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# 2021 Vermont Long-Range Transmission Plan

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**SUMMARY**

Every three years, Vermont Electric Power Company performs a Long-Range Transmission Plan, undertaking study of the transmission and subtransmission systems per Vermont statute. In addition to fulfilling the requirements of identifying and communicating any potential reliability deficiencies, VELCO performs sensitivity analyses based on trends in the electric industry and suppositions of future policy in order to enhance power and energy discourse in the state of Vermont. This paper describes work performed for the latest iteration of the Vermont Long-Range Transmission Plan.

**KEYWORDS**
Long-term Planning, Distributed Generation, Electrification, Load Flexibility, Renewable Energy, High Renewables Penetration

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## 1. Introduction

In 2006, the Vermont Public Service Board (now called the Public Utilities Commission) completed Docket 7081 [1], thereby creating the Vermont System Planning Committee (VSPC). Facilitated by Vermont Electric Power Company (VELCO), the purpose of the committee is to identify reliability issues that may require mitigation within the next 20 years, and where possible to avoid or defer transmission upgrades associated with those reliability issues by the use of a Non-Transmission Alternative (NTA). To identify reliability issues, VELCO transmission planners study the Vermont transmission and subtransmission systems in a process known as the Long-Range Transmission Plan. In July of 2021, VELCO published the latest iteration of that plan [2].

## 2. Reliability Analysis

### 2.1 Load Forecast

In order to account for multiple potential future growth rates of various technologies, the load forecast created for this study included three different load forecast scenarios: a low, a medium, and a high scenario. Of these, the medium forecast is meant to model what is economically expected; that is, it is the scenario that best depicts growth of electric load if business proceeds as usual. This forecast was used to complete the reliability portion of the analysis required by regulation. The low forecast contains only moderate load growth, to the degree that it was not deemed necessary to study, and the high scenario depicts load growth in line with Vermont's energy and climate targets.

Each scenario was completed using a "90/10" forecast, which refers to the probability of the actual load exceeding the forecast. In order to account for some of the highest loads expected to be possible in a given scenario, these 90/10 loads reflecting extreme weather events were used in the analysis, in accordance with typical regional planning practices. Each scenario also included a separate forecast for peak summer and peak winter loads, each of these net of any contribution from behind the meter solar PV.

So as to obtain the best available data, VELCO, worked with the VSPC, the Vermont Department of Public Service, the Vermont Energy Investment Corporation, Efficiency Vermont, and a forecasting consultant on deployment forecasts for such technologies as electric vehicles, cold climate heat pumps, and energy efficiency measures; this in addition to the work performed to forecast conventional loads such as lighting, cooling, and heating. All of these elements were considered in an economic model based on historical data by county, as well as impacts due to weather, climate change, the COVID-19 pandemic, and other factors.

The graphs below show summer and winter peak loads by year for the medium, or economically expected, scenario of the forecast. Specific constituent technology types are shown for illustrative purposes, and are included in the total, but not base load. These technologies are measured on the right axis, with the base and total loads measured on the left. It can be seen that peak loads are not expected to increased very rapidly in the near term; it is only in the mid- to late 2020s that load begins to increase to levels above the typical Vermont peak of about 1,000 MW, or even above the all-time peak of 1,186 MW. Growth in electric vehicle and heat pump load, especially in the winter, are the primary drivers of this increase – mass adoption of electric vehicles is expected to be associated with high loads, a trend that is borne out in this forecast. There is no contribution of solar PV to reduce the net peak load in either the summer or the winter, as Vermont's peaks occur after dark in both seasons. No load management was applied in the reliability analysis using the medium forecasts.

