Village of Morrisville Water & Light Department

2019 Integrated Resource Plan

Filed with the Public Utility Commission

VPPSA
Vermont Public Power Supply Authority

Executive Summary:

Incorporated in 1895, the Village of Morrisville Water & Light Department (MW&L) serves approximately 4,200 retail customers in the Village of Morrisville as well as portions of seven of the surrounding towns: Morristown, Elmore, Hyde Park, Morrisville, Stowe, Johnson and Wolcott all located within the boundaries of Lamoille County in north central Vermont. Almost three-quarters of MW&L's customers are served within the village and town portions of Morrisville. MW&L 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 MW&L is careful to balance maintaining reliability and reasonable cost levels with the need to deliver innovative programs to customers that provide practical value.

MW&L's distribution system serves a mix of residential and small commercial customers. Residential customers make up over 80% of the customer mix while accounting for almost half of MW&L's retail kWh sales. Approximately 648 small commercial customers (about 15%) make up a little over half of retail usage with the remaining retail sales going to public street and highway lighting customers.

Consistent with regulatory requirements, every 3 years MW&L 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. MW&L'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

MWL 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 MW&L'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 MW&L's largest customers is currently anticipated, the potential does exist. MW&L monitors the plans of these large customers in order to anticipate necessary changes to the existing 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

MW&L'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. Located within its service territory, MW&L currently owns and operates three hydroelectric generating stations. Combined, these clean and renewable, power stations provide MW&L with approximately 19% of its energy supply.

When considering future electricity demand, MW&L seeks to supplement its existing resources with market contracts as well as new demand-side and supply resources. MW&L 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. MW&L 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 Renewal 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 MW&L 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, MW&L 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 MW&L 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.

MW&L is near the end of the relicensing process for Cady's Falls, Morrisville #2, and HK Sanders hydro units. All three units are being permitted jointly under the same application and will be subject to additional requirements under the new permit. A three-part impact on

resource plans is expected. We anticipate that HK Sanders will be retired for the purpose of electrical generation on 1/1/2021. The capacity factors for Cady's Falls and Morrisville #2 are expected to drop under the new permit. We anticipate that Cady's Falls and Morrisville #2 may qualify for Low Impact Hydro Institute (LIHI) certification on 1/1/25, which could qualify the units for MA Class II RECs.

MW&L faces three major energy resource decisions and one load-related question over the 2020 – 2039 period covered by this Integrated Resource Plan (IRP).

The first and second of these involves the expiration of a contract at the end of 2022, which represents about 8% of MW&L's energy supply. Eighteen months later, other market contracts, which represent 12% of M&WL's supply, will also expire. As a result, 20% of MW&L's energy supply will expire by mid-2024. Options to replace these two contracts include renegotiating the contract that expires at the end of 2022, signing a PPA for an existing, dispatchable hydro plant to provide energy and Tier I RECs, and signing a PPA for market energy supplies.

The third major energy resource decision involves the costs and benefits of getting LIHI certification effective 1/1/25 for MW&L's Cady's Falls and Morrisville #2 hydroelectric generating facilities.

Analysis of these major resource decisions also addresses the load-related question: What is the rate impact of 1% compound annual load growth? 1% compound annual growth in load could reduce rates in 2032 by 7% compared to the reference case.

The main sources of uncertainty expected to impact these decisions are the price of natural gas and pipeline transportation prices, load growth, the cost of regional transmission service and, REC prices. MW&L is largely hedged for the long run in the capacity market, reducing the impact of capacity prices.

RENEWABLE ENERGY STANDARD

MW&L is subject to the Vermont Renewable Energy Standard (RES) which imposes an obligation for MW&L 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. MW&L' 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 MW&L's TIER III obligation involves energy transformation, or reduction of fossil fuel use within its territory. TIER III 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 MW&L receives credits toward its TIER III obligation. MW&L will be exploring custom electrification opportunities with some of its larger customers, although no proposal has yet taken shape. More detail regarding MW&L's plans to meet its TIER III obligation is available in Appendix B to this document.

ELECTRICITY TRANSMISSION AND DISTRIBUTION

MW&L has a compact service territory as a result of being a small, municipal-owned electric utility and has benefitted from several major system improvements over the past 15 years. MW&L's system consists of approximately 33 miles of 34.5 kV sub-transmission line, 180 miles of distribution line operating at 12.5 kV, 10 substations, and is connected to the transmission systems of Green Mountain Power Corporation (GMP) to the north, Vermont Electric Power Company (VELCO) to the south in Stowe, and the Hardwick Electric Department (and eventually GMP) to the east.

