Ludlow Electric Department

2019 Integrated Resource Plan

Filed with the Public Utility Commission

VPPSA Vermont Public Power Supply Authority

Cover Photo: "The Middle Falls of Buttermilk Falls, Ludlow, Vermont", Courtesy of Greg Parsons, www.newenglandwaterfalls.com

VPPSA
Vermont Public Power Supply Authority

EXECUTIVE SUMMARY

The Village of Ludlow has operated an electric utility system since 1900 in the south-central part of Vermont, in an area where weather events, especially in recent years, have been both challenging and at times highly localized. Ludlow Electric Light Department's (LED) service territory encompasses the Village of Ludlow, parts of the towns of Ludlow, Plymouth, Proctorsville, and Mt. Holly. LED remains guided by the Vermont Public Utility Commission ("PUC") rules as well as by the American Public Power Association's ("APPA") safety manual. As a small municipal utility LED is careful to balance maintaining reliability and reasonable cost levels with the need to deliver innovative programs to customers that provide practical value.

LED's distribution system serves a mix of residential, small commercial, and large commercial customers. Residential customers make up over 80% of the customer mix while accounting for about a third of LED's retail kWh sales. Four large commercial customers (less than 1%) make up almost 40% of retail usage with the remaining 30% of retail sales going to small commercial and public authority customers.

Consistent with regulatory requirements, every 3 years LED is required to prepare and implement a least cost integrated plan (also called an Integrated Resource Plan, or IRP) for provision of energy services to its Vermont customers. Northfield's Integrated Resource Plan (IRP) is intended to meet the public's need for energy services, after safety concerns are addressed, at the lowest present value life cycle cost, including environmental and economic costs, through a strategy combining investments and expenditures on energy supply, transmission and distribution capacity, transmission and distribution efficiency, and comprehensive energy efficiency programs.

ELECTRICITY DEMAND

LED is facing a period of relatively flat demand influenced by several competing factors, all of which carry some uncertainty. Continued adoption of solar net metering reduces demand although the pace at which net metering will grow in Northfield's territory is uncertain. As various incentives aimed at transitioning from fossil fuels to cleaner electricity are made available, increasing acceptance of cold climate heat pumps and similar appliances will likely increase demand, as will an expected increase in the use of electric vehicles.

While no significant change in the demand associated with LED's largest customers is currently anticipated, the potential does exist. With 40% of LED's energy requirements concentrated across 4 large commercial customers, LED monitors the plans of these large customers in order to anticipate necessary changes to the existing resources plan and system infrastructure. In the case of a significant expansion by one or more customers, detailed engineering studies may be needed to identify necessary system upgrades.

ELECTRICITY SUPPLY

LED's current power supply portfolio includes entitlements in a mixture of baseload, firm and intermittent resources through ownership or contractual arrangements of varying duration, with most contracts carrying a fixed price feature. Designed to meet anticipated demand, as well as acting as a hedge against exposure to volatile ISO-New England spot prices, the portfolio is heavily weighted toward hydro, solar and other renewable sources.

When considering future electricity demand, LED seeks to supplement its existing resources with market contracts as well as new demand-side and supply resources. LED believes that in addition to working with financially stable counterparties, it is important for new resource decisions to balance four important characteristics: new resources should be low cost, locally located, renewable and reliable, Market contracts have the advantage of being both scalable and customizable in terms of delivery at specific times and locations. LED anticipates regional availability of competitively priced renewable resources including solar, wind, and hydro. In addition to being a factor in meeting future electricity requirements, this category of resource contributes to meeting Renewable Energy Standard goals. Gas fired generation may have a role to play in the future portfolio for reliability purposes. As battery storage technology matures and proves economically feasible LED sees potential for storage to play an important load management role and to enhance the local impact of distributed generation.

RESOURCE PLANS

Looking ahead to evaluating major policy and resource acquisition decisions, LED employs an integrated financial model that takes into account impacts on load and subsequent effects on revenue and power supply costs, as well effects on investment, financing and operating costs. Use of the integrated model allows for evaluation of uncertainty related to key variables, on the way to identifying anticipated rate impacts over time. While rate trajectory is the primary metric LED relies on to evaluate resource decisions on an individual or portfolio basis, there are other more subjective factors to consider, including resource diversity or exposure to major changes in market rules.

LED faces three major energy resource decisions over the 2020 – 2039 period covered by this Integrated Resource Plan (IRP). The first of these involves the need to cover the roughly 30% of LED's energy requirement that is currently unhedged by long-term contracts over the 2020 to 2022 period. Options being evaluated by LED include leaving the position unhedged, purchasing a fixed-price market contract for energy, or purchasing a fixed-price contract for hydro energy including RECs. The main factors expected to impact this decision are volatility in gas prices, which are a driver of New England energy prices, and expected pricing for RECs needed to meet LED's obligations under Vermont's Renewable Energy Standard.

The second and third major resource decisions faced by LED occur in 2023 and 2032, respectively. Both decisions come about due to the scheduled termination of current long-term contracts. Similar to the first decision described above, the evaluation of options to replace these resources is expected to be primarily influenced by energy price and REC price considerations. LED notes that the latter decision, which will nearly coincide with the expiration of the current renewable energy standard, may be subject to uncertainty arising from changes in RES requirements.

Because LED holds entitlements in capacity resources that equal expected requirements based on demand, no capacity related resource decisions are anticipated.

RENEWABLE ENERGY STANDARD

LED is subject to the Vermont Renewable Energy Standard which imposes an obligation for LED to obtain a portion of its energy requirements from renewable resources. The RES obligation increases over time and is stratified into three categories, Tier I, TIER II and TIER III. LED' s obligations under TIER I can be satisfied by owning or purchasing RECs from qualifying regional resources. TIER II obligations must be satisfied by owning or purchasing RECs from renewable resources located within Vermont. Satisfaction of LED's TIER III obligation involves energy transformation, or reduction of fossil fuel use within its territory. TIER 3 programs can consist of thermal efficiency measures, electrification of the transportation sector, and converting customers that rely on diesel generation to electric service, among other things. By providing incentive programs to encourage conversion of traditional fossil fuel applications LED receives credits toward its TIER III obligation. LED will be exploring custom electrification opportunities with some of its larger customers, although no proposal has yet taken shape. More detail regarding LED's plans to meet its TIER III obligation is available in Appendix B to this document.

ELECTRICITY TRANSMISSION AND DISTRIBUTION

LED has a compact service territory as a result of being a small, municipal-owned electric utility and has consistently pursued upgrade initiatives each year in order to maintain a reliable and efficient system. LED's distribution system consists of approximately 65 miles of distribution line operating at 12.5 kV, with three substations connected to the Green Mountain Power (GMP) transmission system.

In addition to upgrading and routinely maintaining the system to ensure efficiency and reliability, LED is examining the need to modernize in order to support additional distributed generation on the system and to provide more customer oriented services, including load management programs that reduce costs for both LED and its customers. LED is currently engaged with VPPSA in a multi-phased process designed to assess its readiness for AMI, guide it through an RFP process culminating in vendor and equipment selection and ultimately resulting in implementation of an AMI system, provided the resulting cost estimates gained through the RFP process are not prohibitive. LED plans to consider a staged approach to AMI implementation that would prioritize areas of high customer or load concentration while smoothing the overall cost to the system.

LED sees potential value to customers by utilizing rate design, direct load control or other incentive programs as tools to manage both system and customer peak loads in unison. Implementation of an AMI system is expected to enhance LED's ability to deliver these benefits and capture economic development/retention opportunities where possible.

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INTRODUCTION

The Village of Ludlow has operated an electric utility system since 1900 in the south-central part of Vermont, in an area where weather events, especially in recent years, have been both challenging and at times highly localized. Ludlow Electric Light Department's (LED) service territory encompasses the Village of Ludlow, parts of the towns of Ludlow, Plymouth, Proctorsville, and Mt. Holly and can be seen on the Vermont Utility Service Territory map found on the next page. LED remains guided by the Vermont Public Utility Commission ("PUC") rules as well as by the American Public Power Association's ("APPA") safety manual. Well-established practices keep LED operating safely, efficiently, and reliably.

VERMONT PUBLIC POWER SUPPLY AUTHORITY

The Vermont Public Power Supply Authority (VPPSA) is a joint action agency established by the Vermont General Assembly in 1979 under Title 30 VSA, Chapter 84. It provides its members with a broad spectrum of services including power aggregation, financial support, IT support, rate planning support and legislative and regulatory representation. VPPSA is focused on helping local public power utilities remain competitive and thrive in a rapidly changing electric utility environment.

LED is one of twelve member utilities of VPPSA, which is governed by a board of directors that consists of one appointed director from each member. This gives each municipality equal representation. VPPSA's membership includes:

- Ludlow Electric Light Department,
- Barton Village Inc.,
- Village of Enosburg Falls Electric Light Department,
- Hardwick Electric Department,
- Village of Hyde Park,
- Village of Jacksonville Electric Company,
- Village of Johnson Electric Department,
- Lyndonville Electric Department,
- Morrisville Water & Light Department,
- Northfield Electric Department,
- Village of Orleans, and
- Swanton Village Electric Department.

LED and VPPSA are parties to a broad Master Supply Agreement (MSA). Under the MSA, VPPSA manages LED's electricity loads and power supply resources, which are pooled with the loads and resources of other VPPSA members under VPPSA's Independent System Operator – New England (ISO-NE) identification number. This enables VPPSA to administer LED's loads and power supply resources in the New England power markets.

SYSTEM OVERVIEW

LED's distribution system serves a mix of residential and commercial customers, the largest of which is Okemo Mountain Resort (Okemo). Okemo is the largest driver of LED's service load. In 2018 LED's peak demand in the winter months was 13,058 kW and 8,352 kW during the summer months, making 2018 a new historical peak year for both winter and summer peaks. LED is a winter peaking utility. Annual retail energy sales for 2018 were 54,579,417 kWh and its annual load factor was 48%. Up until 2018, the historical peak in the winter was 12,871 kW in December of 2006 and the historical peak in the summer was 7,048 kW in August of 2006. LED is connected to Green Mountain Power's ("GMP") 46 KV transmission system. LED does not own any generation within its service territory, supplying electricity to its customers through contractual entitlements to power plants and wholesale market contracts throughout the region.

The following tables show LED's number of customers, retail sales and system peaks for the past five years.

Table 1: LED's Retail Customer Counts

Data Element	2014	2015	2016	2017	2018
Residential (440)	3,041	2,979	3,001	3,034	3,045
Small C&I (442) 1000 Kw or less	709	650	661	703	704
Large C&I (442) above 1,000 Kw	4	4	4	4	4
Street Lighting (444)	3	3	3	3	3
Interdepartmental Sales (448)	1	1	1	1	1
Total	3,758	3,637	3,670	3,745	3,757
Y/Y	2%	-3%	1%	2%	0%

Table 2: LED's Retail Sales kWh

Data Element	2014	2015	2016	2017	2018
Residential (440)	16,679,120	16,836,198	15,600,471	15,978,156	17,141,759
Small C&I (442) 1000 Kw or less	17,231,761	17,523,280	16,940,918	17,738,108	16,905,568
Large C&I (442) above 1,000 Kw	13,206,060	11,724,280	13,258,860	13,283,160	20,126,143
Street Lighting (444)	342,512	343,535	345,238	248,276	347,690
Interdepartmental Sales (448)	60,016	56,550	55,815	72,664	58,257
Total	47,519,469	46,483,843	46,201,302	47,420,364	54,579,417
YOY	-3%	-2%	-1%	3%	15%

Table 3 LED's Annual System peak Demand kW

Data Element	2014	2015	2016	2017	2018
Peak Demand kW	12,200	12,242	12,309	12,242	13,058
Peak Demand Date	12/30/14	12/28/15	01/20/16	01/13/17	12/18/18
Peak Demand Hour	18	16	19	19	16

STRUCTURE OF REPORT

This report is organized into six major sections plus an appendix and a glossary.

I. ELECTRICITY DEMAND
This chapter describes how LED's electricity requirements were determined and discusses sources of uncertainty in the load forecast.

II. ELECTRICITY SUPPLY
This chapter describes LED's electricity supply resources, and the options that are being considered to supply the electricity needs of LED's customers.

III. RESOURCE PLANS
This chapter compares LED's electricity demand to its supply and discusses how LED will comply with the Renewable Energy Standard.

IV. ELECTRICITY TRANSMISSION AND DISTRIBUTION
This chapter describes LED's distribution system and discusses how it is being maintained to provide reliable service to its customers.

V. FINANCIAL ANALYSIS
This chapter presents a high-level forecast of LED's power supply costs and cost of service.

VI. ACTION PLAN
This chapter outlines specific actions the LED expects to take as a result of this Integrated Resource Plan.

A. APPENDIX
The appendix includes a series of supporting documents and reports, as listed in the Table of Contents.

G. GLOSSARY

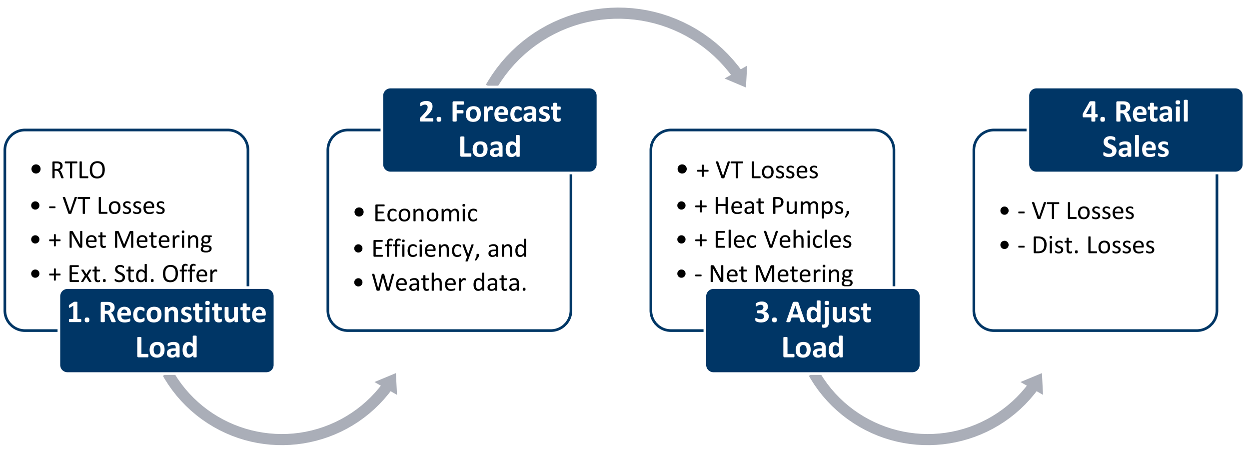
ELECTRICITY DEMAND

I. ELECTRICITY DEMAND

ENERGY FORECAST METHODOLOGY: REGRESSION WITH ADJUSTMENTS

VPPSA uses Itron's Metrix ND software package and a pair of multiple regression equations to forecast LED's peak and energy requirements. Importantly, the peak and energy forecasts are based on the same underlying data sets and the same methodologies that are used to set LED's annual power budget. As a result, the forecasts are updated annually, and variances are evaluated monthly as actual loads become available. The forecast methodology follows a four-step process.

Figure 1: Forecasting Process



1. RECONSTITUTE LOAD

In the past, metered load at the distribution system's tiepoints (boundaries) was used as the 'dependent' variable in the regression equations. However, the growing impact of the net metering and Standard Offer Programs has effectively obscured the historical trends in this data, and this would cause the accuracy of the regression equations to decrease. To preserve the accuracy of the regression forecast, VPPSA "reconstitutes" the Real-Time Load Obligation (RTLO) data by 1.) adding back generation from the net metering and Standard Offer Programs, and 2.) subtracting Vermont's transmission losses. This results in a data set that can be accurately modeled using multiple regression and creates consistency with the historical data.

The resulting, reconstituted load is used as the dependent variable in the regression equations and forms a historical time series data that the regression equations use to predict future loads. The following table summarizes the data that is used to reconstitute the load.

Table 4: Data Sources for Reconstituting RTLO

Data Element	Source
RTLO	ISO-NE
– Vermont Transmission Losses	VELCO[1]
+ Net Metering Program Generation	VPPSA
+ Standard Offer Program Generation	VELCO
= Reconstituted Load	

[1] Vermont Electric Power Company

2. FORECAST LOAD

The regression equations use a series of independent or "explanatory" variables to explain the trends in the reconstituted load data. The equations themselves consist of the explanatory variables that are listed in Table 5.

Table 5: Load Forecast Explanatory Variables

Data Category	Explanatory Variable	Source
Dummy Variables	These variables consist of zeros and ones that capture seasonal, holiday-related, and large, one-time changes in electricity demand.	Not applicable. Determined by the forecast analyst.
Economic Indicators	Unemployment Rate (%)	Vermont Department of Labor
	Eating and Drinking Sales ($)	Woods and Poole
Energy Efficiency	Cumulative EE Savings Claims (kWh)	Efficiency Vermont Reports and Demand Resource Plan
Weather Variables	Temperature – 10-year average heating & cooling degree days.	National Oceanic and Atmospheric Administration (NOAA)

The forecast accuracy of the regression model is very good. Based on monthly data, it has an R-squared of 97.6%, and a Mean Absolute Percent Error (MAPE) of 3.22%.

3. ADJUST LOAD

Once the regression models are complete and the forecast accuracy is maximized, the load forecast is adjusted to account for the impact (both historical and forward-looking) of cold climate heat pumps (CCHP), electric vehicles (EV), and net metering. As new electricity-using devices, CCHPs and EVs increase the load. However, by its nature, net metering decreases it[2].

Because the historical trends for these three items are still nascent, they cannot be effectively captured in the regression equations. In the case of net metering, VPPSA used the most recent three-year average to determine the rate of net metering growth in LED. For CCHPs and EVs, we used the same data (provided by Itron) that the Vermont System Planning Committee (VSPC) used in VELCO's 2018 Long Range Transmission Plan.

Notice that the adjusted load does not account for the presence of the Standard Offer Program. This is a deliberate choice that enables the resource planning model to treat the Standard Offer Program as a supply-side resource instead of a load-reducer.

4. RETAIL SALES

A forecast of retail sales is required to estimate compliance with the Renewable Energy Standard (RES) and is calculated by subtracting Vermont transmission and local distribution losses from the Adjusted Forecast.

[2] For more information on net-metering, please refer to https://vppsa.com/energy/net-metering/.

ENERGY FORECAST RESULTS

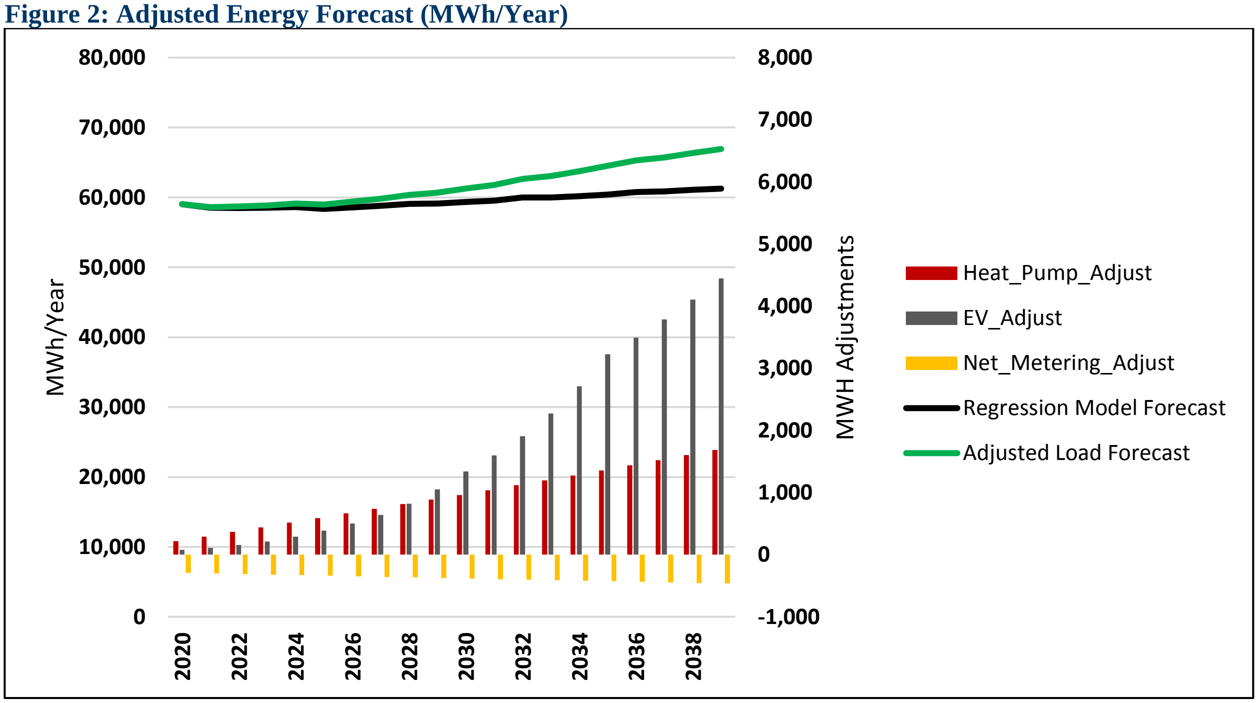
Table 6 shows the results of the Regression Forecast for energy, as well as the adjustments that are made to arrive at the Adjusted Forecast. The Compound Annual Growth Rates (CAGR) at the bottom of the table illustrate the trends in each of the columns. Notice that the Regression Forecast is increasing by 0.2% per year. After making adjustments for CCHPs, EVs, and net metering, the Adjusted Forecast increases by 0.6% per year.

Table 6: Adjusted Energy Forecast (MWh/Year)

Year	Year #	Regression Fcst. (MWh)	CCHP Adjustment (MWh)	EV Adjustment (MWh)	Net Metering Adjustment (MWh)	Adjusted Fcst. (MWh)
2020	1	59,030	219	76	-295	59,031
2025	6	58,352	590	386	-339	58,988
2030	11	59,340	962	1,338	-384	61,256
2035	16	60,387	1,357	3,225	-429	64,540
2039	20	61,255	1,687	4,447	-465	66,924
CAGR		**0.2%**	**10.7%**	**22.5%**	**2.3%**	**0.6%**

The Adjusted Forecast is the result of high CAGRs for heat pumps (10.7%) and electric vehicles (22.5%). During the first seven years of the forecast, these two trends are offset by the net metering program, which grows by the historical three-year average of 2.3% per year. By 2027, the impact of HPs and EVs is greater than the impact of net metering, and load growth begins to noticeably increase, as shown in Figure 2.

Figure 2: Adjusted Energy Forecast (MWh/Year)



All of the trends in these adjustments are highly uncertain. In addition, they offset each other, and their collective impact on the forecast is small. Specifically, their individual and collective impact represents fractions of 1%, which falls well within the forecast error (3.22%).

ENERGY FORECAST – HIGH & LOW CASES

To form a high case, we assumed that the CAGRs for CCHPs almost doubles to 20%, and the growth rate for EVs rises by a third to 30%. Simultaneously, we assume that net metering penetration stops at today's levels. At these growth rates, the market penetration for CCHPs and EVs reaches approximately 100% (all 1,900 customers) in 2039. This is admittedly a rough underestimate because most households and buildings will have more than one CCHP and more than one car. Nevertheless, it gives a reasonable indication of the kind of growth in energy use that is possible: 1.8% per year. This growth rate results in a 34% increase over 2020 electricity use.

Table 7: Energy Forecast – High Case

Year	Year #	Regression Fcst. (MWh)	CCHP Adjustment (MWh)	EV Adjustment (MWh)	Net Metering Adjustment (MWh)	Adjusted Fcst. (MWh)
2020	1	59,030	219	76	-295	59,030
2025	6	58,352	573	302	-295	58,932
2030	11	59,340	1,498	1,202	-295	61,745
2035	16	60,387	3,917	4,781	-295	68,791
2039	20	61,255	8,453	14,428	-295	83,841
CAGR		**0.2%**	**20.0%**	**30.0%**	**0.0%**	**1.8%**

To form a low case, we assumed that the CAGRs for CCHPs and EVs decreases by more than 50% from the base case. In addition, we assumed that the CAGR for net metering nearly doubles. This combination of trends is a worst-case, but still plausible, scenario, and results in a forecast that *increases* by 0.2% per year. Like the base case, this rate of change is well within the forecast error.

Table 8: Energy Forecast - Low Case

Year	Year #	Regression Fcst. (MWh)	CCHP Adjustment (MWh)	EV Adjustment (MWh)	Net Metering Adjustment (MWh)	Adjusted Fcst. (MWh)
2020	1	59,030	219	76	-295	59,030
2025	6	58,352	284	126	-362	58,399
2030	11	59,340	367	208	-445	59,470
2035	16	60,387	475	344	-547	60,660
2039	20	61,255	584	515	-645	61,710
CAGR		**0.2%**	**5.0%**	**10.0%**	**4.0%**	**0.2%**

PEAK FORECAST METHODOLOGY: THE PEAK & AVERAGE METHOD

The peak forecast regression model forecasts the load during the peak hour each day. Because utility loads are strongly influenced by temperature, this peak usually occurs during an hour of relatively extreme temperatures. In winter, this is during a very cold hour, and in summer it is during a very hot hour.

Unlike the energy forecast model, using average weather in the peak forecast model is not appropriate. Why? By definition, the coldest day and hour is always colder than average, and the hottest day and hour is always hotter than average. As a result, using average weather in the peak forecast model would result in a forecast that is biased and too low. In this context, the key question is, "How can historical weather data be used to develop an accurate representation of future weather, while still maintaining the extremes?"

The answer is the rank-and-average method, which is widely accepted[3] and effectively represents the random, real-life extremes in average historical weather. This method assigns a temperature to each day of the year that is representative of the average of the coldest (or hottest) days. It is important to highlight that the rank and average method produces a "50/50" forecast. While one may expect this to be a method for forecasting extreme weather conditions, in reality extreme weather *is* normal.

The accuracy of the peak forecast regression model is good. Based on daily data, it has an R-squared of 83.2%, and a MAPE of 10%.

PEAK FORECAST RESULTS

Table 9 shows the results of the Regression Forecast of peak loads, as well as the adjustments that are made to arrive at the Adjusted Forecast. The CAGR at the bottom of the table illustrate the trends in each of the columns. Notice that the Regression Forecast itself is not changing. It is forecast to be flat. After making adjustments for CCHPs, EVs, and net metering, the Adjusted Forecast actually increases by 0.4% per year. Finally, the table shows that the timing of LED's peak load is forecast to stay in December, at hour 1800 (6:00 PM).

Table 9: Peak Forecast (MW)

MMM-YY	Day	Peak Hour	Regression Forecast	EV Adjustment	CCHP Adjustment	Net Metering Adjustment	Adjusted Forecast
Dec-20	28	18	13.3	0.01	0.06	-0.01	13.4
Dec-25	31	18	13.3	0.05	0.17	-0.01	13.5
Dec-30	27	18	13.4	0.19	0.28	-0.01	13.8
Dec-35	28	18	13.5	0.45	0.40	-0.02	14.3
Dec-39	28	18	13.5	0.62	0.49	-0.02	14.6
CAGR			**0.0%**	**22.9%**	**11.1%**	**3.5%**	**0.4%**

The Adjusted Forecast exceeds the Regression Forecast starting in 2020, but does not become noticeable until after 2025. This is the result of high CAGRs for CCHPs (11.1%) and EVs (22.9%). Unlike the energy forecast, the net metering program does not offset the impacts of EVs and HPs because solar panels are not producing energy at the peak month and hour in this forecast. Notice that the size of the adjustments are small (measured in tenths of a MW), and that the peak load forecast grows by 1.2 MW or 9% by 2039. This can be seen in Figure 3, which shows the peak forecast net of adjustments.

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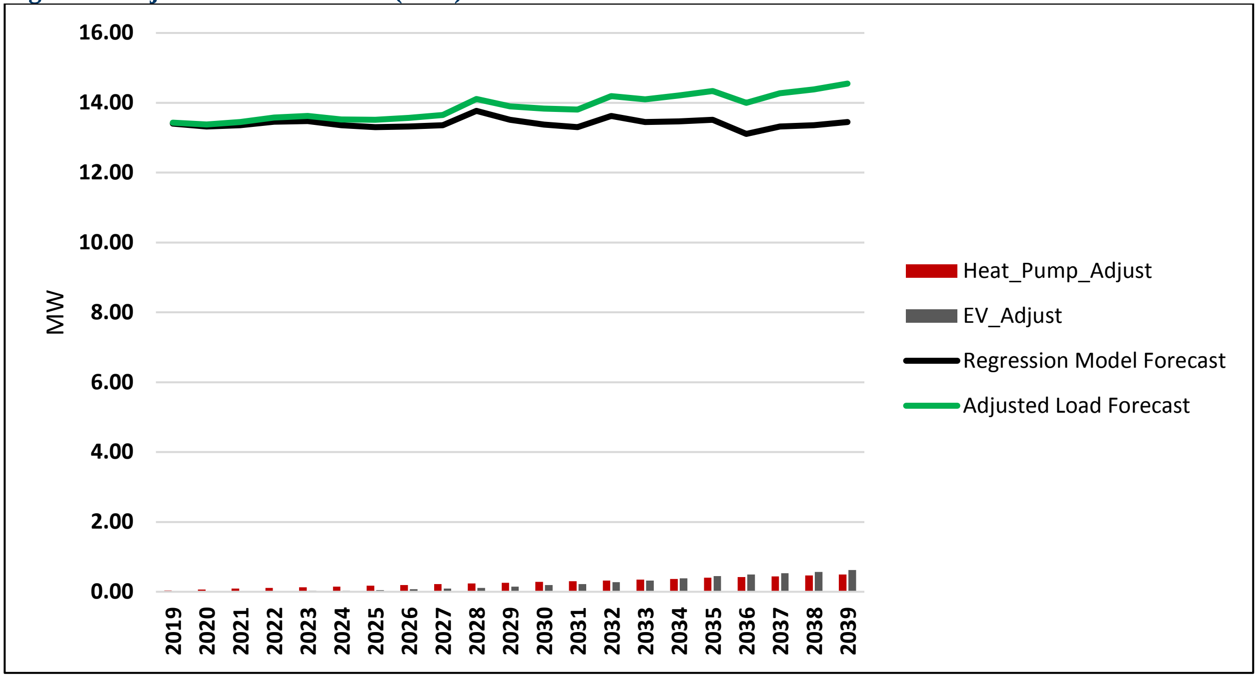
[3] For a more in-depth discussion of the method, please refer to Itron's white paper on the topic. https://www1.itron.com/PublishedContent/Defining%20Normal%20Weather%20for%20Energy%20and%20Peak%20Normalization.pdf

Figure 3: Adjusted Peak Forecast (MW)



PEAK FORECAST – HIGH & LOW CASES

To form a high-case, we assume that neither load controls nor Time-of-Use (TOU) rates are implemented, and then we adopt the same CAGR assumptions from the high case as in the energy forecast. Even under these assumptions, peak load growth does not start to materially impact the system until after 2030. Absent a step change in consumer adoption of CCHPs and EVs, electrification is not likely to produce any peak load growth for the next ten years. However, we will continue to monitor these trends annually during our budget forecasting process.

Table 10: Peak Forecast – High Case

MMM-YY	Day	Peak Hour	Regression Forecast	CCHP Adjustment (MW)	EV Adjustment (MW)	Net Metering Adjustment (MW)	Adjusted Fcst. (MW)
Dec-20	17	18	4.8	0.03	0.00	0	4.8
Dec-25	18	18	4.5	0.09	0.00	0	4.6
Dec-30	18	18	4.4	0.29	0.02	0	4.7
Dec-35	18	18	4.5	0.96	0.09	0	5.6
Dec-39	19	18	4.4	2.50	0.30	0	7.2
CAGR			**-0.4%**	**24.2%**	**33.0%**	**0.0%**	**2.1%**

A plausible low case for the peak forecast would involve applying TOU electric rates and load control devices on all of the major end uses, especially CCHPs and EVs. In theory, this strategy could completely offset any peak load growth resulting from CCHPs and EVs. As a result, it is not necessary to quantify a low case scenario. Peak loads would simply match the Regression Forecast without any adjustments.

FORECAST UNCERTAINTIES & CONSIDERATIONS

Despite strong growth in CCHPs and EVs, LED's electricity demand is expected to be quite flat over the forecast period. However, several uncertainties do exist.

LED presently has about three dozen net metered customers. However, as solar net metering costs continue to decline, the cost of net metered solar could reach parity with the price of grid power. If state policy continues to be supportive of net metering in this event, it could lead to a step change in the adoption rate of net metering, and a quicker erosion of retail sales and revenues for the utility. However, sensitivity analysis indicates that the adoption rate for net metering would have to increase threefold (from 1.9% per year to over 6.0% per year) before it would negate the sales-increasing impact of CCHPs and EVs. This outcome is not likely in the near-term and can be captured in a subsequent Integrated Resource Plan.

A more realistic possibility is that a large net metered project is built. For example, a 500 kW net metered solar project built in 2020 would over double the base of installed, net metered capacity (presently about 200 kW) on the system. In this event, the impact would be captured in interconnection and annual power budgeting processes, and managed accordingly.

LED's largest customers represent an uncertainty to the load forecast, and a major increase or decrease in their capacity or equipment could impact the utility. As a result, LED will continue to work with them to monitor the status of their operations.

ELECTRICITY SUPPLY

II. ELECTRICITY SUPPLY

LED's power supply portfolio is made up of generation resources, long-term contracts, and short-term contracts. The portfolio acts as a diversified, financial hedge that buffers LED and its customers from the cost and volatility of buying electricity from ISO New England on the spot market at the Vermont Zone. The following sections describe each of the 14 power supply resources in LED's portfolio.

EXISTING POWER SUPPLY RESOURCES

1. **Chester Solar**
LED holds a 26.3% (1.26 MW) entitlement in a 4.8 MW solar facility in Chester, Massachusetts. The facility began commercial operation in June 2014, and the Purchased Power Agreement (PPA) includes energy and capacity on a unit contingent basis for a period of 25 years. Renewable energy credits are not included.

2. **Fitchburg Landfill**
LED holds a 17% (818 kW) entitlement of a landfill gas-fired generator at the Fitchburg Landfill in Westminster, MA. Beginning in 2012, the 15-year PPA provided nine participating VPPSA members with 3 MW of firm energy, capacity and renewable attributes for five years. Between 2017 and 2021, the contract supplies 3 MW of firm energy, capacity and renewable attributes plus 1.5 MW of unit contingent energy, capacity and renewable attributes. From 2022 to 2026, the participants will receive 4.5 MW of unit contingent energy, capacity and renewable attributes. The contract includes an option to extend deliveries for an additional five years (2027-2031).

3. **Hydro Quebec US (HQUS)**
In 2010, a long-term, statewide Purchased Power Agreement (PPA) with Hydro Quebec was signed. LED's entitlement under the contract is presently 0.00205% (434 kW) and the kW entitlement will change in future years as shown in the following table.

Time Period	LED Entitlement
Nov 1, 2020 – Oct 31, 2030	434 kW
Nov 1, 2030 – Oct 31, 2035	447 kW
Nov 1, 2035 – Oct 31, 2038	110 kW

HQUS energy will, based on an annual attestation, largely qualify for Vermont RES Tier 1 compliance, though the resource does not generate marketable RECs at this time.

4. **Kruger Hydroelectric Facilities**
The Kruger Hydroelectric Facilities consist of six small facilities in Maine and Rhode Island; Barker Lower, Barker Upper, Blackstone, Brown's Mill, Gardiner and Pittsfield. Their output (excluding renewable attributes) was purchased by VPPSA under three long-term purchased power agreements signed in February 2017. LED has an agreement with VPPSA to purchase 19.29% of their collective output. Finally, these contracts do not include RECs.

5. **McNeil**
VPPSA is a joint owner of McNeil, a 54 MW (summer claimed capability rating) wood-fired generator in Burlington, VT. LED is entitled to a 2.0% share of both the costs and output of the facility. We assume that McNeil is available throughout the forecast period. Finally, McNeil is qualified under a number of state Renewable Portfolio Standards.

6. **New York Power Authority (NYPA) – Niagara**
NYPA provides power to utilities in Vermont under two contracts: Niagara and St. Lawrence. LED's share of the Niagara facility is 3.31% (266 kW), and ends on September 1, 2025. We assume that the

contract is renewed through 2039. Finally, the Niagara contract energy qualifies as a Vermont RES Tier 1 resource though the resource does not generate marketable RECs at this time.

7. **New York Power Authority (NYPA) – St. Lawrence**
LED's share of the St. Lawrence facility is 1.0% (17 kW). The contract ends on April 30, 2032 but we assume that the contract is renewed through the rest of the forecast period.

8. **NextEra 2018-2022**
LED has a PPA with VPPSA to purchase firm, fixed price energy with NextEra, which provides energy from Seabrook Station, a nuclear facility in Seabrook, New Hampshire. LED has an 16.5% (2.8 MW) share of the on-peak energy and a 17.6% (2.1 MW) share of the off-peak energy, which expires on December 31, 2022. While this resource is not qualified under any state RPS, it is tracked separately due to its carbon-free emission profile.

9. **Project 10**
LED has an agreement with VPPSA to purchase a portion of the power produced by Project 10, an oil-fired peaking generator located in Swanton, VT. LED's share of Project 10's benefits and costs is 10%, and we assume that Project 10 is available throughout the forecast period.

10. **Public Utilities Commission (PUC) Rule 4.100**
LED is required to purchase power from small power producers through Vermont Electric Power Producers, Inc. (VEPP Inc.), in accordance with PUC Rule 4.100. LED's share of VEPPI power in 2018 was 0.88%, and the current contracts between VEPP Inc. and its power producers will expire in 2020. We assume that there are no new participants in the 4.100 program for the rest of the forecast period. This is consistent with the relatively recent changes to Rule 4.100 that returned PURPA purchasing obligations to the host utility.

11. **Public Utilities Commission (PUC) Rule 4.300**
LED is required to purchase power from small power producers through the Vermont Standard Offer Program, in accordance with PUC Rule 4.300. Some of the Standard Offer resources are configured as load-reducers and are not settled in the wholesale markets, resulting in lower reported loads. LED's share of Standard Offer power in 2018 was 0.96%.

12. **Ryegate Facility**
LED receives power from the Ryegate biomass facility, a 20.5 MW generator in East Ryegate, Vermont. In 2018 LED received 0.93% of the energy from the plant. Under Vermont statutes, Ryegate is the only plant eligible to meet 30 V.S.A. § 8009, and at this time, we have assumed that there may be a renewal of the current contract upon expiration. As a result, we assume that the generator is available throughout the forecast period. Currently LED is entitled to a portion of the RECs produced by the facility.

13. **Stonybrook Station**
LED purchases 0.528% of the power from the Massachusetts Municipal Wholesale Electric Company's ("MMWEC") 352 MW Stony Brook Intermediate Project. The facility is located in Central Massachusetts and operates on natural gas or fuel oil. LED has a contingency commitment to make debt service payments whether or not the units are operating.

14. **Market Contracts**
LED meets the remainder of its load obligations through ISO New England's day-ahead and real-time energy markets, and through contracts (physical and financial) that are less than five years in duration. Market purchases range in size, duration, and counterparty, and are desined to balance LED's supply resources with its load obligations in ISO New England's markets.

Table 11 summarizes the resources in the portfolio based on a series of important attributes. First the megawatt hours (MWH) and megawatts (MW) are shown to show the relative size of each resource. The delivery pattern indicates what time of the day and week the resource delivers energy, and the price pattern indicates how the resource is priced. Notice that most of the resources are fixed price. This feature provides the hedge against spot market prices. If the resource produces Renewable Energy Credits[4] (RECs), that is indicated in the seventh column, followed by the resource's expiration date and whether we assumed that it would be renewed until 2039.

