system of pipes. If the pressure is too low, the pipes cannot carry enough water to satisfy the needs of those connected to them. If the voltage is too low, the electric system cannot carry enough electricity to satisfy the needs of those connected to it.