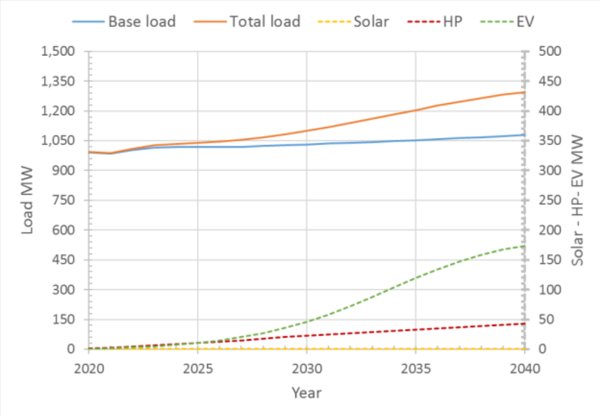


Figure 1: Summer Peak Load Components

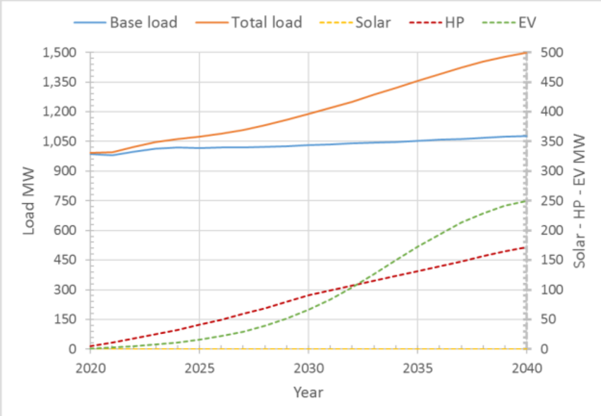


Figure 2: Winter Peak Load Components

### 2.2 Electric Vehicles

The adoption rate of electric vehicles in Vermont is not expected to increase very quickly in the near-term, but rather to increase later this decade. Vermont Energy Investment Corporation (VEIC) provided three scenarios for an electric vehicle forecast, along with the corresponding energy consumption data, and in doing so accounted for recent market trends, as well as relying on industry reporting and their expert knowledge. It was this information that was used in the peak load forecast, with about 72,000 electric vehicles expected to be registered in the state by 2030, and 256,000 expected by 2040.

### 2.3 Heat Pumps

Formerly reserved for use in warmer climates than that of Vermont, heat pumps are expected to be a major contributor to peak loads in Vermont in future years. Cold climate heat pumps can function with reasonable efficiency even at negative temperatures, though losses are evident at very low temperatures. Gains in the cold weather efficacy of this technology continue, and so it is reasonable to expect that electricity will become a major source of energy for heating. Presently, many Vermonters with heat pumps also have backup heating system fueled by propane, natural gas, or wood pellets.

Efficiency Vermont provided three forecast scenarios for the deployment of heat pumps in collaboration with members of the Load Forecasting subcommittee of the VSPC. A deployment rate of about 6,000 units per year is forecasted in the medium, economically expected case in the near-term, increasing to over 10,000 units per year at the end of the decade, contributing to a total expected deployment of 78,000 units in 2030 and 149,000 units in 2040. Though these levels of growth are much higher than forecasted in previous planning cycles, Efficiency Vermont’s knowledge of the market potential and actual installation data support the conclusion.

### 2.4 System Impacts

No reliability issues on the transmission system were found in this analysis when considering the first ten years of the planning horizon, such that no system upgrades or other measures to avert system issues were needed. Because VELCO has phase-shifting transformers at some of the tie-lines with New York and New Hampshire, it is possible to pre-position the system to manage flows within acceptable limits accounting for post-contingency conditions. However, there were observed instances of subtransmission lines overloading, some of them known issues; these results were communicated to the distribution utilities which own them. It was assumed that, for a severe overload on a subtransmission line, that the line would trip or be disconnected by operator action. Though this would have the potential to adversely impact nearby transmission elements, no such adverse transmission impacts were found.