In addition to upgrading and routinely maintaining the system to ensure efficiency and reliability, MW&L is examining the need to modernize in order to support beneficial electrification and additional distributed generation on the system and to provide more customer oriented services, including load management programs that reduce costs for both MW&L and its customers. MW&L 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. .

MW&L sees potential value to customers from 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 MW&L's ability to deliver these benefits and capture economic development/retention opportunities where possible.

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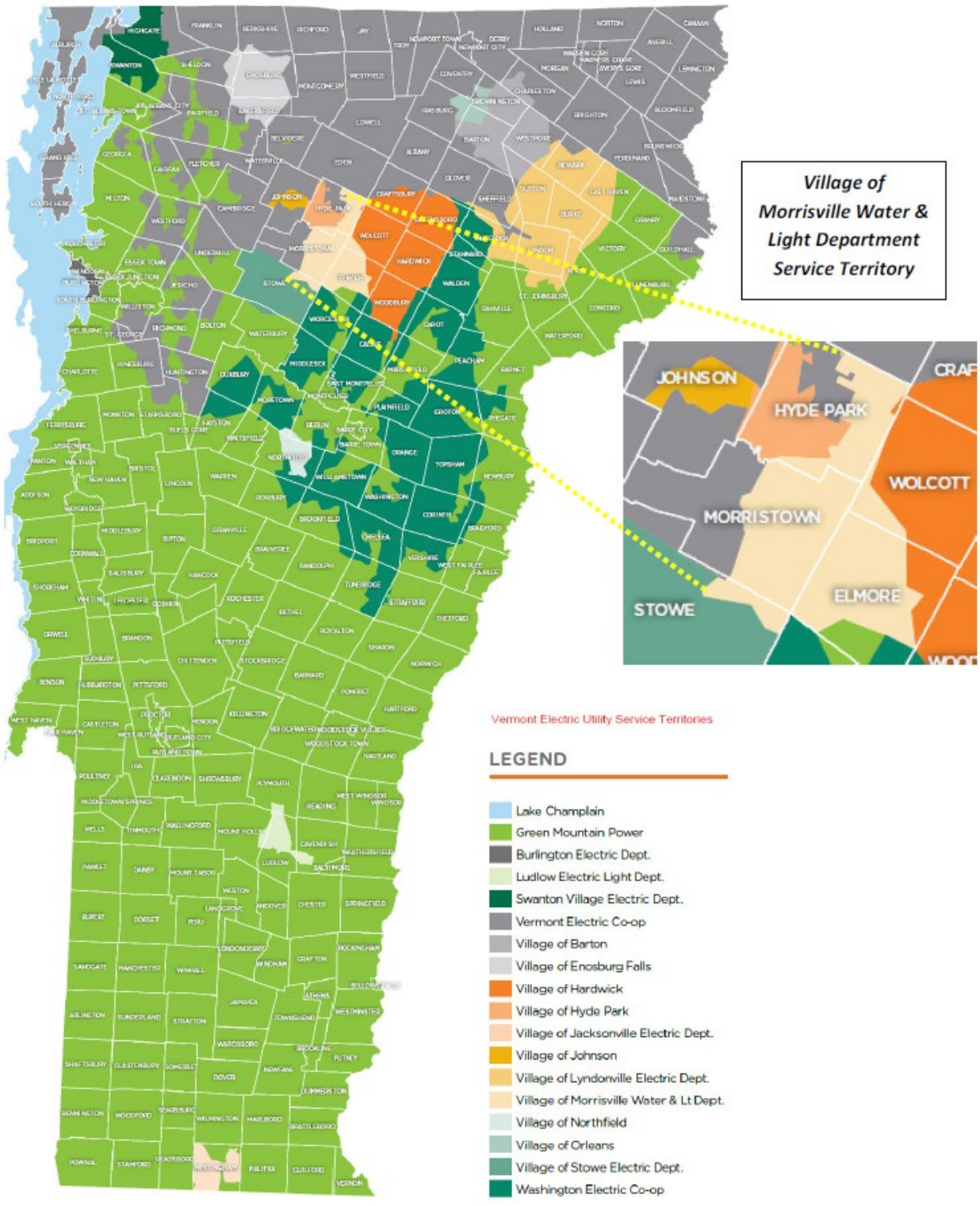
Introduction:

Located in Lamoille County in north central Vermont, the Village of Morrisville Water & Light Department (MW&L) was incorporated in 1895. Its service territory (shown on the map below) encompasses the Village of Morrisville as well as portions of seven of the surrounding towns: Morristown, Elmore, Hyde Park, Morrisville, Stowe, Johnson and Wolcott. About 70% of Morrisville's customers are served within the village and town portions of Morrisville. Morrisville serves approximately 4,200 retail customers.