Table 11: Existing Power Supply Resources

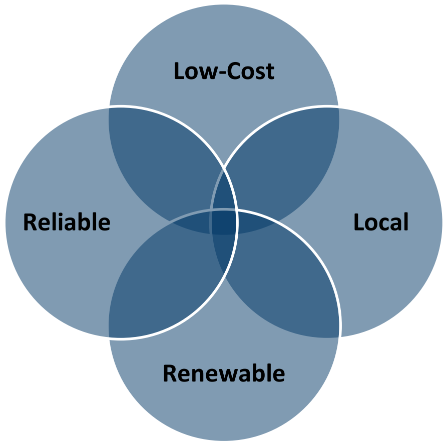
RESOURCE	2020 MWH	% of MWH	2020 MW	Delivery Pattern	Price Pattern	RECs	Expiration Date	Renewal to 2039
1. Chester Solar	1,776	3.1%	0.501	Intermittent	Fixed		6/30/39	No
2. Fitchburg Landfill	5,749	10.0%	0.571	Firm	Fixed	✓	12/31/31	No
3. HQUS	2,544	4.4%	0.000	Firm	Indexed	✓	10/31/38	No
4. Kruger Hydro	4,886	8.5%	0.191	Intermittent	Fixed		12/31/37	No
5. McNeil Facility	5,489	9.5%	1.04	Dispatchable	Variable	✓	Life of unit.	Yes
6. NYPA – Niagara	2,747	4.8%	0.464	Baseload	Fixed	✓	09/01/2025	Yes
7. NYPA – St. Lawrence	213	0.4%	0.013	Baseload	Fixed		04/30/2032	Yes
8. NextEra 2018-2022	11,534	20.0%	0.000	Firm	Fixed	✓	12/31/2022	No
9. Project 10	59	0.1%	3.865	Dispatchable	Variable		Life of unit.	Yes
10. PUC Rule 4.100	250	0.4%	0.036	Intermittent	Fixed		2020	No
11. PUC Rule 4.300	1,430	2.5%	0.012	Intermittent	Fixed	✓	Varies	No
12. Ryegate Facility	1,521	2.6%	0.117	Baseload	Fixed	✓	10/31/2021	Yes
13. Stonybrook Station	95	0.2%	1.569	Dispatchable	Variable		Life of unit.	Yes
14. Market Contracts	19,421	33.7%	0.000	Firm	Fixed		< 5 years.	N/A
Total MWH	**57,714**	**100.0 %**	**8.438**					

[4] Note that RECs are defiLED broadly in this table, and that the "emissions attributes" from non-renewable (but also non-carbon emitting) resources such as nuclear are included in this table.

FUTURE RESOURCES

LED will seek out future resources that meet as many of the following criteria as possible. Ideally, future resources will meet four criteria by being low-cost, local, renewable and reliable.

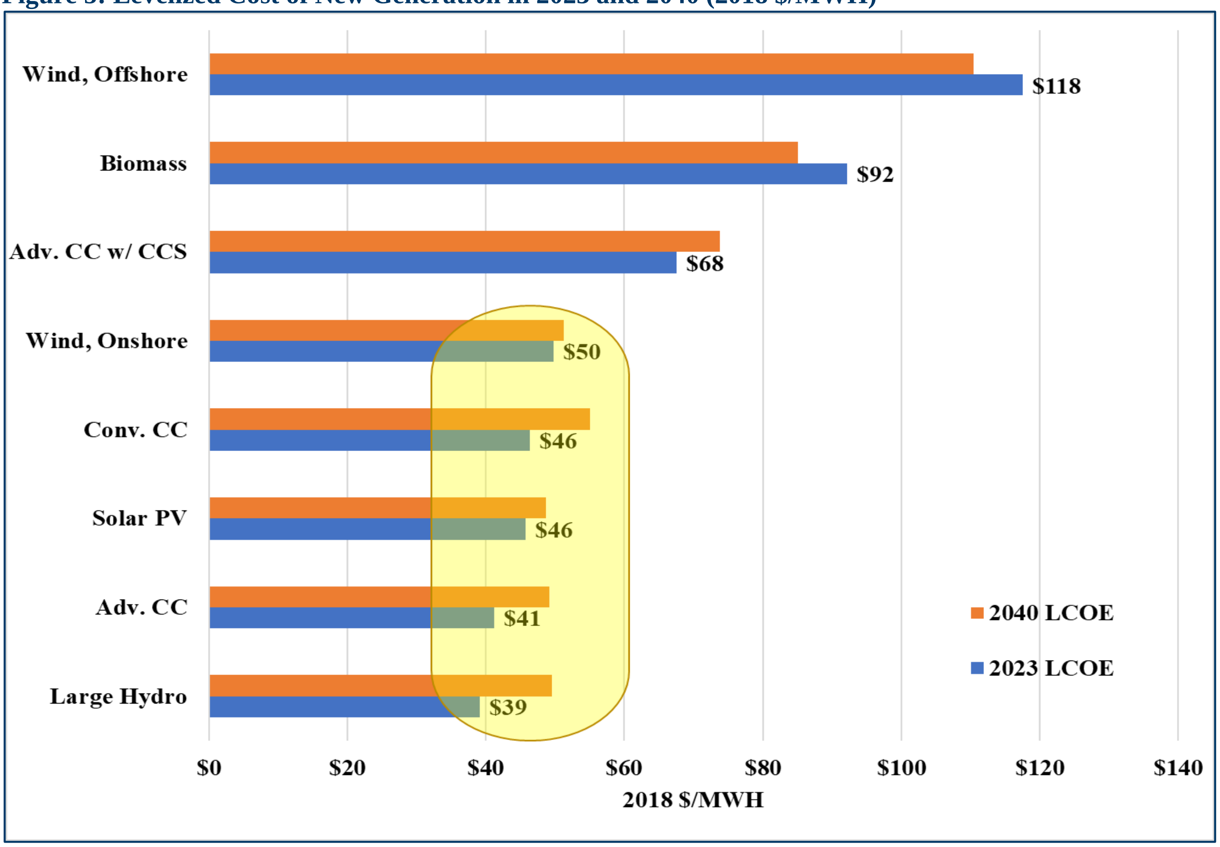
Figure 4: Resource Criteria



- ✓ **Low-Cost** resources reduce and stabilize electric rates.
- ✓ **Local** resources are located within LED's Regional Planning Commission area or within Vermont.
- ✓ **Renewable** resources meet or exceed RES requirements.
- ✓ **Reliable** resources not only provide operational reliability, but are also owned and operated by financially strong and experienced companies.

These criteria enable LED to focus on subset of generation technologies, and to exclude coal, geothermal and solar thermal generation which do not meet them. Resources that LED may consider fall into three categories: 1.) Existing resources in Table 11, 2.) Demand-side resources, and 3.) New resources in Figure 5.

Figure 5: Levelized Cost of New Generation in 2023 and 2040 (2018 $/MWH)[5]



[5] Source: US Energy Information Administration, https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf

While these cost estimates represent national averages, they do illustrate the competitive range of new generation technologies in and around the New England region. For example, ISO New England continues to get interconnection requests from all five of the lowest-cost technologies in Figure 5 (highlighted in yellow). In addition, LED would also evaluate new offshore wind and biomass projects, which continue to attract development in the region.

CATEGORY 1: EXTENSIONS OF EXISTING RESOURCES

This plan assumes that five existing resources are extended past their current expiration date. These include McNeil, Ryegate, Project 10, Stonybrook and NYPA. Depending on how contract negotiations align with the Resource Criteria, other existing resources may be extended including the Fitchburg Landfill Gas, NextEra 2018-2022, and Kruger Hydro resources. Where resource needs remain, market contracts will be used to supply them.

1.1 MARKET CONTRACTS

Market contracts are expected to be the most readily available source of electric supply for energy, capacity, ancillary services and renewable attributes (RECs). By conducting competitive solicitations through VPPSA, LED can not only get access to competitive prices (low-cost), but it also can structure the contracts to reduce volatility (stable rates) and potentially include contracts for RECs for RES compliance. Market contracts are also scalable and can be right sized to match LED incremental electric demands by month, season and year. In many cases, the delivery point for market contracts can be set to the Vermont Zone reducing potential price differential risks between loads and resources. Finally, the financial strength of the suppliers in the solicitation can be predetermined. The combination of these attributes makes market contracts a good fit for procuring future resources.

CATEGORY 2: DEMAND-SIDE RESOURCES

The lowest cost, most local source of energy is often energy that is conserved or never consumed. As a result, LED will continue to welcome the work of the Efficiency Vermont (EVT) and Capstone Community Action in its service territory. LED will also continue to work with its customers, both large and small, to uncover demand response opportunities. This includes best practices for demand management as LED continues to implement its energy transformation programs under RES.

CATEGORY 3: NEW RESOURCES

VPPSA regularly meets with developers throughout New England, and through VPPSA staff, LED will continue to monitor and evaluate new generation resources in the New England region.

3.1 WIND GENERATION (ON AND OFF-SHORE)

On-shore wind projects continue to be developed in New England, and entitlements to such projects can often be negotiated at competitive prices. RECs are often bundled into the PPA, making this resource a good fit for the low-cost and renewable criteria. Off-shore wind projects are in development, but the costs remain substantially higher than for on-shore wind. As a result, LED would approach such projects with more reserve.

3.2 GAS-FIRED GENERATION

As Project 10 approaches an investment in a major overhaul and the requirements for reserves, voltage support and other ancillary services shift, LED will investigate simple and combined cycle (CC) generation. This includes entitlements to new or existing plants in New England, and to traditional peaking generation which continue to provide reliable peak-day service to the New England region. It should be noted that as a participant in ISO New England's markets, the marginal cost of supply is set by these same resources, and that the benefit of owning an entitlement in one is primarily to reduce heat rate risk.

3.3 SOLAR GENERATION

Solar development is increasingly common and cost-effective, particularly at utility scales. Plus, it can be deployed locally. Furthermore, solar is expected to be the primary technology that is employed to meet its Distributed Renewable Energy (TIER II) requirements under RES. For these reasons, solar is likely to be a leading resource option, and LED will continue to investigate solar developments both within its service territory and outside of it.

3.3.1 NET METERING

While net metering participation rates are presently modest and are forecast to grow modestly, LED will monitor the participation rate closely as solar costs approach grid parity. Should grid parity occur, not only would net metered solar penetration be expected to take off but the costs of the existing program would likely cause upward rate pressure[6]. As a result, net metered solar is an inferior option when compared to lower-cost and utility scale solar projects.

3.4 HYDROELECTRIC GENERATION

Hydroelectric generation is widely available in the New England region, and can be purchased within the region or imported from New York and Quebec. Furthermore, it can be sourced from either small or large facilities. Like all existing resources, price negotiations begin at or near prevailing market prices. As a result, existing hydro generation could be both low-cost (or at least at market) and renewable.

BATTERY STORAGE

Any discussion of future resources would be remis without including battery storage. While still in its initial phase of commercialization, there are six use cases where storage is being installed. According to a recent analysis by Lazard[7], use cases fall into two categories:

1. **In-Front-of-the-Meter**
   a. Wholesale (Used as a replacement for peaking generation.)
   b. Transmission and Distribution (Used to defer or replace traditional T&D investments.)
   c. Utility-Scale (Solar + Storage)

2. **Behind-the-Meter**
   a. Commercial & Industrial (Used as a standalone way to reduce demand charges.)
   b. Commercial & Industrial (Solar + Storage)
   c. Residential (Solar + Storage)

All of the In-Front-of-the-Meter use cases are large-scale, and small public power utilities like LED may be best served by participating in such projects as a joint owner or entitlement holder, not the lead participant. However, where local T&D constraints are present or when utility-scale solar plus storage sites are being developed, LED will work through VPPSA to quantify the business case. Similarly, the business case for Behind-the-Meter applications will be quantified as those opportunities are identified.

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[6] An excellent discussion of net metering and rate-design policy issues by Dr. Ahmad Faruqui can be found in the October 2018 issue of Public Utilities Fortnightly. https://www.fortnightly.com/fortnightly/2018/10/net metering-faq

[7] For a current analysis and list of use cases, please refer to the "Levelized Cost of Storage Analysis – Version 4.0", Lazard, November 2018. https://www.lazard.com/perspective/levelized-cost-of-energy-and-levelized-cost-of-storage-2018/

REGIONAL ENERGY PLANNING (ACT 174)

As part of the Southern Windsor County Regional Planning Commission (SWCRPC), LED is part of a Regional Energy Plan that was approved by the SWCRPC Board of Commissioners in June 2018. The purpose of the plan is to give the SWCRPC greater input into local energy permitting decisions before PUC, as explained in the Executive Summary:

> “The intent of this plan is to serve as the energy element of the Southern Windsor County Regional Plan per 24 V.S.A. §4348a(a)(3) as well as to meet the requirements of an “Enhanced Energy Plan” in accordance with 24 V.S.A. §4352. The Southern Windsor County Regional Planning Commission (SWCRPC) intends to submit this Plan to the Commissioner of Public Service for a determination of energy compliance, which would enable this document to receive “substantial deference” in Section 248 proceedings.”[8]

This plan is presently before PUC, and is expected to give SWCRPC “substantial deference” before PUC for applications that seek a Certificate of Public Good (CPG). The full plan is included in the appendix, and all future resource decisions will be made with this plan in mind. Specifically, LED will consult with the SWCRPC on resource decisions that involve potential siting of new resource in Vermont.

[8] Southern Windsor County Regional Energy Plan, Southern Windsor County Regional Planning Commission, June 25, 2018, Page iii

RESOURCE PLAN

III. RESOURCE PLANS

DECISION FRAMEWORK

LED will generally evaluate major policy decisions, such as resource acquisitions, using the integrated financial model developed in this IRP. The primary quantitative evaluation metric will be the impact that a decision has on LED’s retail cost of service per kWh over time. (i.e the effect on the rate trajectory)

When evaluating significant decisions, LED will identify the key variables whose potential range of possible outcomes (due to uncertainty) has the largest impact on the retail costs of service per kWh. LED will consider the impacts on potential decisions of changes from the base case assumptions to assist in evaluating the risks associated with the decision. This analysis could include evaluating ranges of potential values for the key variables either via simple replacement of the base assumptions in either the power supply or the integrated financial model as appropriate. Another potential (and similar) evaluation would be to review the decision under extreme (but improbable values) to consider how sensitive the decision is to unexpected outcomes.

Some decisions, such a simple or short-term resource acquisitions, may not have integrated effects. In such cases, the impact of the resource decision on power costs may be used as a proxy for the relative impact on overall retail costs per kWh.

For example, a simple choice between two resources could be evaluated in this streamlined manner. (Assuming that the resources do not impact non-power supply costs, retail sales volumes, or are not needed under all load forecast cases.) Decisions with small relative impacts may not warrant detailed evaluation at all. It is important to scale the effort spent evaluating a decision, to its potential impact on the utility. Larger decisions that impact power supply costs, as well as non-power-supply costs and/or sales volumes would generally require the use of the full financial model to evaluate.

Any quantified potential impact on rates, determined either through the power supply or integrated financial model, will be considered in conjunction with other metrics that are less easily converted to numerical values in the final decision-making process. Such factors might include resource diversity, risk of fundamental changes in market rules, and other factors.

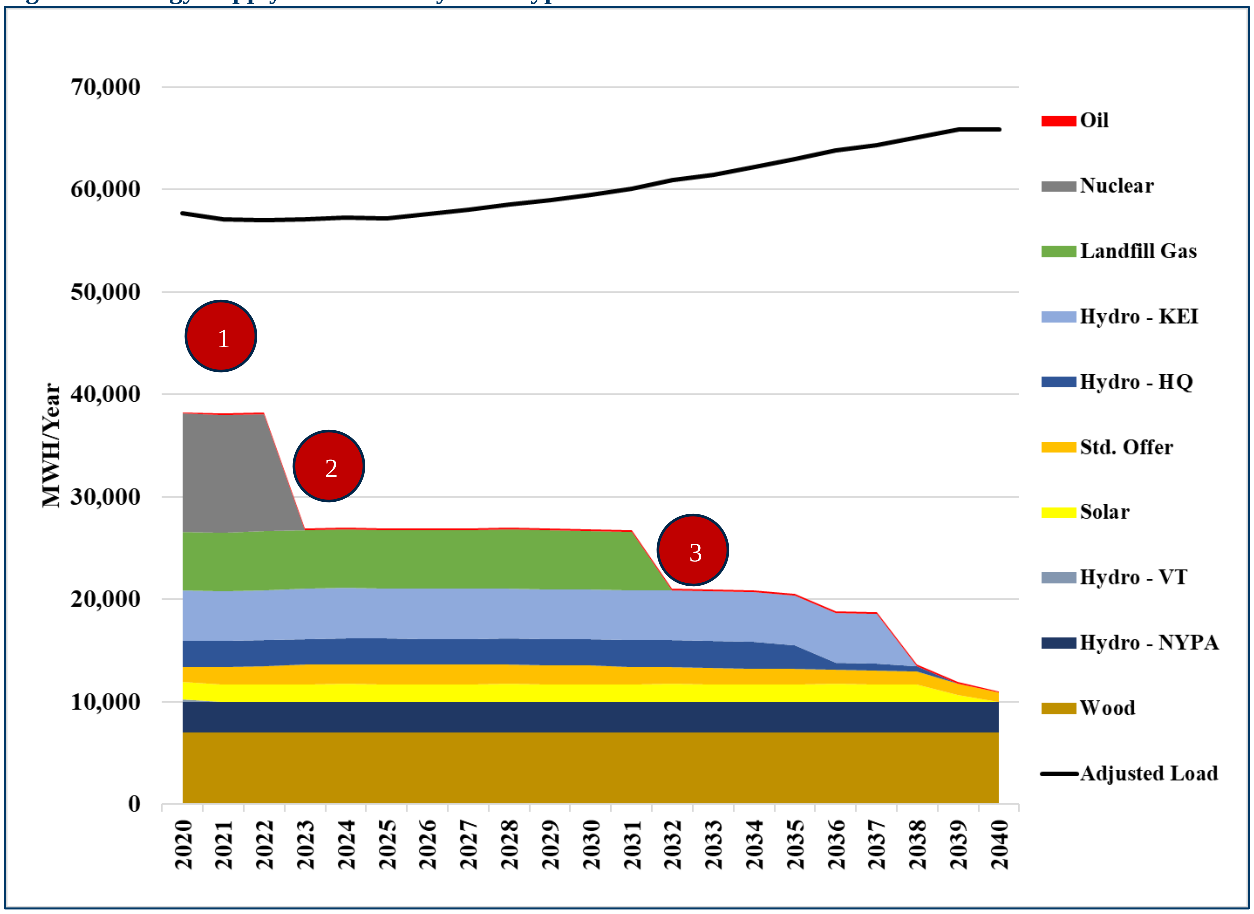
ENERGY RESOURCE PLAN

Figure 6 compares LED's energy supply resources to its adjusted load. There are three major resource decisions that, in total, will affect about 60% of LED's energy supply between 2020 and 2031. Importantly, the first two decisions occur during the first three years of the forecast period (2020-2022), and these two decisions will affect about 50% of LEDs energy supply.

DECISION 1: 2020-2022

First, notice that about two-thirds of LED's energy requirements are hedged by long-term resources between 2020 and 2022. The remaining third will be hedged before the start of each calendar year by purchasing fixed-price market contracts. The cost and rate impact of this short-term purchase is expected to be minimal, neither increasing nor decreasing LED's overall energy costs.

Figure 6: Energy Supply & Demand by Fuel Type



DECISION 2: 2023+

The second resource decision occurs at the end of 2022 when the NextEra 2018-2022 Contract expires. This can be seen in Figure 6 by the decrease in the gray-shaded "Nuclear" area. This contract supplies about a fifth of LED's energy, and represents a significant energy resource decision. (Because this is an energy-only resource, it is not a significant capacity resource decision.) Because the pricing in the NextEra 2018-2022 Contract is very similar to the forecast of market prices, cost and rate impacts are expected to be neutral.

As indicated in the Electricity Supply chapter, LED may elect to negotiate a new or extended contract with NextEra. However, the timing of the contract's expiration coincides with a 4% increase in the Total

Renewable Energy (TIER I) requirements (from 59% to 63%) under RES. As a result, LED may consider an energy resource that includes low-cost renewable energy credits such as an existing hydro facility. In any event, the resource decision will be made with LED's Resource Criteria (Figure 4) in mind, and the term of the new resource will be negotiated so that it does not expire at the same time as the other major resources in the portfolio, namely the Fitchburg Landfill Gas Facility which expires at the end of 2031.

DECISION 3: 2032+

The third major resource decision will coincide with the expiration of the Fitchburg Landfill Gas contract. This resource will represent about 10% of LED's energy requirements in 2031, and because it produces premium RECs that are being sold out-of-state to reduce the overall cost of the portfolio, it does not impact RES compliance. However, its expiration will be just one year before the culmination of RES. As a result, the decision to extend this contract or replace it with another resource will be influenced by RES requirements and any subsequent energy policies that are being considered at that time. Finally, the market value of this resource is presently forecast to be about the same as its costs, and if this turns out to be the case, then the cost and rate impacts of this resource decision may be neutral. Table 12 summarizes the energy resources decisions LED faces in the coming twelve years.

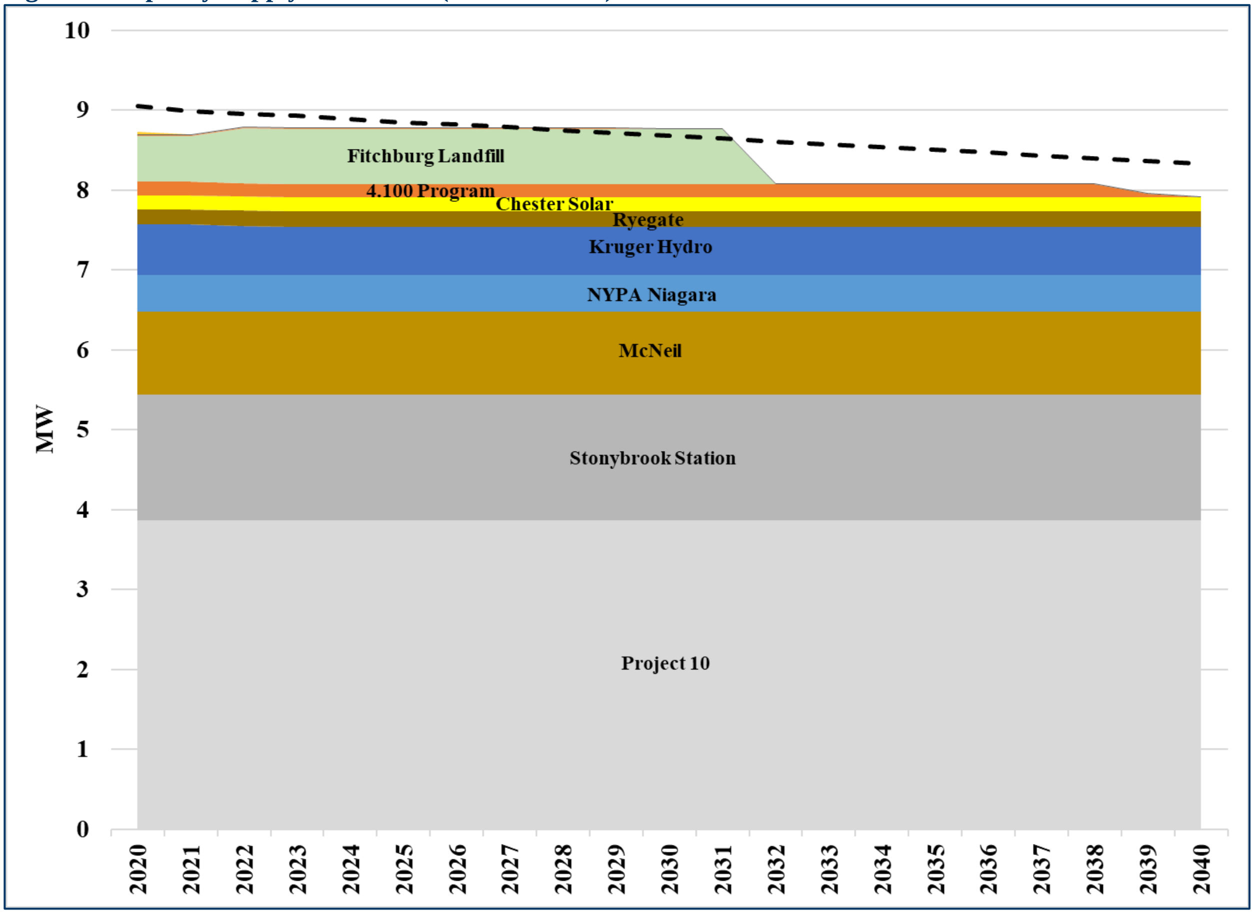
Table 12: Energy Resource Decision Summary

Resource	Years Impacted	% of MWH	Rate Impact	RES Impact
1. Short-Term Market Purchases	2020-2022+	33%	Neutral	None
2. NextEra 2018-2022	2023+	20%	Neutral	Possible
3. Fitchburg Landfill Gas	2032+	10%	Neutral	Possible

CAPACITY RESOURCE PLAN

Figure 7 compares LED's capacity supply to its demand. Three resources provide about 75% of LED's capacity. In 2020, Project 10 provides about 44% , Stonybrook Station provides about 18%, and McNeil provides another 12%.

Figure 7: Capacity Supply & Demand (Summer MW)



Because the supply of capacity is about equal to the demand, no resource decisions are necessary unless the reliability of Project 10, Stonybrook, or McNeil drops for an extended period of time. As a result, the reliability of these three resources will be the key to minimizing LED's capacity costs, as explained in the next section.

ISO NEW ENGLAND'S PAY FOR PERFORMANCE PROGRAM

Because LED is part of ISO New England, its capacity requirements are pooled with all of the other utilities in the region. As a result, if Project 10 or McNeil are not available, LED will be provided with (energy and) capacity by ISO New England. However, ISO New England's Pay for Performance[9] (PFP) program creates financial payments (and potential penalties) for generators to perform when the grid is experiencing a scarcity event.

[9] For an overview of the PFP program, please visit https://www.iso-ne.com/participate/support/customer-readiness-outlook/fcm-pfp-project.

The following table illustrates the range of performance payments that LED's 10% share of Project 10 creates in ISO New England's PFP Program. Depending on ISO-NE's load at the time of the scarcity event and Project 10's performance level, LED could receive up to a $5,000 payment or pay up to a $6,000 penalty during a one-hour scarcity event. This represents a range of +7% or -9% of LED's monthly capacity budget. However, such events are not expected to occur more than a few times a year (if at all), and they frequently last less than one hour.

Table 13: Pay for Performance Ranges for One Hour of Project 10 Operation[10]

ISO-NE Load	Performance Payment Rate	0% Performance	50% Performance	100% Performance
10,000	$2,000/MWH	-$3,000	$1,000	$5,000
15,000	$2,000/MWH	-$4,000	$0	$4,000
20,000	$2,000/MWH	-$5,000	-$1,000	$3,000
25,000	$2,000/MWH	-$6,000	-$2,000	$2,000

[10] Please refer to the following presentation from ISO-NE for the details of how the performance payments are calculated. https://www.iso-ne.com/static-assets/documents/2018/06/2018-06-14-egoc-a4.0-iso-ne-fcm-pay-for-performance.pdf

RENEWABLE ENERGY STANDARD REQUIREMENTS

LED's obligations under the Renewable Energy Standard[11] (RES) are shown in Table 14. Under RES, LED must purchase increasing amounts of electricity from renewable sources. Specifically, its Total Renewable Energy (Tier I) requirements rise from 59% in 2020 to 75% in 2032, and the Distributed Renewable Energy[12] (Tier II) requirement rises from 2.8% in 2020 to 9.4% in 2032. Note that this plan assumes that both the Tier I and Tier II requirements are maintained at their 2032 levels throughout the rest of the study period.

Table 14: RES Requirements (% of Retail Sales)

Year	Tier I: Total Renewable Energy (A)	Tier II: Distributed Renewable Energy (B)	Net Tier I Net Total Renewable Energy (A) - (B)	Tier III: Energy Transformation
2020	59%	2.80%	56.20%	2.67%
2021	59%	3.40%	55.60%	3.33%
2022	59%	4.00%	55.00%	4.00%
2023	63%	4.60%	58.40%	4.67%
2024	63%	5.20%	57.80%	5.34%
2025	63%	5.80%	57.20%	6.00%
2026	67%	6.40%	60.60%	6.67%
2027	67%	7.00%	60.00%	7.34%
2028	67%	7.60%	59.40%	8.00%
2029	71%	8.20%	62.80%	8.67%
2030	71%	8.80%	62.20%	9.34%
2031	71%	9.40%	61.60%	10.00%
2032	75%	10.00%	65.00%	10.67%
2033-2039	75%	10.00%	65.00%	0.00%

Under RES, the Tier II requirements are a subset of the Tier I requirements. As a result, we subtract the Tier II percentage from the Tier I percentage to get the Net Tier I requirement in the fourth column. Notice that the net Tier I requirement declines every second and third year until the Tier I requirement increases. When these percentages are multiplied by the forecast of retail sales (which decline during the 2020-2030 period), the result is a seesaw effect where the Net Tier I requirement declines every second and third year. This effect can be seen more clearly in Figure 8 in the next section.

The final column shows the Energy Transformation (Tier III) requirement. Because it is designed to reduce fossil fuel use, the Tier III requirement is fundamentally different from Tier I and Tier II requirements. And unlike the Tier I and Tier II requirements…which count only electricity that is produced and consumed in an individual year[13]…Tier III programs account for the "lifetime" the fossil fuel savings. For example, if a Tier III program installs a CCHP in 2020, the fossil fuel savings from that CCHP are counted such that the full

[11] For more information on the RES program, please visit https://vppsa.com/energy/renewable-energy-standard/.

[12] Distributed Renewable Energy must come from projects that are located in Vermont, are less than five MW in size, and are built after June 30th, 2015.

[13] For simplicity, we assume that no banking occurs in this example. In practice, banking excess TIER I and TIER II credits for use in future years is permitted under RES.

ten-years of the CCHP's expected useful life accrue to the 2020 Tier III requirement. For this reason, we do not carry the 2032 requirement into the 2033-2039 period.

The RES statute provides a second way to comply with its requirements, the Alternative Compliance Payment (ACP). In the event that a utility has not achieved the requisite amount of Tier I, Tier II or Tier III credits in a particular year, then any deficit is multiplied by the ACP, and the funds are remitted to the Clean Energy Development Fund (CEDF).

However, utilities with a RES deficit may also petition the Public Utilities Commission (PUC) for relief from the ACP, or they may petition PUC to roll the deficit into subsequent compliance years. As a result, there are multiple ways to comply with RES requirements.

Table 15: ACP Prices[14] ($/MWH)

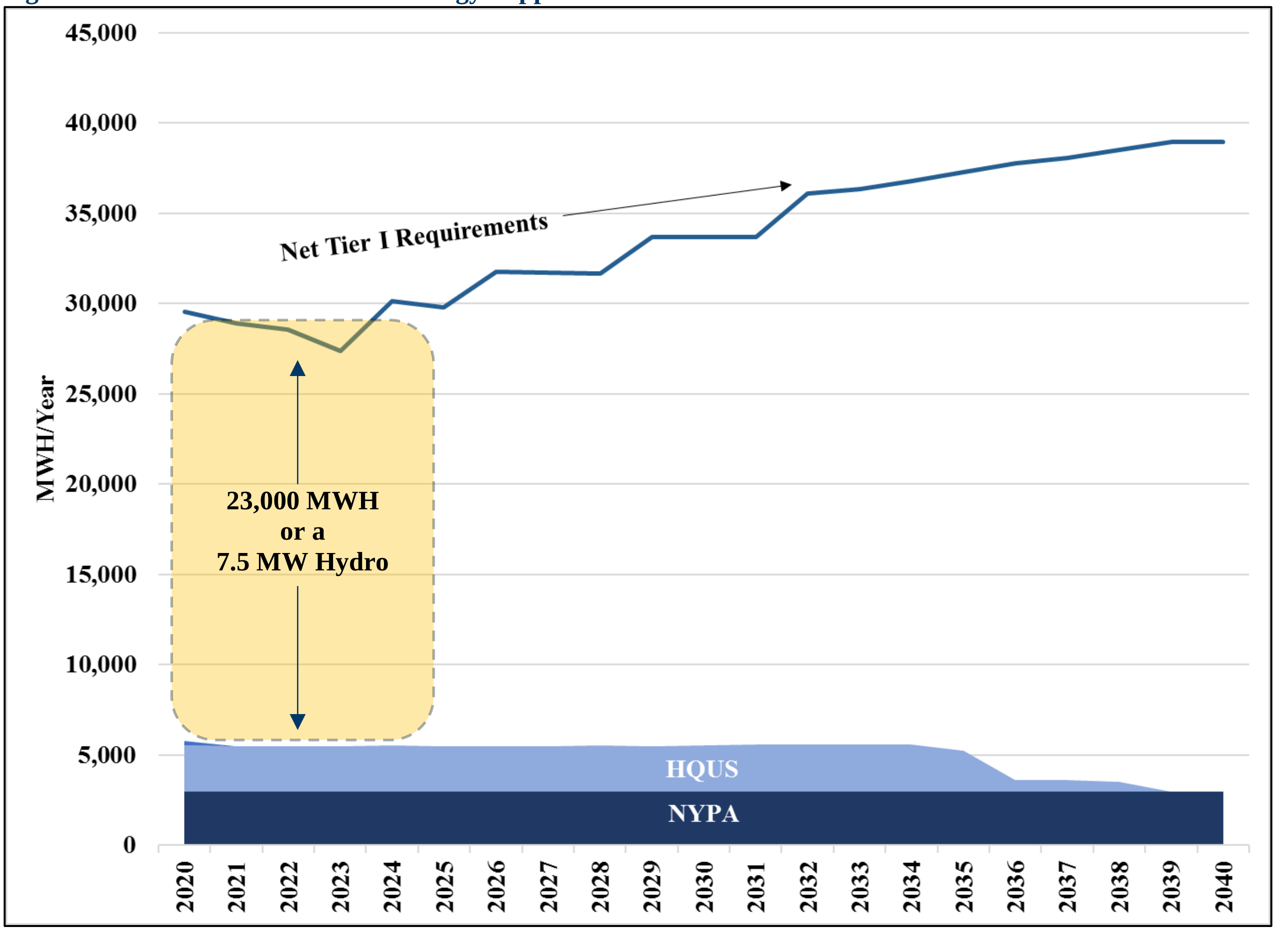
Year	TIER I	TIER II & III
2020	$10.00	$60.00
2021	$10.22	$61.32
2022	$10.44	$62.67
2023	$10.67	$64.05
2024	$10.91	$65.46
2025	$11.15	$66.90
2026	$11.39	$68.37
2027	$11.65	$69.87
2028	$11.90	$71.41
2029	$12.16	$72.98
2030	$12.43	$74.59
2031	$12.70	$76.23
2032	$12.98	$77.90

[14] Please note that these are estimates, and grow at inflation.

TIER I - TOTAL RENEWABLE ENERGY PLAN

Between 2020 and 2025, LED's Net Tier I requirement is about 28,000 MWH per year. There are three hydroelectric resources that contribute to meeting the Net Tier I requirement; NYPA, HQUS, and the (miniscule) remainder of PUC's 4.100 program. These resources add up to about 5,000 MWH per year or 22% of LED's Net Tier I requirement. Through 2025, the remaining Net Tier I requirement (deficit) is about 23,000 MWH.

Figure 8: Tier I -Total Renewable Energy Supplies



In the early years of the 2020s, LED is likely to meet its Net Tier I requirements by purchasing Maine Class II (ME II) Renewable Energy Credits (RECs). These are presently the lowest cost source of Tier I-compliant RECs in the region, and their price has ranged from a low of $1.00 to a high of $2.50 per MWH over the past four years. At the current price of $1/MWH, the cost of complying with Net Tier I in 2020 to 2025 period with ME II RECs would be about $23,000 per year.

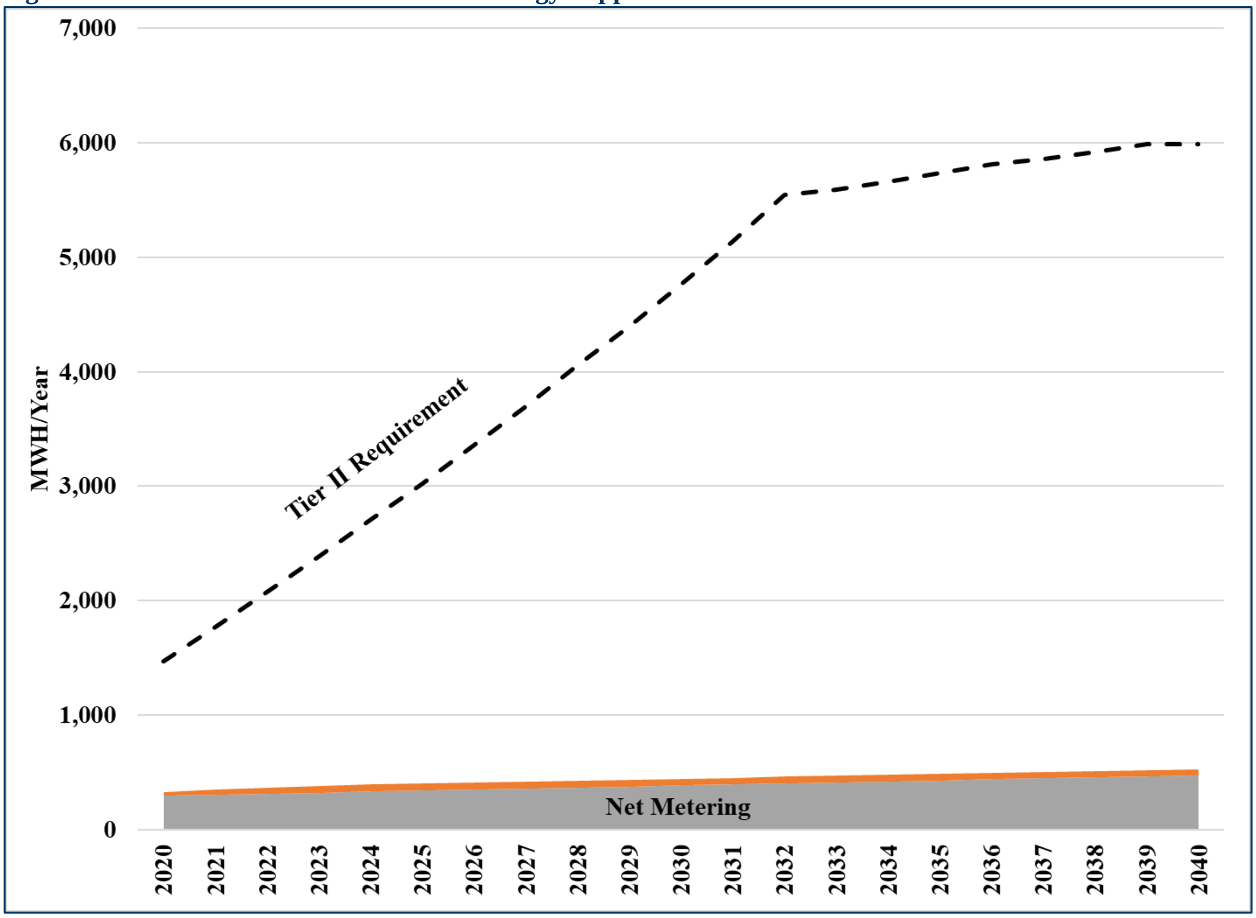
As mentioned in the Energy Resource Plan, the expiration of the NextEra 2018-2022 PPA creates an opportunity to purchase a resource that provides both energy and RECs. The 23,000 MWH per year deficit is equivalent to a 7.5 MW hydro facility[15], and if the output from a hydro resource of this size and capacity factor was purchased (including RECs), the Net Tier I deficit between 2023 and 2025 would be erased. To fulfill the entire Net Tier I requirement through 2032, a 11.5 MW hydro facility (35,000 MWH per year) would be necessary, and after 2032, a 12.5 MW hydro facility (38,000 MWH per year) would be necessary to maintain 65% Net Tier I.