## 2.5 Loss of Load

Another result of the disconnection of system elements necessitated by post-contingency conditions is the potential for loss of load. Vermont, as well as the other New England states, can be exposed to loss of service to load based on ISO New England criteria, which states that any load lost as a result of a single event should not exceed 100 MW, and any load lost as a result of an N-1-1 outage should not exceed 300 MW. None of the instances mentioned above exceed those criteria, though there are several cases where load in excess of 100 MW is lost for an N-1-1 condition. Because concerns over pooled transmission facility (PTF) expenditure lead to this ISO-NE criteria, the degree to which regionally-funded transmission projects to fix these issues are possible is limited. It is possible to rectify these issues with additional or reinforced subtransmission facilities, or with locally-funded transmission projects, which may well be appropriate for the most severe events. It may not be desirable from a budget or cost/benefit standpoint for a Vermont distribution utility to fix all such issues, though.

# 3. High Load Sensitivity Analysis

## 3.1 High Load Forecast

One of the considerations made in development of the long-range plan is that of the climate and energy targets of Vermont. Passed into law in 2020, the Vermont Global Warming Solutions Act (or GWSA) [3] codified the goals set forth in the 2016 Comprehensive Energy Plan [4], performed by the Vermont Department of Public Service. The terms of the GWSA require three milestones of reduction in state greenhouse gas emissions:

- By January 1, 2025: not less than 26% below 2005 emissions;
- By January 1, 2030: not less than 40% below 1990 emissions; and
- By January 1, 2050: not less than 80% below 1990 emissions.

In order for Vermont to meet these requirements, electrification in the heating and transportation sectors must exceed the business-as-usual growth expected in the medium forecast. As such, a high load forecast was created such that it would roughly reflect the numbers of electric vehicles and heat pumps needed in 2040 for the state to be on track to meet its 2050 target based on the best information available at the time, with input from various stakeholders. Below is a graph of the high forecast as compared to the medium forecast, discussed previously. As a result of the hypothetical prescriptions for these technology growth rates in the high forecast, we see the load magnitudes in later years of the 20-year time horizon are accentuated drastically. Without any load management, the summer peak load in 2040 would be about 1,450 MW, and the winter peak load in 2040 would be about 1,800 MW.

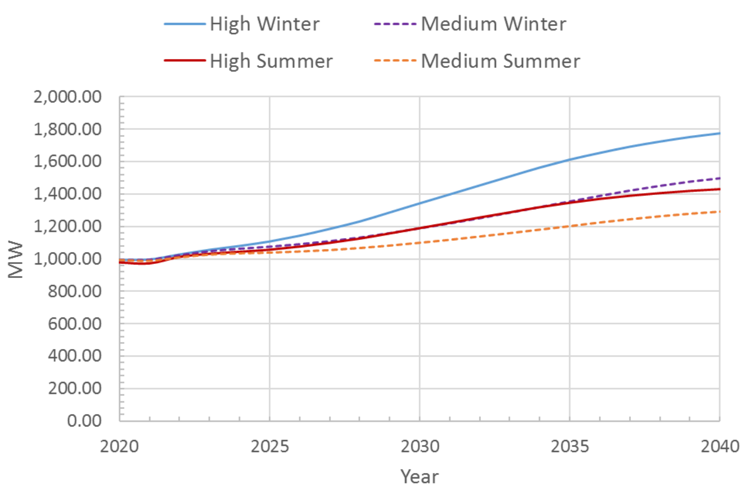


Figure 3: Forecast Scenarios Peak Load Comparison

In January 2020, 3,716 electric vehicles were registered in Vermont, with a year-over-year increase in adoption rate that would result in Vermont coming up short of its targets. As such, the high scenario was tailored to meet Vermont's climate targets, which resulted in a total of about 412,000 light duty electric vehicles in 2040, out of a state total of 450,000 light-duty vehicles. Considering the coincidence of electric vehicle charging that currently prevails in Vermont, it is expected that the high scenario would result in a summer peak demand contribution from electric vehicles of approximately 400 MW. It is worth noting that, because this forecast accounted only for electrification of light-duty transportation, there is the potential for further electrification to occur in heavy-duty transportation, or above the 90% light-duty electrification contemplated. Expansion in this direction will be a topic of future study in the 2024 Long-Range Transmission Plan.