Figure 1: MW&L's Distribution Territory



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.

MW&L is one of eleven member utilities of VPPSA, who 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:

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

MW&L and VPPSA are parties to a broad Master Supply Agreement (MSA). Under the MSA, VPPSA manages MW&L'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 MW&L's loads and power supply resources in the New England power markets.

System Overview

In 2018 MW&L's peak demand in the winter months was 8,502 kW and 9,143 kW during the summer and shoulder months. Annual energy retail sales for 2018 were 45,788,872 kWh and the annual load factor for 2018 was 61.8%.

MW&L is connected to the transmission systems of Green Mountain Power Corporation (GMP) to the north, Vermont Electric Power Company (VELCO) to the south in Stowe, and the Hardwick Electric Department (and eventually GMP) to the east.

Table 1: MW&L's Retail Customer Counts

Data Element	2014	2015	2016	2017	2018
Residential (440)	3,389	3,415	3,441	3,463	3,568
Small C&I (442) 1000 kW or less	595	595	604	642	648
Large C&I (442) above 1,000 kW	0	0	0	0	0
Street Lighting (444)	2	2	3	3	3
Public Authorities (445)	0	0	0	0	0
Interdepartmental Sales (448)	0	0	0	0	0
Total	3,986	4,012	4,048	4,108	4,219

Table 2: MW&L's Retail Sales

Data Element	2014	2015	2016	2017	2018
Residential (440)	20,887,095	21,103,642	20,760,686	20,767,905	21,688,925
Small C&I (442) 1000 kW or less	23,824,413	23,912,370	23,455,361	23,246,887	24,062,506
Large C&I (442) above 1,000 kW	0	0	0	0	0
Street Lighting (444)	115,266	114,144	90,362	37,400	37,441
Public Authorities (445)	0	0	0	0	0
Interdepartmental Sales (448)	0	0	0	0	0
Total	44,826,774	45,130,156	44,306,409	44,052,192	45,788,872
YOY	0%	1%	-2%	-1%	4%

Table 3: MW&L's Annual System Peak Demand (kW)

Data Element	2014	2015	2016	2017	2018
Peak Demand kW	9,446	8,957	8,639	8,816	9,143
Peak Demand Date	12/27/14	08/19/15	08/11/16	12/28/17	07/02/18
Peak Demand Hour	18	14	13	18	15

Structure of Report

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

I. Electricity Demand
This chapter describes how MW&L's electricity requirements were determined and discusses sources of uncertainty in the load forecast.

II. Electricity Supply
This chapter describes MW&L's electricity supply resources, and the options that are being considered to supply the electricity needs of MW&L's customers.

III. Resource Plans
This chapter compares MW&L's electricity demand to its supply and discusses how MW&L will comply with the Renewable Energy Standard.

IV. Electricity Transmission and Distribution
This chapter describes MW&L'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 MW&L's power supply costs and cost of service.

VI. Action Plan
This chapter outlines specific actions the MW&L expects to take as a result of this Integrated Resource Plan.

A. Appendix : Letters List
The appendix includes a series of supporting documents and reports, as listed in the Table of Contents.