[15] We have assumed a thirty-five percent capacity factor, which results in about 22,000 MWH per year.

TIER II - DISTRIBUTED RENEWABLE ENERGY PLAN

The dashed line in Figure 9 shows LED's Distributed Renewable Energy (Tier II) requirement, which rises steadily from about 1,500 MWH in 2020 to 5,500 MWH in 2032. The net metering program (plus a small contribution from PUC's 4.300 Program) is expected to fulfill about 20% of the Tier II requirement in 2020, but by 2025, these programs are expected to fulfill only about 13%. As a result, another Vermont-based renewable resource(s) will be required.

Figure 9: Tier II - Distributed Renewable Energy Supplies



This resource is likely to be a distributed solar project, and it needs to be at least 1 MW to fill the deficit in the early 2020s. By 2032, 3 MW of solar is required to meet and then maintain the Tier II percentage. If it is built early in the 2020's, a 3 MW project would also produce enough surplus MWH to fulfill the majority of the Energy Transformation (Tier III) requirements. In addition, it would contribute to meeting the objectives of the SWCRPC's Energy Plan. For these reasons, LED will seek to develop a 3 MW solar project in Southern Windsor County using the existing partnership between VPPSA and Encore Renewable Energy[16].

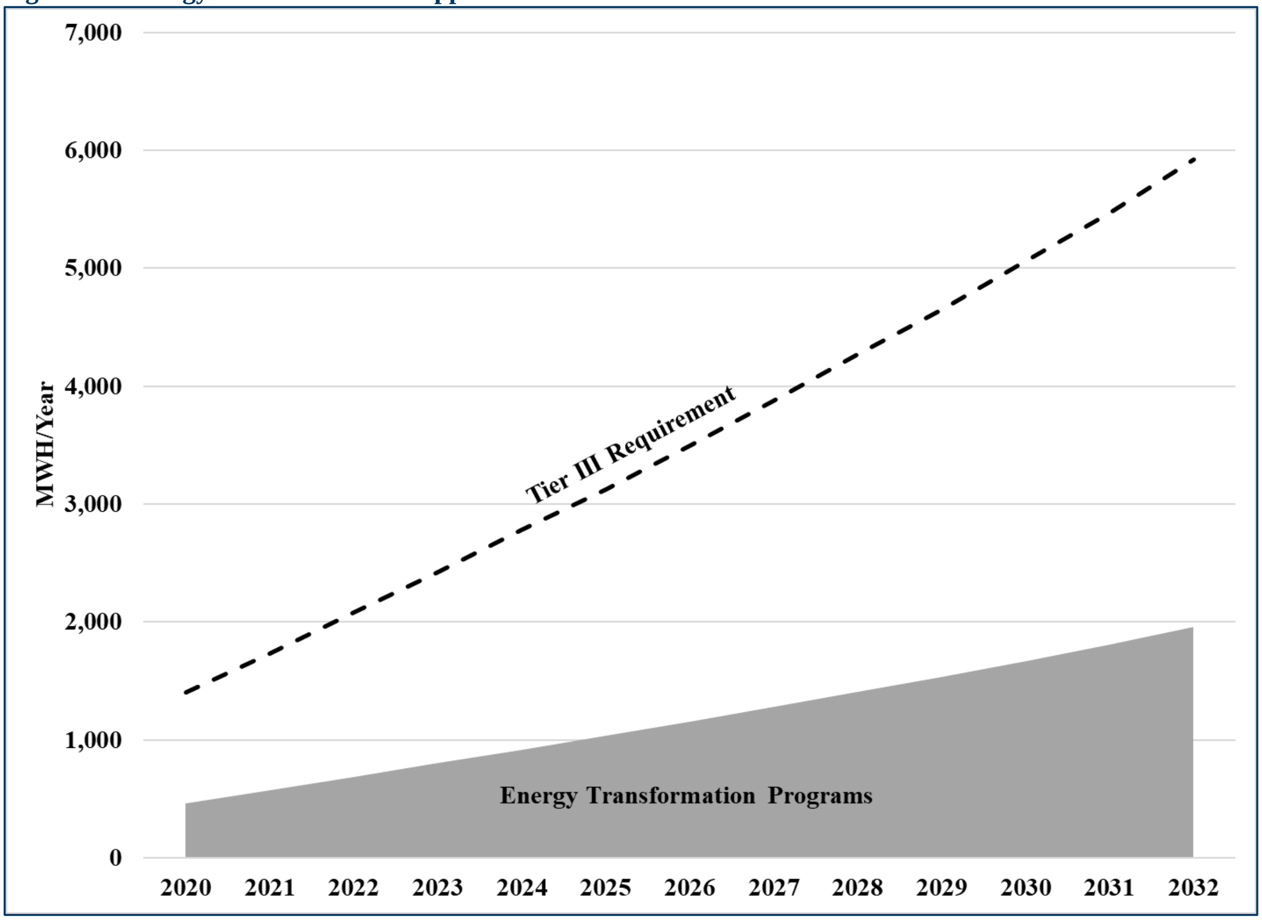
In the event that the project is not built, then LED will most likely work with other VPPSA members to develop a solar project elsewhere in Vermont. In any years where there is a deficit, LED plans to purchase qualifying RECs to meet its Tier II requirement. In recent years, the cost of these RECs has been 60% to 90% lower than the ACP.

[16] https://encorerenewableenergy.com/vermont-public-power-supply-authority-and-encore-renewable-energy-partner-to-increase-solar-generation-for-member-communities/

TIER III - ENERGY TRANSFORMATION PLAN

The dashed line in Figure 10 shows LED's Energy Transformation[17] (Tier III) requirements, which rise from 1,400 MWH in 2020 to almost 6,000 MWH in 2032. Energy Transformation programs are presently budgeted to fulfill about a third of the requirement, and are shown in the gray-shaded area of Figure 10. These programs cover a range of qualifying technologies including EVs, CCHPs, and HPWHs. More detail on these programs can be found in Appendix B (VPPSA's 2019 Tier 3 Annual Plan) and on VPPSA's website.

Figure 10: Energy Transformation Supplies



The remaining Tier III requirements are likely to be fulfilled by a distributed solar project, but could also be supplied by a large custom Tier III project as contemplated in the Tier 3 Annual Plan. Purchasing qualifying RECs under the Tier II requirement could also fulfill the deficit. In any event, LED will follow a four-part strategy to fulfill its Tier III requirements.

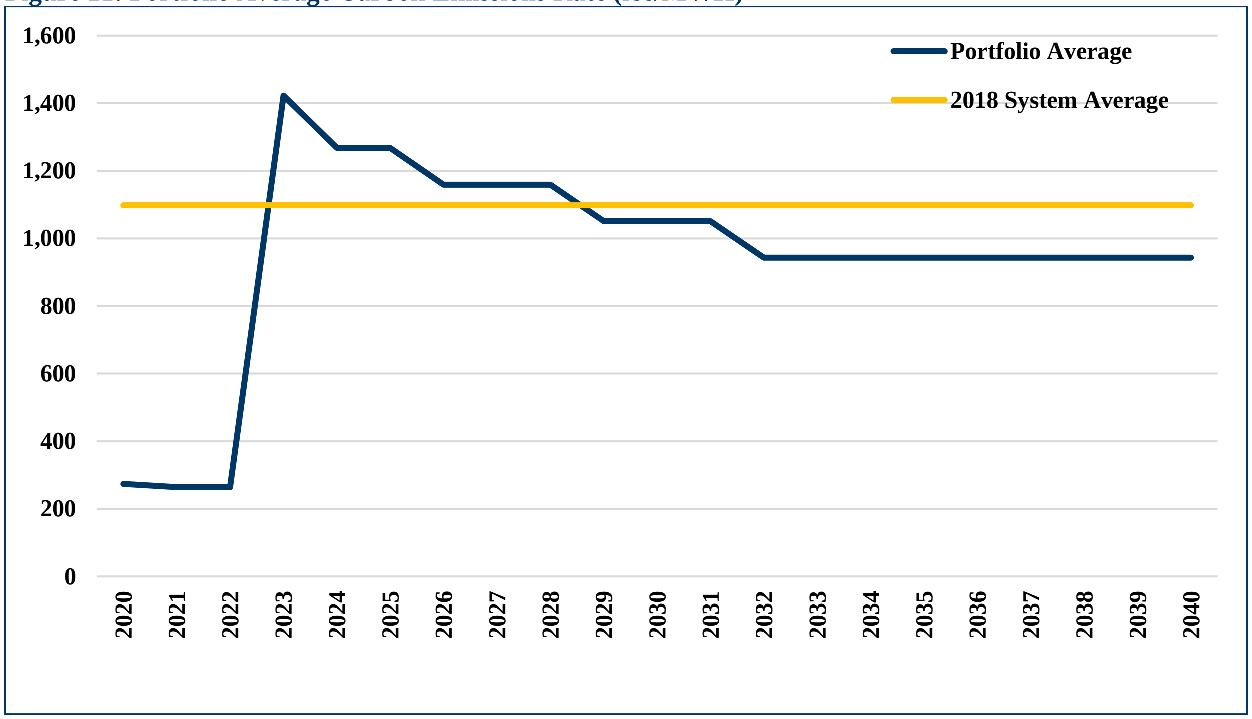
1. Identify and deliver *prescriptive* Energy Transformation ("Base Program") programs, and/or
2. Identify and deliver *custom* Energy Transformation ("Custom Program") programs, and/or
3. Develop a 3 MW solar project in southern Windsor County or elsewhere in Vermont, and/or
4. Purchase Tier II-qualifying renewable energy credits.

[17] The Energy Transformation requirements are also known as "Tier 3" requirements.

CARBON EMISSIONS RATE

Figure 11 shows an estimate of LED's carbon emissions compared to the 2018 system average emissions in the New England region[18]. The emissions rate between 2020 and 2022 is below 300 lbs/MWH because of the NextEra 2018-2022 contract, which includes the carbon-free emissions attributes of Seabrook Station, a nuclear generator in Seabrook NH. After this contract expires, carbon emissions increase to about 1,400 lbs/MWH because the same MWHs are being supplied by fossil fuels. We assume that the carbon emissions rate of these MWH will be equal to the 2018 NEPOOL Residual Mix which is a proxy for the fossil fuel emissions rate in the region.[19]

Figure 11: Portfolio Average Carbon Emissions Rate (lbs/MWH)



The carbon emissions rate starts to decline in 2024 as a result of increasing RES requirements and drops below the system average by 2029. This decline continues until 2032, when the RES requirements end. The emissions rate remains stable after 2032 because this plan assumes that the RES requirements will be maintained.

[18] The source of this data is the NEPOOL GIS. https://www1.nepoolgis.com/

[19] For current the value of the NEPOOL Residual Mix, please visit https://www.nepoolgis.com/public-reports/.

TRANSMISSION & DISTRIBUTION

IV. ELECTRICITY TRANSMISSION & DISTRIBUTION

TRANSMISSION AND DISTRIBUTION SYSTEM

LED receives transmission service from GMP (previously owned by Central Vermont Public Service). LED owns approximately 1,800 feet of 46KV transmission line that connects from the GMP transmission to the Rt. 103 Substation, Commonwealth Avenue Substation and the Smithville Substation. The Commonwealth Avenue transmission is #1 copper stranded conductor, Rt. 103 transmission is 4/0 ACSR conductor and the Smithville transmission is .477 mcm ACSR conductor. All three transmission lines have gang operated air breaks to isolate from the GMP transmission line. The GMP 46 KV transmission is a loop feed system, so LED's substations can be fed from Mt. Holly to the north or from Cavendish to the south.

LED has approximately 65 miles of distribution lines operating at 12.5 KV located in the Village of Ludlow, towns of Ludlow, Plymouth and Proctorsville.

LUDLOW SUBSTATIONS

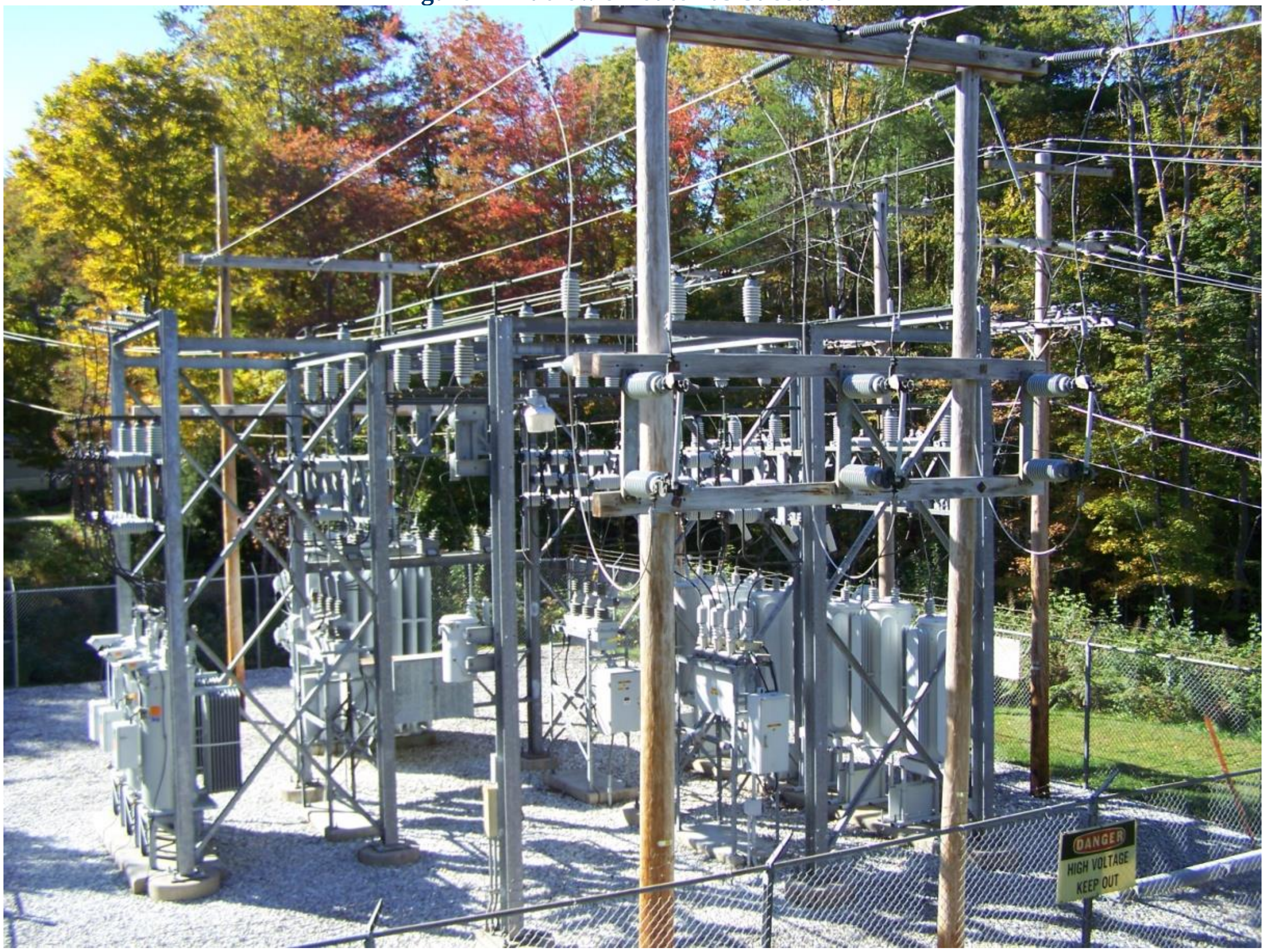
LED owns and operates three substations. Each substation is briefly described below.

RT. 103 SUBSTATION

The Rt. 103 Substation is located in the Town of Ludlow on Mega Watt Lane just north of the Village of Ludlow. It consists of a 14 MVA transformer with the high side voltage of 46 KV and the low side voltage of 12,470/7200 grounded wye. There are three 4/0 circuits feeding out of the substation with each one protected by an ABB vacuum type recloser. All 3 circuits can be tied together or tied to a different substation to conduct maintenance on the substation transformer or any other work to be conducted. All three reclosers have the ability to download information to see what the loads are on each phase and when any outages have occurred. The voltage regulators on the Jackson Gore circuit are electronic type that also provide information such as loads and power factor on all 3 phases.

LED is evaluating upgrading 6 out of 9 regulators to current technology over the next 2 to 3 years depending to some extent on load growth.

Figure 12 Ludlow's Route 103 Substation



COMMONWEALTH AVENUE SUBSTATION

The Commonwealth Avenue substation is located in the Village of Ludlow on Commonwealth Avenue. It consists of a 15 MVA transformer with the high side voltage of 46 KV and the low side voltage of 12,470/7200 grounded wye. There are two 4/0 circuits feeding out of the substation with each one protected by a Cooper oil circuit type recloser. Both circuits can be tied together or tied to a different substation to conduct maintenance on the substation transformer or any other work to be conducted. Since the last IRP, LED has added switches to enable banking of regulators in order to feed either circuit, or both circuits, coming out of the substation. Both reclosers have the ability to download information to see what the loads are on each phase and when any outages or faults have occurred. The voltage regulators on both circuits are electronic type that also provide information such as loads and power factor on all 3 phases.

Figure 13 Ludlow's Commonwealth Substation

SMITHVILLE SUBSTATION

The Smithville Substation is located in the Town of Ludlow on DeRoo Lane just south of the village of Ludlow. It consists of a 14 MVA transformer with the high side voltage of 46 KV and the low side voltage of 12,470/7200 grounded wye. There is only one 4/0 circuit feeding out of the substation which is protected by a breaker. The one circuit can be tied to another feeder from the Commonwealth Substation to conduct maintenance on the substation transformer or any other work to be conducted.

LED recently upgraded regulators due to load growth. LED installed underground circuit to replace about a mile of overhead cross-country line from the substation to rt 103, improving reliability by minimizing storm damage and also improving aesthetics.

Figure 14 Ludlow's Smithville Substation

CIRCUIT DESCRIPTION:

Table 16 Ludlow Circuit Description

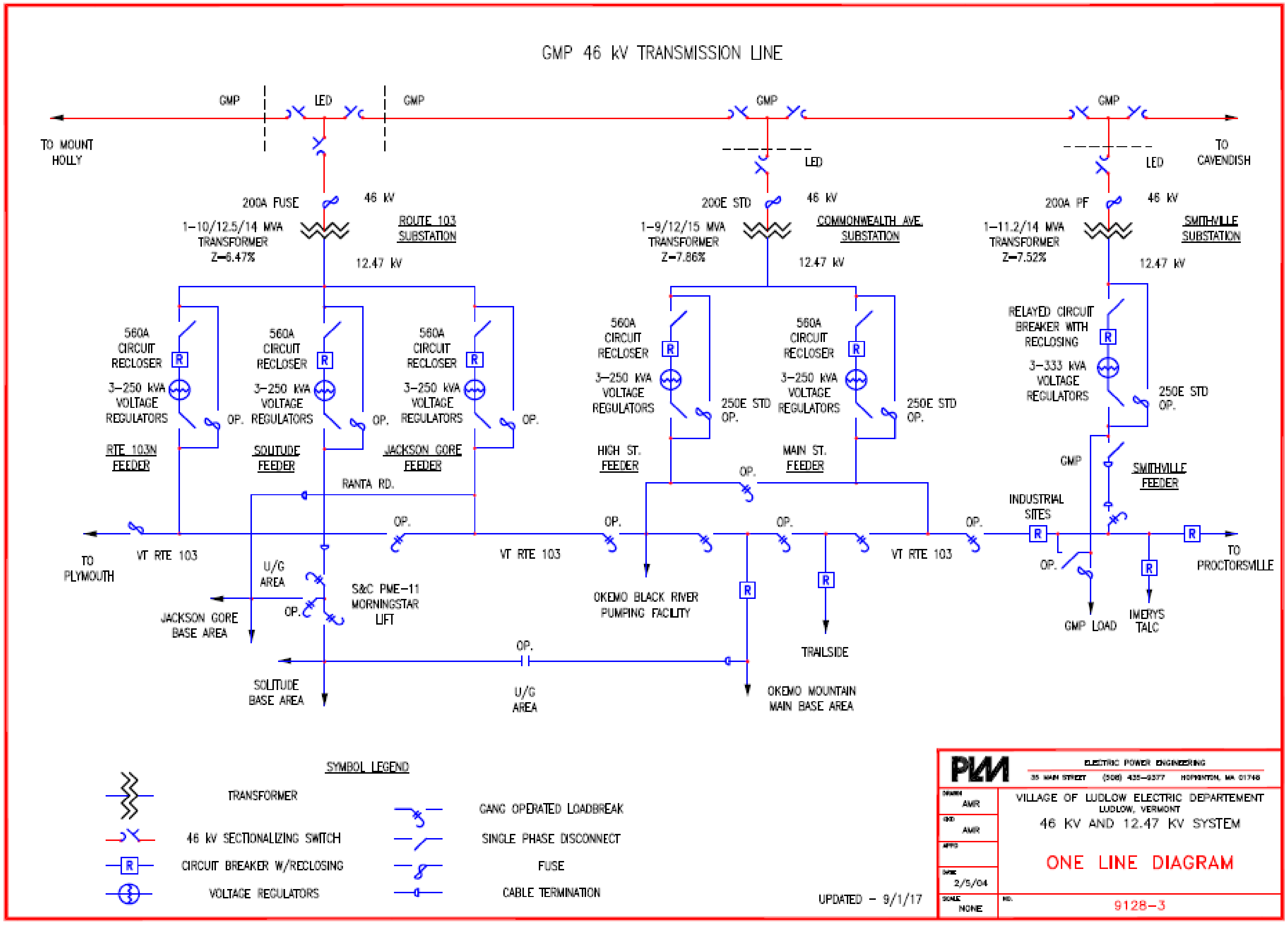
Circuit Name	Description	Length (Miles)	# Customers by Circuit	Outages by Circuit 2018
Lake Area	A 4/0 circuit protected by ABB vacuum type recloser, feeding out of the Rt. 103 Substation.		676	7
Solitude	A 4/0 circuit protected by ABB vacuum type recloser, feeding out of the Rt. 103 Substation.		150	1
Jackson Gore	A 4/0 circuit protected by ABB vacuum type recloser, feeding out of the Rt. 103 Substation.		15	2
High St.	A 4/0 circuit protected by a Cooper oil circuit type recloser, feeding out of the Commonwealth Avenue Substation.		1,006	5

Main St.	A 4/0 circuit protected by a Cooper oil circuit type recloser, feeding out of the Commonwealth Avenue Substation.		1,258	8
Smithville	A 4/0 circuit protected by a breaker, and reclosers feeding out of the Smithville Substation.		598	5

For additional details about each circuit, please see the "LED SUBSTATIONS" section (above). Note that one outage on each circuit was due to total system outage caused by LED's Transmission Service Provider. LED uses the Public Utility Commission Rule 4.900 Outage Report to evaluate the cause, number, and length of outages.

A ONE-LINE DIAGRAM OF UTILITY SYSTEM:

Figure 15 Ludlow System One line Diagram



T&D SYSTEM EVALUATION

System reliability is important to its customers and LED has a number of initiatives underway to improve reliability. Each of these initiatives is summarized below.

OUTAGE STATISTICS

LED tracks all outage statistics as part of its Service Quality Reliability Plan (SQRP). These outage statistics allow us to examine causes by circuit and develop plans for the most cost-effective reliability improvements. The following table summarizes SAIFI and CAIDI results for the past five years. LED's Vermont Public Utility Commission Rule 4.900 Electricity Outage Reports, reflecting the last five years (2014-2018) in their entirety, can be found at the end of this document.

	Goals	2014	2015	2016	2017	2018
SAIFI[20]	**3.0**	1.2	0.0	0.2	1.2	2.3
CAIDI[21]	**0.9**	1.3	0.6	0.5	0.3	0.6

A coordination study was completed by PLM in 2009 for all substation feeder reclosers and line reclosers. Any recommendations were addressed and completed in 2010. LED reviews fuse coordination and updates configuration on an ongoing, case by case basis, whenever and wherever a change is made to the system. This approach reduces the frequency of full system fuse coordination studies. LED has commissioned a full T&D system planning study to be performed by PLM during the remainder of 2019; a full review of fuse coordination will be included in this effort.

LED tracks all outage statistics as part of its Service Quality Reliability Plan ("SQRP"). As noted above, LED also uses the Public Utility Commission Rule 4.900 Outage Report to evaluate the cause, number, and length of outages in order to correct any problems and prevent any issues that may materialize in the future. These outage statistics allow LED to examine causes by circuit and develop plans for the most cost-effective reliability improvements. The baseline targets are met by a good maintenance program, tree clearing and the installation of fault locators on overhead feeders.

Currently, LED has feeder back up capabilities on all main circuits. The circuits can be fed from either substation with some manual switching involved.

Animal guards are installed on all new transformers and other equipment that can accommodate them. Guards are also installed on existing transformers and equipment during routine maintenance and as soon as possible after an outage occurs.

LED uses fault locators on all primary underground lines and uses overhead fault locators on all feeds out of the substations and various places on the system. The fault locators help in determining the location and phase that had experienced a fault.

POWER FACTOR MEASUREMENT AND CORRECTION

During November of 2007 LED conducted a power factor study of its system which was performed by PLM Engineering. The study looked at capacitors currently used on line and where new ones need to be placed. Some of the units are fixed banks and others are switched banks. LED completed the installation of the new capacitors in August 2011 which have helped LED achieve a power factor of just over 99%.

[20] System Average Interruption Frequency Index

[21] Customer Average Interruption Duration Index

DISTRIBUTION CIRCUIT CONFIGURATION

In 1999, LED converted its entire system voltage to 12,470/7,200 grounded wye. LED installs low loss distribution transformers that are evaluated and uses tree wire on primary overhead lines. LED addresses circuit configuration, phase balancing and fuse coordination on a continuous basis as the system changes. All main feeders have backups with other feeders with circuits from the same substation or from other substations. All circuits feeding from the substation are protected by electronic reclosers. Information is obtained on phase loading. During peak loads amperage recorders are installed in various locations to identify peak loads and average loads per phase, which also helps on fuse sizing for engineering. Phases that are unbalanced are addressed by identifying locations and scheduling an outage to move transformer taps or line taps to the appropriate phase for engineering.

SYSTEM PROTECTION PRACTICES AND METHODOLOGIES;

LED has system protection practices that cover transmission, substation and distribution operation. Each protection methodology is discussed briefly below.

TRANSMISSION SYSTEM PROTECTION:

The transmission system is protected by GMP and VELCO.

SUBSTATION PROTECTION:

The substation equipment is protected by high side fuses.

DISTRIBUTION PROTECTION:

The distribution system protection involves circuit reclosers and fuses. All side taps off the main line distribution feed are fused.

SMART GRID INITIATIVES

EXISTING SMART GRID

Currently there are not any plans to install SCADA on the distribution side. On the transmission side, LED worked with GMP to install SCADA controlled switches for the transmission that feeds from the Cold River Tap to the Rt. 103 Substation from the north of Ludlow and from the south at the Smithville Substation tap which feeds from Ascutney. Fiber has been installed at the Smithville Substation but has not been installed at Rt.103 or the Commonwealth substations at this time. LED has installed new reclosers on its system that provide it with important data on loads, faults and other important information.

In 2013, Elster Solutions estimated the cost of AMI on the LED system to be approximately 1.5 million dollars. That study concluded that AMI was not cost-effective for LED at that time. Steep terrain in much of LED’s territory is one of the obstacles, as it requires more infrastructure than a flat terrain. While AMI may save a limited amount on meter reading expenses, LED highly values having a person physically visit each meter on a regular basis. LED’s linemen read all the meters, spending only 60 to 70 hours per month on reading meters. The physical observations made by the meter reader during that time help gain knowledge of the system as well as an awareness of specific reliability and safety issues.

Having meter readers get to know customers on a personal level is another added mutual benefit.

PLANNED SMART GRID

Beginning in 2018, LED began participating in a multi-phased, VPPSA joint-action project intended to (1) assess individual member readiness for AMI, (2) guide participating members through an RFP process culminating in vendor and equipment selection and (3) guide members through the implementation phase. At the end of the initial assessment phase individual members will make the choice to go forward with the RFP process, or not. Upon completion of the RFP phase of the project, individual members will have the information needed to examine the business case and make a decision to commit to implementation of an AMI system, or not.

At this time LED is participating in the initial readiness assessment phase of the project, gaining information pertaining to its initial readiness, potential required changes to staffing and operating processes, as well as potential benefits to municipal electric, water and wastewater systems. As the assessment phase wraps up later in 2019, LED will decide whether to proceed to the RFP phase of the process. LED may consider a staged implementation, focusing first on areas with the highest customer density or load concentration.

LED is mindful of the many facets of the evolving grid and their impact on the value of implementing AMI. Advanced metering may play a key role in taking advantage of more sophisticated rate design and load management/retention opportunities as we see continued expansion of net metering, heat pump installations, and adoption of electric vehicles.

LED recognizes the potential value of utilizing rate design, direct load control or other incentive programs as tools to manage both system and customer peak loads in unison to create value for both the utility and the customer. In the absence of an AMI system, or pending development and implementation of an AMI system, LED will explore the use of pilot programs or tariffs that may be implemented using currently available technology. Initial efforts in this area will focus on larger customers with the greatest opportunity to manage loads in a way that will reduce both system and customer costs, capture economic development/retention opportunities and reduce carbon footprint where possible.
Working with VPPSA, Efficiency Vermont, and other stakeholders, LED stays abreast of these developments and the strategies needed to maintain a safe, reliable, and economically viable distribution system.

LED is also mindful of the increasing importance of cybersecurity concerns, and the relationship of those concerns to technology selection and protection. While LED is not presently required to undertake NERC or NPCC registration, VPPSA is a registered entity, and the presence of LED’s Controller on the VPPSA Board of Directors provides LED with knowledge and insight regarding ongoing cybersecurity developments and risks. On a more local level, LED endeavors to purchase and protect its IT systems (with assistance from VPPSA as needed), in a manner intended to minimize security risks to the system and its ratepayers. LED remains mindful of the balance between the levels of cyber security risk protection and the associated costs to its ratepayers.

OTHER SYSTEM MAINTENANCE AND OPERATION;

RECONDUCTORING FOR LOSS REDUCTION;

When rebuilding an area, LED re-conductors lines with lower loss conductors. The majority of LED's lines already have low loss conductors. The average distribution line losses are around 3.32%

TRANSFORMER ACQUISITION

LED evaluates the life-cycle cost when replacing transformers. LED bids out to a minimum of three to four manufacturers for low loss transformers (amorphous core) and evaluates them over the 20-year time period. LED does not purchase rebuilt transformers.

CONSERVATION VOLTAGE REGULATION;

LED's voltage setting is done with voltage regulators in substations only; voltage is set between 120 and 121.5 volts to provide proper voltage to the first and last customers. LED does not have voltage regulators outside the substations due to the short distance to last customers.
LED participates in the ISO-New England voltage reduction tests twice a year, in the Spring and Fall. LED monitors customer voltage on last customers of a circuit being fed from each substation to make sure proper voltage is supplied. LED does this by installing a voltage recorder at the meter and downloading the information to review.

DISTRIBUTION TRANSFORMER LOAD MANAGEMENT (DTLM)

As previously mentioned, LED evaluates the life-cycle cost when replacing transformers. LED bids out to a minimum of three to four manufacturers for low loss transformers (amorphous core) and evaluates them over the 20-year time period. LED does not purchase rebuilt transformers. LED does not currently have an official DTLM program. Every transformer that is worked on is thoroughly checked.

SUBSTATIONS WITHIN THE 100 AND 500 YEAR FLOOD PLAINS

None of LED's substations fall within the 500 year flood plain.

THE UTILITY UNDERGROUND DAMAGE PREVENTION PLAN (DPP)

All of LED's primary underground facilities are owned by LED while all of its secondary underground facilities are customer-owned. The company standard for minimum depth required for the laying of facilities is 36 inches. The facilities are located by sensor. The facilities documented with drawings are sufficient to find and mark their location upon a notice of planned excavation in the area. LED has an underground Damage Prevention Plan in place. It was filed with the Department of Public Service in November 2016.

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SELECTING TRANSMISSION AND DISTRIBUTION EQUIPMENT

LED purchases standard certified transmission and distribution equipment from established trusted vendors. The majority of LED's equipment is purchased from Westco and Irby. LED prioritizes quality equipment over low purchase prices.

MAINTAINING OPTIMAL T&D EFFICIENCY

System maintenance includes a number of components. Each is discussed below.

SUBSTATION MAINTENANCE:

LED inspects each of the substations monthly. Transformer oil test are done annually. Reclosers and regulators are tested every two years by TSI and UPG. The internal battery at the reclosers has an internal test that is done once per month. Any failure will be displayed and picked up during monthly inspections. In addition to the visual inspections an infrared inspection is done every year in December when we are experiencing our heaviest load. Any problems are addressed as soon as possible. The following form (below) is used when performing substation inspections.

Figure 16 Ludlow Substation Inspection Form

Substation:___________________________________Month/Year:______________________________

Description	**OK**	**Needs Attention**		**Description**	**OK**	**Needs Attention**
Transformer				**Air Breaks & Disconnects**		
Oil Levels Correct						
Gauges in Good Condition						
Any Oil Leaks						
Bushings HV / LV						
Fans Tested				**Other Equipment**		
Pressure Gage + or -				Fence		
Heaters				Gate		
Reclosers				Signs		
Bushings				Ground Straps on fence, etc.		
Battery				Trees		
Disconnects				Hard Hat		
				First Aid Kit		
Regulators				Phone		
Bushings				Switch Sticks		
Any Oil Leaks				Tags		
Oil Level Correct				Rubber Gloves		
Switches & By Passes				Lock		
Control Power On						
Test Reg. 3 to 5 Steps						
Set Into Auto Position						
Reset Drag Hand						
Test Output Voltage						

Checked By:_____________________________________Date and Time:______________________________

Comments:____

POLE INSPECTION:

Currently, LED has an internal pole inspection process in place. LED's system is very condensed, so it is able to inspect the system on a regular basis for problems with poles, crossarms, etc. This also ties in with the capital plan of rebuilding lines before problems arise. LED has never had a pole fail on its own. LED does have a complete GPS with inventory of all poles which it can obtain the date of the pole as long as the date was legible at the time of gathering the information. LED replaces poles as needed, on an ongoing basis. In recent years, LED replaced as many as 200 poles. LED replaces numerous poles per year, and it considers its pole inventory to be in good shape. Many poles are changed for make-ready work. Also, LED visually inspects poles during the regular line of work and is able to make observations of all poles over the course of two years. Given the compact nature of its system, the ability to inspect all poles within a two year cycle, and the additional cost associated with retaining outside contractors, LED plans to continue with the internal pole inspection program and is in the process of developing a spreadsheet system for tracking pole inspections.

EQUIPMENT MAINTENANCE:

LED has replaced all of its porcelain disconnects on its system. These disconnects have been a cause of several outages over the years. A program was developed to replace them back in 2006 and was completed in 2008. any insulators and connectors that need to be replaced, are replaced any time work is being done on a pole.

ENERGY LOSSES AND SYSTEM EFFICIENCY:

LED has a standard conductor size of 1/0 and 4/0 AAA conductor for overhead lines which provides lower inventory cost. The standard conductor size for primary underground is 1/0, 4/0 and 500 mcm aluminum 220 mill which also helps in lower inventory cost. To provide system efficiency for underground, LED has been installing loop feeds into all developments with underground feeds and has loop feeds on all major underground feeders. LED has 13.74 miles of primary underground lines. To provide system wide efficiency all substations are phased with each other and with manual switching any substation can pick up the load of another substation whether it is scheduled maintenance or an unplanned outage.

LED monitors system energy losses by tracking metered system load at its interconnections to GMP and comparing it to metered energy sales to our customers. Also, LED takes into account for street lighting using standard lighting cycles and average consumption data on the different lighting fixtures used within the system. This calculation is done annually. LED tries to meter as much as possible, as it is important to LED to maintain an accurate measure of load. Even the SCADA system is metered. LED's total distribution line losses in 2018 were 3.32%.

In efforts to reduce losses, LED has converted its entire system voltage to 12,470/7200 grounded wye. This was completed in 1999. LED installs amorphous core distribution transformers and uses tree wire on primary overhead lines.

TRACKING TRANSFER OF UTILITIES AND DUAL POLE REMOVAL (NJUNS)

LED does not currently use NJUNS, but it does send pole information to TDS and Comcast and they respond very well for pole transfers. LED does not currently have any dual poles on its system so this system is working sufficiently.

RELOCATING CROSS-COUNTRY LINES TO ROAD-SIDE

LED relocates cross-country lines to road-side when such relocation can be done consistent with cost consideration and customer concerns in terms of rights-of-way. Some customers do not want to see the lines in front of their houses. This has not been overly problematic so far. There have been a few issues with easements. If it is determined to be problematic to relocate a cross-country line to road-side, LED rebuilds the line where it is currently located.

DISTRIBUTED GENERATION IMPACT:

Currently, distributed generation is not having a great impact on LED. LED has only 6 solar customers with a combined total installed capacity of 183 kW and very little new solar net metering is in the "pipeline."

INTERCONNECTION OF DISTRIBUTED GENERATION

LED recognizes the unique challenges brought on by increasing penetration levels of distributed generation. LED adheres to the procedures set forth in Rule 5.500 for the interconnection of new generation. Per rule 5.500, a fast track screening process is utilized to expedite the installation of smaller generators which are less likely to result in issues that affect existing distribution customers. If a proposed installation fails the screening criteria, a Feasibility Study and/or System Impact Study is performed to fully identify and address any adverse effects that are a direct result of the proposed interconnection. These studies, performed by LED or their representatives, typically include a review of the following issues that may arise as a result of a new generator interconnection:

- Steady state voltage (per ANSI C84.1)
- Flicker (per IEEE 1453)
- Temporary overvoltage due to load rejection and/or neutral shift
- Effective grounding (per IEEE 1547 & IEEE C62.91.1)
- Overcurrent coordination
- Equipment short circuit ratings
- Effect of distributed generation on reverse power and directional overcurrent relays
- Voltage regulator and load tap changer control settings (bi-directional operation)
- Unintentional Islanding
- Thermal loading of utility equipment
- Power factor and reactive compensation strategy
- Impact to underfrequency load shed
- Increased incident energy exposure (arc flash)

In addition, recognizing that the aggregate of many smaller installations which individually pass Rule 5.500 screening criteria can present problems that would otherwise go unnoticed, LED will maintain detailed records of installed generation including location, type, and generating capacity. This information will allow LED to periodically review how much generating capacity is installed on a particular feeder or substation transformer and identify any concerns as penetration increases over time.

For example, one issue of growing concern is the aggregate of smaller distributed generators being large enough to require voltage sensing on the primary side of substation power transformers for ground fault overvoltage protection. If a transmission (or sub-transmission) ground fault occurs and the remote terminals operate to clear the fault, an overvoltage due to neutral shift can occur when the ratio of generation to load in the islanded portion of the system is greater than 66% (presumes a standard delta primary, grounded-wye secondary substation power transformer). Supplementing the process outlined in Rule 5.500 with detailed recordkeeping and periodic reviews of how much distributed generation is installed by feeder will help member utilities identify these types of issues before they occur.

As distributed generation penetration increases within LED's service territory, LED may consider performing a system-wide hosting capacity study and/or providing hosting capacity maps as a tool to steer development of future medium to large-scale distributed generation to the most suitable locations. This type of hosting study can result in significant up-front costs that must be born by the ratepayers of LED. As a reasonable compromise, LED may suggest that potential developers locate facilities within reasonable proximity to an existing substation and within portions of the system with low penetration levels of existing distributed generation, both of which should increase the likelihood that the facility will be able to successfully interconnect.

INVERTER REQUIREMENTS

Consistent with ISO New England requirements related to inverter "ride-through" settings, LED now requires owners/ developers of all new DER installations to self-certify installation of inverters compliant with the Inverter Source Requirement Document (SRD) of ISO New England, with settings consistent with IEEE 1547-2018 and UL 1741 SA. This document is included as Appendix E at the end of this document. LED recognizes the need to standardize efforts aimed at certifying inverter compliance with the ISO SRD and will work with VPPSA and PSD to achieve use of common forms and process in this regard.