The heat pump forecast for the high scenario was also tailored to meet Vermont's climate targets; with about 75,000 units expected in 2030 and 150,000 units expected in 2040 for the medium scenario, it was observed that more electrification of the heating sector was required in the high forecast. In the high forecast, the values increase to 110,000 units in 2030 and 255,000 units in 2040.

### 3.2 Load Management

Because of the very high loads corresponding to electric vehicles and heat pumps in the high load scenario, it was expected that many transmission facilities and subtransmission facilities would be in need of replacement or upgrade. To avoid this, and to produce results that were useful to a majority of stakeholders in Vermont, the modeling of load management was deemed necessary in analysis of the high load scenario. There are presently several initiatives in Vermont, in operation or development, that would coordinate many distributed energy resources to reduce the state load in certain hours. Because these efforts are relatively new, they were not explicitly included in the forecast. However, it is recognized that these efforts will be needed to ensure grid reliability in the face of system concerns. Efficiency Vermont and the distribution utilities, in collaboration with other Vermont entities, have commenced control of such devices as electric vehicle chargers, cold climate heat pumps, heat pump water heaters, other HVAC devices, and distributed battery energy storage systems. While energy storage was not modeled in this analysis, it was considered as a potential solution should any reliability deficiency arise.

In total, the load control programs currently implemented in Vermont are capable of controlling on the order of magnitude of a few tens of megawatts. This controllable amount is expected to increase in future years, especially as the number of controllable devices increases, and as the control technology to orchestrate the effective dispatch of devices improves in availability and quality. Some distribution utilities offer electric vehicle chargers as an incentive for residential consumers to purchase or lease an electric vehicle, and these chargers are equipped with the capability of being controlled remotely. The stipulation of use is that the distribution utility may disconnect the electric vehicle in order to avoid or mitigate a peak load event, with the availability for the customer to opt out of the event at some cost. It has been the practical experience thus far of these utilities that about 75% of electric vehicle owners join this program, and that very few participants choose to opt out of load reduction events. As such, it was decided to model load management in the high scenario with 75% reduction in electric vehicle charging load. This brought the 2040 summer peak load to a value of 1,209 MW, and the 2040 winter peak load to a value of 1,471 MW.

### 3.3 System Impacts

By using 75% electric vehicle load reduction, it was seen that there were no transmission issues in 2040, despite the high loads modeled. Much the same as the 10-year reliability analysis, the phase-shifting transformers were able to be utilized to mitigate potential issues. The higher thermal conductor ratings in effect in the winter months also served to alleviate potential issues. Because forecasting beyond ten years comes with much uncertainty, it is impossible to guarantee that this result will hold in future analyses. However, this result is encouraging for the long-term future of electrification efforts in Vermont.

## 4. High Generation Sensitivity Analysis

### 4.1 Generation Forecast

Since the completion of the 2021 Long-Range Transmission Plan, solar PV in Vermont has grown to over 400 MW, and other forms of distributed generation to over 63 MW. This growth of distributed generation primarily in solar PV, is expected to continue for some years. According to the economic forecast produced, installation of solar PV would level off around 2025. However, the Tier II section of Vermont's Renewable Energy Standards, which sets requirements on the distribution utilities' supply of energy and electrification efforts, presently requires that 10% of electricity sales be supplied by small, in-state, renewable resources by 2032. This would result in about 690 MW of solar PV by 2032. However, discussion in the Vermont legislature about the potential to increase the Tier II obligation to 20% led to the study of another scenario, wherein solar PV would reach about 1,190 MW in 2032.