B. Glossary

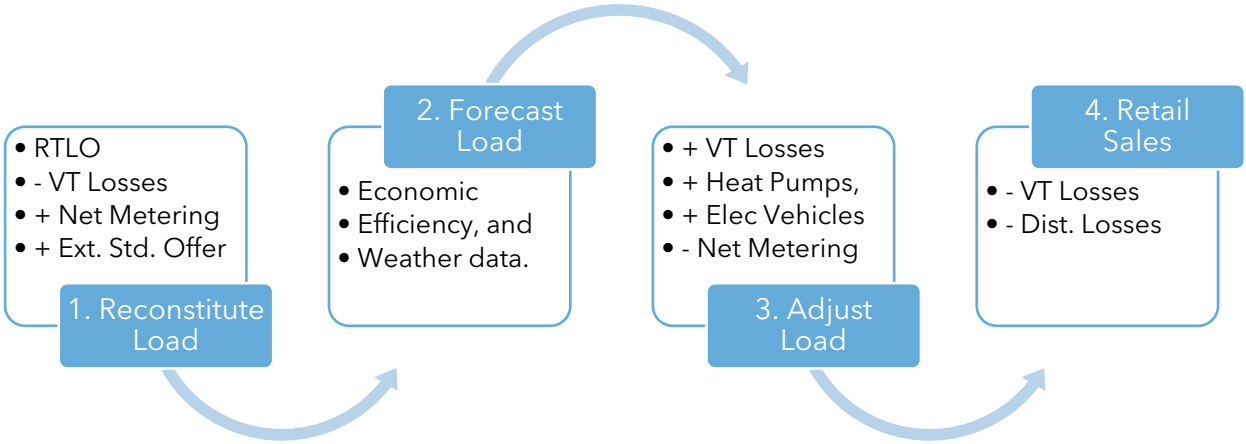
Electricity Demand

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 MW&L'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 MW&L'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 2: Forecasting Process



1. Reconstitute Load

In the past, metered load at the distribution system's tie points (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	

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 adjusted R-squared of 93%, and a Mean Absolute Percent Error (MAPE) of 1.46%.

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

[1] Vermont Electric Power Company

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

in Morrisville. 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.

Energy Forecast Results

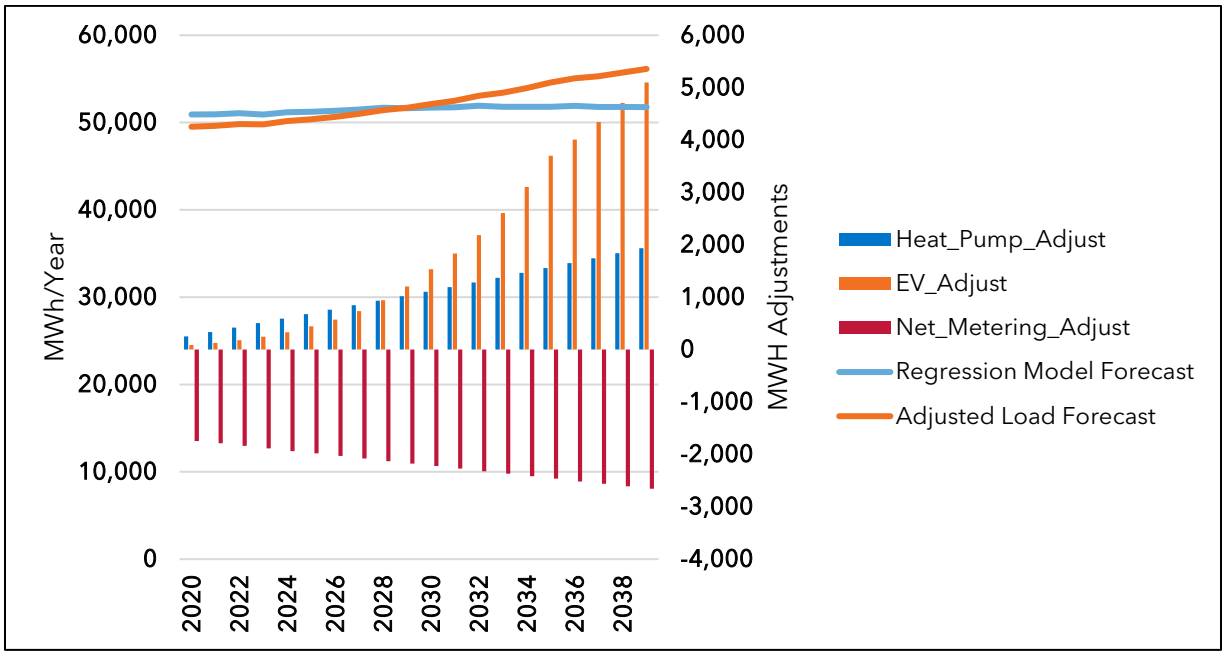
Table 6 shows the results of the Regression Forecast for energy, as well as the adjustments that are made to arrive at the Adjusted Forecast. The Compound Annual Growth Rates (CAGR) at the bottom of the table illustrate the trends in each of the columns. Notice that the Regression Forecast itself is increasing by 0.1% per year. After making adjustments for CCHPs, EVs, and net metering, the Adjusted Forecast increasing 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**	50,925	251	88	-1,745	49,519
2025	**6**	51,233	676	442	-1,982	50,369
2030	**11**	51,702	1,103	1,534	-2,223	52,116
2035	**16**	51,796	1,556	3,698	-2,464	54,586
2039	**20**	51,766	1,934	5,098	-2,657	56,142
CAGR		**0.1%**	**10.7%**	**22.5%**	**2.1%**	**0.6%**