VEGETATIVE MANAGEMENT/TREE TRIMMING

LED has a 7 year average tree clearing and trimming cycle on its distribution lines. The sub-transmission lines are mowed with a tractor every 2 years to keep the brush from growing so the only tree work necessary is side trimming trees on the edge of the right-of-way. This is why the sub-transmission lines can go for an average of 10 years before needing to be trimmed. Tree trimming is tracked in a database and inspection of the lines dictates if an area might need attention before its regular schedule.

Depending on the weather pattern and the type of trees some areas will last longer than others and trimming might not have to be done as often as others. Some areas might not have to be trimmed for several years while others might have a few sections of line that need to be trimmed sooner than the scheduled time. All lines are trimmed to the edge of the right-of-way. The tree trimming width is 15 feet on either side of the line for 3 phase line and 10 feet on either side of the line for single phase lines.

LED uses contract tree crews and also uses in-house crews to do the work. LED routinely reviews the tree trimming program, utilizing inspections and feedback from its outage reports, to assure that the program maintains the vegetation and brush within its right-of-way appropriately and to make modifications to the management program in the event that the program is not maintaining adequate clearances of brush from the lines. In addition to its vegetative and brush management program, LED has a program to identify danger trees. Danger trees are identified by all of our utility personnel while patrolling the lines or inspecting the system. Once a danger tree is identified, it is promptly removed if it is within LED's right-of-way. For danger trees outside of the right-of-way, LED contacts the property owner, explains the hazard, and with the owner's permission removes them. Where permission is not granted, LED will periodically follow up with the property owner to attempt to obtain permission. Again, the success of this program is measured by whether danger trees are a root cause of system outages.

LED serves 65 miles of T&D line and has approximately 45 miles of line that requires vegetative management. It has budgeted $40,000 per year for the last 10 years and will budget the same for the next 3 years. The number of miles trimmed varies due to the trimming of three phase lines vs. single phase lines, which are not as time consuming due to the size of the right-of-way, or if the line is off road less area is trimmed in a year. Also, some of the lines require more tree removals than others which contribute to fewer miles trimmed in a year.

The majority of tree species in our service territory are pine, oak and maple. Most of our tree-related outages are due to severe storms with trees outside of the right-of-way coming in contact with the power lines. LED does not use herbicides on its system.

The emerald ash borer has not yet become an active issue in LED's territory. LED is monitoring developments and coordinating efforts with VPPSA and VELCO and will make use of any guidance that becomes available as a result. If and when the emerald ash borer does surface in LED's territory, affected trees will be cut down, chipped and properly disposed of.

Table 17 Ludlow Vegetation Trimming Cycles

	Total Miles	Miles Needing Trimming	Trimming Cycle
Transmission	0.5 Miles	0.5 Miles	10 Years
Distribution	65	45	7

Table 18 Ludlow Vegetation Management Costs

	2016	2017	2018	2019	2020	2021
Amount Budgeted	$40,000	$40,000	$40,000	$40,000	$40,000	$40,000
Amount Spent	$55,005	$54,225	$44,032	x	x	x
Miles Trimmed	6	7	5.5	6.5	6.5	6.5

Table 19 Ludlow Tree Related Outages

	2014	2015	2016	2017	2018
Tree Related Outages	6	4	2	3	12
Total Outages	28	17	17	16	28
Tree-related outages as % of total outages	21%	24%	12%	19%	43%

The 2018 tree related outages, shown in the above table, were all due to high wind events which brought down large trees that were all located outside of the right-of-way.

STORM/EMERGENCY PROCEDURES

Like other Vermont municipal electric utilities, LED is an active participant in the Northeast Public Power Association ("NEPPA") mutual aid system, which allows LED to coordinate not only with public power systems in Vermont, but with those throughout New England. Representatives of LED are also on the state emergency preparedness conference calls, which facilitates in-state coordination between utilities, state regulators and other interested parties. LED uses the www.vtoutages.com site during major storms especially if it experiences a large outage that is expected to have a long duration. LED believes it is beneficial to inform the Public Service Department if it is experiencing these types of outages.

PREVIOUS AND PLANNED T&D STUDIES

FUSE COORDINATION STUDY

As previously mentioned, while a specific stand-alone study has not been done, LED's fuse coordination is continuously monitored and updated by LED and PLM any time the system is modified. In the event of an outage, LED has the capability to manually switch 100% of its customers to a backup feeder.

SYSTEM PLANNING AND EFFICIENCY STUDY

In addition to the distribution system planning, explained above, LED has completed planned work on the transmission system. LED rebuilt the Commonwealth Avenue transmission line in 2011. That line is 1,200 feet in length and consists of new poles, crossarms, anchors and insulators.

LED has commissioned PLM to perform a comprehensive system planning and efficiency study during the remainder of 2019. This study will include a system-wide review of existing overcurrent protection and branch fusing. Any recommended upgrades or changes will be documented in the study report.

A copy of the recommendations from the last Distribution System Planning Study performed by PLM in 1993 in provided in Appendix F to this document.

CAPITAL SPENDING

CONSTRUCTION COST 2016-2018

Figure 17 Ludlow Historic Construction Cost

Ludlow Electric Department		Historic Construction		
		2016	2017	2018
Imerys Upgrade	Dist	441,109		
Pole replacements	Dist	51,429		
Bbucket Truck	Dist	197,000		
Misc Plant & general	General	63,630		
Reclosers	Dist		23,000	
Pole replacements	Dist		67,000	
Misc Plant & General	Dist		61,790	
	Dist			
	Dist			
Smithville Sub Battery	Dist			6,000
Recloer & Overhead lines	Dist			27,710
Pickup	Dist			32,485
Computer Equipment	Dist			29,486
Misc Plant & General	General			12,427
Total Construction		**$ 753,168**	**$ 151,790**	**$ 108,108**
Functional Summary:				
Prod		-	-	-
General		63,630		12,427
Distribution		689,538	151,790	95,681
Transmission		-	-	-
Total Construction		753,168	151,790	108,108

PROJECTED CONSTRUCTION COSTS (2020-2022):

Figure 18 Ludlow Projected Construction Cost

Ludlow Electric Department		Projected Construction		
Historic Construction		**2020**	**2021**	**2022**
Digger Truck	General	275,000		
Line relocation	Dist	150,000		
Misc Plant	Dist	100,000		
Rt 103 Sub Regulators	Dist		75,000	
Misc Plant	Dist		100,000	
Computer Upgrades	General		50,000	
Bucket Truck	General			325,000
Rt 103 Sub Regulators	Dist			75,000
Misc Plant	Dist			125,000
Total Construction		**$ 525,000**	**$ 225,000**	**$ 525,000**
Functional Summary:				
Prod		-	-	-
General		275,000	50,000	325,000
Distribution		250,000	175,000	200,000
Transmission		-	-	-
Total Construction		525,000	225,000	525,000

V. FINANCIAL ANALYSIS

The most immediate question facing LED is how to fulfill unhedged energy requirements between 2020 and 2025. The solution to the first three years of this timeframe is outlined in the Resource Plan section under Energy Resource Plan Decision 1. We have elected to evaluate the first five years of the open position to illustrate the decision-making process between two prototypical market contracts. The leading resource options are summarized in Table 20. Notice that volume and term remain consistent while the product and all-in-price vary.

Table 20: Energy Resource Options & Characteristics

Resource Option	Price Structure	Volume	Product	Term	All-In Price
Status Quo	Variable at market prices.	20,000 MWH	7x24 Energy	5 Years, 2020-24	$51.93
Market Contract	Fixed at levelized market prices.	20,000 MWH	7x24 Energy	5 Years, 2020-24	$48.96
Hydro + Tier I RECs	Fixed at levelized market prices.	20,000 MWH	7x24 Energy + RECs	5 Years, 2020-24	$51.56

The status quo option is to leave energy requirements unhedged. These requirements would be fulfilled by ISO New England's energy markets at the Locational Marginal Price (LMP) at the Vermont Zone. As a result, the price structure in Table 20 is variable at market prices. The status quo option is only listed in this table for comparison purposes. In practice, VPPSA would not leave energy requirements unhedged.

The remaining two resource options are to purchase a fixed-price market contract for energy or to purchase a fixed-price contract for existing hydroelectric energy plus RECs. The resource need is short-term by nature, thus new long-term resources like solar or wind are not considered. Similarly, new demand-side resources are not considered as they have already been captured by the load forecast.

To evaluate these options, we calculated the fixed all-in price of each of the two options by levelizing the forecast of annual energy and REC prices in our budget models. This enables us to evaluate how the resources would perform under different market conditions, summarized in Table 21.

Natural gas prices are the primarily determinant of electricity prices in New England. REC prices are an increasing risk because of the need to fulfill RES requirements. We chose to test the resource options against changes in these two markets. Historical data indicates that natural gas prices have changed by +/- 50% over time. Tier I REC prices have seen a low of about $1. The ACP sets the upper bound of $10 for Tier I RECs.

Table 21: Range of Market Conditions

Market Price Condition	Natural Gas Price Range	Tier I REC Price Range
Low	-50%	$1.00
Base	100%	$2.50
High	150%	$10

Because LED is short on both energy and Tier I RECs, the lowest-cost outcomes would occur when market prices decrease. Conversely, the highest-cost outcomes would occur when market prices increase. This reduces the number of scenarios we need to analyze to nine.

VPPSA's fully integrated financial model incorporates power supply, capital, financing, and other operating costs. LED's transmission and distribution system has been routinely upgraded so there is no significant maintenance or construction backlog; as a result, ongoing construction costs are not anticipated to be a significant cost driver for the foreseeable future. Coupled with a projection of relatively stable loads, power supply costs are expected to be the primary driver of LED's modest rate trajectory. Overall rates are estimated to grow at a 2.3% compound annual growth rate over the 2020-2039 period. The financial model is summarized in Appendix G. Using the financial model, we estimated LED's revenue requirements under each market condition. The results of each scenario are shown in the following table.

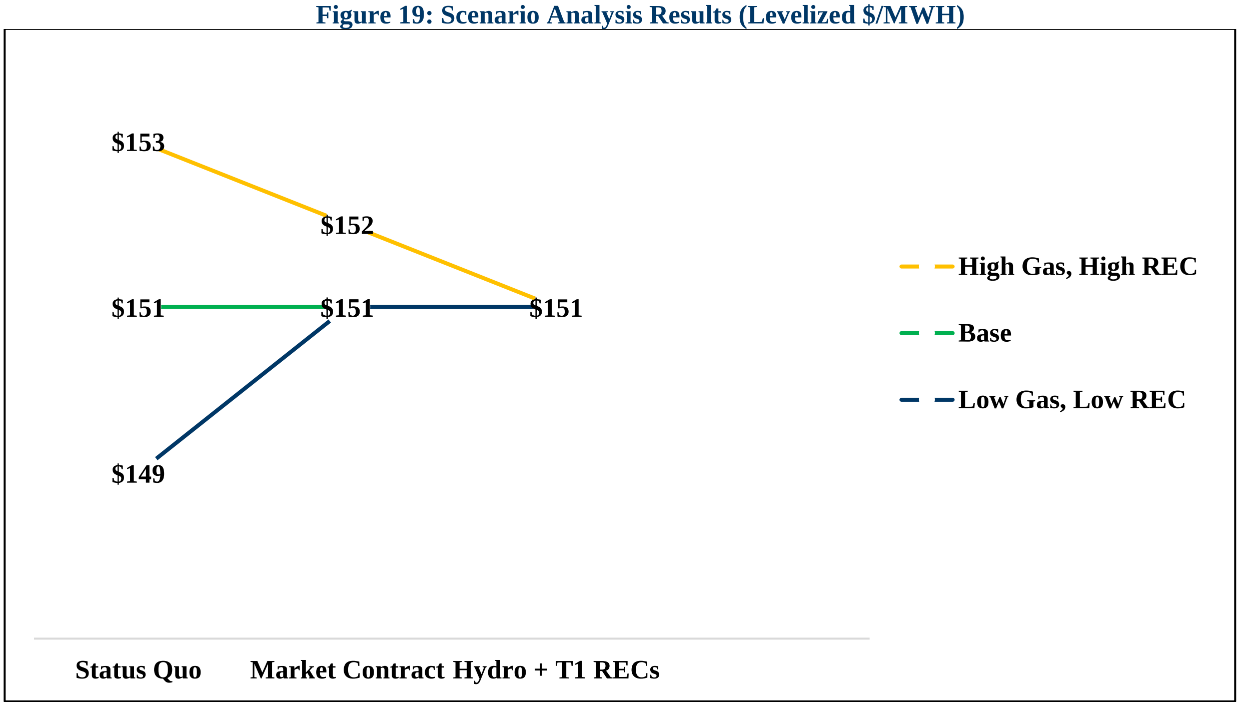
Table 22: Scenario Analysis Results (Levelized $/MWH)

Decision Option	Low Gas, Low REC	Base Case	High Gas, High REC
Status Quo	149	151	153
Market Contract	151	151	152
Hydro + T1 RECs	151	151	151

The lowest and highest cost scenarios are both the result of the status quo decision option. This makes sense because this option leaves the energy and REC requirements unhedged and exposed to the full range of potential to spot market prices. If prices decrease, LED's cost also decreases. But if prices increase, LED's cost increases.

The range of cost outcomes narrows under the market contract option because the energy market risk has been hedged. The narrowest range of outcomes occurs under the Hydro + Tier I REC option because the energy and the REC price risk has been hedged. Notice that the cost outcomes of this option match the base case. This result is not surprising, and simply means that LED's costs were "locked in" at today's market prices. In any event, the benefits of hedging energy and REC risk is more vividly illustrated in the following figure.

Figure 19: Scenario Analysis Results (Levelized $/MWH)



Looking from left to right, the lines in Figure 19: Scenario Analysis Results (Levelized $/MWH) converge to $151/MWH. This illustrates the risk-reducing nature of buying resources at fixed prices. In this example, the lowest risk resource is Hydro + T1 RECs because changes in market prices no longer impact the financial outcome. While some policy makers may prefer this scenario, others may prefer to carry more (variable) price risk in the hopes that a lower cost outcome can be realized. Using decision analysis, the final step in the process is to have policy makers choose the probability of each market condition occurring (Table 21). The final resource decision becomes a probability-weighted average of the decision-making body's collective market view.

ACTION PLAN

VI. ACTION PLAN

Based on the foregoing analysis, we envision taking the following actions.

1. **Automated Metering Infrastructure (AMI)**
   - LED will participate in an evaluation of AMI readiness which, if results are positive, will lead to preparation of an RFP leading to vendor and equipment selection and ultimately to implementation of an AMI system. Upon completion of the RFP phase of the project, LED will have the information needed to examine the business case and make a decision to commit to implementation of an AMI system, or not. LED recognizes that cost reduction, while desirable, is but one of many factors that must be weighed in making the decision to go forward with AMI. LED sees the potential for a number of future benefits that, while difficult to quantify in cost/benefit terms, will clearly be desirable to various stakeholders. These benefits include (but may not be limited to) improved system control/optimization, ability to deliver/administer more creative customer and load management initiatives, and ability to accommodate emerging initiatives such as EV charging. LED also notes that unanticipated initiatives may emerge over time that positively impact the perceived value of having an AMI system in place. LED is considering the potential benefit of a staged implementation that would initially focus on limited areas of high load or customer concentration.
2. **Distribution System Planning and Efficiency Study**
   - Work with PLM to complete a full system planning study that includes a comprehensive system-wide assessment of fusing coordination

3. **Energy Resource Actions**
   - Manage year to year energy market requirements using fixed-price, market contracts that are less than five years in duration.
   - Consider replacing the NextEra 2018-2022 Contract with a 3.5 to 5 MW hydro entitlement that includes bundled energy and renewable energy credits.
   - Replace the Fitchburg Landfill Gas resource with the end of RES in mind.

4. **Capacity Resource Actions**
   - Manage and monitor the reliability of Project 10 and McNeil to minimize Pay-for-Performance (PFP) risk and maximize PFP benefits.

5. **Tier I Requirements**
   - Consider replacing the NextEra 2018-2022 Contract with a 3.5 to 5 MW hydro plant that includes bundled energy and renewable energy credits.
   - Make forward purchases of qualifying RECs on the regional market to manage REC price and ACP risk.

6. **Tier II Requirements**
   - Develop and complete the Bone Hill Solar or a comparable, Vermont-based solar project.
   - Make forward purchases of qualifying RECs on the Vermont market to manage REC price and ACP risk.

7. **Tier III Requirements**
   - Identify and deliver prescriptive and/or custom Energy Transformation programs, and/or
   - Develop and complete the Bone Hill Solar or a comparable, Vermont-based solar project, and/or

- Purchase Tier II-qualifying renewable energy credits.

- Investigate options for engaging customers in active load control programs and tariffs, including end-uses such as electric thermal storage, CCHPs, and HPWHs.

8. Peak Load Management Pilot Program

- Explore ways to align reductions in customer demand charges with utility coincident peak costs through use of a pilot tariff.

9. Pole Inspection Tracking Process

- Develop a tracking and reporting process for pole inspections.

10. Net Metering

- Monitor the penetration rate and cost of solar net metering for future grid parity, and advocate for appropriate policies to mitigate potential upward rate pressure.

11. Storage

- Monitor cost trends and potential use cases, and
- Identify Behind-the-Meter use cases and sites, and
- Develop project-specific cost-benefit analysis.
-

APPENDIX

APPENDIX A: CVRPC REGIONAL ENERGY PLAN

This appendix is provided separately in a file named:

Appendix A - Regional-Energy-Plan-Adopted-06-25-2018.pdf

APPENDIX B: 2019 TIER 3 ANNUAL PLAN

This appendix is provided separately in a file named:

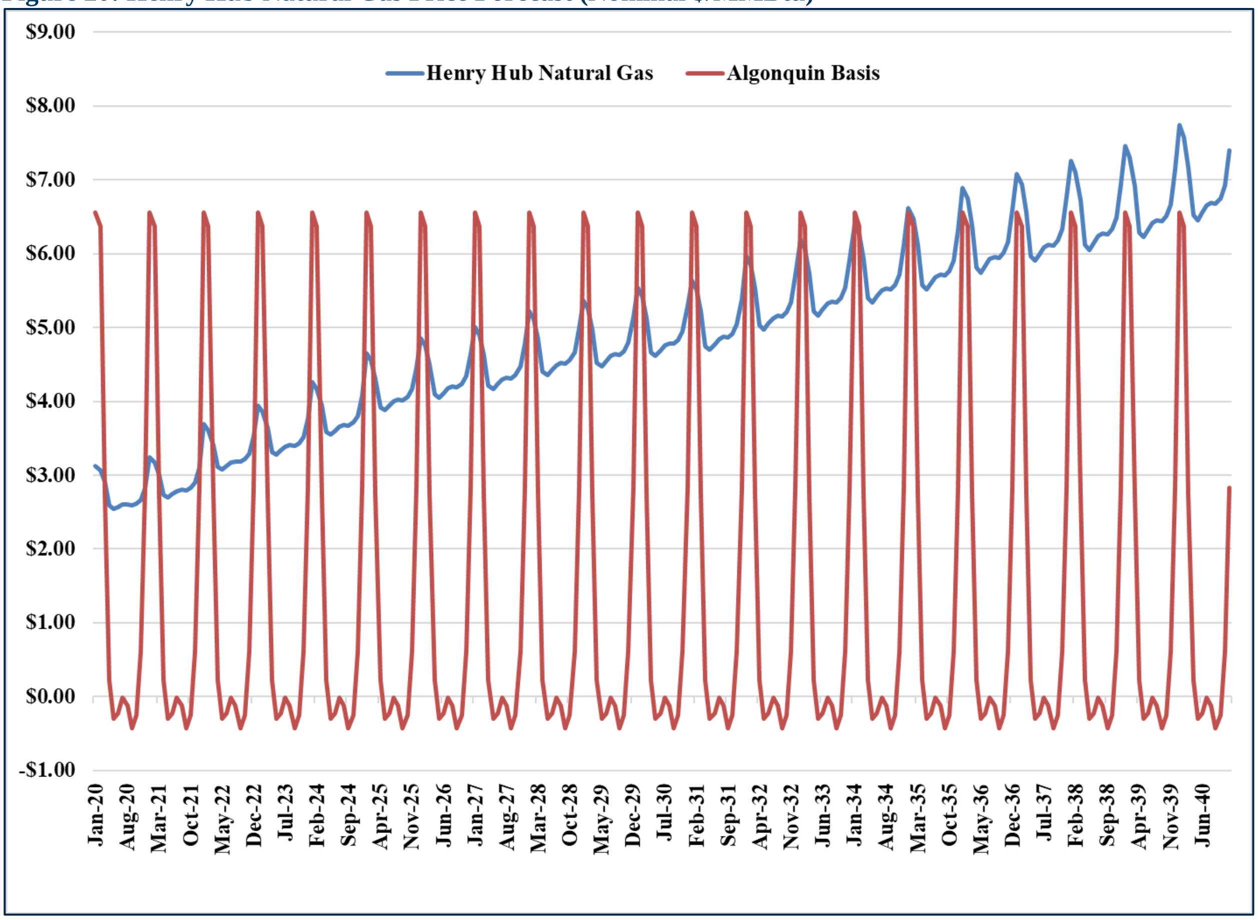
Appendix B - VPPSA Tier 3 2019 Annual Plan.pdf

APPENDIX C: PRICING METHODOLOGY

ENERGY PRICING

Energy prices are forecast using a three-step method. First, a natural gas price forecast is formed by combining a 3-month average of NYMEX Henry Hub futures prices for the period 2020 to 2021 with the Energy Information Administration (EIA) Annual Energy Outlook (AEO) Henry Hub forecast for the period 2022 to 2039. The forecast of Henry Hub Natural Gas prices can be seen in Figure 20.

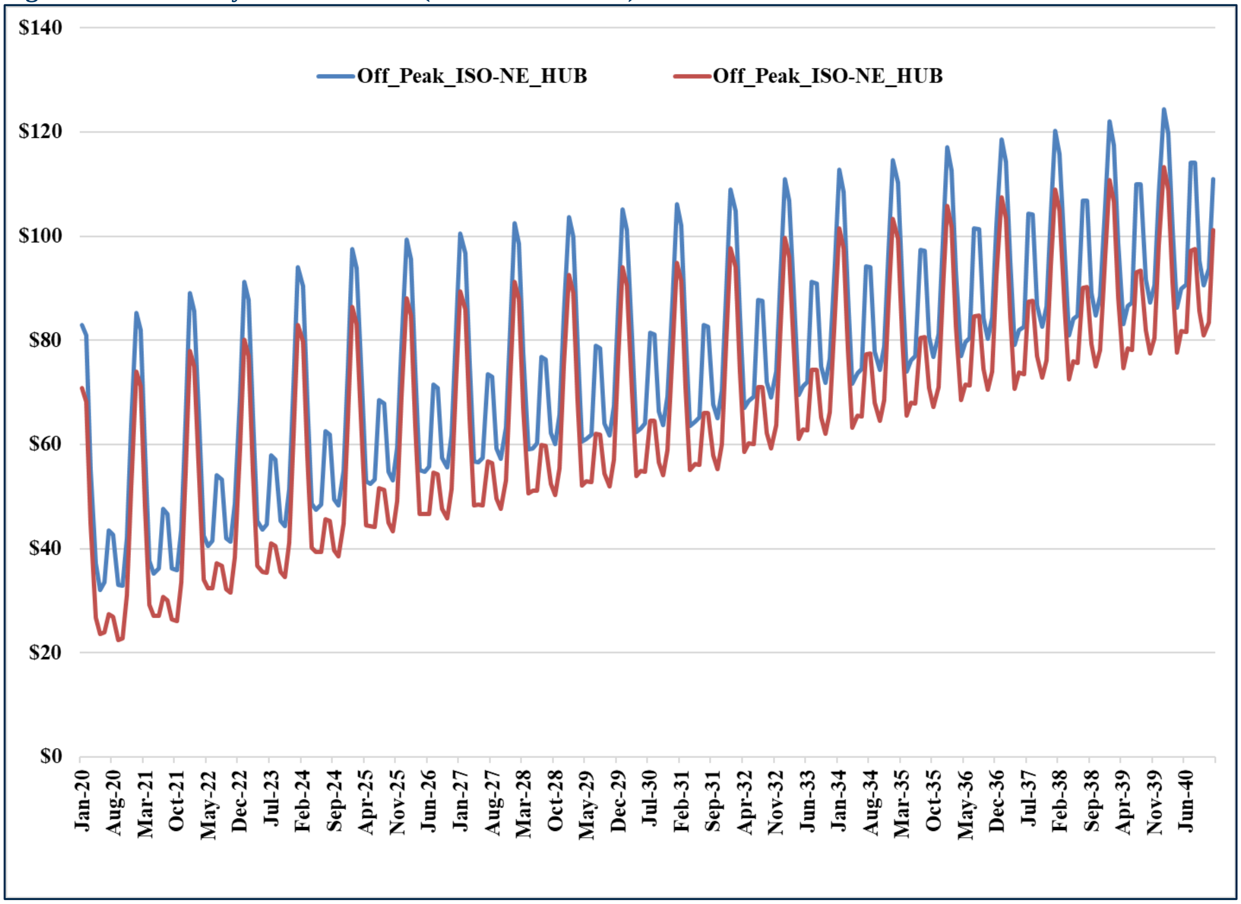
Figure 20: Henry Hub Natural Gas Price Forecast (Nominal $/MMBtu)



Second, we use NYMEX futures prices (between 2020-2021) to find 1. the cost of transportation (basis) to the Algonquin Hub and 2. the cost of on and off-peak energy at the Massachusetts Hub (MA Hub). These prices are used to calculate an implied heat rate (MMBtu/MWH) and a spread between on and off-peak electricity prices. These values (sometimes called shapes) are used for the remainder of the forecast period.

Third and finally, we multiply the natural gas price forecast by the implied heat rate to get the on-peak electricity price. From this value, we subtract the spread between the on and off-peak prices to get the off-peak price. The results can be seen in Figure 21.

Figure 21: Electricity Price Forecast (Nominal $/MWH)

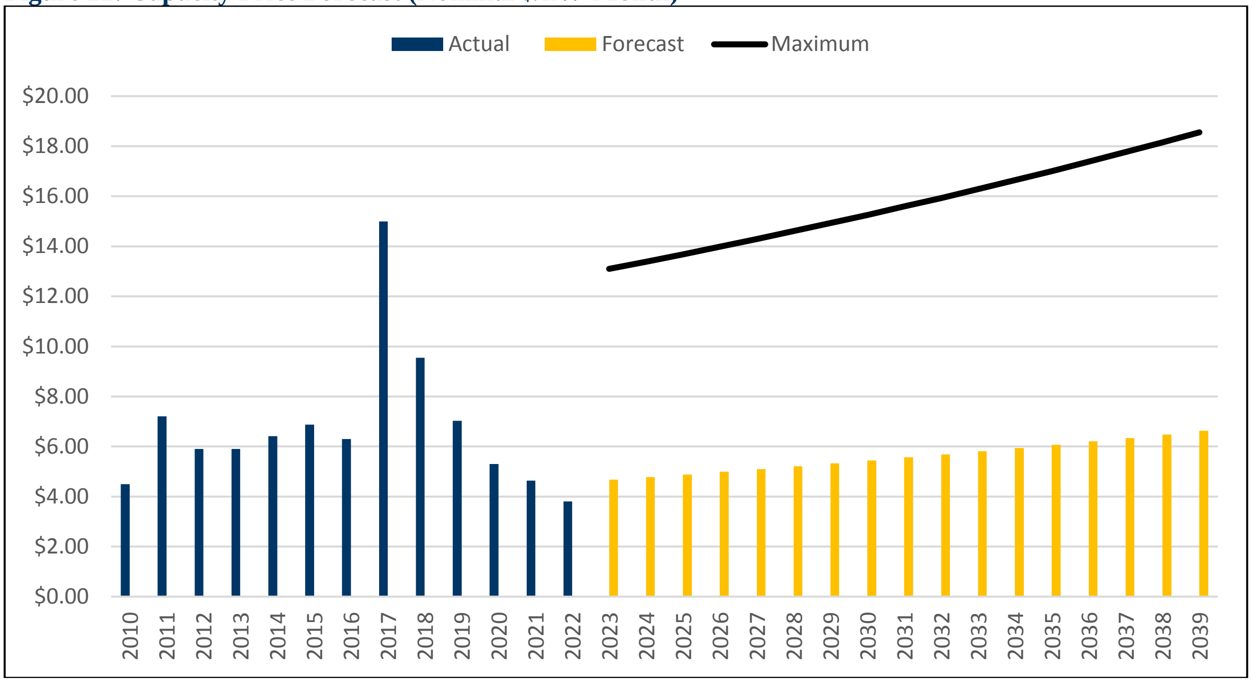


In keeping with the function of ISO-NE's Standard Market Design, we use a five-year average basis between Locational Marginal Price (LMP) nodes to adjust the price forecast at the MA Hub to the location of LED's load and resources.

CAPACITY PRICING

The capacity price forecast is an average of the last three years of actual auction results plus inflation, and it grows from $4.68 per kW-month in 2023 to $6.77 per kW-month in 2039. Significant upside price risk does exist, as shown by the Maximum line in Figure 22. This line represents the Forward Capacity Auction Starting Price plus inflation.

Figure 22: Capacity Price Forecast (Nominal $/kW-Month)



APPENDIX D: PUC RULE 4.900 OUTAGE REPORTS

Village of Ludlow Electric Light Department 2014

This report is pursuant to PSB Rule 4.903B. It is to be submitted to the Public Service Board and the Department of Public Service no later than 30 days after the end of the calendar year.

Electricity Outage Report -- PSB Rule 4.900

Name of company	Village of Ludlow Electric Light Department
Calendar year report covers	2014
Contact person	Howard R. Barton, Superintendent
Phone number	802-228-3721
Number of customers	3,703

System average interruption frequency index (SAIFI) =	**1.2**
Customers Out / Customers Served	
Customer average interruption duration index (CAIDI) =	**1.3**
Customer Hours Out / Customers Out	

	Outage cause	Number of Outages	Total customer hours out
1	**Trees**	6	55
2	**Weather**	13	5,447
3	**Company initiated outage**	0	0
4	**Equipment failure**	2	38
5	**Operator error**	0	0
6	**Accidents**	0	0
7	**Animals**	7	134
8	**Power supplier**	0	0
9	**Non-utility power supplier**	0	0
10	**Other**	0	0
11	**Unknown**	0	0
	Total	28	5,675

Note: Per PSB Rule 4.903(B)(3), this report must be accompanied by an overall assessment of system reliability that addresses the areas where most outages occur and the causes underlying most outages. Based on this assessment, the utility should describe, for both the long and the short terms, appropriate and necessary activities, action plans, and implementation schedules for correcting any problems identified in the above assessment.

Village of Ludlow Electric Light Department 2015

This report is pursuant to PSB Rule 4.903B. It is to be submitted to the Public Service Board and the Department of Public Service no later than 30 days after the end of the calendar year.

Electricity Outage Report -- PSB Rule 4.900

Name of company	Village of Ludlow Electric Light Department
Calendar year report covers	2015
Contact person	Howard R. Barton, Superintendent
Phone number	802-228-3721
Number of customers	3,711

System average interruption frequency index (SAIFI) = 0.0
Customers Out / Customers Served

Customer average interruption duration index (CAIDI) = 0.6
Customer Hours Out / Customers Out

	Outage cause	Number of Outages	Total customer hours out
1	**Trees**	4	10
2	**Weather**	0	0
3	**Company initiated outage**	4	22
4	**Equipment failure**	4	26
5	**Operator error**	0	0
6	**Accidents**	0	0
7	**Animals**	5	19
8	**Power supplier**	0	0
9	**Non-utility power supplier**	0	0
10	**Other**	0	0
11	**Unknown**	0	0
	Total	17	77

Note: Per PSB Rule 4.903(B)(3), this report must be accompanied by an overall assessment of system reliability that addresses the areas where most outages occur and the causes underlying most outages. Based on this assessment, the utility should describe, for both the long and the short terms, appropriate and necessary activities, action plans, and implementation schedules for correcting any problems identified in the above assessment.

Village of Ludlow Electric Light Department 2016

This report is pursuant to PSB Rule 4.903B. It is to be submitted to the Public Service Board and the Department of Public Service no later than 30 days after the end of the calendar year.

Electricity Outage Report -- PSB Rule 4.900

Name of company	Village of Ludlow Electric Light Department
Calendar year report covers	2016
Contact person	Howard R. Barton, Superintendent
Phone number	802-228-3721
Number of customers	3,752

System average interruption frequency index (SAIFI) = 0.2
Customers Out / Customers Served

Customer average interruption duration index (CAIDI) = 0.5
Customer Hours Out / Customers Out

	Outage cause	Number of Outages	Total customer hours out
1	**Trees**	2	35
2	**Weather**	8	291
3	**Company initiated outage**	0	0
4	**Equipment failure**	3	8
5	**Operator error**	0	0
6	**Accidents**	0	0
7	**Animals**	4	6
8	**Power supplier**	0	0
9	**Non-utility power supplier**	0	0
10	**Other**	0	0
11	**Unknown**	0	0
	Total	17	340

Note: Per PSB Rule 4.903(B)(3), this report must be accompanied by an overall assessment of system reliability that addresses the areas where most outages occur and the causes underlying most outages. Based on this assessment, the utility should describe, for both the long and the short terms, appropriate and necessary activities, action plans, and implementation schedules for correcting any problems identified in the above assessment.

Village of Ludlow Electric Light Department 2017

This report is pursuant to PSB Rule 4.903B. It is to be submitted to the Public Service Board and the Department of Public Service no later than 30 days after the end of the calendar year.

Electricity Outage Report -- PSB Rule 4.900

Name of company	Village of Ludlow Electric Light Department
Calendar year report covers	2017
Contact person	Howard R. Barton, Superintendent
Phone number	802-228-3721
Number of customers	3,749

System average interruption frequency index (SAIFI) = 1.2
Customers Out / Customers Served

Customer average interruption duration index (CAIDI) = 0.3
Customer Hours Out / Customers Out

	Outage cause	Number of Outages	Total customer hours out
1	**Trees**	3	14
2	**Weather**	3	36
3	**Company initiated outage**	2	8
4	**Equipment failure**	4	99
5	**Operator error**	0	0
6	**Accidents**	2	260
7	**Animals**	1	2
8	**Power supplier**	1	812
9	**Non-utility power supplier**	0	0
10	**Other**	0	0
11	**Unknown**	0	0
	Total	16	1,230

Note: Per PSB Rule 4.903(B)(3), this report must be accompanied by an overall assessment of system reliability that addresses the areas where most outages occur and the causes underlying most outages. Based on this assessment, the utility should describe, for both the long and the short terms, appropriate and necessary activities, action plans, and implementation schedules for correcting any problems identified in the above assessment.

Village of Ludlow Electric Light Department

This report is pursuant to PSB Rule 4.903B. It is to be submitted to the Public Service Board and the Department of Public Service no later than 30 days after the end of the calendar year.

Electricity Outage Report --PSB Rule 4.900

Name of company	Village of Ludlow Electric Light Department
Calendar year report covers	2018
Contact person	Howard R. Barton, Superintendent
Phone number	802-228-3721
Number of customers	3796

System average interruption frequency index (SAIFI) = Customers Out / Customers Served	**2.3**
Customers average interruption duration index (CAIDI) = Customer Hours Out / Customers Out	**.58**

	Outage Cause	Number of Outages	Total Customer Hours Out
1	**Trees**	12	163
2	**Weather**	2	584
3	**Company initiated outage**	3	32
4	**Equipment failure**	2	4
5	**Operator error**	0	0
6	**Accidents**	0	0
7	**Animals**	7	152
8	**Power Supplier**	2	4100
9	**Non-utility power supplier**	0	0
10	**Other**	0	0
11	**Unknown**	0	0
	Total	**28**	**5035**

Note: Per PSB Rule 4.903(B)(3), this report must be accompanied by an overall assessment of system reliability that addresses the areas where most outages occur and the causes underlying most outages. Based on this assessment, the utility should describe, for both the long and the short terms, appropriate and necessary activities, action plans, and implementation schedules for correcting any problems indentified in the above assessment.

APPENDIX E: INVERTER SOURCE REQUIREMENTS

Inverter Source Requirement Document of ISO New England (ISO-NE)
This Source Requirement Document applies to inverters associated with specific types of generation for projects that have applied for interconnection after specific dates. These details will be described in separate document(s). This document was developed with the help of the Massachusetts Technical Standards Review Group and is consistent with the pending revision of the IEEE 1547 Standard for Interconnection and Interoperability of Distributed Resources with Associated Electrical Power Systems Interfaces. All applicable inverter-based applications shall:

- be certified per the requirements of UL 1741 SA as a grid support utility interactive inverter
- have the voltage and frequency trip settings
- have the abnormal performance capabilities (ride-through)
- comply with other grid support utility interactive inverter functions statuses

These specifications are detailed below and are consistent with the amended IEEE Std 1547a-2014.

1. **Certification per UL 1741 SA as grid support utility interactive inverters**

   In the interim period while IEEE P1547.1 is not yet revised and published, certification of all inverter- based applications:

   a. shall be compliant with only those parts of Clause 6 (Response to Area EPS abnormal conditions) of IEEE Std 1547-2018 (2nd ed.)1 that can be certified per the type test requirements of
   UL 1741 SA (September 2016). IEEE Std 1547-2018 (2nd ed.) in combination with this document
   replaces other Source Requirements Documents (SRDs), as applicable;

   b. may be sufficiently achieved by certifying inverters as grid support utility interactive inverters per the requirements of UL 1741 SA (September 2016) with either CA Rule 21 or Hawai'ian Rule 14H as the SRD. Such inverters are deemed capable of meeting the requirements of this document.

2. **Voltage and frequency trip settings for inverter based applications**

   Applications shall have the voltage and frequency trip points specified in Tables I and II below.

3. **Abnormal performance capability (ride-through) requirements for inverter based applications**

   The inverters shall have the ride-through capability per abnormal performance category II of IEEE Std 1547-2018 (2nd ed.) as quoted in Tables III and IV.

The following additional performance requirements shall apply for all inverters:

a. In the Permissive Operation region above 0.5 p.u., inverters shall ride-through in Mandatory Operation mode, and
b. In the Permissive Operation region below 0.5 p.u., inverters shall ride-through in Momentary Cessation mode.

1
7.3 as a proxy, subject to minor
editorial changes.

Consistent with IEEE Std 1547-2018 (2nd ed.) the following shall apply:

a. DER tripping requirements specified in this SRD shall take precedence over the abnormal performance capability (ride-through) requirements in this section, subject to the following:
    1. Where the prescribed trip duration settings for the respective voltage or frequency magnitude are set at least 160 ms or 1% of the prescribed tripping time, whichever is greater, beyond the prescribed ride-through duration, the DER shall comply with the ride-through requirements specified in this section prior to tripping.
    2. In all other cases, the ride-through requirements shall apply until 160 ms or 1% of the prescribed tripping time, whichever is greater, prior to the prescribed tripping time.
b. DER ride-through requirements specified in this section shall take precedence over all other requirements within this SRD with the exception of tripping requirements listed in item a. above. Ride-through may be terminated by the detection of an unintentional island. However, false detection of an unintentional island that does not actually exist shall not justify non- compliance with ride-through requirements. Conversely, ride-through requirements specified in this section shall not inhibit the islanding detection performance where a valid unintentional islanding condition exists.

4. Other grid support utility interactive inverter functions statuses

Other functions required by UL 1741 SA shall comply with the requirements specified in Table V. For functions not activated by default, the inverter is compliant if tested to the manufacturers stated capability.