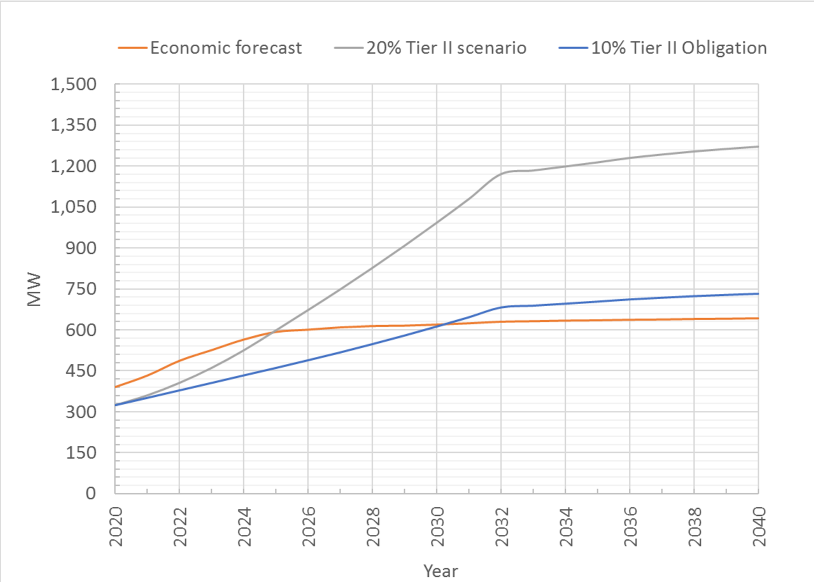


Figure 4: Solar PV Scenarios

### 4.2 System Impacts

To observe the potential impacts to transmission under the 20% Tier II scenario, the same distribution of solar across the state as exists today was modeled, such that a defined area with 10% of the roughly 400 MW today would have 10% of the 1,190 MW in 2032. With this arrangement, several transmission overloads were observed, despite use of the phase-shifting transformer at the Sand Bar substation to reduce loading on nearby lines. Because there is an HVDC line connecting Vermont to Hydro Quebec in the northwest Vermont, and because there are several wind plants in the north of the state, north-south transmission lines were loaded to the point of exceedance of thermal ratings with the addition of more solar PV nearby. Subtransmission facilities were also observed to be overloaded in several places throughout the state. Because the solar PV installations were assumed to contribute reactive power at a fixed power factor, no voltage issues were seen.

### 4.3 Optimized Distribution

To avoid the violations of thermal criteria seen in the 20% Tier II scenario, an alternate approach was evaluated. By allocating solar PV by zone of the state, and allowing no more than would cause the first violation of transmission or subtransmission criteria, the Optimized Distribution of solar PV was updated for the 2021 Long-Range Transmission Plan. In the figure below, it can be seen that there is little capacity for additional distributed generation in the northernmost zones of the state, but that there is more capacity available in the southern zones. Noting a one-for-one impact between imports at Sand Bar and additional PV, it was found that 996 MW could be accommodated without violation of transmission and subtransmission criteria, and without overloading distribution transformers.