The Adjusted Forecast is the result of high CAGRs for CCHPs (10.7%) and EVs (22.5%). But during the first five years of the forecast, these two trends are more than offset by the net metering program, which grows by the historical three-year average of 2.1% per year. By 2025, the impact of CCHPs and EVs is on part with the impact of net metering, and the load growth accelerates from that year forward.

Figure 3: Adjusted Energy Forecast (MWh/Year)



The accuracy of the underlying regression model is very good at 93% adjusted R-squared, and the mean absolute percent error (MAPE) is low at 1.46%. While all of the trends in the adjustments are uncertain, they are expected to cause significant load growth after 2030.

Energy Forecast – High & Low Cases

To form a high case, we assumed that the CAGR for CCHPs and EV's about doubles to 25% and 40% respectively. Simultaneously, we assume that net metering penetration stops at today's levels. At these growth rates, 2039 energy demand rises by over 200% compared to 2020 electricity use, a result that is driven by the 40% CAGR for EVs. Because of the nature of compound growth, the increase in energy demand does not start to accelerate until 2030. As a result, there is ample opportunity to monitor these trends during the annual budget and the tri-annual IRP cycles.

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**	50,925	251	88	-1,745	49,519
2025	**6**	51,233	766	471	-1,745	50,726
2030	**11**	51,702	2,338	2,533	-1,745	54,828
2035	**16**	51,796	7,136	13,622	-1,745	70,809
2039	**20**	51,766	17,422	52,329	-1,745	119,772
CAGR		**0.1%**	**23.6%**	**37.7%**	**0.0%**	**4.5%**

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 doubles. This combination of trends is a plausible worst-case scenario, and results in a forecast that *decreases* by 0.4% per year.

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**	50,925	251	88	-1745	49,519
2025	**6**	51,233	320	141	-2563	49,131
2030	**11**	51,702	409	227	-3766	48,572
2035	**16**	51,796	522	366	-5534	47,149
2039	**20**	51,766	634	536	-7529	45,407
CAGR		**0.1%**	**4.7%**	**9.5%**	**7.6%**	**-0.4%**

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.

Finally, the accuracy of the peak forecast regression model is good. Based on daily data, it has an R-squared of 78.3%, and a MAPE of 2.7%.

[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

Peak Forecast Results

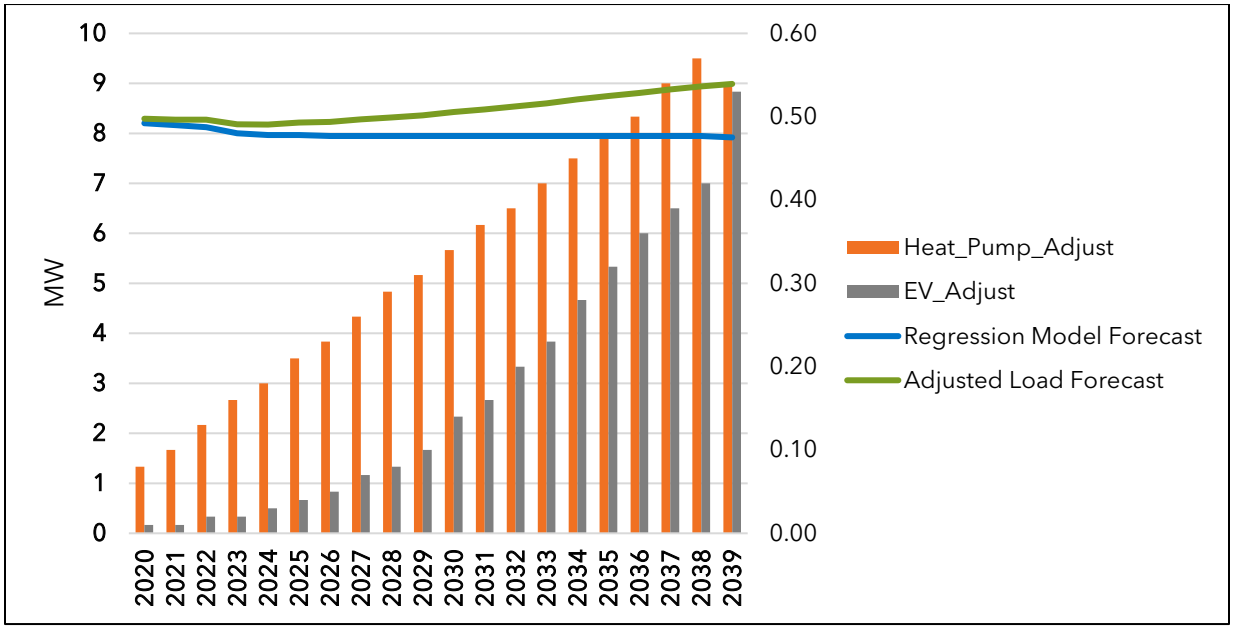
Table 9 shows the results of the Regression Forecast of peak loads, as well as the adjustments that are made to arrive at the Adjusted Forecast. The CAGR at the bottom of the table illustrate the trends in each of the columns. Notice that the Regression Forecast itself is flat. After making adjustments for CCHPs, EVs, and net metering, the Adjusted Forecast actually increases by 1.0% per year. Finally, the table shows that the timing of MW&L's peak load is forecast to stay in January at 1900 (7:00 PM).