5. Definitions

The following definitions which are consistent with IEEE Std 1547-2018 (2nd ed.) and UL 1741 SA shall apply:

cease to energize: Cessation of active power delivery under steady state and transient conditions and limitation of reactive power exchange. This may lead to momentary cessation or trip.

clearing time: The time between the start of an abnormal condition and the DER ceasing to energize the utility's distribution circuit(s) to which it is connected. It is the sum of the detection time, any adjustable time delay, the operating time plus arcing time for any interposing devices (if used), and the operating time plus arcing time for the interrupting device (used to interconnect the DER with the utility's distribution circuit).

continuous operation: Exchange of current between the DER and an EPS within prescribed behavior while connected to the utility's distribution system and while the applicable voltage and the system frequency is within specified parameters.

mandatory operation: Required continuance of active current and reactive current exchange of DER with utility's distribution system as prescribed, notwithstanding disturbances of the utility's distribution system voltage or frequency having magnitude and duration severity within defined limits.

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momentary cessation: Temporarily cease to energize the utility's distribution system while connected to the utility's distribution system, in response to a disturbance of the applicable voltages or the system frequency, with the capability of immediate restore output of operation when the applicable voltages and the system frequency return to within defined ranges.

permissive operation: operating mode where the DER performs ride-through either in mandatory operation or in momentary cessation, in response to a disturbance of the applicable voltages or the system frequency.

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Table I: Inverters' Voltage Trip Settings

Shall Trip – IEEE Std 1547-2018 (2nd ed.) Category II					
Shall Trip Function	Required Settings		Comparison to IEEE Std 1547-2018 (2nd ed.) default settings and ranges of allowable settings for Category II		
	Voltage (p.u. of nominal voltage)	Clearing Time(s)	Voltage	Clearing Time(s)	Within ranges of allowable settings?
OV2	1.20	0.16	Identical	Identical	Yes
OV1	1.10	2.0	Identical	Identical	Yes
UV1	0.88	2.0	Higher (default is 0.70 p.u.)	Much shorter (default is 10 s)	Yes
UV2	0.50	1.1	Slightly higher (default is 0.45 p.u.)	Much longer (default is 0.16 s)	Yes

Table II: Inverters' Frequency Trip Settings

Shall Trip Function	Required Settings		Comparison to IEEE Std 1547-2018 (2nd ed.) default settings and ranges of allowable settings for Category I, Category II, and Category III		
	Frequency (Hz)	Clearing Time(s)	Frequency	Clearing Time(s)	Within ranges of allowable settings?
OF2	62.0	0.16	Identical	Identical	Yes
OF1	61.2	300.0	Identical	Identical	Yes
UF1	58.5	300.0	Identical	Identical	Yes
UF2	56.5	0.16	Identical	Identical	Yes

Table III: Inverters' Voltage Ride-through Capability and Operational Requirements

Voltage Range (p.u.)	Operating Mode/ Response	Minimum Ride-through Time(s) (design criteria)	Maximum Response Time(s) (design criteria)	Comparison to IEEE Std 1547-2018 (2nd ed.) for Category II
V > 1.20	Cease to Energize	N/A	0.16	Identical
1.175 < V ≤ 1.20	Permissive Operation	0.2	N/A	Identical
1.15 < V ≤ 1.175	Permissive Operation	0.5	N/A	Identical
1.10 < V ≤ 1.15	Permissive Operation	1	N/A	Identical
0.88 ≤ V ≤ 1.10	Continuous Operation	infinite	N/A	Identical
0.65 ≤ V < 0.88	Mandatory Operation	Linear slope of 8.7 s/1 p.u. voltage starting at 3 s @ 0.65 p.u.: T = 3 s + 8.7 s (V − 0.65 p.u.) VRT 1 p. u.	N/A	Identical
0.45 ≤ V < 0.65	Permissive Operation [a,b]	0.32	N/A	See footnotes a & b
0.30 ≤ V < 0.45	Permissive Operation [b]	0.16	N/A	See footnote b
V < 0.30	Cease to Energize	N/A	0.16	Identical

The following additional operational requirements shall apply for all inverters:

a. In the Permissive Operation region above 0.5 p.u., inverters shall ride-through in Mandatory Operation mode, and
b. In the Permissive Operation region below 0.5 p.u., inverters shall ride-through in Momentary Cessation mode with a maximum response time of 0.083 seconds.

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Table IV: Inverters' Frequency Ride-through Capability

Frequency Range (Hz)	Operating Mode	Minimum Time(s) (design criteria)	Comparison to IEEE Std 1547-2018 (2nd ed.) for Category II
f > 62.0	No ride-through requirements apply to this range		Identical
61.2 < f ≤ 61.8	Mandatory Operation	299	Identical
58.8 ≤ f ≤ 61.2	Continuous Operation	Infinite	Identical
57.0 ≤ f < 58.8	Mandatory Operation	299	Identical
f < 57.0	No ride-through requirements apply to this range		Identical

Table V: Grid Support Utility Interactive Inverter Functions Status

Function	Default Activation State
SPF, Specified Power Factor	OFF[2]
Q(V), Volt-Var Function with Watt or	OFF
SS, Soft-Start Ramp Rate	ON Default value: 2% of maximum current output
FW, Freq-Watt Function OFF	OFF

2
with unity PF.

APPENDIX F: 1993 SYSTEM PLANNING STUDY

VILLAGE OF LUDLOW ELECTRIC LIGHT DEPARTMENT
LUDLOW, VERMONT

SYSTEM PLANNING STUDY

1.0 OVERVIEW OF STUDY

A Distribution System Planning Study was performed for the Village of Ludlow Electric Department (LED). The major focus of the study was to:

1. Determine the long term distribution system requirements of the LED through the year 2013 which are necessary to continue to provide reliable electrical service to its customers.

2. Develop and review alternatives to meet expected load conditions in a least cost manner utilizing proven loss savings techniques including, but not limited to those items specifically referenced in the Vermont DPS Twenty Year Plan criteria.

Alternatives were selected or rejected based on Net Present Value of Revenue Requirement calculations. A recommended long-term action plan was then developed by scheduling the selected alternatives at the appropriate time.

2.0 SUMMARY OF FINDINGS AND RECOMMENDATIONS

The LED system consists of three (3) 12.47 kV distribution feeders and four (4) 4.16 kV distribution feeders, which combined, serve a total winter peak demand of 10.2 MW. The system has 28 MVA of installed 44/12.47 kV substation transformer capacity and 4.0 MVA of 44/3.16 kV substation capacity.

The annual load forecast used for this study predicts a system peak demand of 12.7 MW in the year 2013. A circuit by circuit load forecast was developed and is included as Table 4.3 of this report.

A review of the LED system indicates, that, overall, the system is in good physical condition, operating efficiently, and able to provide reliable power to all customers in the service territory now and throughout the study period. No overloaded substation equipment or distribution primary conductors were found. Some additional reactive support may be required during the later years of the study period, although this will depend on LED's ability to improve the power factor of individual customer loads. No additional distribution capacitors can be firmly recommended at this time.

Primary voltage levels within range A of ANSI C84.1-1982 were found to exist at all system locations except one throughout the study period. It is recommended that LED install a recording voltmeter on a service supplied by Scott and Scott transformer 12-16 or 12-17 on the High Street feeder to determine whether a low voltage condition actually exists. This voltmeter should be installed during the 1993-1194 winter peak load period. If necessary, the voltage level on this circuit could be raised by adjusting the load tap changer voltage controls on the number one transformer at Commonwealth Avenue substation.

A variety of loss savings techniques were applied to the system model, including those items listed in the Vermont DPS Twenty Year Plan criteria. The reduced kW and kWH equivalent dollar savings associated with each option were compared to the implementation cost using Net Present Value of Revenue Requirement calculations to determine the break even year. It is recommended that LED immediately undertake all measures found to break even within ten years. The first year combined energy and demand savings would be approximately $8000. A summary of action items is included at Table 2.1 of this section.

TABLE 2.1

LUDLOW ELECTRIC DEPARTMENT

VERMONT DPS 20-YEAR PLAN CRITERIA ANALYSIS SUMMARY

DPS Criteria No.	ACTION ITEM	System Losses Before	System Losses After	Loss Reduction (kW)	1993 Savings ($)	1993 Cost ($)	Break Even Year	Status
7.1	Transfer all Okemo Mountain Load to Okemo Feeder	242.4	207.2	35.2	6159	300	1	Complete
7.1	Transfer all Okemo Mountain load to Okemo Feeder, install auto transfer	242.4	207.2	35.2	6159	2500	1	Complete
7.2	Network Smithville and Okemo Feeders	207.2	205.5	1.7	297	1500	20+	Complete
7.1	High Street Feeder transferred to Okemo Feeder Stepdown	207.2	223.8	(16.6)	-	-	-	Complete
7.1	Balance Phase Loading – Smithville Feeder	207.2	205.0	2.2	385	300	1	Complete
7.1	Balance Phase Loading – Rt.103 N Feeder	205.0	200.5	4.5	787	300	1	Complete
7.1	Remove Voltage Regulator – Rt. 103 N Feeder	200.5	200.2	0.3	100	300	4	Complete
7.1	Balance Phase Loading – High Street, Mill Street Feeders	200.2	199.1	1.1	192	300	2	Complete

7.2	**Network Main Street and High Street**	**199.1**	**198.3**	**0.8**	**140**	**12500**	**20+**	**Complete**
7.5	**Reconductor Smithville Feeder – Substation to Main Street**	**199.1**	**183.6**	**15.5**	**2712**	**48000**	**15**	**Complete**
7.8	**Reduce operating voltage to 100% of nominal (see comments section 7.8)**	**199.1**	**197.6**	**1.5**	**262**	**0**	**1**	**Complete**
7.6	**Convert Main Street Feeder to Smithville 12.47 kV**	**199.1**	**205.2**	**(6.1)**	**-**	**-**	**-**	**Complete**
7.6	**Convert High Street Feeder to Smithville 12.47 kV**	**199.1**	**209.8**	**(10.7)**	**-**	**-**	**-**	**Complete**
7.6	**Covert all 12.47 kV to 34.5 kV (two 34.5 kV feeders)**	**199.1**	**49.4**	**149.7**	**26195**	**1450000**	**20+**	**Will not be doing**
7.6	**Convert all feeders to 34.5 kV**	**199.1**	**35.9**	**163.2**	**28558**	**1550000**	**20+**	**Will not be doing**
7.4	**Activate existing capacitor switching, off peak**	**28.4**	**26.2**	**2.2**	**123**	**0**	**1**	**Complete**
7.4	**Add additional capacitor switching, off peak**	**26.2**	**23.2**	**3.0**	**167**	**4500**	**19**	**Complete**

APPENDIX G: FINANCIAL MODEL SUMMARY

Figure 23 Ludlow Revenue Requirement Summary

Ludlow Electric Department

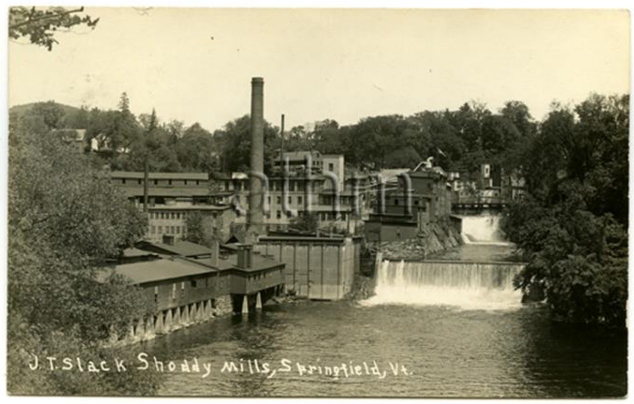
Base Case Projected Revenue Requirement 2020-2039

	2020	2021	2022	2023	2024	2029	2034	2039
Revenue Requirement Increase %		2.04%	1.81%	2.42%	3.30%	2.76%	3.19%	3.19%
Retail Load MWH	55,083	54,686	54,780	54,911	55,151	56,637	59,477	62,448
Retail Load Growth		-0.7%	0.2%	0.2%	0.4%	0.6%	1.1%	0.9%
Retail Revenue Requirements								
Production O&M	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Purchased Power &TBO	6,162,555	6,264,884	6,350,265	6,486,830	6,708,489	7,858,567	9,260,843	11,035,671
Other O&M	764,843	781,669	798,866	816,441	834,403	930,315	1,037,253	1,156,483
A&G	1,037,012	1,059,826	1,083,142	1,106,972	1,131,325	1,261,368	1,406,359	1,568,017
Depreciation	167,933	180,178	184,608	197,711	201,254	219,512	247,096	281,560
Taxes	330,796	335,666	349,875	356,380	362,655	413,116	461,425	528,640
Total Operating Expenses	$8,463,139	$8,622,223	$8,766,757	$8,964,333	$9,238,126	$ 10,682,878	$ 12,412,977	$ 14,570,371
Other Income & Expense								
Misc. Electric Revenue	54,951	56,160	57,396	58,659	59,949	66,840	74,523	83,090
Other Income	662,891	662,618	663,272	664,971	665,087	667,045	670,770	675,971
Interest Expense	4,542	4,642	4,744	4,848	4,955	5,524	6,159	6,867
Net Income	$ 193,746	$ 197,702	$ 201,271	$ 206,139	$ 212,951	$ 248,863	$ 291,846	$ 345,454
Total Revenue Requirement	$7,943,584	$8,105,789	$8,252,103	$8,451,690	$8,730,996	$ 10,203,380	$ 11,965,689	$ 14,163,632
Average Retail Rate $/MWH	$ 144.2	$ 148.2	$ 150.6	$ 153.9	$ 158.3	$ 180.2	$ 201.2	$ 226.8
YOY rate change		2.8%	1.6%	2.2%	2.9%	2.2%	2.1%	2.3%
Average Rates - CAGR	2.3%							
Key Cash Related Items								
Cash provided by operations	$ 202,782	$ 218,983	$ 226,982	$ 244,953	$ 255,308	$ 468,375	$ 538,942	$ 627,015
Bonds Issued	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Construction expenditure	$ (525,000)	$ (225,000)	$ (525,000)	$ (167,500)	$ (130,050)	$ (456,910)	$ (158,530)	$ (275,030)
Long Term Debt Principal Payment	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Operating reserve Balance	$ 677,782	$ 671,765	$ 723,747	$ 801,200	$ 726,459	$ 831,032	$ 1,021,777	$ 1,171,980
TIER (EBIT/INT)	**8.7**	**9.4**	**9.9**	**10.7**	**11.9**			
Debt Service Coverage (EBITDA/(P&I))	**80.6**	**82.4**	**82.3**	**84.3**	**84.6**			

GLOSSARY

CAGR	Compound Annual Growth Rate
CC	Combined Cycle (Power Plant)
CCHP	Cold Climate Heat Pump
DPS	Department of Public Service or “Department”
TIER II	Distributed Renewable Energy (Tier II)
EIA	Energy Information Administration
ET	Energy Transformation (Tier III)
EV	Electric Vehicle
EVT	Efficiency Vermont
HPWH	Heat Pump Water Heater
IRP	Integrated Resource Plan
kVA	Kilovolt Amperes
MAPE	Mean Absolute Percent Error
MVA	Megavolt Ampere
MW	Megawatt
MWH	Megawatt-hour
LED	Ludlow Electric Department
NYPA	New York Power Authority
PUC	Public Utility Commission
R^2	R-squared
RES	Renewable Energy Standard
RTLO	Real-Time Load Obligation
SCADA	Supervisory Control and Data Acquisition
TOU	Time-Of-Use (Rate)
TIER I	Total Renewable Energy (Tier I)
VFD	Variable Frequency Drive
VSPC	Vermont System Planning Committee

Southern Windsor County Regional Energy Plan



Adopted

June 25, 2018

Southern Windsor County Regional Planning Commission

Acknowledgements

The Southern Windsor County Regional Energy Plan was developed by the Southern Windsor County Regional Planning Commission with support and assistance from the following organizations:

Vermont Public Service Department

Vermont Energy Investment Corporation

Bennington County Regional Commission

Public input was sought through a series of presentations during the development of this draft plan. Thanks to the many town officials and members of the public who provided valuable feedback. We would like to extend a special thanks to town energy coordinators and town energy committee members for your valuable coordination and assistance.

Executive Summary

❖ Background and State Energy Goals

Vermonters rely on energy to support their lifestyles. We are heavily reliant on fossil fuels for much of the energy that is currently consumed in both Vermont and southern Windsor County. Fossil fuels are problematic due to a number of factors, including their finite supply, highly variable costs, negative environmental impacts (e.g. extraction operations, fuel distribution, emissions, climate change), and need to be imported from outside of the region. In response, Vermont has established ambitious goals to conserve energy, increase the utilization of renewable energy, and reduce greenhouse gas emissions.

The intent of this plan is to serve as the energy element of the Southern Windsor County Regional Plan per 24 V.S.A. §4348a(a)(3) as well as to meet the requirements of an "Enhanced Energy Plan" in accordance with 24 V.S.A. §4352. The Southern Windsor County Regional Planning Commission (SWCRPC) intends to submit this Plan to the Commissioner of Public Service for a determination of energy compliance, which would enable this document to receive "substantial deference" in Section 248 proceedings. Accordingly, this Plan hereby embraces the following State energy goals:

> Expanding upon the statutory goal of 25% renewable by 2025 [10 V.S.A. § 580(a)], the ***2016 Vermont Comprehensive Energy Plan (CEP)*** establishes the following set of goals:
>
> 1. Reduce total energy consumption per capita by 15% by 2025, and by more than one third by 2050.
> 2. Meet 25% of the remaining energy need from renewable sources by 2025, 40% by 2035, and 90% by 2050.
> 3. Three end-use sector goals for 2025:
>   a. Transportation: 10% renewable;
>   b. Buildings: 30% renewable; and,
>   c. Electric power: 67% renewable.
>
> 10 V.S.A. § 578(a) calls for **reducing emissions of greenhouse gases** from the 1990 baseline by:
>
> 1. 50% by January 1, 2028;
> 2. 75% by January 1, 2050, If practicable using reasonable efforts.
>
> **25 by 25 State goal** [10 V.S.A. § 580]: By the year 2025, produce 25% of the energy consumed within the State through the use of renewable energy sources, particularly from Vermont's farms and forests.
>
> **Building efficiency goals** [10 V.S.A. §581]
>
> 1. To improve substantially the energy fitness of at least … 25% of the State's housing stock by 2020 (approximately 80,000 housing units).
> 2. To reduce annual fuel needs and fuel bills by an average of 25% in the housing units served.
> 3. To reduce total fossil fuel consumption across all buildings by an additional one-half percent each year, leading to a total reduction of … 10% annually by 2025.

4. To save Vermont families and businesses a total of $1.5 billion on their fuel bills over the lifetimes of the improvements and measures installed between 2008 and 2017.
5. To increase weatherization services to low-income Vermonters by expanding the number of units weatherized, or the scope of services provided, or both, as revenue becomes available in the Home Weatherization Assistance Fund.

❖ Regional Energy Profile

Current energy usage is discussed in Section III; some key points are summarized below:

- Transportation accounts for nearly half of the region's current energy costs, with electricity at 25% and heating at about 26%.
- As a rural area, we are heavily reliant upon the automobile for personal mobility. According to Estimates for the region, more than 283 million vehicle miles were traveled in 2015. Significant changes are needed in order to meet our targets. This will probably be the most difficult sector to address.
- Electricity consumption has been fairly level over the past few years. Looking to electric vehicles and heat pumps as strategies to meet the statewide energy goals will place additional demands on electricity, which will need to be off-set by reducing demand in other ways and increasing generation of electricity from renewable sources.
- Our building stock is old[1], indicating that weatherization may have a large impact on energy demand for heating. We are far behind meeting our statutory goal for weatherization of homes by 2020.
- Fossil fuels are currently used to heat about 75% of all homes in the region.
- Heating commercial and industrial buildings is estimated to cost about $8 million annually, or about $9,500 per business.

Targets are established for the region in Section IV. They illustrate the levels of change that will likely be needed in order to meet the stated energy goals. These goals are extremely ambitious. Therefore, the changes needed to meet them are also significant.

❖ Policies and Implementation Actions

In order to meet the above energy goals, the SWCRPC has identified a number of implementation strategies. These strategies are detailed in Section V, and some are highlighted below:

We will encourage the **conservation and efficient use of energy** through various means that include, but are not limited to, the following:

- Support municipal energy planning initiatives and educational outreach efforts.
- Increase public awareness of energy efficiency programs made available through Efficiency Vermont, and provide staff support to assist Efficiency Vermont's education and outreach efforts.
- Encourage building techniques and technologies that reduce general energy demand or peak energy demand (e.g. day-lighting buildings or utilizing energy storage systems).
- Assist towns and partner organizations with education and outreach efforts to influence behavioral changes needed to meet these goals.

---

[1] 1972 is the median year homes were built in Windsor County

We will promote efforts to **reduce transportation energy demand**, **decrease single-vehicle occupant use**, and encourage **renewable or lower-emission energy sources for transportation** through various means that include, but are not limited to, the following:

- Increase awareness of existing services and programs such as public transportation services and the Go Vermont program.
- Assist towns with the maintenance and improvement of pedestrian and bicycling infrastructure in village centers, and with the connection of residential neighborhoods to common destinations, such as schools and job centers.
- Promote or encourage high-speed internet development/access in order to enable telecommuting.
- Encourage development of infrastructure necessary for the wider use of electric vehicles (i.e. EV charging stations).

The SWCRPC has established policies to encourage **land use patterns and densities that are more likely to result in energy conservation**. These policies can be found primarily in the land use chapter of the *Southern Windsor County Regional Plan*. Policies in the transportation element of the *Regional Plan* also contribute toward this end.

This Plan establishes policies on the development and siting of renewable energy projects. In our baseline year (2015), this region had about 9.41 MW of renewable energy capacity – or 17,942 MWh of renewable energy generation – from known existing facilities (i.e. 276 solar arrays, 4 residential-scale wind turbines, and 6 hydropower facilities). In order to meet the stated energy goals, considerably more renewable energy generation is needed. This region's 2050 target for new renewable energy generation is 194,612 MWh (nearly 11 times the baseline renewable energy generation in 2015). The region encourages new renewable energy generation in the types and in the appropriate scales as discussed in Section V. In general, this Plan calls for a mix of roof-top solar, ground-mounted solar, residential-scale wind, and, where feasible, hydropower at existing dam sites. Commercial-scale wind (i.e. no greater than 50 meters at the height of the hub) may be acceptable if it meets the policies contained in Section IV. The SWCRPC encourages the use of biomass primarily for heating. Smaller-scale biomass power generation facilities may be appropriate if they generate both heat and power, and meet the policies laid out in this Plan.

Megawatt (**MW**) is a unit of electrical power equal to one million watts. A MW is equal to 1,000 kilowatts (kW). This unit of measurement is used in this plan to represent the installed capacity of power generation facilities.

Megawatt hour (**MWh**) is a unit of measure of electric energy. A MWh is equal to 1,000 kilowatt-hours (kWh). A MWh is the amount of electricity generated by a one megawatt (MW) power generation facility producing electricity for one hour (i.e. generation output). On an electricity bill, electricity usage is commonly reported in kilowatt-hours.

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A. Energy Data Summaries
B. Regional Energy Maps
C. Glossary
D. Acronyms

Section I: Introduction

A. Background of Regional Enhanced Energy Planning in Vermont

In 2016, two initiatives advanced energy planning in Vermont: Act 174 (2016) and a pilot program to develop regional enhanced energy plans.

The ***Department of Public Service*** provided funding for a pilot project to support the development of new energy plans by three of the state's regional planning commissions. The Department recognized that local and regional enhanced energy planning would help to advance Vermont's energy goals and facilitate implementation the **2016 Vermont Comprehensive Energy Plan**, The three pilot plans utilize statewide data, and serve as a model for similar plans in the remaining regions around the state, including southern Windsor County.

The ***Department of Public Service*** is funding the development of this plan. The ***Department of Public Service***, the ***Vermont Energy Investment Corporation (VEIC)***, the ***Energy Action Network***, and other organizations also provide staff and technical support for the regional planning process.

Act 174 (2016) enables municipalities and regional planning commissions to obtain "substantial deference" in the Section 248 permitting process for renewable energy generation facilities, but only if they have completed enhanced energy plans. On November 1, 2016, the Department of Public Service published standards that local and regional plans must meet in order to qualify as enhanced energy plans under Act 174.

Each of the regional plans has been developed using quantifiable energy conservation and renewable energy generation targets. VEIC developed these targets, in consultation with the regional planning commissions, using the **Long-Range Energy Alternatives Planning System or LEAP. LEAP is** a computerized system used for modeling future energy supply and demand. The model presupposed achieving the state goal to generate **90% of all energy used in Vermont from renewable sources by 2050**. The output of the energy model predicted total energy usage statewide and in each region projected over time (from 2015 through 2050), broken down by sector and fuel type. The regional planning commissions then worked with local communities to determine what those numbers meant in practical terms, and developed regional strategies guided by the resulting quantitative targets.

The regional planning commissions also worked with officials from several state agencies, nonprofit organizations, interest groups, and utility companies to define parameters used in the creation of renewable energy generation maps. The maps illustrate areas where renewable energy development is more feasible based on the presence of renewable energy resources and accounting for environmental and other locally identified constraints. The regional planning commissions reached out to local communities to identify general guidelines to consider when siting generation facilities.

B. ENERGY BASICS[2]

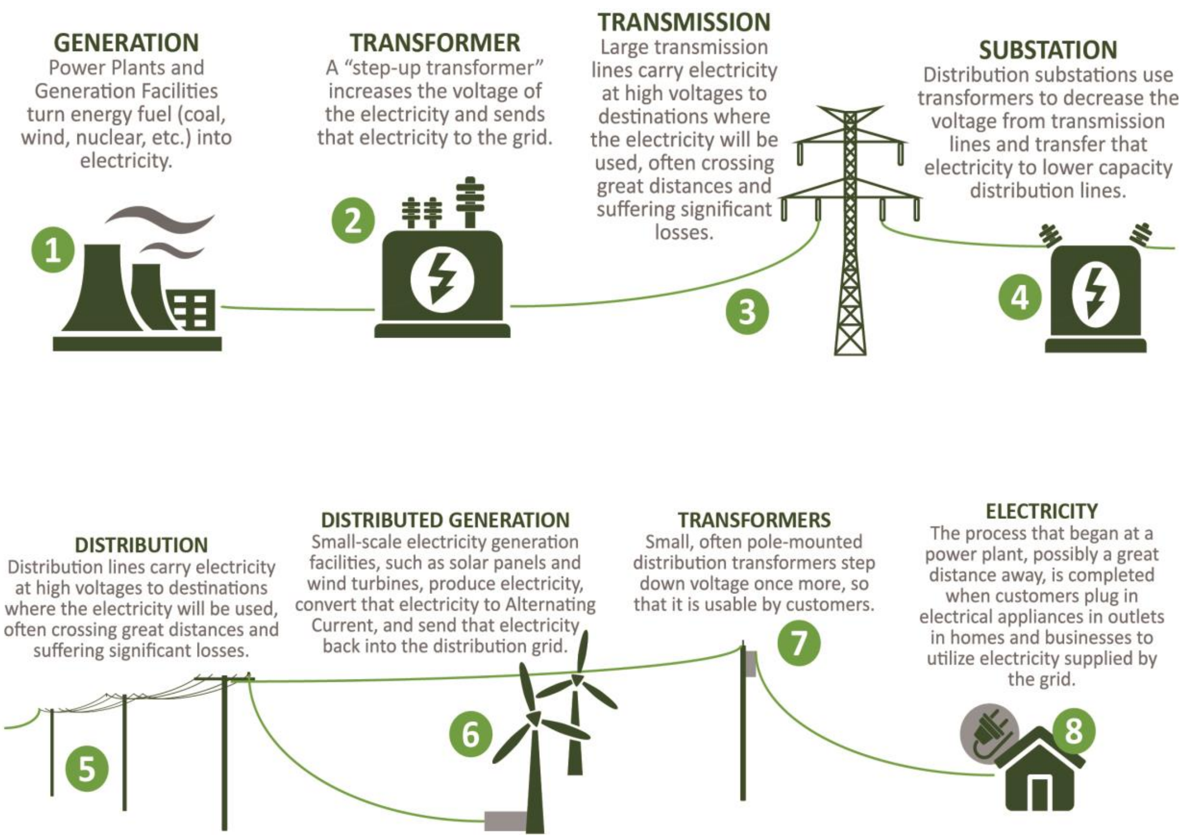
Scientists define energy as the ability to do work. Modern civilization is possible because people have learned how to change energy from one form to another and then use it to do work. People use energy to move cars along roads and boats through water, to cook food on stoves, to make ice in freezers, and to light and heat homes.

Energy comes in different forms: heat (thermal), light (radiant), motion (kinetic), electrical, chemical, nuclear, and gravitational. For the purpose of this plan, we are talking about energy that is used for heating buildings, transportation, and providing electricity.

Energy sources can be categorized as renewable or nonrenewable. Most of the energy consumed in the United States is from nonrenewable energy sources. Nonrenewable energy sources include petroleum products – such

Figure 1. Understanding the Grid

The diagram below outlines the major components in the electrical generation and distributic grid. (Source: Northwest Regional Energy Plan.)



as oil, natural gas, and coal – and nuclear energy. Unlike fossil fuels, which are finite, renewable energy sources

[2] Based on information from the U.S. Energy Information Administration (U.S. EIA) https://www.eia.gov/energyexplained/

regenerate. Renewable energy sources include: solar energy from the sun, geothermal energy from heat inside the earth, wind energy, biomass, biofuels, and hydropower from flowing water.

In general, electricity is generated at power plants and moves through a complex system of electricity substations, transformers, and power lines – sometimes called "the grid" – that connect electricity producers and consumers. Figure 1 illustrates how "the grid" functions. Most "local" grids are interconnected for reliability and commercial purposes, forming larger, more dependable networks that enhance the coordination and planning of the electricity supply. In Vermont, VELCO operates the electric transmission system. In our region, Green Mountain Power and Ludlow Electric provide power within their respective service areas. Power is also generated at smaller, decentralized facilities, such as solar panels and wind turbines (i.e. "distributed generation").

C. Purpose of Plan

Vermonters rely on energy to support their lifestyles. We are heavily reliant on fossil fuels for much of the energy that is currently consumed in southern Windsor County. Fossil fuels are problematic due to a number of factors including, their finite supply, highly variable costs, negative environmental impacts (e.g. extraction operations, fuel distribution, emissions, climate change), and need to be imported from outside of the region. In response, Vermont has established ambitious energy goals to conserve energy, increase the utilization of renewable energy, and reduce greenhouse gas emissions.

The intent of this plan is to serve as the energy element of the Southern Windsor County Regional Plan per 24 V.S.A. §4348a(a)(3) as well as to meet the requirements of an "Enhanced Energy Plan" in accordance with 24 V.S.A. §4352. The Southern Windsor County Regional Planning Commission (SWCRPC) intends to submit this Plan to the Commissioner of Public Service for a determination of energy compliance, which would enable this document to receive "substantial deference" in Section 248 proceeding. Accordingly, this Plan hereby embraces the State Energy Goals as referenced in 24 V.S.A. §4302(7), 10 V.S.A. §578(a), 10 V.S.A. §580, 10 V.S.A. §581, and in the 2016 Vermont Comprehensive Energy Plan.

D. ENERGY GOALS

In the 2016 Vermont Comprehensive Energy Plan (CEP), the State of Vermont identified a number of goals and strategies to achieve energy conservation throughout the state. The most significant of these goals is referred to as **"90/50"**. (See Below.)

By 2050, 90% of Vermont's total energy will be derived from renewable sources.

This overarching goal has informed the regional conservation strategies and renewable generation requirements that are articulated throughout this plan.

State Statutes and the 2016 Vermont Comprehensive Energy Plan (CEP) contain energy planning goals that include but are not limited to:

- By 2025, 25% of remaining energy needs will be met by renewable sources, 40% by 2035, and 90% by 2050

- By 2025, total energy consumption per capita will be reduced by 15%, and by 2050

by more than one-third.

- By 2025 Renewable sources will meet the demand for 10% of transportation needs, 67% of electricity demand, and 30% of building energy demand.
- By 2032, 75% of electricity demand will be derived from renewable sources
- By 2050, 50% of electricity will be obtained from locally distributed energy generation.
- Major reductions in contributions to greenhouse gas emissions will be made.
- By 2020, 80,000 housing units will undergo weatherization in Vermont.

The SWCRPC hereby adopts the goals established in statute and in the 2016 CEP for the region. The region will strive to achieve these goals through the detailed policies and actions identified in this plan. Below is a list of some of the methods outlined in this plan to further energy conservation and efficiency efforts within our region:

- Reduce total energy consumption throughout all sectors, including: electricity, space heating, and transportation.
- Support efforts at the local level to choose energy efficient and renewable options.
- Create a diverse mix of energy sources to reduce the impact of supply restriction.
- Utilize local, renewable sources of energy to decrease reliance on out-of-region, and out-of-state forms of fuel.
- Select energy choices that help preserve the environment.
- Strive for both an adequate supply of electricity, as well as a distribution network to meet the region’s needs.
- Maximize energy efficiency by matching fuel type to end use.
- Support adaption and lifestyle changes that contribute to meeting the State’s goals for future energy use and generation.

E. Plan Organization

This Plan is intended to address the Guidance for Regional Enhanced Energy Planning Standards as developed by the Vermont Department of Public Service on March 2, 2017. This document is organized into the following sections:

- Section I is an introduction that presents background information and highlights key issues for the region.
- Section II documents the current energy use in the region, including in the transportation, heating, and electricity sectors.

- Section III lists the regional energy targets that were developed based upon the Vermont Energy Investment Corporation (VEIC)'s Long-Range Energy Alternatives Planning (LEAP) system. The purpose of the targets is only to provide a sense of the scale of change needed to meet the State energy goals.
- Section IV lists policies and implementation strategies (or "pathways") for the region to pursue in order to meet these energy goals. This section includes specific pathways including, but not limited to, energy conservation, transportation, land use, and the siting of renewable energy projects.

F. Key Issues

❖ Energy Security

The state of Vermont has come to rely heavily on energy sources that are primarily from out-of-state sources. For example, the majority of electricity supply for the state is provided by hydroelectric facilities in Quebec and Labrador. Although this electricity is being generated through a renewable source at low cost, continuing the dependency on out-of-state sources could leave the state and region vulnerable to uncertain supply and cost. In Vermont, all gasoline and diesel fuels are imported to support vehicular transportation. Moreover, fossil fuels, such as transportation fuels, have a finite supply, highly variable costs, and well-documented negative environmental impacts. The scarcity of non-renewables, as well as dependence on outside suppliers, will leave the state and the region at risk. Creating facilities to generate renewable energy throughout the state will counter long-term security issues by ensuring consistent supply and helping to manage costs.

To provide the state with better energy security, one of the state goals calls for 25% of the energy used within the state to be produced (from renewable sources) within the state by 2025 [10 V.S.A. §580(a)].

Technologies must be carefully selected to ensure that net energy yields are as high as possible. Electricity generation from wind and hydropower has high energy returns relative to other renewables, provided they are sited in areas where the resource is sufficiently concentrated and relatively close to end users. Solar energy for thermal applications can be effective, and photovoltaic generation is becoming more efficient and cost-competitive. Wood biomass has proven to be a high-yielding heat source, provided it is sustainably harvested and used near its source in order to limit transportation costs. Other "renewable" energy technologies are less promising; the energy required to grow, harvest, and process corn into ethanol, and then to transport it for use, often exceeds the energy content of the resulting fuel.

Figure 2: Utilizing energy sources that are renewable and locally-available (e.g. solar, wind, woody biomass, and hydropower) should be more commonplace.

Aggressive energy conservation efforts, electricity generation from properly sited in-state renewable sources, and heating from locally-sourced biomass offer the best long-term approach to ensuring the region's energy security. There is no question that some significant portion of Vermont's future energy supply will have to be imported, but increasing local generation will result in greater security, less risk, and improved efficiency.

❖ Environmental Protection

Over the last few centuries, the reliance on fossil fuels to support our way of life has had a blatant, damaging impact on the environment. For Vermont, climate change has the potential to threaten both our economy and quality of life. These harmful effects have become increasingly apparent due to impacts on forests, which threaten the maple syrup industry. Furthermore, a warmer climate and unpredictable weather will also impact the skiing industry. More frequent severe weather events are likely to result in damage to infrastructure and property, which will have additional financial impacts. The environmental damage alone calls for a change in energy use and the way in which it is obtained, but the threat to our safety and local economy provides even further justification for transitioning to renewable, less-impactful energy sources. See the state's Climate Change in Vermont website for more information.

Figure 3: Reduce greenhouse gas emissions from 1990 levels

40% reduction by 2030

80% to 95% reduction by 2050

(2016 VT Comprehensive Energy Plan)

❖ Economic Needs and Opportunities

In the Region, recent annual expenditures on energy for space heating, transportation, and electricity are estimated to be roughly $117 million, equivalent to about $4,600 per person. The state of Vermont spends over $3 billion on energy expenses annually. The burden of paying for the high cost of energy falls on the consumer. Furthermore, the majority of the money being spent on these forms of fuel, such as gasoline and diesel, are not only leaving both the region and state, but in many cases the country. If this money could be retained within the local economy, the financial gain would have an immense impact and help to improve quality of life for local residents.

The changes required to decrease overall energy use within the region may stimulate economic growth by encouraging businesses to innovate, creating jobs within the state and region. According to the Public Service's Department's *Clean Energy Industry Report for 2015*, there are now 2,500 "clean energy" businesses employing 16,000 people in the state. Transitioning to renewable energy sources has benefits for the state and region including, achieving greater energy security and environmental protection, retaining much of the money spent on energy locally, and creating new business and job opportunities.

❖ Adaptation and Lifestyle

Ultimately, achieving many of the state and regional energy goals will require people to change their behaviors and lifestyles. Reductions in daily energy use will require more than just efficiency improvements. People will have to alter their behavior patterns, using electricity, transportation, and heating systems with greater thought given to limiting energy use and increasing energy efficiency. Changing behavior is very difficult, but it is critical in order to reach the state's ambitious energy goals.

Section II: Regional Energy Supply and Consumption

The following section summarizes the existing conditions and analyzes recent trends related to energy supply and consumption in the region. All estimates and projections presented in this Plan are derived from 2015 base year data from a variety of federal, state and regional sources, unless indicated otherwise. These sources include, the U.S. Census Bureau, Vermont Energy Investment Corporation (VEIC), Vermont Center for Geographic Information (VCGI), Vermont Agency of Transportation (VTrans), Vermont Agency of Commerce and Community Development (ACCD), Vermont Department of Public Service, and others. Examining current energy consumption and sources provides a basis for projections of future renewable energy needs and potential savings from conservation, increased efficiency, and the use of alternative fuel sources.

Energy usage is broken down by the following sectors:

- Residential Space Heating and Home Weatherization
- Commercial/Industrial Space Heating
- Transportation
- Electricity

Figure 4 shows total energy use by sector in Vermont. Transportation is the largest component at nearly 40% of total energy use.