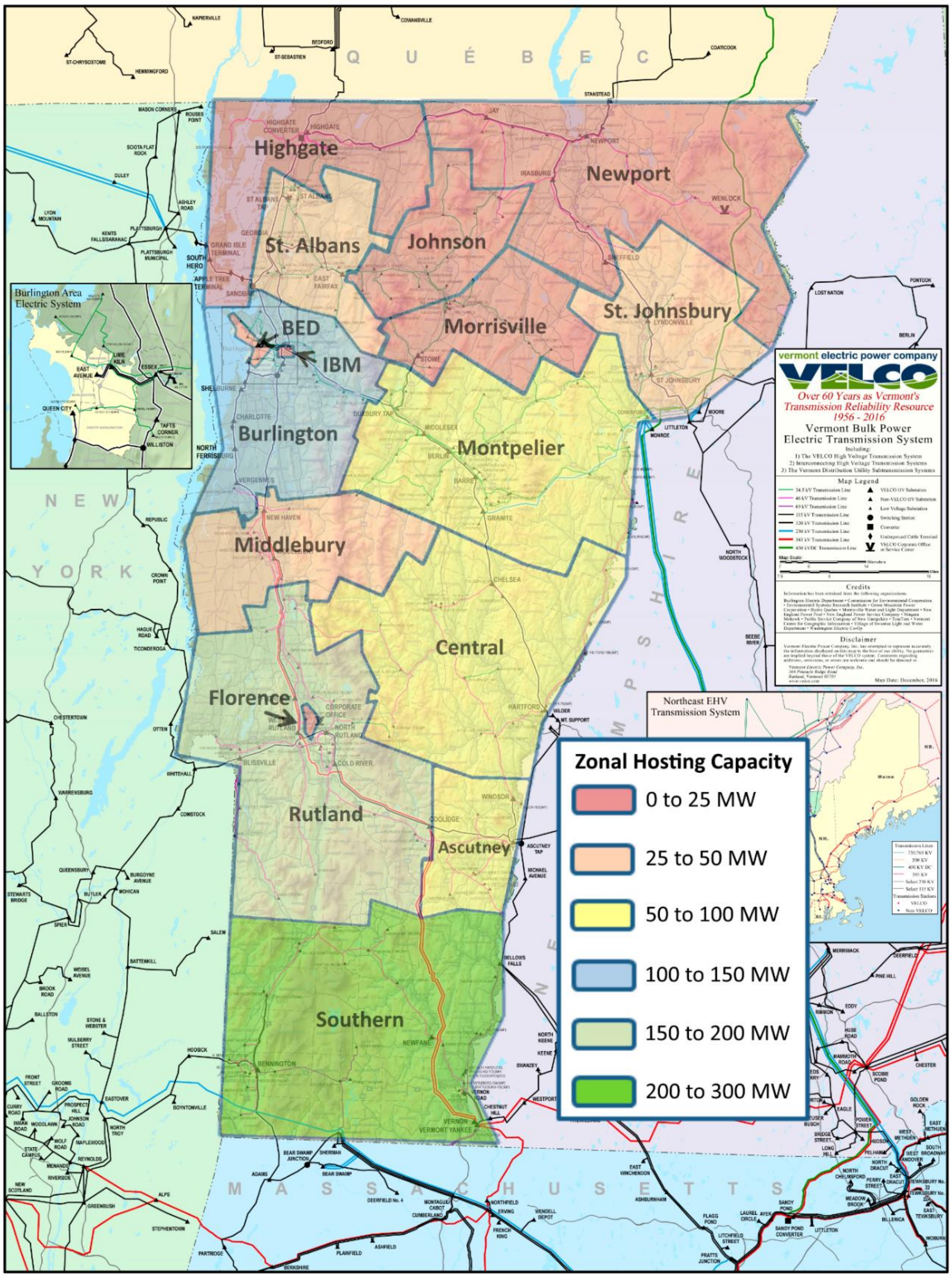


Figure 5: Optimized Distribution

## 5. Conclusion

In the 2021 Vermont Long-Range Transmission Plan, analyses performed in previous iterations of the plan were advanced with higher forecasts of load and of generation, and new lessons learned about the capabilities of the system in the face of what may be demanded of it. Peak loads are expected to grow, first slowly but then more rapidly in the coming decade, which growth the transmission system is equipped to handle. However, in order to accommodate the kind of growth needed to meet Vermont's energy and climate targets without significant investment in transmission infrastructure, care must be taken to improve and expand load management capabilities, and proper regulations and incentives put in place to direct distributed generation to those areas with transmission, subtransmission, and distribution capacity. Finally, coordinated statewide planning efforts, including all energy stakeholders in Vermont, are needed to make a vision of the future for the grid into a reality.

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