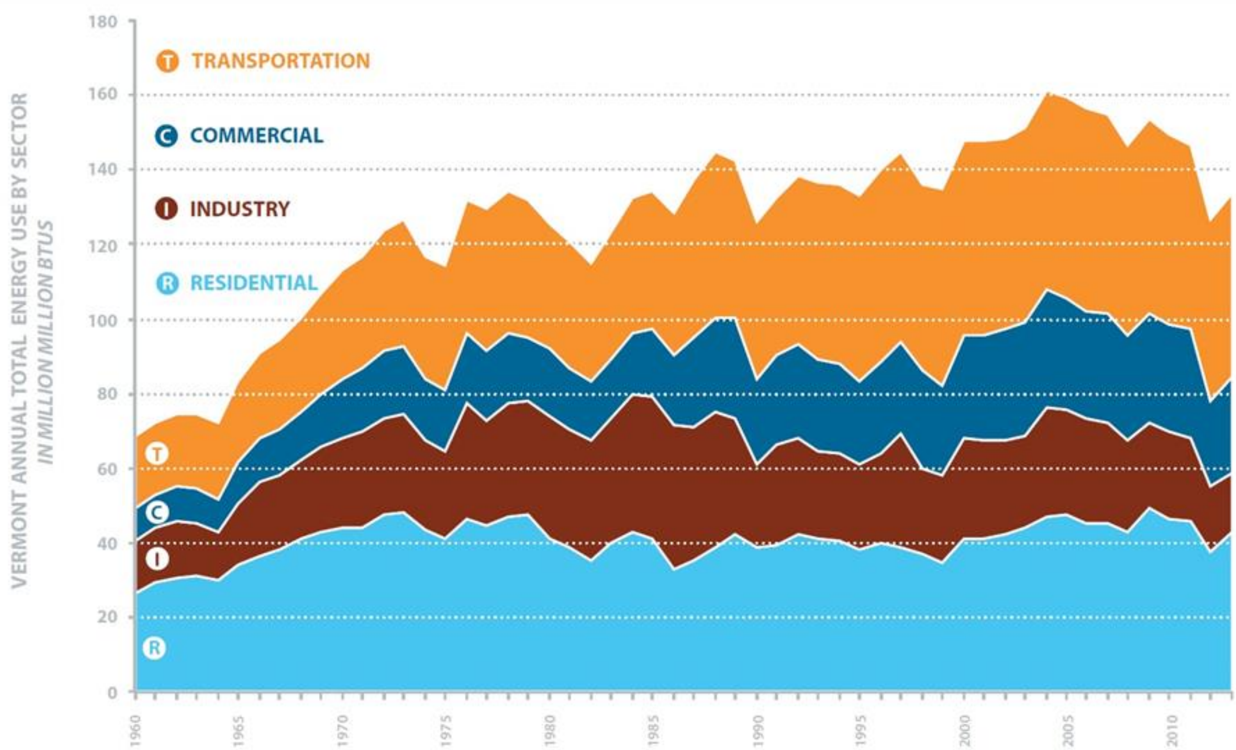


Figure 4: This graph shows the annual energy use by sector in Vermont between 1960 and the baseline year of 2015. (Source: Vermont Energy Investment Corporation)

Examining current energy consumption and sources will help identify inefficiencies and determine strategies for conservation and areas that can be accommodated with renewable sources of energy.

A. Heating

❖ Residential Heating

Figure 5: Renewable energy systems were more the exception than the rule in the region in 2015. However, there are a lot more systems being installed in the last few years, such as this solar hot water system (evacuated tubes) on a house in Weathersfield. (Julia Lloyd Wright)

In the region, roughly $22 million is spent on residential heating annually. Of approximately 14,000 households in the region, about 11,000 are occupied year-round. According to the American Community Survey, the average annual heating cost is $2,100 per household[3]. Fuel oil is the most widely consumed residential heating fuel in the region for both owner and renter occupied households. For owner occupied households, wood, in the form of cord wood and wood pellets, is the second most commonly used fuel source in the region at about 22%. Conversely, propane gas is the second most common fuel source for renter occupied households in the region at about 25%. Renter occupied spaces also utilize electricity as a heating source, while very few owner-occupied homes do (*See Figure 7*[4]). An increasing number of households are using electricity as a heating source, likely due to programs that encourage the use of cold-climate heat pumps.

Figure 6: A masonry heater is a very efficient way to heat a home with wood. (Peter Hudkins)

When examining potential strategies for improving energy usage, it is important to understand how housing characteristics impact space heating usage. In the region about 30% of the housing stock are rental homes. It may be more challenging to incentivize energy efficiency investments in both lower-income owner occupied units as well as rental properties.

Geothermal heat pumps are now often encouraged for new developments by some local companies, but we do not have good data on how many of those systems currently exist. Wood is the only locally-sourced fuel type, and its use supports the local forestry economy.

[3] Calculated by the SWCRPC based on the number of housing units, heating fuel types and average fuel costs for 2015.

[4] U.S. Census Bureau ACS (2011-2015); Fact Finder, table: B25117

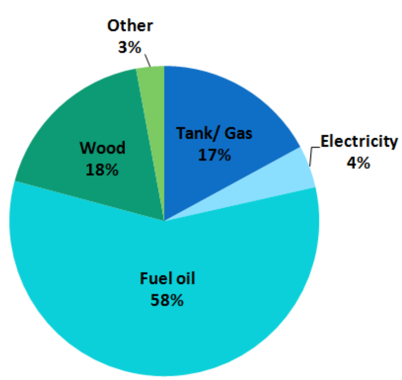
Median house size in the northeast of the U.S. has increased by 61% since 1073. Median house size was 1,450 square feet in 1973, and increased to 2,336 square feet in 2010. While new construction is subject to energy

Figure 7. Home Heating Estimates

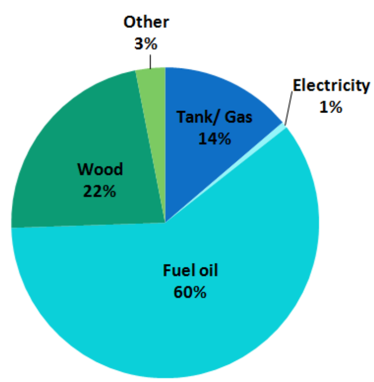
The following table shows current regional heating fuel use based on fuel and household type.

Home Heating Fuel Type	Number of Households	Average Annual Use	Annual Cost
Propane/Gas	1,813	1,810,365 gal	6,245,759
Electricity	469	9,097,715 KWh	1,338,274
Fuel Oil/Kerosene	6,129	4,374,861 gal	12,030,869
Wood	1,900	9,247 cord	2,066,010
Other	312	N/A	
Total	**10,623**		**21,680,912**

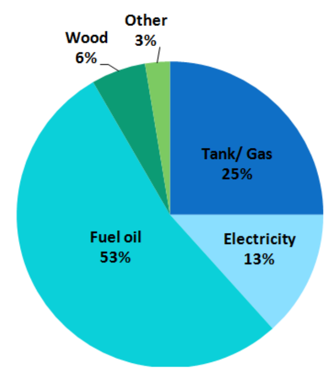
building codes, building smaller new homes will also help to reduce energy demand for heating. In addition, smaller homes – such as tiny houses, cottages, bungalows, co-housing and/or accessory dwelling units – are gaining in popularity and provide needed housing options for our changing demographics.



All Households in Southern Windsor



Owner Households in Southern Windsor



Renter Households in Southern Windsor

❖ Home Weatherization

Weatherization of homes is an important step in the efforts to decrease energy utilized for space heating and create better efficiency. Slightly more than half of the homes throughout the state, and the region, are more than 50 years old. Therefore, roughly half of the housing stock in the state and region is likely to be poorly insulated and not properly air-sealed. To remedy this issue, the state passed Act 92 (10 V.S.A. § 581) in 2008 that called for **20% of the state's housing units to be properly weatherized by 2017 (about 60,000 homes), and 25% by 2020 (about 80,000 homes)** statewide**.** According to the Comprehensive Energy Plan as of 2014, roughly 18,300 units had been weatherized, which is well shy of this goal[5].

There are several programs throughout the state to help private home owners and businesses properly weatherize their existing buildings. Programs offered by ***Efficiency Vermont*** and ***SEVCA*** have made improvements to about 900 housing units since 2009 in the Region. Additional programs, such as ***Vermont Weatherization Assistance Program****,* offer assistance to low income families, with a particular focus on elderly individuals or those with disabilities. Strategies that educate the public and make these programs more widely available will help in meeting weatherization goals for the state and the region. Local weatherization programs have had varying levels of success, but generally not anywhere near the scale needed to meet the goals set out in state statute.

Table 1: Weatherization of Housing Unit Goals

Region	# Units Since 2009	2017 Goal	2020 Goal
State of Vermont	20,909	60,000	80,000
Southern Windsor County	900	2,100	2,600

❖ Commercial and Industrial Heating

Determining the heating costs for commercial and industrial structures is more difficult than for residential structures due to the lack of data regarding the square footage of existing non-residential buildings. Calculating estimates for the size of the buildings were made[6], which allowed for estimates of energy use and costs associated with that use. In this region, commercial and industrial buildings utilize roughly 40% of space heating fuel. It must be taken into account that, within the region, there is a wide range in size and use of commercial and industrial space. There are about 900 businesses in the region inhabiting over 8,000 estimated square feet of space on average. Commercial and industrial heating-related costs are estimated to be as high as $8 million annually in the region, which is about $9,500 per business. Many of the larger industrial buildings, those of approximately 10,000 square feet and larger, are located in Springfield and Windsor. The SWCRPC estimated that total energy use by the commercial and industrial sector exceeded 360 billion BTUs of fuel oil and gas[7].

Oil and propane are the primary heating fuels for commercial buildings throughout the region with wood used commonly as well. Industrial buildings also primarily utilize oil and propane, but wood sees wider use as a heating source in industrial than in commercial buildings. In addition, some industrial buildings heat with coal as well. As with residential structures, the age, size and location of these buildings will dictate what renewable fuel sources make the most sense to switch over to, as well as what energy conservation measures can be taken. In

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[5] 2016 Vermont Comprehensive Energy Plan

[6] Based upon estimate of average commercial/manufacturing floor space per employee from the U.S. Energy Information Administration

[7] Based on the number of units, estimated floor space, heating fuel types and average fuel costs for 2015.

general, weatherization can reduce heating demand regardless of fuel source. As such, weatherization is encouraged as a priority investment to make before pursuing heating system upgrades.

B. Transportation

The transportation sector dominates energy use more than any other sector in the state and region. This is due to the heavy reliance on automobiles for private transportation in this rural area. The 2014 *Housing and Transportation Affordability* study evaluated the majority of Windsor County, including all of the towns within the region. The study presupposed that a household's transportation budget was affordable if it did not exceed 15% of annual household income. The study found that the majority of the area in the study exceeded that 15% affordability target for a median household income ($41,000).[8] This study estimated household transportation costs for a certain income level and based on a variety of prevailing conditions (e.g. demographics, housing and work locations, commuting patterns, proximity to services, and other factors). As a rural area with many residents traveling to jobs and services in locations outside of the region, transportation costs tend to be higher. We observe that when people purchase homes, the focus is often to find as big and as nice of a home as the household can afford, which is usually located in a more rural area. However, the choice to live in rural areas, as opposed to within town centers, generally means a greater reliance on transportation for routine travel needs. This transportation usually takes the form of single occupant vehicle (SOV) travel.

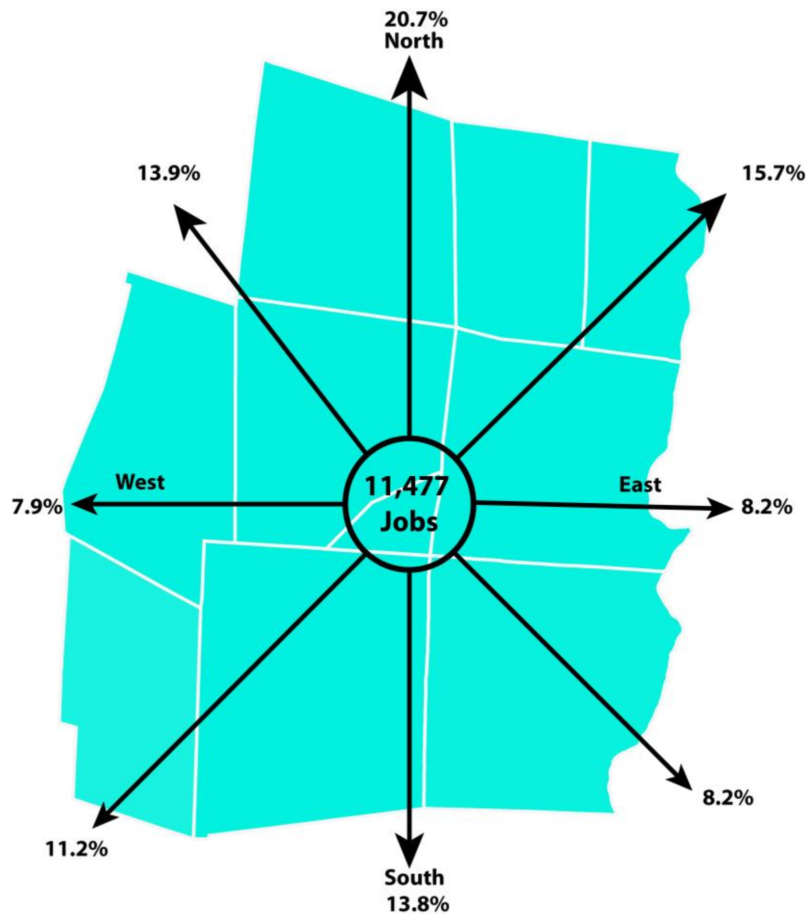


Figure 8: Commuting out of the Region. The graph above illustrates commuting patterns for residents in the region who are working outside of southern Windsor County.

Not surprisingly, petroleum-based fuels are the predominant fuel type used for transportation. Vermonters utilize roughly 306 million gallons of gasoline per year. Residents of the Region consume an estimated 17 million of those gallons to travel an estimated 283 million miles annually.[9] Moreover, heavy duty vehicles, such as trucks and buses, add an additional 2 million gallons of diesel fuel consumption per year within the Region. There are nearly 19,000 personal vehicles in the region, which residents

[8] East Central Vermont Housing and Transportation Affordability

[9] https://www.afdc.energy.gov/states/vt

generally rely on for meeting their travel needs. Workers living in this region have relatively long commuting distances. For example, a typical resident in Springfield commutes approximately 22.2 miles per day to reach jobs in and around the region, largely in SOVs. All resident Springfield workers combined commute over 97,000 miles per day.

Table 2: Regional Transportation Estimates	
Total Number of Vehicles	18,790
Estimated Gallons of Fuel	16,803,287
Total Miles Traveled	283,300,512
Total Estimated Cost	$57,551,257

While Springfield is the traditional job center for the region, many Springfield jobs are filled by people that live elsewhere and many Springfield residents travel to work in other towns. This results in greater travel distances for work, which could be minimized if people chose to live and work locally. Our relatively rural and low-density development patterns in the region generally result in SOV travel, although the Upper Valley commuter bus has good ridership.

Transportation issues within the region harken to a much larger economic problem facing the region: limited job opportunities result in residents commuting outside of the region, typically to the Upper Valley where wages tend to be higher. Localization of jobs would enable walking or biking to work, and in some larger towns, such as Springfield, public transportation could be utilized better. However, this transition would require a greater mix of employment options within the region and/or significant behavior changes.

Since the region is predominantly rural, walking and biking could only become common practice in limited areas. Larger towns have sidewalk networks in the built-up areas. VTrans is generally in support of making state routes bicycle-friendly, but to do so can be expensive. As a result, bicycling facilities are not as robust as many residents would like them to be. A practical solution for reducing the region's use of non-renewables in the transportation sector would be carpooling, as many residents in the region are employed in the Upper Valley. *Go Vermont* is a program currently supported by the state that provides online ride matching services. Currently, the park and ride lots found along I-91 are heavily used. There are two public transportation providers in the region, Southeast Vermont Transit and Ludlow Municipal Transit. Travel to destinations such as Boston, New York, Burlington, and Montreal are served by Dartmouth Coach, Vermont Translines and Greyhound, which are found just outside the region in White River Junction and Lebanon, NH. The Windsor Amtrak station and a few nearby train stations serve the region to provide access by train to northern Vermont and New York City. Other options to reduce transportation fuel demand include telecommuting, plug-in hybrid vehicles, electric vehicles, and the use of biofuels. Future technologies may present other options.

Units of Measurement

1 Kilowatt (KW) = 1,000 watts of electrical power

1 Megawatt (MW) = 1,000 KW

1 Gigawatt (GW) = 1,000 MW

1 Kilowatt Hour (KWh) = power consumption of 1,000 watts for 1 hour

1 Megawatt Hour (MWh) = 1,000 KWh

1 Gigawatt Hour (GWh): = 1,000 MWh

C. Electricity

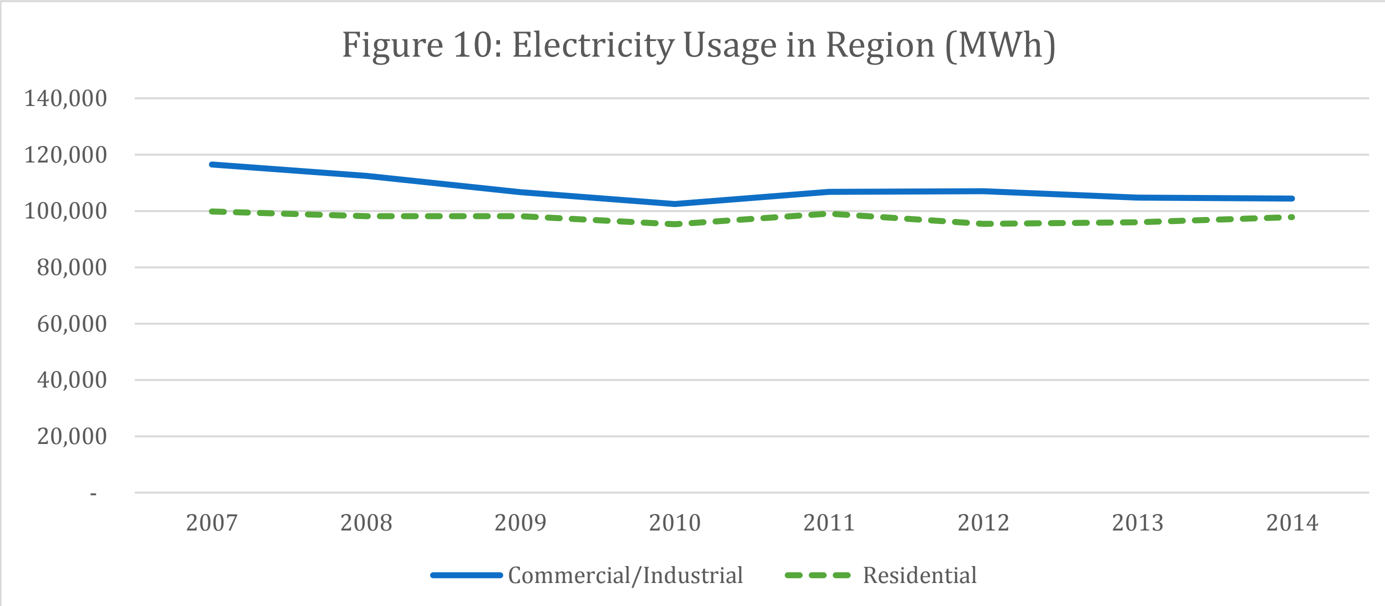
According to the **Vermont Comprehensive Energy Plan (CEP)**, the state consumed roughly 5,500 GWh of electricity in 2014. This amount was down from 2007, when it was closer to 6,000 GWh, and had stayed relatively constant until 2014. This consistency over this eight-year period may be partly due to the growing popularity of energy efficient appliances and lighting. In 2014, the CEP indicated that the state generated 45% of its electricity from renewable sources. Further, the CEP projected that by 2017 this would increase to 55%, and, by 2032, to 75%.

Throughout Vermont's history, electricity use in the winter has been consistently higher than in the summer. However, on average, electricity consumption during both seasons has consistently risen since 1990 according to Vermont Electric Power Company (VELCO). Consumption of electricity is projected to rise over the next twenty years, as more heating/cooling needs in the region will be sourced with electricity, contrary to the flat trends in recent electricity use depicted in Figure 10. Changing climate conditions, and the trend toward hotter summers, may result in greater future electricity demand in the summer as residents rely more on air conditioning.

As used in the LEAP model, electricity consumption was determined based on zip codes, not individual towns. The map in Figure 9 illustrates how the zip codes correlate to each town. Figure 10 shows electricity usage trends for the region as a whole. Electricity consumption in the residential sector has been relatively constant since 2007, and there was a slight decrease in the commercial/industrial sector in that time period.

Figure 9. Map of Regional Zip Codes. Data organization regarding electricity consumption was based upon the zip codes outlined above.

As one would expect,Springfield (05156), Ludlow (05149), and Windsor (05089) as regional hubs for commecial development, show the greatest electricty consumption in the commercial and industrial sector.



Efficiency Vermont has also made available electricity consumption data for 2014 through 2016 at the town-level. Below is a summary of the average residential electricity consumption in 2015 for each town:

- Baltimore 8,224 KWh
- West Windsor 7,315 KWh
- Weathersfield 7,211 KWh
- Springfield 6,921 KWh
- Windsor 6,731 KWh
- Chester 6,689 KWh
- Reading 6,565 KWh
- Andover 6,465 KWh
- Cavendish 6,255 KWh
- Ludlow 5,491 KWh

❖ Regional Generation

Ludlow Electric is the electricity provider for portions of Ludlow and Cavendish. Green Mountain Power (GMP), a public utility, provides electricity to the remainder of the region and beyond. GMP's power supply comes from several generation facilities throughout New England and Quebec, as well as from short-term system or open-market purchases and individual Purchase Power Agreements (PPA). Fuel sources for GMP generating facilities are primarily renewable, with hydro, nuclear, and wind comprising over 65%. [10]

There are no significant non-renewable energy generation facilities in the region, with the exception of backup generators at substations. Electricity transmission service is provided by the Vermont Electric Power Company (VELCO). The existing transmission lines, three-phase power lines and substations are shown on the Utility

[10] Northwest Regional Planning Commission, Regional Energy Plan, Adopted June 28, 2017

Service Map. Consideration should be given to the condition of our electricity transmission system and its ability to support the state and regional goals for renewable energy targets. The SWCRPC should engage with VELCO as it relates to this issue when updating Vermont's Long-Range Transmission Plan. Emerging technologies, such as battery storage, may help to address capacity issues with the grid.

Table 3: Renewable Energy Generation in Southern Windsor County

Renewable Source	# of Sites	Installed Capacity (MW)	Annual Generation (MWh)
Solar	276	6.6	8,087
Wind	4	0.02	65
Hydropower	6	2.8	9,790
TOTAL	**286**	**9.4**	**17,942**

At this time in this region, energy production from renewable sources is limited. The region currently has 6.6 MW of installed capacity of solar energy between both roof-mounted and ground-mounted sites, the majority of which are residential units.[11] Only a few residential-scale wind turbines have been installed to date. The total installed capacity of these turbines, located in Cavendish, Ludlow, and Springfield, is roughly 0.02 MW. Active hydropower sites include the Green Mountain Power hydroelectric facility in Cavendish and five smaller facilities in Springfield that are all located along the Black River. These hydro facilities have over 2.8 MW of installed capacity. In addition, the Wilder and Bellows Falls hydropower facilities are located outside of the region, but affect some areas within southern Windsor County that lie along the Connecticut River. Biomass is presently used exclusively for heat.

In order to meet the 90/50 goal outlined in Vermont's Comprehensive Energy Plan, major increases in renewable electricity production for both the state and the region will be needed.

Section III: Regional Energy Targets

Attaining state energy goals will require each region to set targets for energy use, conservation, and generation. This Section projects regional energy needs, and establishes future energy targets to meet state goals. The **Long-range Energy Alternatives Planning (LEAP)** software system, which was relied upon for estimating projections and determining the regional energy targets, is described below. The purpose of establishing energy targets is to provide guidance and a sense of the scale of change needed to meet the energy goals. Individual targets presented in this plan are not intended to be interpreted as actionable goals.

This section first looks at the methodology used for determining the state and regional energy targets under the 90/50 goal scenario, and dissects these targets by energy use sector and by fuel type over the projected period (2015 to 2050). The section closes with an analysis of the projected additional demand for electricity in the region derived from the projected use targets, and how this demand may be met through generation from renewable sources.

[11] http://www.vtenergydashboard.org

In general, it will be difficult to accomplish the significant levels of change and investment that will be needed to reach our energy goals. However, this is a working plan that represents one potential pathway to attain our 90/50 energy goal. As conditions change, this plan should be updated accordingly in the future.

A. LEAP Model & Methodology

LEAP System and Energy Targets

British Thermal Units

BTUs are the standard measurement throughout the plan to allow for easy conversion between different fuel sources.

Measurement	BTUs
1 gallon of gasoline	124,000
1 gallon of diesel	139,000
1 gallon of heating oil	139,000
1 gallon of propane	91,330
1 cord of wood	20,000,000

To generate the regional targets needed to meet overall state guidelines for energy conservation, RPCs throughout the state partnered with Vermont Energy Investment Corporation (VEIC). VEIC staff utilized the **Long-range Energy Alternative Planning (LEAP)** software system to produce an energy use model to project future energy usage for the region. The model is based on current energy usage and projections.

This complex model allows users to project energy consumption and demand for types of fuel with inputs that reflect current trends in usage and future energy needs in the region. Population growth, number of households, commercial building square footage, vehicle miles traveled, and fuel source assumptions are examples of the type of data input used to model and project consumption.

To determine regional targets, the **LEAP** model compared two scenarios – the ***"reference scenario"*** versus the *"**goal scenario**."* The ***reference scenario*** is essentially a "do-nothing" scenario which assumed a continuation of existing policies and energy usage in combination with an increase in vehicle fuel efficiency based on industry

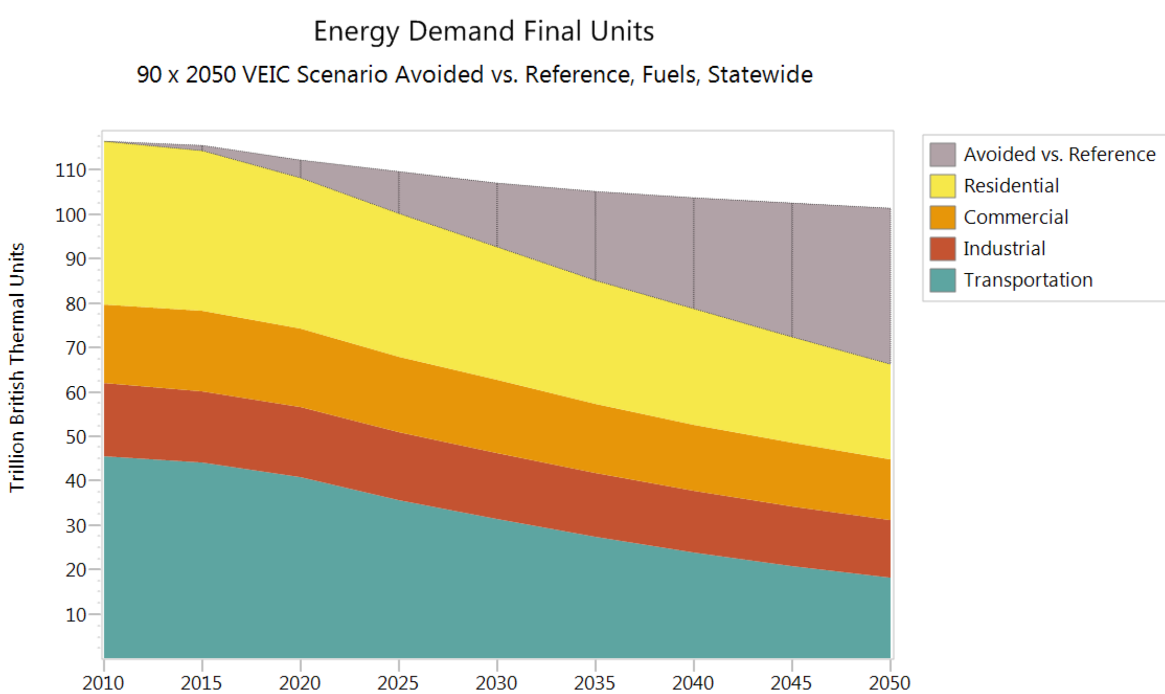


Figure 11: Projected statewide energy consumption by sectors comparing the reference scenario (gray portion) and the 90% by 2050 goal (Source: Vermont Energy Investment Corporation)

projections. The regional ***goal scenario*** was designed to represent a regional energy supply/demand projection that attains Vermont's goal of meeting 90% of energy demand with renewable sources by 2050.

Statewide Energy Targets

The statewide model for energy demand by sector under the goal scenario is shown in Figure 11. Implementation of the statewide energy plan versus a continuation of current policies is projected to reduce total statewide consumption by significant levels. This difference in energy demand between these two scenarios represents the amount of energy consumption that will need to be eliminated through conservation, efficiencies, and other means in order to meet the state and regional goals.

B. Regional Energy Targets by Sector

The Regional LEAP Goal Scenario estimates that a 50% reduction in total energy consumption will be required to meet our 90/50 goal. This dramatic decline by 2050 is despite projected future conditions (i.e. a very modest population increase per ACCD population projections), and relies primarily on the assumptions made for increased efficiency and conservation. As residential heating makes the switch to heat pumps (i.e. cold-climate heat pumps or ground-source heat pumps as defined in Appendix C) and transportation to electric vehicles and away from fossil fuels, these sectors will be powered by electricity that is generated with renewable sources. Due to the greater efficiency of electricity compared to fossil fuels, overall energy consumption is expected to decrease. This can be seen in Figure 12 below. As with the statewide scenario, most of this decline will come from the regional residential heating and transportation sectors.

Overall, the total amount of energy utilized in the region will decline by 50% by 2050.

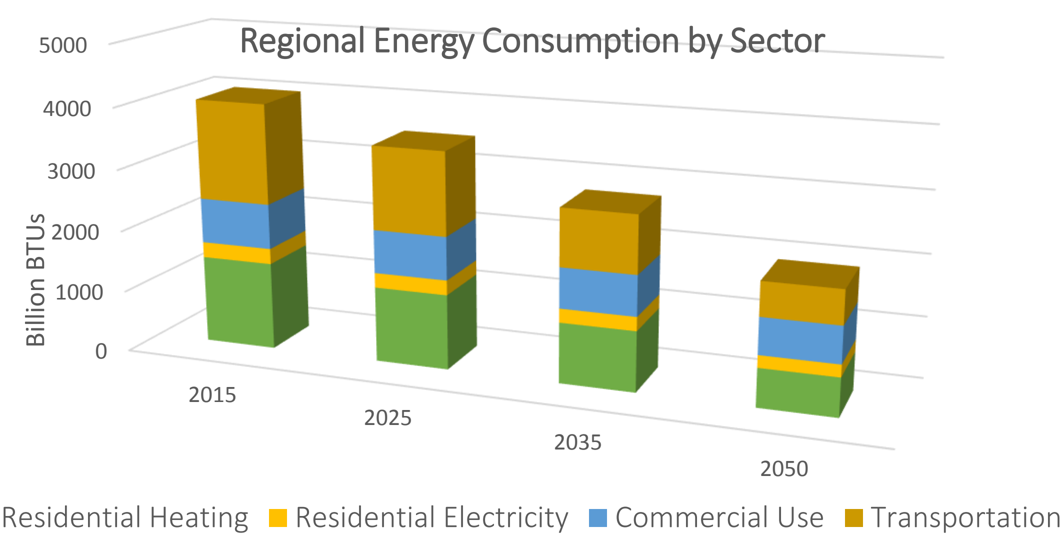


Figure 12: Southern Windsor County Regional Energy Targets by Sector (Source: LEAP Regional Model Goal Scenario)

The regional targets clearly show that a substantial increase in efficiency, conservation, and electrification of energy production and consumption will be needed across all sectors Residential heating and transportation in particular will be transformed, with the most dramatic change over the next 30 years. Transportation energy consumption will need to drop by over 65%, and Residential Heating by 56%, in order to meet the 90/50 goal by

2050. Note that these aspirational targets are primarily intended to show the scale and types of changes needed to achieve the energy goals. They represent only one potential pathway to 90/50.

C. Regional Energy Use by Fuel Type

In order to meet 90/50 energy targets, the changes required for the region generally mirror the changes necessary for the entire state. Figure 13 below illustrates the following changes in regional energy consumption by fuel type across all sectors:

- A dramatic reduction in total energy consumption by approximately 50%;
- A shift from nonrenewable to renewable direct energy sources; and,
- Growth in demand for electricity generated from renewable sources.

The direct consumption of energy from nonrenewable fuels such as diesel, gasoline and heating oil will fall from 69% of total energy consumption to 8% by 2050, according to the LEAP analysis. Direct energy consumption from renewable fuels, such as wood for heating, ethanol and biodiesel, will increase from 18% to 53% of total regional energy consumption over the same period. Electricity consumption, which currently makes up only 13% of regional energy demand, will make up the difference and increase to 39% of total energy consumption due to the increase in utilization of electricity for space heating and transportation. Currently, generation of electricity by renewable sources is minimal as a percent of total generation, but will become the primary fuel source by 2050 in order to meet state goals. The breakdown of electricity generation by fuel source and transition to renewable fuels is described in the section on target electricity generation.

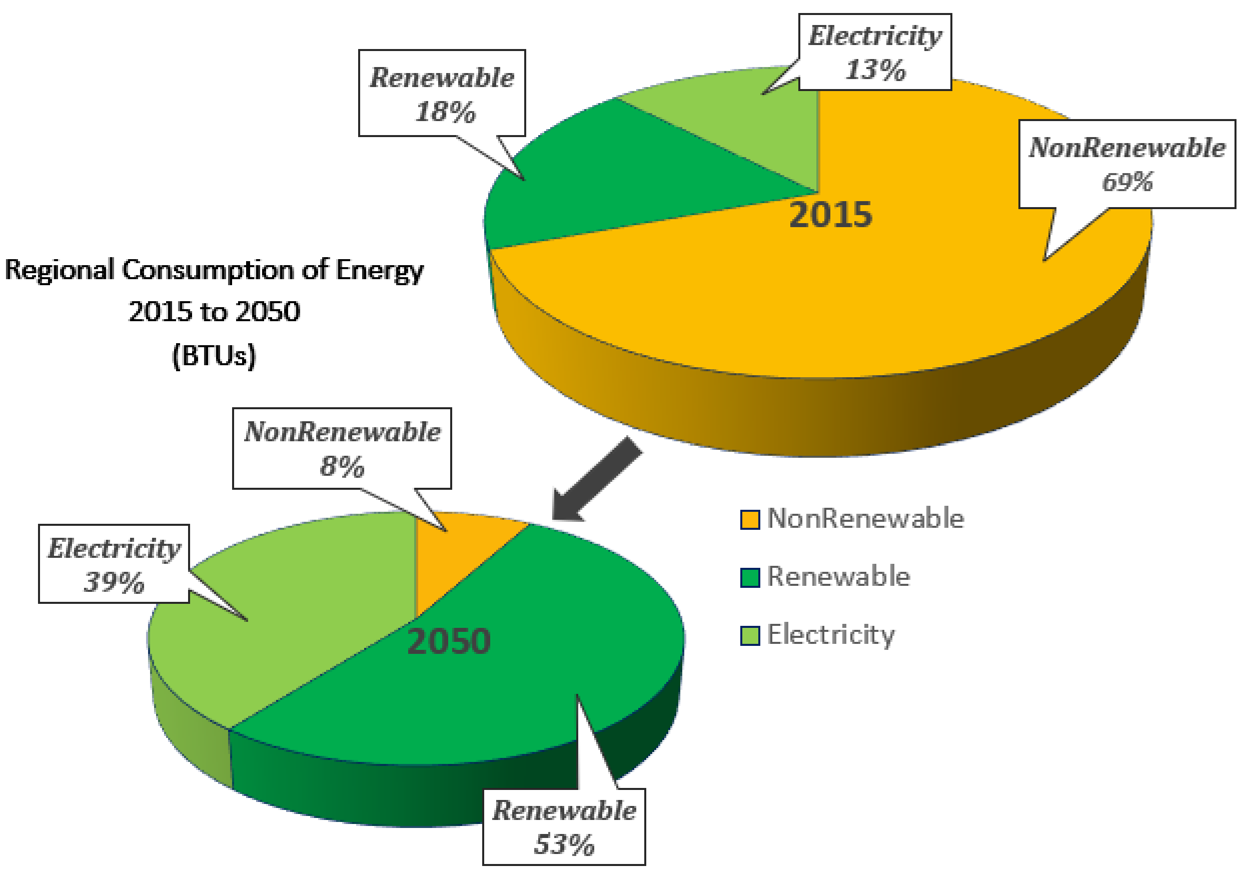


Figure 13: Regional targets for energy consumption across all sectors. Note how the size of the 2050 pie chart shrinks to about half the size of 2015, reflecting the overall reduction in energy demand needed to meet energy goals. Electricity will largely be generated from renewable sources by 2050. The other energy sectors are broken down by renewable and non-renewable, reflecting the significant shift away from non-renewables by 2050.

90% of regional energy demand will be generated with renewable sources by 2050.

Figure 14 below gives a closer look at the breakdown by fuel source. In order to meet the energy goals, transportation fuels that today are primary sources of fuel, such as gasoline and diesel, will need to be almost entirely eliminated by 2050. It is anticipated that, along with increased vehicle electrification, biodiesel will be utilized as an alternative to the fuels used now by the trucking fleet. More on these changes can be found in the transportation and space heating portions of this section. Although compressed natural gas is expected to be utilized by other regions throughout the state, the Region has no pipeline and it will therefore not be incorporated in this plan as a "bridge" fuel. Under this scenario, fuel oil for heating is replaced by heat pumps and wood, including cord and pellet. Due to the elimination of other fuel sources, wood increases as a proportion of total energy consumption, going from 15% in 2015 to 28% by 2050.

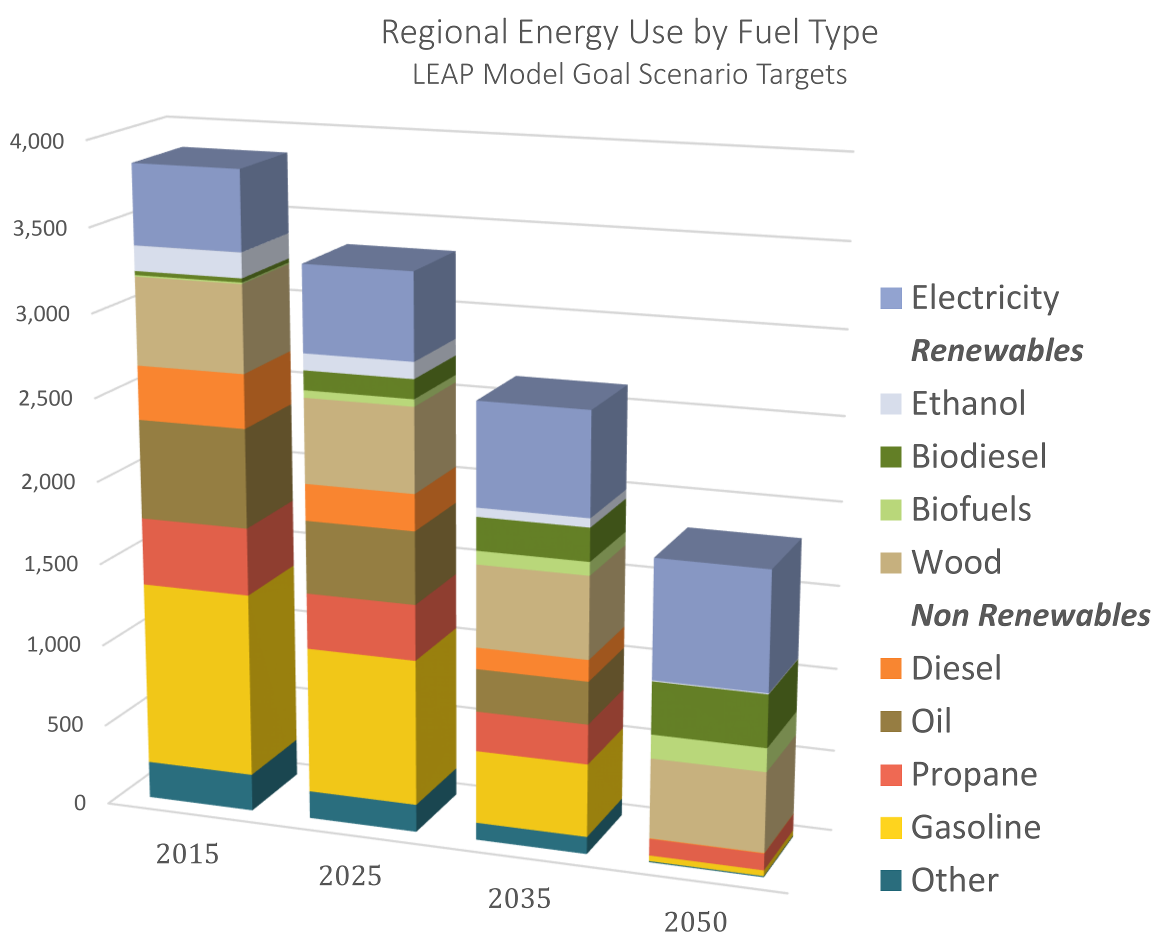


Figure 14: Southern Windsor County Regional Energy Targets by Fuel Type (in billion BTUs)

D. Residential Energy Targets

Regional residential energy targets encompass all energy consumption in the home. **To achieve the 90/50 goal, the amount of energy used in homes will need to be reduced by more than 50%, with a reduction in non-renewable sources from 60% to 6% as depicted in Figure 15 below.** Of the total residential energy demand in 2015, home heating accounted for 85% and the remainder for other uses including appliances and lighting**.**

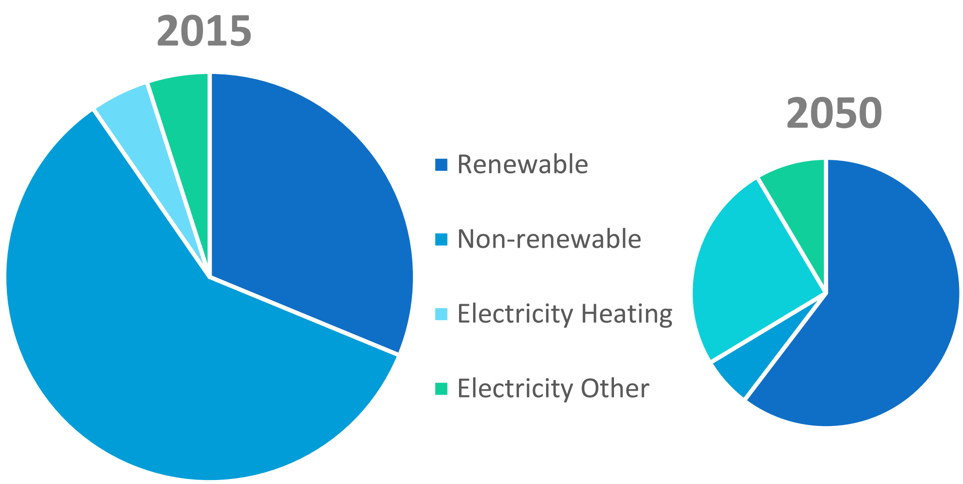


Figure 15: Southern Windsor County Residential Energy Consumption Targets for Goal Scenario

Table 4: Residential Thermal Fuel Targets by Percent of Total Systems			
System Type	**2025**	**2035**	**2050**
Wood Heating	34%	40%	55%
New Heat Pumps	3%	8%	18%

The transition to more efficient appliances and lighting, as well as proper weatherization of existing homes, will help to reach this reduction. It is anticipated that inefficient heating systems will be replaced, or at least supplemented by air source heat pumps, to further reduce dependence on non-renewable forms of heating. It has been projected that, by 2025, heat pumps will only account for 3% of residential heating energy demand. By 2050, however, it will have risen to 18%[12]. With the exception of a small amount of propane remaining for kitchen appliance use, by 2050 almost all fossil fuels will be eliminated as energy sources in the residential sector.[13]

Figure 16 breaks down residential energy consumption in the region by fuel type. Cord wood, fuel oil and propane are the three primary heating fuels, today comprising over 80% of total home energy use. Currently single family homes burn over 5.5 million gallons of oil per year, but by 2050 this will be reduced to a negligible amount. By 2050, fuel oil together with propane will all but disappear to be replaced by more efficient heat pumps. Wood as a heating source for homes will have increased from 30% to 50% of residential energy use. Although cord wood falls off, the use of more efficient wood pellets will increase.

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[12] These targets are based upon the LEAP Model System for the Regional Goal Scenario.
[13] These targets are based upon the LEAP Model System for the Regional Goal Scenario.

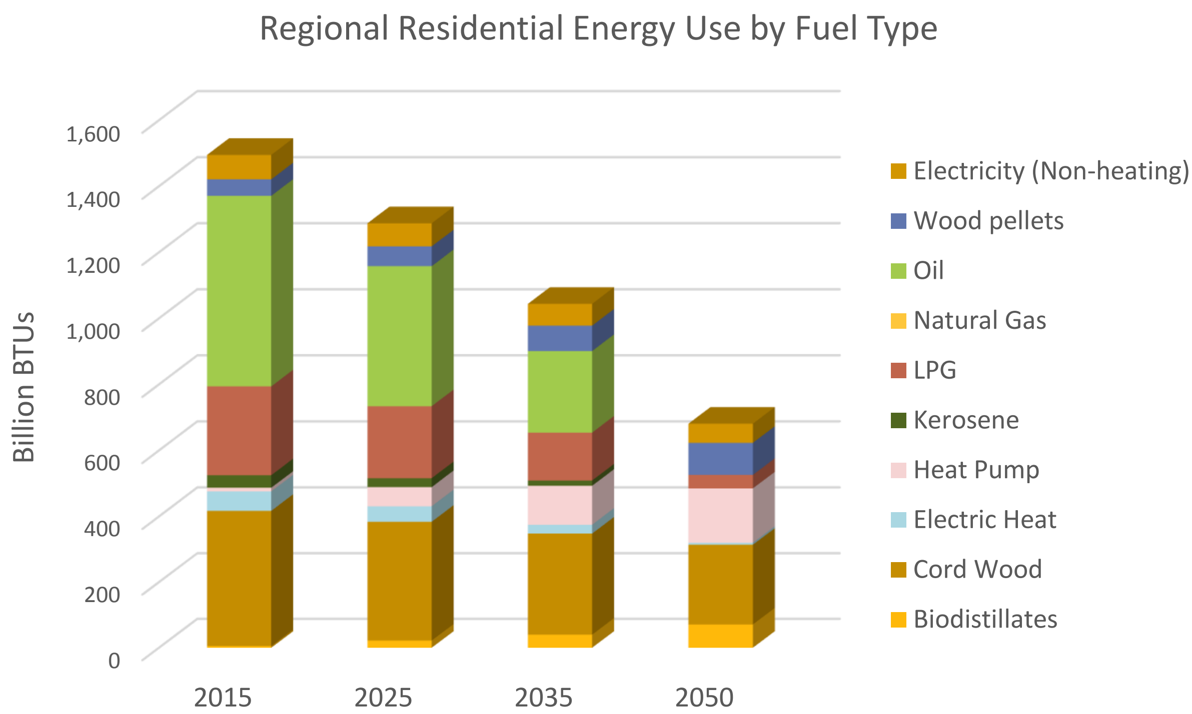


Figure 16: Southern Windsor County Residential Energy Consumption Targets by Fuel Type

The LEAP model assumes that weatherization and conservation improvements in the region will account for more than 30% of the overall drop in residential heating demand. The Regional Planning Commission has predicted that in order to achieve residential thermal efficiency throughout the region, **17% of homes will need to be weatherized by 2025, increasing to 31% by 2035, and 63% by 2050.** Strategies to achieve these goals can be found in the following section.

As mentioned in the previous section, multi-family housing units, and especially renter occupied households, predominantly utilize fuel oil and propane for heat at the present time. The LEAP model expects these, often large, complexes to shift to wood chips or pellets as a primary heating source in the future. These wood-burning systems are regarded as being more efficient and more cost-effective. Some buildings have already begun the transition. For example, the Old Windsor Village, in the town of Windsor, has insulated the building, upgraded the windows, and converted to a pellet heating system. Smaller rental properties are more likely to convert to air-sourced heat pumps (i.e. cold-climate heat pumps). Ground-sourced heat pumps (i.e. geothermal heat pumps) are best for new construction applications. It is anticipated that weatherization and efficiency improvements will be made in both renter- and owner-occupied spaces in order to increase heating efficiency and help decrease overall consumption.

E. Commercial & Industrial Energy Targets

The commercial and industrial sectors are not projected to have as dramatic a decline in energy consumption as the residential and transportation sectors. This sector is projected to reduce overall energy consumption by only 20% and will, therefore, represent a larger portion of total regional energy usage at over 30%. While electricity use is projected to remain relatively constant, use of wood and biofuel will increase as propane and fuel oil consumption falls. By 2050, commercial/industrial electricity consumption will represent roughly half of the sector's overall energy usage. Wood will follow at 25%.

The utilization of wood for heating is estimated to rise for both commercial and industrial space, due to increased use of biomass heating in larger buildings instead of oil and propane. **It is expected that by 2025, 33 new wood heating systems will be installed in facilities within the region. Then by 2035 a total of 73 new units are expected to be installed, and finally, by 2050, 149 new units will be installed.** Some larger facilities have already converted to wood chip or wood pellet heating systems, such as the Weathersfield School in Ascutney and the Springfield High School and Technical Center. In addition to new wood heat systems, new heat pumps will also be installed in some facilities. **By 2025, 14 heat pump units will be installed, followed by 30 units by 2035, and 62 units by 2050.** (See Table 5.)

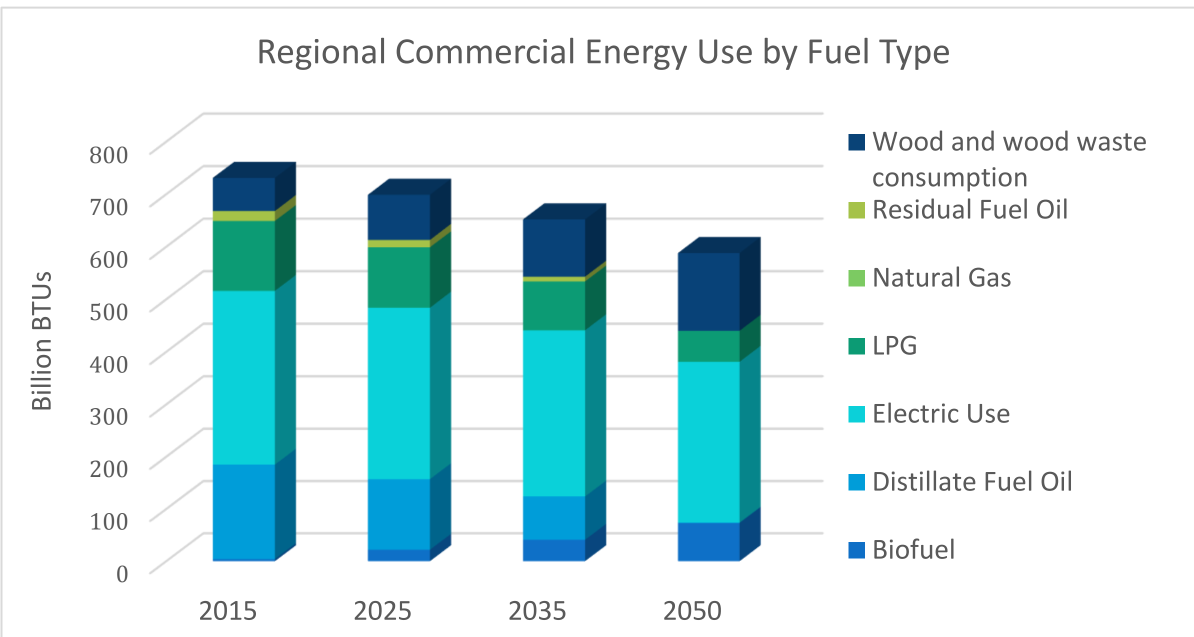


Figure 17: Southern Windsor County Commercial Energy Consumption Targets by Fuel Type

Within the commercial sector, the LEAP model assumes that oil-based fuels will be reduced dramatically over time, and completely eliminated by 2050. In the industrial sector, similar non-renewable fossil fuels, such as coal, will also be removed from the fuel source mix by 2050. Conversely, propane is anticipated to remain as a fuel source for both sectors, but at half the current usage in the commercial sector by 2050. In addition to converting heating fuel sources, it will be necessary to weatherize commercial and industrial buildings to conserve resources. **The model has estimated that by 2025 only 4% of commercial establishments are**

expected to be weatherized properly, **followed by 7% by 2035, and then only 15% by 2050**[14]**.** These targets seem low; exceeding these targets is preferable.

Table 5: Commercial Thermal Fuel Targets by Number of Systems			
System Type	**2025**	**2035**	**2050**
New Wood Heating	33	73	149
New Heat Pumps	14	30	62

Although transportation is a key cost component for regional commerce, due to the reliance on shipping materials both in and out of the region, the future energy demand for the transportation sector will be addressed in the section below.

Table 6: Weatherization Targets as a Percent of Total Establishments			
Sector	**2025**	**2035**	**2050**
Residential	17%	31%	63%
Commercial & Industrial	4%	7%	15%

F. Transportation Energy Targets

The transportation sector currently accounts for 40% of the region's total energy use. **The LEAP model has projected that the transportation sector will require an overall reduction in energy demand of up to 65% to meet the 90/50 goal**. As shown in Figure 18, non-renewable fossil fuels, gasoline and diesel, are currently the predominant fuel types consumed in transportation at 88%. However, fossil fuel consumption will drop to 7% by 2050 with their replacement by biofuels and electricity.

Privately owned vehicles in the region use roughly 17 million gallons of gasoline to travel up to 300 million miles annually. Diesel fuel utilized for heavy duty vehicles, such as trucks and buses, add an additional 2 million gallons of fuel consumption per year. This reliance on non-renewable fuels will require a major transition in the transportation sector to reliance on renewable sources of energy instead. Lifestyle changes will also be necessary to reduce overall energy demand. The LEAP model estimates that a steady decline in gasoline consumption will need to occur over the next 35 years, from the current 17 million gallons to only 350,000 gallons by 2050. Diesel fuel consumption will also need to experience a similar reduction to a negligible amount by 2050.

[14] These targets are based upon the LEAP Model System for the Regional Goal Scenario.

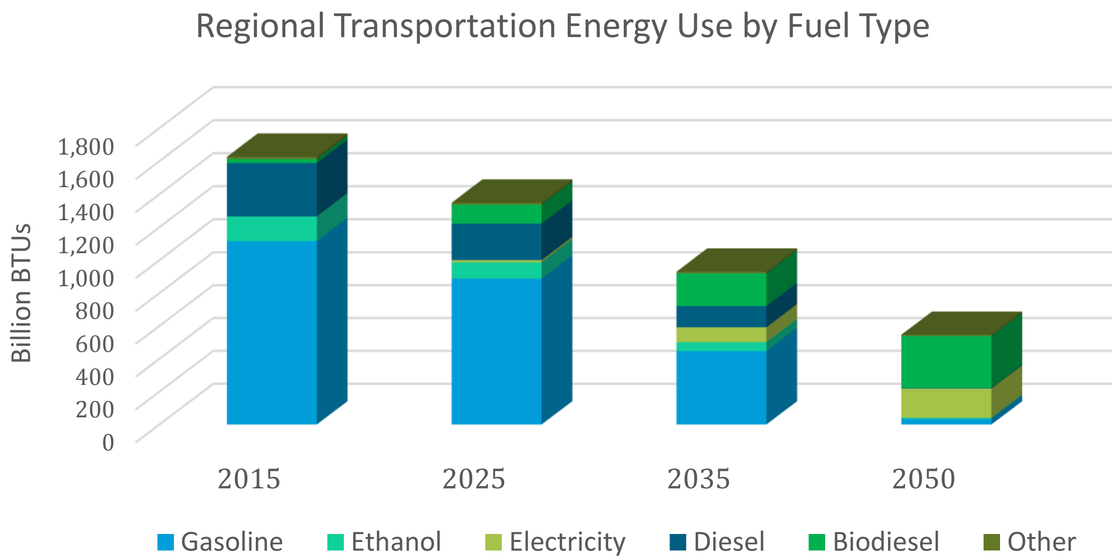


Figure 18: Southern Windsor County Transportation Energy Consumption Targets by Fuel Type

As the transition is made away from non-renewable fossil fuels, the transportation sector will need to employ alternative fuels sources, such as electricity. The LEAP model assumes that the widespread adoption of electric vehicles will represent one of the key means of achieving the energy goals. Electric cars will become more prevalent in Vermont as a viable option for private vehicles if extended-range and all-wheel-drive features become readily available and affordable features. Based on LEAP data, electric vehicle adoption will get off to a slow start. **By 2025, electric passenger car usage will meet only 1% of transportation energy demand, but will rise substantially over the next 25 years to 70% of demand by 2050.**

Charging stations are presently located in two sites in Springfield; one is in the parking lot next to the town office, and several plug-ins are located at the I-91 Exit 7 park and ride facility. In order to meet the projected increase in electric car use, there will need to be a significant increase in the number of available charging stations throughout the region.

It is expected that biodiesel will slowly replace diesel as the primary fuel source for heavy duty vehicles. The LEAP data estimates that the number of passenger vehicles using biodiesel will be 1% by 2025, and will only rise to 13% by 2050. For heavy duty vehicles, however, biodiesel will be the primary renewable fuel, reaching 32% by 2025, 58% by 2035, and 96% by 2050. However, biodiesel is not currently a widely utilized fuel, and engine warranties may not cover damages if biodiesel is used at certain fuel blend concentrations (e.g. above B20). Ethanol, which is used as a blend with gasoline, is often labeled as a renewable fuel. Yet, ethanol will see decreasing use over the next 35 years due to its complex and resource intensive production process.

To achieve the major reduction in total energy use for the transportation sector required to meet the 90/50 goal, the transition away from non-renewable sources alone will not be sufficient. A decline in ***vehicle miles traveled*** **(VMT)** will also be required. **The LEAP model has assumed that, despite a slight increase projected in population, the vehicle miles traveled should remain relatively constant over the next 35 years.** Changes in lifestyle and land-use patterns will contribute to reductions in VMT. These changes will be accomplished by consolidating growth and investment within village and town centers. VMT can also be reduced by shortening commute distances and increasing public transportation usage, telecommuting, bicycling, and carpooling.

The anticipated changes in the transportation sector needed to meet the 90/50 goal, specifically the transition away from fossil fuels, would lead to a decline in the number of traditional fueling stations. This transition would need to be managed to minimize the impacts on Vermont (e.g. automotive fueling businesses, transportation fund revenues, tourism industry).

Table 7: Transportation Fuel Targets by Percent of Total Vehicles			
Vehicle Type	**2025**	**2035**	**2050**
Electric	1%	14%	70%
Biodiesel	1%	4%	13%
Heavy Duty Biodiesel	32%	58%	96%

G. Electricity Generation Targets

State Electricity Generation Targets

As mentioned in Section II, the majority of the Vermont's electricity is provided by out-of-state sources, most notably Hydro Quebec, as well as limited in-state sources. This leaves the state of Vermont vulnerable. The closing of the Vermont Yankee nuclear power plant further limited the amount of electricity generated within the state. To compensate for this loss in electricity generation, some regions have utilized natural gas and wood biomass powered generators. Other renewable sources of energy will be able to further bridge this growing gap of electricity production. Nuclear has very high life-cycle costs for energy production, and there is no permanent long-term plan for waste storage. It seems unlikely that a new nuclear power plant will be permitted in Vermont. For the purposes of this

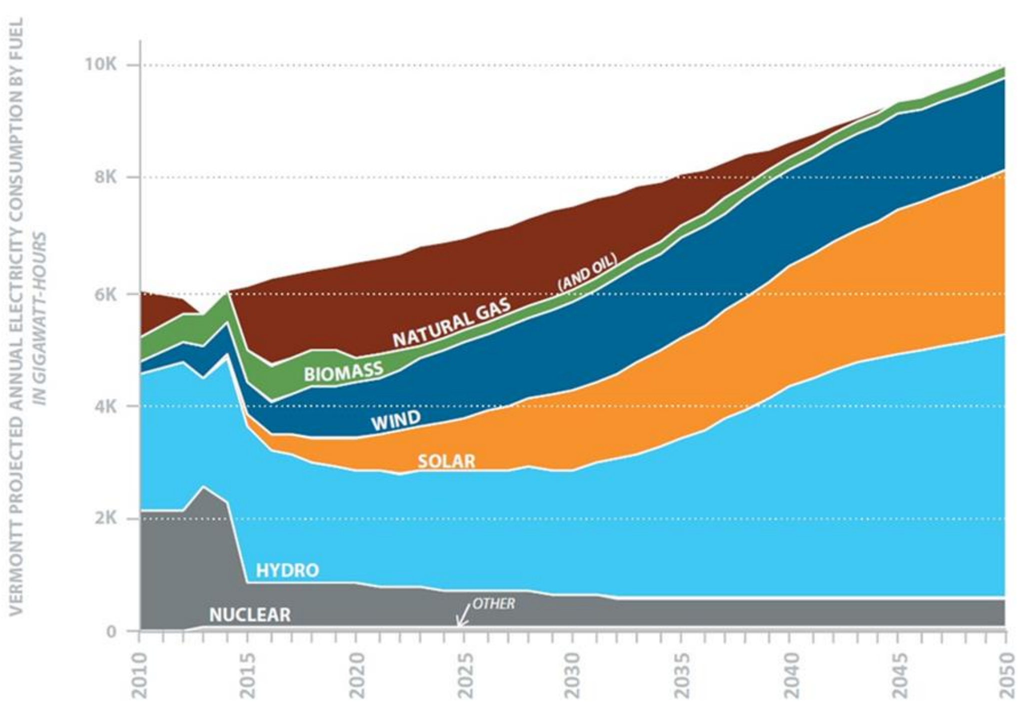


Figure 19: Projected Electricity Consumption Annually in Vermont (VEIC)

plan, we are assuming that no new non-renewable power plants (i.e. nuclear or fossil fuel-based power plants) will be constructed in this region.

Due to the dramatic increase in electricity consumption required for the state to achieve the 90/50 goal, it is estimated that 50% of Vermont's electricity will need to be produced in-state. Figure 19 shows that by 2050 total state annual electricity demand will increase from 6,000 GWh to 10,000 GWh. This increase is primarily due to the transition for heating and transportation away from fossil fuels to electricity. Anticipating the increased demand for electricity production, the LEAP model has predicted that hydro, solar, and, wind power will be the prevailing sources of electricity production throughout the state. Hydroelectric is estimated to provide half of the state's electricity production by 2050, however, the majority of this supply will be imported. Projections also indicate that nuclear power, along with natural gas, will decrease over time as sources of electricity. By 2050, there should be little to no fossil fuel-based -electricity production in the state. Figure 19 also shows that in-state solar and wind generation will provide 5KGwh or 50% of total electricity demand by 2050.

Regional Electricity Generation Targets

As noted earlier, the need for electricity within the region will double over the plan period, and will become a considerable portion of the region's overall energy usage by 2050. The increase in regional electricity consumption by sector is shown in Figure 20. The remainder of this section will discuss the projected regional electricity generation targets as modeled by LEAP and one scenario for providing that additional generation capacity.

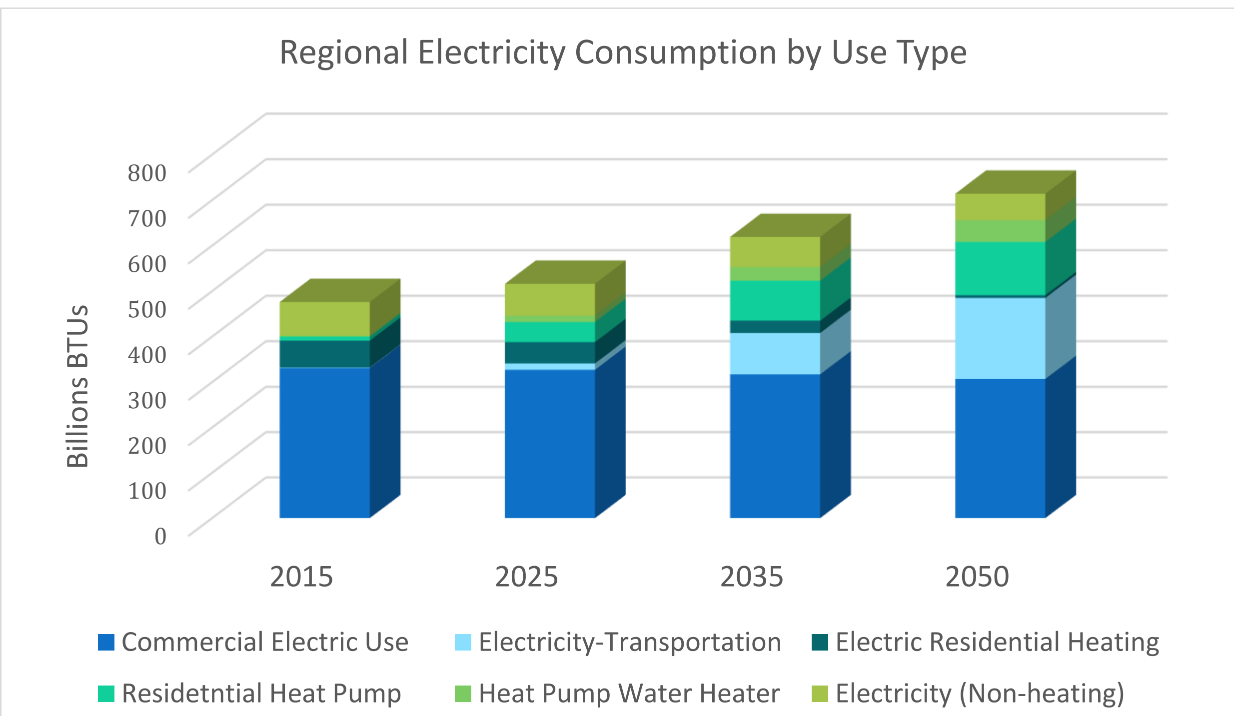


Figure 20: Southern Windsor County Electricity Consumption Targets by Use Type

The Department of Public Service and the regional planning commissions developed targets for regional generation. Targets were allocated to regions based on estimates generated by the LEAP model. Population and current and prospective generation potential were among the variables considered when determining the regional generation target. The intent of the targets is to achieve the overall state goals of generating 50% of statewide electricity demand in-state, and to have 90% of all energy come from renewable sources.

The resulting regional renewable generation target for the southern Windsor County region of 194,612 MWh was then broken down by town and is outlined in Table 8. The target MWh generation for each town in the region was determined by the regional planning commission. Each town's target is based on several factors, each as a percentage of the regional total: town population; the potential land area for ground-mounted solar generation, which is determined from resource mapping (See the maps in Appendix B); and each town's commercial/industrial electricity usage. For reference purposes only, the potential land area used for this exercise was based on solar potential within 1 mile of 3-phase power lines in each municipality.

Table 8: Renewable Energy Generation Targets By Town	**Population**	**Percent Contribution**	**Target (MWh)**
Andover	550	5%	10,261
Baltimore	292	2%	3,496
Cavendish	1504	7%	13,588
Chester	3110	12%	24,015
Ludlow	2140	11%	21,825
Reading	708	4%	8,298
Springfield	9258	32%	62,386
Weathersfield	2794	11%	21,811
West Windsor	1136	5%	9,884
Windsor	3496	10%	19,078
Total Regional Target	**24,988**	**100%**	**194,612**

H. Renewable Energy Generation Targets

❖ Statement of Policy on the Development and Siting of Renewable Energy Resources

The intent of this plan is to provide for the development of renewable energy resources per 24 V.S.A. §4302(c)(7) in order to achieve the goals established in the *2016 Vermont Comprehensive Energy Plan*. In order to meet 90% of Vermont's energy need from renewable sources by 2050 a significant amount of new renewable energy generation will be necessary, in addition to conservation efforts. Our target to meet the 90% by 2050 state goal is to develop 194,612 MWh of new renewable energy generation output. (This target is

equivalent to installed capacity of 158.7 MW of ground-mounted solar.) The purpose of this sub-section is to articulate how we wish to achieve the Region's target.

❖ Renewable Generation Targets

As further described blow, developing a mix of renewable generation types is desirable in order to meet the overall renewable targets established in this plan. The targets presented in Table 9 represent one possible scenario for how southern Windsor County can meet the region's overall renewable generation target.

Table 9: Renewable Generation Targets (MWh)	2025	2035	2050
Rooftop Solar	6,630	10,605	23,861
Ground-Mounted Solar	41,235	82,661	158,876
Wind (residential-scale)	613	3,066	6,132
Hydro	175	974	5,743
Total New Renewable Generation Target	**48,653**	**97,306**	**194,612**

This particular scenario for regional renewable generation targets was determined based on resource mapping, assumptions on site cost feasibility, and regional preferences regarding industrial wind generation. (See the related discussion in Section IV). Resource mapping, which is described in more detail in the sub-section below, identifies site generation potential for both solar and wind. Site generation potential is determined based on known and potential land use constraints. The following assumptions were then applied to determine the region's renewable generation targets.

1. Maximize the potential that the region has for rooftop solar.
2. Maximize the potential for generating hydro power at 22 existing dam sites.
3. Determine contribution from residential-scale wind turbines. (Utility-scale and commercial-scale wind generation are not considered in this scenario.)
4. Determine ground-mounted solar generation from preferred sites and most cost efficient mapped areas.

As more fully explained in the Energy Resource Map sub-section below, these targets represent a very small percentage of the total potential for the region. In 2050, our ground-mounted solar target is only 2.4% of the region's solar potential. This 2050 ground-mounted solar target is equivalent to about 130 MW of installed capacity, which might require an estimated 1,040 acres of land to accommodate the solar arrays and related facilities. The wind target is only 0.02% of the total potential in southern Windsor County, representing the installation of about 200 residential-scale wind turbines, each approximately 30 meters high measured at the hub.

There are a few projects in development that are not incorporated in the existing conditions baseline for the region. These projects, discussed in more detail below, are either recently approved but not yet constructed and online, or petitions for a Certificate of Public Good are still pending. It is the SWCRPC's assumption that once approved and online, these pending new facilities will contribute toward meeting the new renewable generation targets.

❖ Energy Resource Maps

This section describes how energy resource maps are generated and interpreted when analyzing the region's potential for solar and wind generation.

POTENTIAL AREAS

The wind and solar maps both include "potential areas," which depict the portions of the region that have the potential for renewable energy generation based upon computer models and GIS mapping data. These areas do not represent "preferred sites" nor do they indicate with exact precision where solar and wind projects are desired to be constructed. Rather, they delineate where the potential for generation exists, and aid in evaluating whether sufficient land area exists to meet our regional renewable generation targets. In fact, some sites located outside of the mapped potential areas may prove to be viable for renewable energy generation.

Potential areas reflect two types of constraints: "known constraints" and "possible constraints." Both are described below:

"Known Constraints" involve conditions which would likely make development not feasible. Known constraints include the following resources:

a) Vernal pools with a surrounding 50-foot buffer;
b) DEC river corridors;
c) FEMA floodways;
d) State significant natural communities and rare, threatened and endangered species;
e) National wilderness areas; and,
f) Class 1 and Class 2 wetlands.

"Possible Constraints" have potential for renewable energy generation, but have one or more of the constraints listed below. These constraints signal conditions that would likely require mitigation and which may render a site unsuitable after a site-specific study has been conducted. Currently adopted and in-force state, regional or local policies may prevent development in areas with Possible Constraints.

a) Agricultural soils (NRCS-mapped prime agricultural soils, soils of statewide importance or soils of local importance);
b) Act 250 agricultural soil mitigation areas;
c) FEMA special flood hazard areas (floodplain);
d) Protected lands (state fee lands and private conservation lands);
e) Deer wintering areas;
f) ANR conservation design highest priority forest blocks; and,
g) Hydric soils.

The accompanying maps show "prime" areas for both solar and wind resources. These prime areas represent potential areas that avoid both types of constraints (i.e. "known constraints" and "possible constraints").

The accompanying maps also show "secondary" areas for both solar and wind resources. These secondary areas do not have any "known constraints" based on available GIS data, but they have one or more "possible constraints" present.

See the Constraints Map for more detail.

PREFERRED SITES

The following sites indicate preferred locations for siting a generator of a specific size or type in this region:

a) Rooftops of existing buildings;
b) Remediated brownfield sites;
c) Disturbed portions of extraction sites (i.e. gravel pit, quarry);
d) Vacant lands within industrial parks; and,
e) Any preferred sites that are clearly and specifically identified in a municipal plan that has received an affirmative determination of energy compliance.

The SWCRPC reached out to our towns as part of the process to develop this plan. Local planning commissions and energy committees found it very challenging to identify specific preferred sites on a map. No specific preferred sites were located on a map for this Regional Energy Plan. The SWCRPC will work with developers and municipal boards to consider proposed preferred sites under PUC Rule 5.100 for any specific sites not clearly within the above categories.

UNSUITABLE AREAS

This category represents areas that are not suitable for renewable energy generation projects (i.e. "no go" areas). Unsuitable sites include the presence of one or more of the "known constraints" as described above. However, there may be other unsuitable areas that cannot be mapped at this time (i.e. archeological resources).

The SWCRPC will provide technical assistance to our member towns to develop local enhanced energy planning maps, including but not limited to identifying local constraints and preferred sites.

Solar Resource Potential

The growth of solar power generation projects in this region has been significant between 2013 and 2017. According to data provided in support of this enhanced energy planning process as of May 2017, this region has 276 known solar project sites with a total capacity of nearly 6.6 MW. Common issues with ground-mounted solar projects include, but are not limited to, choosing a suitable site for the scale of the project, setbacks from roads and adjacent buildings, landscaping/screening, maintenance, and site decommissioning.

The Potential Solar Resources Map shows where prime and secondary ground-mounted solar potential sites are located in relation to transmission lines and three-phase power lines. The solar potential data is based upon a computer model that takes slope direction, slope steepness, and solar radiation values into consideration. Figure 21 depicts the proportional relationship between the total land area in the region, prime solar potential land area, and estimated land area needed to meet the ground-mounted solar target.

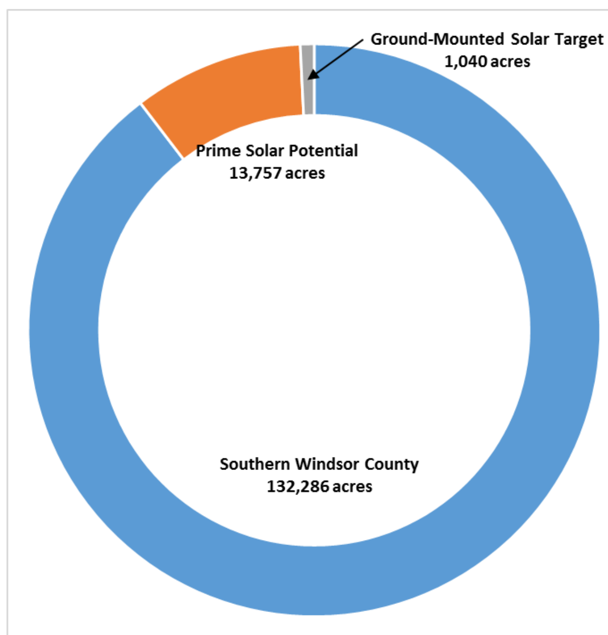


Figure 21: Proportional relationship between total land area in the region, land area of prime solar potential, and the estimated land area needed to address our renewable target via ground-mounted solar in Table 9.

Approximately 43,700 total acres of combined prime and secondary solar potential land areas were in the region. That is about 33% of the region's total land area. Reducing the solar potential area to include only those areas within 1 mile from 3-phase power lines resulted in a reduced solar potential land area of just over 18,000 acres, or nearly 14% of the land area of the region. There are nearly 6,175 acres of prime solar potential land within 1 mile of 3-phase power lines. If we were to meet our region's total renewable energy target through ground-mounted solar alone, we would need an estimated 1,270 acres, which is about 1% of the total land area in the region. These areas represent a combination of public and privately-owned lands.

Certain projects are perfectly sited, such as a 150 kW photovoltaic array constructed on town-owned land on a south-facing slope behind the Cavendish wastewater treatment facility. It is hidden from view from most vantage points. There are no neighbors, and travelers on the adjacent section of VT Route 131 would never know it is located there. (See Figure 23.)

In 2016, a petition was withdrawn for a 4.5 MW ground-mounted solar project proposed to be located on the prison lands in Windsor due to local opposition and concern for both the scale of the project and impacts upon scenic resources and wildlife habitat. The SWCRPC did not take a formal position on the project.

In 2017, the Public Utility Commission issued a Certificate of Public Good (CPG) for a 20 MW solar power generation facility in Ludlow and Cavendish known as the Coolidge Solar Project [Docket #8685]. This project is not included in the existing conditions data presented in this plan due to the timing of the CPG. Despite the project's large size, the visual impacts are highly localized due to its location in a bowl-shaped area. The Coolidge Solar Project is in very close proximity to the existing Coolidge Substation.

Wind Resource Potential

According to available data (May 2017), there are four known wind turbine sites in this region, generating about 0.02 MW of installed capacity and nearly 65 MWh of output. There have not been any commercial- or utility-scale wind power proposals in this region to date. Notable local opposition has been observed for recent utility-scale wind turbine proposals in Grafton and Windham, located adjacent to this region.

The wind potential (i.e. utility-scale) is greatest in the western portion of the region. However, residential-scale wind generation may be possible throughout most of the region at lower elevations. The Wind Resources Map shows where prime and secondary wind potential sites are located in relation to transmission lines and three-phase power lines. The wind potential data is based upon a numerical weather model and a micro-scale wind flow model to produce a high-resolution (200m) wind resource map. The models are the product of a collaborative effort between the Massachusetts Technology Collaborative, the Connecticut Clean Energy Fund and the Renewable Energy Trust Northeast Utilities. It is intended as a preliminary assessment of wind potential areas.

Table 10: Summary of Generalized Wind Turbine Types

Scale	Hub Height	Lower Wind Speed Cutoff	Generalized Capacity
Residential	30 meter	4.5 m/s	≤ 10 kW
Community/Commercial	50 meter	5.5 m/s	≤ 100 kW
Utility	70+ meter	6.5 m/s	≥ 1 MW

A significant portion of the potential wind areas are located further than one mile away from transmission and three-phase power lines, which makes them more expensive and less feasible to develop for wind power generation. Local concern has been expressed about potential wind project impacts including forest fragmentation, damage to wildlife habitat, degradation of scenic resources and ridgelines, and excessive noise[15]. These concerns are consistent with the Land Use policies and Goals established in the Regional Plan with respect to natural, cultural, and scenic resource preservation and the constraints placed on industrial development[16]. Input received while doing outreach in Andover and Ludlow, in particular, showed very little support for utility-scale wind projects, especially since a project often involves 10-15 turbines and the related clearing for access roads and interconnection. The siting of utility-scale wind is a divisive issue in this region and across Vermont as a whole.

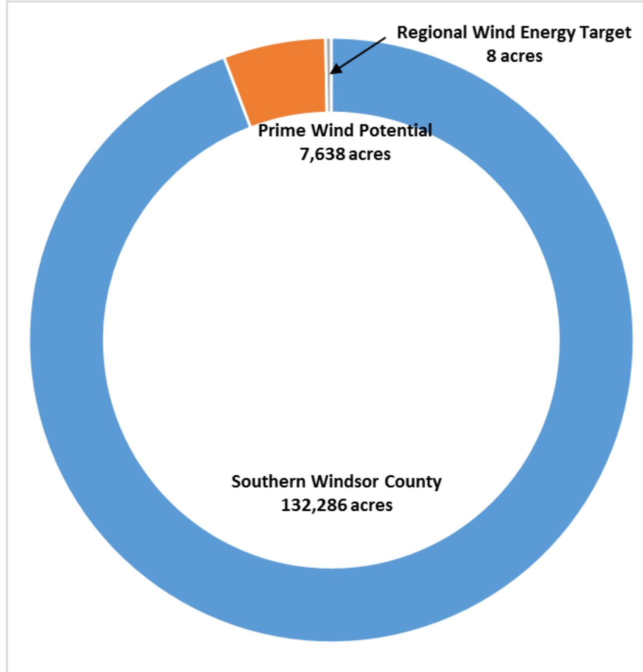
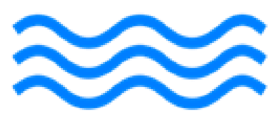


Figure 22: This graph illustrates the proportional relationship between the total land area in region, estimated wind potential land area, and the approximate land area needed to meet our wind target in Table 9.

The SWCRPC remains committed to providing for wind generation as a component of meeting our regional renewable energy targets, but only through the construction of appropriately-scaled wind generation facilities. Through consultation with our towns, and based upon an analysis of generation potential and likely negative impacts, the SWCRPC has concluded that utility-scale wind power does not conform to this plan.

If a municipality, through its local planning process, identifies a preferred location(s) for utility-scale wind facilities within their boundaries, the SWCRPC may consider amending this plan to account for this local preference. Coordination and consensus among neighboring municipalities will be a critical component of any process to amend the regional plan in this regard. Additionally, the SWCRPC shall only consider such an amendment if the location, or locations, identified by the municipality do not include "known constraints" and mitigate impacts to "possible constraints" as identified in this plan.

Hydroelectric Resource Potential



Six existing hydro facilities are located in the southern Windsor County region, totaling almost 2.8 MW of capacity (see Map 4). These existing hydro dams include the GMP facility in Cavendish and five dams in Springfield: Fellows, Gilman, Comtu Falls, Lovejoy and Slack Dam. A number of other existing dams in this region do not presently generate hydro-power.[17] The process to permit a hydro facility is complex and, as a result, we are assuming that new hydro facilities can only be established or re-established at existing dam sites. However, the cost and attendant permitting procedures may discourage the

[15] Including both infrasound, low-frequency noise as well as the typical loudness and frequency noise impacts

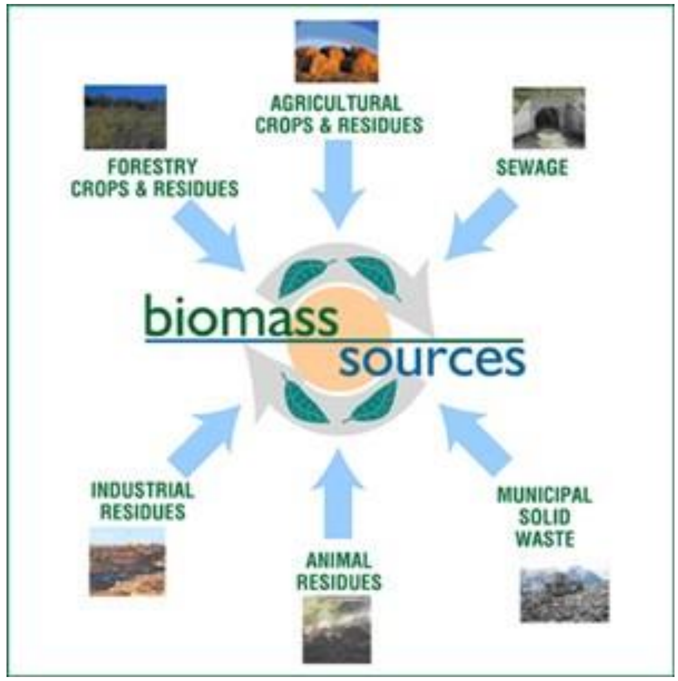
[16] Many wind potential areas coincide with both the Resource future land use category as well as notable sites identified in the Scenic Lands and Open Space Policies.

[17] Existing and Potential Hydro Sites from Vermont Sustainable Jobs Fund, 2010,

development of new hydro facilities. Our renewable energy generation scenario summarized in Table 9 represents generating power at the existing dam sites in the region, as depicted on Map 4. The generation potential for each dam site is based upon estimates provided by the Vermont Sustainable Jobs Fund.

The hydropower facilities along the Connecticut River are not located within this region. However, towns along the eastern boundary of the region are adjacent to the impoundment area of the Bellows Falls facility and, as a result, are affected by dam operations.

Biomass Resource Potential



Biomass is primarily to be used in the region for heating buildings. Approximately 80% of the land in the region is forested, representing a potentially significant renewable local energy resource. According to the 2010 analysis by the Biomass Energy Resource Center, Windsor County as a whole annually produces approximately 104,055 green tons of Net Available Low-grade Growth (NALG) wood. This represents the estimated amount of wood used for biomass fuel that can be sustainably harvested from Windsor County above and beyond current levels.[18] Around 1,900, or approximately 18%, of the region's homes currently use cord wood or wood pellet heating systems. By 2050, 55% of all homes should use Biomass as a heating fuel in order to meet the 90/50 goals.   There are a number of wood chip or wood pellet heating plants in larger commercial and industrial buildings in this region currently, and it is anticipated that this use will increase with time.

Supplying sustainably harvested wood products for heating is also beneficial to the local economy. The SWCRPC supports wood processing industries as long as they conform to the best practices outlined in the Regional Plan. The Regional Plan supports forestry management practices that further "regional goals concerning open space, wildlife habitat, air and water quality, scenic resources, access to recreation, and the tourism economy" and logging operations that "follow Vermont's Acceptable Management Practices, and help conserve valuable forest, air, water, wildlife, and recreation resources."[19] By adhering to these principles, this region has the potential to support an expanded, sustainable use of biomass resources that also benefits the local economy.

In 2014, a proposed 25-35 MW wood-fired biomass power generating facility in North Springfield was denied by the Public Utility Commission due, in part, to expected annual greenhouse gas emissions and the low level of thermal efficiency at which the project would operate [Docket No. 7833]. The impact of wood deliveries on the road network was a concern for some towns in the area and for the SWCRPC. However, the merits of each proposed project should be duly considered.

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[18] Biomass Energy Resource Center, Vermont Wood Fuel Supply Study (2010 Update), 2010.

[19] Pages 71-72.

Section IV: Energy Strategies

The following section provides policies and strategies to achieve the regional targets and goals outlined in the previous section. These strategies represent implementation pathways that are intended to meet the need for both energy conservation and generation in the region that will make progress towards our energy goals.

By 2050, 90% of Vermont's total energy will be derived from renewable sources.

The following are policies and strategies to be executed by the SWCRPC as well as private citizens and businesses owners. Although residents of the region cannot be forced to change current energy patterns, steps to encourage conservation through education and incentives can be provided. The implementation strategies outlined below represent the initial framework designed to achieve the 90/50 goal, and are expected to evolve over time to better meet the needs of the region.

General Energy Conservation Strategies

Total regional energy use to decrease by 50%

1) Encourage towns to establish energy committees to serve as advisory committees in accordance with 24 V.S.A Chapter 117 §4433 and §4464.
2) Work with town energy committees and other organizations to provide outreach and education for businesses concerning energy conservation practices for new construction and retrofits.
3) Encourage towns to support their local energy committees (e.g. providing meeting spaces, conducting public outreach, releasing press releases, putting out calls for volunteers, coordinating with schools and services, and asking for input from the committees on all matters related to energy).
4) Support local efforts to identify businesses/facilities that are large energy consumers (manufacturing, industrial parks, and schools) and encourage their participation in Energy Efficiency Utility (i.e. Efficiency Vermont) programs.
5) Support municipal efforts to encourage the development of locally-controlled renewable energy projects.
6) Encourage statewide discussions with stakeholders (e.g. trucking industry, fuel dealers) about the transition from our current energy situation towards our ambitious energy goals for 2050.

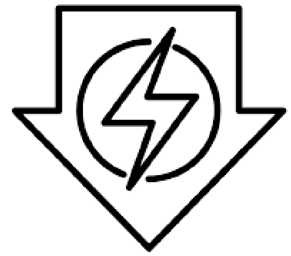
A. Electricity Conservation

Electricity Targets

- By 2050, electricity consumption will increase to 35% of overall energy use in the region.
- Increase in electricity consumption indicates 50% will need to be produced in state.

As outlined in the previous section, electricity consumption will become a greater contributor to the region's overall energy consumption over time. In order to realize the state goals as in the manner assumed by the LEAP model, additional electricity production will be required throughout the region. However, despite the increased need for electricity use, overall energy consumption must be reduced. The following strategies highlight necessary steps in conservation. Implementation steps to support increased electricity production are included below, in Section D.

1) Support programs, such as Efficiency Vermont, that promote the use of energy efficient equipment and devices.
2) Support and encourage manufacturers to provide energy efficient utilities and appliances.
3) Encourage expansion of energy storage systems within the region to reduce peak energy demand and provide backup power.
4) Promote building/design techniques that take advantage of day-light in order to minimize the need for daytime use of artificial lighting.
5) Influence behavioral changes to reduce electricity consumption at the individual level.
6) Support and encourage school participation in the Vermont Energy Education Program to foster an early appreciation for energy savings.



B. Transportation Conservation

The region's transportation sector will require a 65% reduction in overall energy consumption, which is the largest reduction in usage for any sector. This massive reduction in energy use will require considerable changes in how transportation is utilized throughout the region. This will be best achieved through conservation, utilization of fuel efficient vehicles, and land use pattern changes. The following strategies highlight necessary steps to reduce transportation energy use.

Transportation Targets

- The transportation sector accounts for 40% of the region's energy use.
- By 2050, overall transportation energy consumption will need to be reduced by 65%
- Privately owned vehicles consume 17 million gallons of gasoline per year – this will need to be reduced to 350,000 gallons by 2050.

1) Assist with efforts to increase awareness of existing public transportation services
2) Work with public transportation providers to evaluate and plan for future service modifications.
3) Promote the GO Vermont program, which provides ride share, vanpool, public transportation, and park and ride options.
4) Identify key areas where improvements to bicycle and pedestrian access would be beneficial (in downtowns and surrounding areas for example) and work to improve access and infrastructure in those areas.
5) Encourage upgrades to internet speeds throughout the region in order to enable telecommuting as a way to reduce the need to drive to work.
6) Prioritize projects that close gaps in the transportation network, for example by providing pedestrian or bicycle connections between residential neighborhoods, village centers, schools, and work destinations.
7) Promote a jobs/housing balance that allows more residents to live and work within the same community in order to decrease single-occupant vehicle travel, reduce greenhouse gas emissions, and conserve energy.

8) Goals and policies in the land use and transportation chapters of the Southern Windsor County Regional Plan serve as statements of policy on patterns and densities of land use likely to result in conservation of energy.
1) Electric Vehicles Promote the Drive Electric Vermont webpage, which informs drivers of financial incentives, dealers, and recharging stations for EVs.
2) Contact local vehicle dealers to encourage them to offer EV and fuel-efficient vehicles both for sale and lease.

3) Partner with Drive Electric Vermont, nonprofit organizations, vehicle dealers, and/or state agencies to organize high-visibility events where people can see and test drive EVs, such as county fairs, energy fairs, and summer festivals.
4) Partner with Drive Electric Vermont, the Vermont Clean Cities Coalition, and other organizations to promote the expansion of workplace charging, in particular by continuing to fund incentives that help employers cover the costs of installing charging stations.
5) Promote and seek grants to fund the installation of DC fast-charging infrastructure at strategic locations along major travel corridors and in transit hubs such as park-and-ride locations.
6) Expand the use of electric vehicles throughout the region by supporting education, availability, and infrastructure.
7) Promote the use of electric-assist bicycles.

C. Thermal Efficiency

NET ZERO
energy • waste • water

Steps to reduce energy consumption for residential and commercial building heat will require a focus on weatherization measures and the installation of alternative heating systems. As previously stated, members of the community cannot be forced to weatherize their private homes or businesses. Therefore the strategies suggested below are intended to provide resources and education to further incentivize thermal efficiency.

Thermal Efficiency Targets

- Weatherization and conservation measures will help decrease residential heating demand by 30%
- Wood as a heat source will increase in both Commercial and Industrial sectors with the installation of biomass heating systems.

Residential Heating Efficiencies

1) Inform residents about Efficiency Excellence Network (EEN) contractors by providing links to EEN information through our website.
2) Promote the use of Vermont's residential building energy label/score.
3) Educate and promote State energy codes for residential structures (RBES).
4) Educate local zoning staff about their statutory role to promote the use of residential and commercial building energy standards by:

a) Distributing State energy code information to all applicants seeking a zoning permit for a structure that is heated or cooled.
b) Issuing a certificate of occupancy only after the applicant provides a certificate that ensures compliance with the State Energy code.

5) Encourage all residential Act 250 projects to follow the residential stretch energy code.
6) Promote and educate the public on energy codes for both residential and commercial buildings.
7) Encourage geothermal heat pumps for new construction.

Commercial Heating Efficiencies

1) Work with towns, partner organizations, and EEUs to offer workshops and educational opportunities for businesses on efficiency in new construction, retrofits, and conservation practices.
2) Identify large energy usage customers, such as large businesses, manufactures, and schools, as targets to encourage participation in commercial and industrial EEU programs.
3) Encourage all commercial Act 250 projects to follow commercial stretch energy guidelines.
4) Encourage new buildings to incorporate net-zero ready construction methods.
5) Educate and promote State energy codes for commercial structures (CBES).
6) Assist local planning commissions in considering incentives (e.g. density bonuses) for developments that exceed the state's stretch energy code to locate in and around village centers and downtowns.

Weatherization

1) Inform towns and residents about Energy Efficient Utility (EEU) programs and the state Weatherization Assistance Program for low-income households and encourage residents to participate.
2) Encourage reductions in energy wasted through heating by creating more efficient buildings through weatherization and use of high-performance building methods.
3) Support local weatherization initiatives.
4) Work with partners to improve upon the availability and accessibility of data about completed weatherization projects within the region.

D. Renewable Energy Generation

General Renewable Energy Generation Strategies

Total regional renewable generation of 194,612 MWh by 2050

The following tactics focus on implementing strategies for increasing renewable energy production, which will contribute to achieving the 90/50 goals for all previous sectors (Electricity, Transportation, and Thermal Efficiency).

1) Show support for renewable energy generation facilities that conform to our statements of policy on the development and siting of renewable energy resources.
2) Promote and/or structure policies and incentive programs to promote installation of solar projects where there is electricity demand and on locations where the land has already been impacted by previous development (e.g. roofs, parking lots, landfills).
3) Promote the utilization of passive solar design and siting principles to be incorporated into new buildings in order to reduce heating loads.

4) Support updates to municipal building standards and energy codes that promote incorporation of solar photovoltaics for new construction and major renovations.

Solar Generation

The following statements of policy apply to the development of solar energy generation projects in the Southern Windsor County region:

Figure 23: This is a photo of the Town-owned 150 kW solar project in Cavendish as described on page _. This is an example of a perfectly sited project. Because it is not visible from any major public roads and has no neighbors, no landscaping is warranted. (Credit: Peter LaBelle)

1) Encourage the exploration of newer technologies that improve energy production and/or reduce impacts as they become available.
2) Encourage infrastructure improvements that further our energy goals (e.g. larger container sized battery storage systems).
3) Support rooftop solar projects.
4) Encourage the location of solar projects on preferred sites, as identified in this Plan, as long as they are appropriately designed and scaled for the character of the area in which they are located.
5) Support residential-scale ground-mounted solar projects.
6) Ground-mounted solar projects of 150kW and greater must demonstrate that the proposed project siting is appropriate in scale as it relates to the character of the area in which it is to be located, and that all reasonable options have been considered in siting the facility.
7) The setback standards in 30 V.S.A. §248(s) apply to all applicable ground-mounted solar projects.
8) All ground-mounted solar projects of 150 kW or greater[20] that are within view of major roadways (i.e. interstate highways, state highways, US routes, and Class 1 and Class 2 town highways) must provide adequate landscaping in order to appropriately screen the project from the view of the traveling public.
    a) This landscaping must consist of a mix of native plants that provide adequate screening during all months of the year (i.e. conifers or a mix of deciduous and conifers).
    b) All landscaping materials will be planted at a size that provides adequate screening within 5 years of being planted.
9) The applicant must maintain any landscape plantings required for mitigation, including the replacement of any dead or diseased vegetation serving as part of the landscape mitigation measures, throughout the life of the project or until the project ceases commercial operation.
10) The applicant is expected to provide a plan for the site to be adequately decommissioned at the time when the project ceases commercial operation in accordance with PUC Rule 5.900.

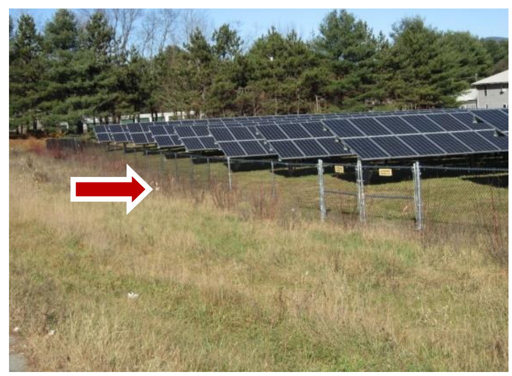


Figure 24: This project is an example of inadequate landscaping/screening. Note deciduous shrubs do not provide year-round screening, small plants will take many years to grow up to provide effective screening, and a lack of mowing the grass between the landscaping and roadway, which is to the left of the photo.

[20] This includes all applicable projects that are not exempt under PUC Rule 5.800.

11) Ground-mounted solar facilities must avoid "known constraints".
12) Ground-mounted solar facilities must not have undue adverse impacts on "possible constraints". In addition, applicants shall demonstrate that the project will not have undue adverse impacts on significant wildlife habitat, wildlife travel corridors, stormwater, water quality, flood resiliency, important recreational facilities or uses, scenic resources identified in this plan, or inventoried historic or cultural resources. Project proposals must consider placement of such facilities in locations where impacts are minimal or employ reasonable measures to mitigate undue adverse impacts on the applicable resources.

Wind Generation

The following statements of policy apply to the development of wind energy generation projects in the region:

Figure 25: This photo is an example of a vertical axis wind turbine.

1) The SWCRPC supports the installation of residential-scale wind turbines (i.e. not to exceed 30 meters in height, measured at the hub).
2) The SWCRPC encourages consideration of newer technologies (e.g. vertical axis wind turbines).
3) Commercial-scale wind turbines (i.e. not to exceed 50 meters in hub height) must demonstrate that the proposed project siting is appropriate in scale as it relates to the character of the area in which it is to be located, and the applicant must also demonstrate that all reasonable options have been considered in siting the facility.
4) All wind turbines and related facilities (e.g. access roads, power line interconnections) must avoid "known constraints".
5) All wind turbines and related facilities must not have undue adverse impacts on "possible constraints". In addition, applicants shall demonstrate that the project will not have undue adverse impacts on public safety (e.g. ice shedding, ice throw), significant wildlife habitat, wildlife travel corridors, stormwater, water quality, flood resiliency, important recreational facilities or uses, scenic resources identified in this plan, or inventoried historic or cultural resources. Project proposals must consider placement of such facilities in locations where impacts are minimal or employ reasonable measures to mitigate undue adverse impacts on the applicable resources.

Hydroelectric Generation

This plan assumes that the construction of new dams is highly unlikely due in part to the negative impacts dams have on rivers and streams. Dams act as a barrier that interferes with natural river dynamics, resulting in negative consequences such as:

- Sediment build-up above the dam (up-stream), and erosion of the stream bed below the dam (down-stream);
- Lowered dissolved oxygen levels;
- Higher water temperatures;
- Impeded nutrient flow - nutrients are blocked from flowing downstream of the dam;
- Fragmented aquatic passage; and/or,
- Trapped pollution in the sediment build-up above the dam (up-stream).

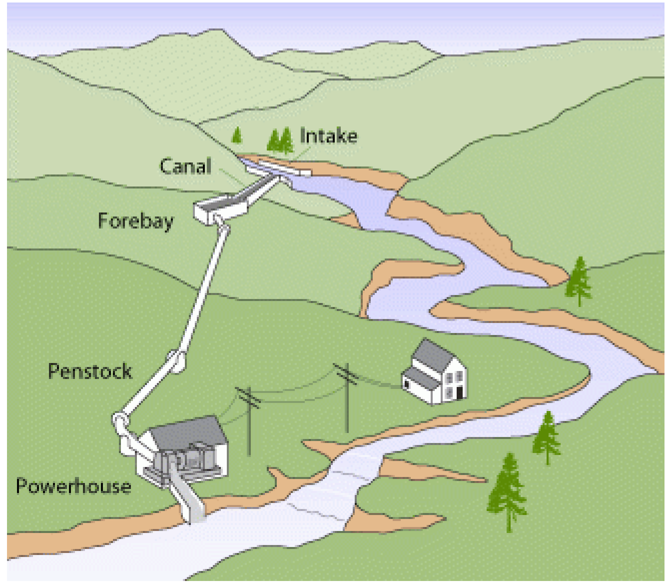


Figure 26: Illustration of a micro-hydropower system (U.S. Department of Energy)

Additionally, the recurring fluctuation of water levels as a result of hydropower operations can cause piping erosion. Common issues of concern include, but are not limited to, erosion, methylmercury, fish passage and recreation.

The following statements of policy apply to the development of hydropower projects that impact southern Windsor County:

1) Encourage exploration of micro-hydropower that has minimal impacts on environment.
2) Support efforts to discuss the possibility of exemptions to FERC or other permitting requirements for micro-hydropower projects.
3) The applicant must provide adequate levels of data and analysis in order to evaluate the impacts that the hydropower facility will have on river dynamics and flood resiliency.
4) When hydropower facilities are to be licensed or relicensed, best management practices must be considered to avoid or minimize undue adverse impacts. Such practices include but are not limited to: providing adequate fish passage, moderating ramping rates, maintaining daily operating logs to be sure that the water levels remain within license limits, and requiring an independent gage to be installed to verify dam operations.
5) A mitigation and enhancement fund shall be considered as one way to help address potential negative impacts of dam operations.

Biomass

While the primary intent of this energy plan is to support the use of biomass for heating, biomass power generating facilities that are modest in scale (possibly 10 MW or less) and that produce both heat


Figure 27: Wood chip heating system at Weathersfield School.

and power may be desirable in certain locations (i.e. industrial parks).

The following statements of policy apply to the development of biomass projects that impact the region:

1) The SWCRPC supports biomass for the purpose of heating buildings (e.g. wood stoves, masonry heaters, wood pellet stoves, wood chip boilers).
2) Wood processing industries shall meet all applicable goals and policies in the Land Use, Economic Development and Natural Resources sections of the *Regional Plan*.
3) Biomass power plants must demonstrate that the proposed project siting is appropriate in scale as it relates to the character of the area in which it is to be located, and the applicant must also demonstrate that all reasonable options have been considered in siting the facility.
4) Applicants for a biomass power plant must demonstrate that they have an adequate and sustainable wood supply for the proposed facility.
5) Biomass power plants must not have undue adverse impacts on air quality or the regional transportation system. If such a facility is proposed, transporting fuel via railroad is strongly encouraged.

Figure 28: Wood stove (Peter Hudkins)

Southern Windsor County has very limited potential for biogas at any commercial scale. There may be some opportunities; for example, capturing methane from anaerobic digesters to generate heat or power at wastewater facilities. The SWCRPC, supports efforts to generate heat or power from biogas that is a bi-product from the ongoing uses at existing facilities, such as municipal wastewater facilities, composting facilities, or farms.

Presently, there are no food waste composting facilities in this area of the scale that would contribute toward energy generation. The Solid Waste Implementation Plan (SWIP) for the Southern Windsor/Windham Counties Solid Waste Management District does not call for any such facilities at this time.

Vermont Public Power Supply Authority
Putting the Public in Power.
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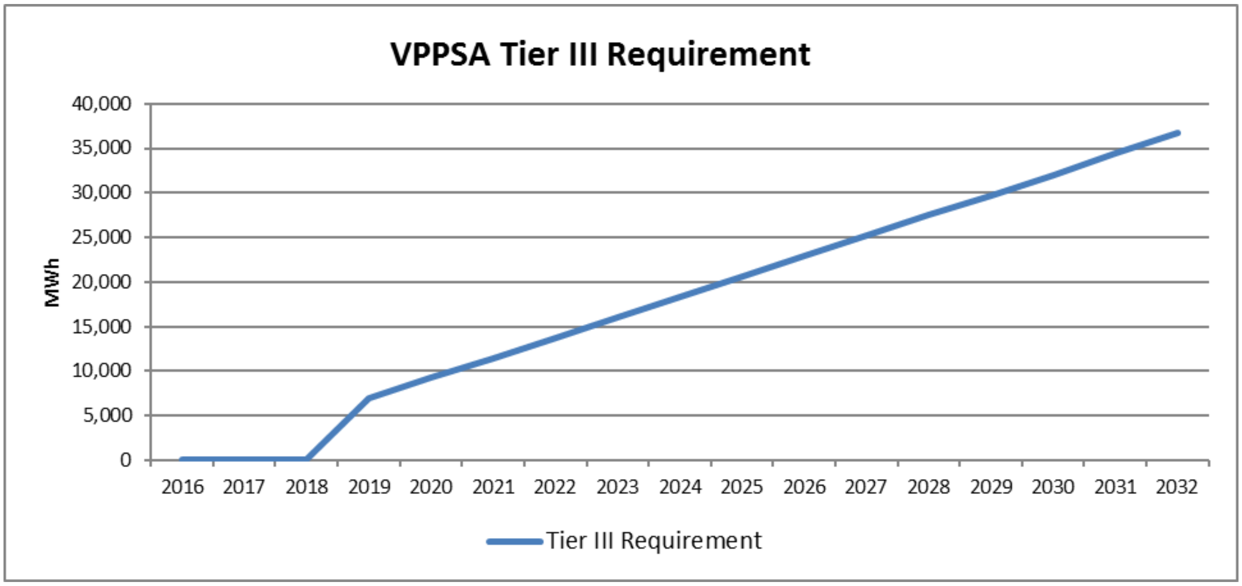
Vermont Public Power Supply Authority 2019 Tier 3 Annual Plan

In accordance with the Public Utility Commission's ("PUC") *Final Order in Docket 8550*, Vermont Public Power Supply Authority ("VPPSA") is filing this Annual Plan describing its proposed 2019 Energy Transformation programs. Vermont's Renewable Energy Standard ("RES"), enacted through Act 56 in 2015, requires electric distribution utilities to either generate fossil fuel savings by encouraging Energy Transformation projects or purchase additional Renewable Energy Credits from small, distributed renewable generators ("Tier 2"). Utilities' Energy Transformation ("Tier 3") requirements are established by 30 V.S.A. § 8005(a)(3)(B), which states that "in the case of a provider that is a municipal electric utility serving not more than 6,000 customers, the required amount shall be two percent of the provider's annual retail sales beginning on January 1, 2019.[1]" The 12 municipal Members of VPPSA are each eligible to have their obligation begin in 2019 under this provision. In addition, under 30 V.S.A. § 8004 (e) "[i]n the case of members of the Vermont Public Power Supply Authority, the requirements of this chapter may be met in the aggregate." The VPPSA Member utilities plan to meet Tier 3 requirements in aggregate in 2019.

VPPSA Tier 3 Obligation

In 2019, VPPSA's aggregate requirement is estimated to be 6,917 MWh or MWh equivalent in savings. Obligations increase rapidly, doubling within three years.



[1] 30 V.S.A. § 8005(a)(3)(B)

Prescriptive Programs

VPPSA plans to meet these challenging requirements through a mix of programs and measures that meet each statutory goal for Tier 3 while mitigating costs that could put upward pressure on rates.

VPPSA Electric Vehicle Program

Despite lower operating and maintenance costs associated with Electric Vehicle ("EV") and plug-in hybrid electric vehicles ("PHEVs"), the upfront cost continues to be a major barrier to greater EV penetration in the state. EVs and PHEVs remain a relatively low percentage of overall vehicle sales in the state. According to Drive Electric Vermont, the number of plug-in vehicles (EVs and PHEVs) in the state increased by 844 vehicles, or 48%, over the past year and these vehicles comprised 3.4% of new passenger vehicle registrations over the past quarter. Nonetheless, there were only 2,612 plug-in vehicles registered in Vermont as of July 2018. VPPSA and other utilities are working to raise awareness of the benefits of plug-in vehicles and help alleviate the financial barriers to EV and PHEV adoption. VPPSA will continue to offer customer rebates for the purchase or lease of EVs and PHEVs. The customer incentive for purchasing or leasing an electric vehicle will be $800 and the customer incentive for purchasing or leasing a plug-in hybrid electric vehicle will be $400. Low-income customers[2] will receive an additional $200 towards the purchase or lease of an EV or PHEV.

The VPPSA utilities offered an EV Pilot Program on a voluntary basis in 2018. The Pilot enabled VPPSA to develop the necessary infrastructure to implement programs across utility service territories and determine how its Members can best benefit from Tier 3 aggregation. The structure put in place to track Tier 3 costs and benefits under the EV Pilot Program will be replicated as 2019 Tier 3 programs are rolled out. Savings accrued during the 2018 Pilot Program will be banked for use to meet 2019 or future compliance obligations, consistent with 30 V.S.A. § 8005(a)(3)(F)(iv).[3]

VPPSA Cold Climate Heat Pump Program

In 2019, VPPSA will offer customer rebates for the purchase of cold climate heat pumps ("CCHP") in the amount of $300. For customers that can demonstrate a defined level of building performance, the CCHP rebate will be increased to $400. The additional incentive, even if it isn't utilized, serves to highlight the importance of overall building performance. Because heat pumps in high-performing buildings will have less impact on peaks, this also serves to assist in

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[2] According to the PUC's *Order Implementing the Renewable Energy Standard* dated 6/28/2016, "A low-income customer shall be defined as a customer whose household income is at or below 80% of Vermont statewide median income.

[3] Act 56 requires the Public Utility Commission to adopt rules: "… (iv) To allow a provider who has met its required amount under this subdivision (3) in a given year to apply excess net reduction in fossil fuel consumption, expressed as a MWH equivalent, from its energy transformation project or projects during that year toward the provider's required amount in a future year."

managing demand during those high cost times. In order to be eligible for the higher incentive amount, customers will need to demonstrate that their homes were "weatherized" according to a list of standards developed and circulated by the Department of Public Service ("DPS") during the CCHP measure characterization by the Technical Advisory Group ("TAG").

VPPSA Heat Pump Water Heater Program

VPPSA intends to provide rebates to customers that install heat pump water heaters ("HPWH") to replace fossil-fuel fired water heaters. These incentives will be provided in conjunction with Efficiency Vermont ("EVT") HPWH rebates. VPPSA and EVT are currently negotiating a Memorandum of Understanding ("MOU") to implement this joint program and define the "savings split" between the VPPSA utilities and EVT.

Savings from Heat Pump Water Heaters, Cold Climate Heat Pumps, and Plug-in and Electric Vehicles will be estimated using measure characterizations created by the Tier 3 TAG. VPPSA's budget and estimated savings for prescriptive Tier 3 Programs is summarized below.

VPPSA Tier 3 Prescriptive Program Expected Costs and Savings

Measure	***Savings/unit (MWH)***	***Incentive Amount***	***Admin Cost***	***Total Cost***	***Volume***	***Cost/MWH***	***Total Credit (MWH)***	***Budget***
EV	24.6	$800	$148	$948	15	$38.52	369	$14,215
PHEV	13.7	$400	$148	$548	30	$39.98	411	$16,431
CCHP	12.8	$300	$148	$448	80	$35.09	1021	$35,815
CCHP (wz)	15.8	$400	$148	$548	20	$34.75	315	$10,954
HPWH*	5.69	$300	$148	$448	5	$78.68	28	$2,238
TOTAL					150	**$37.14**	**2144**	$79,653

**reflects expected savings split with EVT*

Other Tier 3 Measures

Incentives for Electric Vehicle Supply Equipment

Several VPPSA members have identified possible locations for the installation of electric vehicle charging stations within their territories. These utilities are working with potential charging station hosts to apply for funding from the Volkswagen Mitigation Trust Fund for public EV chargers. Should these installations move forward, VPPSA members may provide financial contributions and/or technical assistance in addition to that already provided in support of the application to facilitate the installation of electric vehicle charging infrastructure.

Fork Lifts and Golf Carts

In addition to the prescriptive rebate programs described above, VPPSA is actively seeking out opportunities for fuel switching golf carts and fork lifts to electricity. Both of these measures were recently characterized by the TAG and together provide substantial potential for fossil fuel savings. VPPSA anticipates working with businesses that may wish to replace fossil fuel equipment with electric-powered equipment and is exploring what level of incentive would be needed for these conversions.

Commercial and Industrial Customers

Commercial and industrial ("C&I") customers will be served on an individual, custom basis in 2019. VPPSA continues to explore cost-effective Tier 3 custom projects, including converting utility customers from diesel generators to electric service. In addition, C&I customers that have potential Tier 3 projects are being identified by Efficiency Vermont through a joint arrangement with VPPSA to ensure that these customers receive comprehensive efficiency services. To date, opportunities have been identified at a ski resort, a furniture maker, a quarry, and a candy manufacturer. VPPSA has and will continue to work with the Department on custom projects to ensure savings claims are valid and able to be evaluated.

Equitable Opportunity

The Tier 3 incentives offered by VPPSA will be available to all of the VPPSA Members' customers. Discussions with vehicle dealerships around the electric vehicle rebate program indicated that many low- to moderate-income customers take advantage of PHEV leases. By providing additional incentives for income-eligible customers, as well as by making the incentives available for both vehicle leases and vehicle purchases, VPPSA's EV rebate program is designed to be accessible to low-income customers.

The ability to bring financial benefits to all customers, rather than just participating customers, makes electrification an attractive Tier 3 option from an equity perspective. All of a host utility's customers have the potential to benefit from the increased electric sales that accompany electrification programs such as VPPSA's electric vehicle, heat pump, and heat pump water heater programs. If additional kWh can be procured at costs at or below the costs embedded in a utility's rates, increasing the number of kWh delivered through the utility's system allows the fixed costs of operating the utility to be recovered over a larger number of units, driving the per kWh rate down. VPPSA's analysis shows that the incentive dollars paid to customers in rebates for electrification measures are expected to be recovered through increased sales over the life of the measures, making these programs revenue neutral or, more likely, economically beneficial for non-participating ratepayers.

Collaboration/Exclusive Delivery

Strategic electrification of the transportation and heating sectors is an appropriate responsibility of the Vermont's distribution utilities, who are charged with procuring electric supply and managing the distribution grids across the state. Strategic electrification is outside of the purview of the state's energy efficiency utilities, whose mandate is to achieve cost-effective electric and thermal efficiency savings (where the presumption is that reductions in load do not have the possibility for adverse distribution/transmission system impacts/costs). Distribution utilities are uniquely positioned to promote heating and transportation electrification while assessing and mitigating grid impacts. If electrification is going to deliver its potential climate and economic benefits to Vermonters, it must be carried out in a way that does not disproportionately increase utility costs.

VPPSA and Efficiency Vermont are working together to define how the two entities can provide holistic efficiency services to residential, commercial, and industrial customers. A Memorandum of Understanding to govern this engagement and interaction is under development. In many cases, this partnership will involve VPPSA providing incentives for electrification measures, which can provide benefits to all utility ratepayers, while EVT provides incentives for thermal and electric efficiency measures.

Currently, VPPSA and EVT are engaged in a targeted community effort in Northfield that will continue through early 2019. This initiative involves enhanced outreach to customers regarding VPPSA and EVT incentives, in-person communication with small businesses, and educational workshops on a series of energy efficiency topics. VPPSA and EVT will evaluate whether such joint targeted efforts have the potential to generate greater savings and/or better align with a community's specific energy efficiency needs. If successful, this model may be adapted and deployed in other VPPSA municipalities.

VPPSA has also been working with NeighborWorks of Western Vermont, a comprehensive weatherization service provider that recently expanded its service territory to include the Northeast Kingdom. VPPSA has provided marketing support in the form of utility bill stuffers to NeighorWorks to promote awareness of this new service offering. NeighborWorks, in turn, will be making customers aware of VPPSA's incentives. The collaboration with NeighborWorks is ongoing, and VPPSA sees the thermal efficiency services offered by NeighborWorks as complementary to the electrification measures promoted by VPPSA.

Regarding VPPSA's EV program, the natural partners are vehicle dealers located throughout the VPPSA Members' service territories. VPPSA has done direct outreach to local dealers that sell EVs to ensure they are aware of the VPPSA rebate program. VPPSA is not aware of other energy service providers currently offering electric vehicle incentives in the VPPSA utilities' service territories, as transportation electrification is outside of the purview of Efficiency Vermont. Another partner in VPPSA's EV program is Drive Electric Vermont, who has been consulted regarding program design considerations and also engaged in helping develop customer educational materials.

Best Practices and Minimum Standards

Over the long-term, electric vehicles and heat pumps have the potential to significantly increase loads for Vermont utilities. Through ongoing distribution planning efforts, the VPPSA members have identified that their systems remain robust, and the expected growth in annual and local peak demand associated with proposed measures can generally be sustained if monitored and deployed carefully. According to the load forecast developed by VELCO and the Vermont System Planning Committee in conjunction with VELCO's Long-Range Transmission Plan, load growth associated with strategic electrification is not expected to impact the transmission grid for the next eight to ten years. In the short-term, VPPSA's strategy for managing increased load will rely largely on customer education. The VPPSA member utilities will continue to monitor load impacts of the electrification of home heating, water heating, and EV charging to determine when more active load management will be necessary.

With regards to EVs, it is expected that the majority of home charging will occur during overnight, off-peak hours. Through VPPSA's EV Pilot Program, informational materials about the ideal time to charge vehicles will be provided to customers that receive rebates.

Under VPPSA's heat pump program, customers that can demonstrate that their homes have been weatherized will receive a higher incentive for the installation of a heat pump. This increased incentive will encourage customers to improve the thermal performance of their homes, thus allowing heat pumps to operate more effectively. Customers will be informed of the benefits of weatherization and provided with resources for increasing the performance of their homes. Heat pumps installed in well-insulated homes have the potential to mitigate the grid impacts of heating electrification as compared with heat pumps installed in poorly insulated buildings.

Ultimately, in the long term VPPSA expects that active load control will be necessary to manage EV charging and, to some extent, heat pump usage. Managing when the increased load from strategic electrification occurs will enable utilities to collect added revenue from increased electric sales without significant increases in the costs associated with higher peak loads. Effective load control requires a combination of rate offerings and technology that either provide active control or verify customer adherence to desired goals. These technologies have historically been challenging to implement in rural areas of Vermont where communication systems are lacking and the cost of the required back-office systems is often prohibitive. Some form of interval metering is needed for most types of load control rate offerings. The VPPSA Members are currently exploring the viability of installing advanced metering ("AMI") technology within their territories and expect to have consultant recommendations on whether to move forward with AMI deployment by early 2019. In addition, VPPSA is in discussions with VELCO about the viability of extending VELCO's fiber optic network into VPPSA member distribution systems to both facilitate AMI technology and provide a platform for expanded broadband coverage in areas of the state that do not currently have access. AMI and/or broadband technology will facilitate the implementation of demand response and load control programs that will allow utilities to manage increased electrification load in the most cost-effective manner.

VPPSA Tier 3 Strategy

VPPSA intends to deploy Energy Transformation programs, with a focus on electrification measures, to residential and commercial and industrial customers to satisfy the VPPSA Members' Tier 3 obligations. VPPSA is ramping up Tier 3 programs at an aggressive yet considered pace in its first Tier 3 compliance year. To the extent that there is a shortfall in savings from Energy Transformation programs, VPPSA will employ alternative strategies for meeting Tier 3 requirements in a cost-effective manner. One component of VPPSA's Tier 3 strategy is to purchase Tier 2 RECs when prices are low as a hedge against a shortfall in savings from Tier 3 programs. To the extent that Tier 2 RECs are less expensive than implementing Tier 3 programs, VPPSA will exercise this strategy to benefit its Members. In addition, for VPPSA members that own Tier 2 eligible generating resources, Tier 2 RECs may be the primary strategy for Tier 3 compliance. VPPSA's Tier 3 strategy may also include providing incremental support to the state's Weatherization Assistance Program. Since the RES was enacted, VPPSA has explored developing a Tier 3 program focusing on weatherization but found that program to be cost-prohibitive. Given the PUC's August 24, 2018 Order in Case 17-4632 regarding Washington Electric Cooperative's Tier 3 savings claim for weatherization work, it may be prudent for VPPSA to implement the same type of Tier 3 program at a cost significantly lower that the Tier 3 Alternative Compliance Payment.