Table 9: Peak Forecast (MW)

MMM-YY	Peak Hour	Regression Forecast	EV Adjustment	CCHP Adjustment	Net Metering Adjustment	Adjusted Forecast
Jan-20	1800	8.2	0.01	0.08	0.00	8.3
Jan-25	1800	8.0	0.04	0.21	0.00	8.2
Jan-30	1800	7.9	0.14	0.34	0.00	8.4
Jan-35	1800	7.9	0.32	0.48	0.00	8.7
Dec-39	1800	7.9	0.53	0.54	0.00	9.0
CAGR		**-0.2%**	**22.0%**	**10.0%**		**0.4%**

The peak load forecast starts at 8.3 MW and ends at 9.0 MW. The Adjusted Forecast exceeds the Regression Forecast immediately in 2020 due to high CAGRs for CCHPs (10%). By 2035, EV's are forecast to be responsible for as much peak load growth as CCHP's. This amounts to a 0.4% CAGR, and can be seen in Figure 4.

Figure 4: Adjusted Peak Forecast (MW)



Peak Forecast – High & Low Cases

To form a high-case, we assumed 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 2030. Absent a step change in consumer adoption of CCHPs and EVs, electrification is not likely to produce any appreciable peak load growth for the next ten years. However, we will continue to monitor these trends annually.

Table 10: Peak Forecast – High Case

MMM-YY	Peak Hour	Regression Forecast	CCHP Adjustment (MW)	EV Adjustment (MW)	Net Metering Adj. (MW)	Adjusted Fcst. (MW)
Jan-20	**1900**	8.2	0.01	0.08	0.00	8.3
Jan-25	**1900**	8.0	0.04	0.24	0.00	8.3
Jan-30	**1900**	7.9	0.22	0.75	0.00	8.9
Jan-35	**1900**	7.9	1.16	2.27	0.00	11.4
Jan-39	**1900**	7.9	4.44	5.55	0.00	17.9
CAGR		**-0.2%**	**35.6%**	**23.6%**		**3.9%**

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

Because of strong growth in CCHPs and EVs, MW&L's electricity demand is expected to grow by 0.6% annually over the forecast period. The uncertainties facing MW&L stem from the growth rate of net-metering, CCHPs and EVs all of which are nascent trends that will almost certainly progress at different rates than forecast.

Net Metering

MW&L presently has 106 residential scale (< 15 kW) net metered customers with a total installed capacity of about 720 kW. In addition, there are nine customers who have arrays between 15 and 150 kW, and they total 614 kW. 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, it could lead to a step change in the adoption rate of net metering, and a quicker erosion of retail revenues for the utility.

Given the small size of the customer base and the nascent trends involved, net-metering represents a key uncertainty for MW&L to monitor, especially if larger net metered projects are proposed. For example, a 500 kW net metered solar project built in 2020 would represent an almost 40% increase in the base of installed, net metered capacity on the system. In this event, the impact would be captured in interconnection and annual power budgeting processes and managed accordingly.

Electricity Supply

II. Electricity Supply

MW&L'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 MW&L 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 18 power supply resources in MW&L's portfolio.

Existing Power Supply Resources

1. Cady's Falls Hydro

MW&L owns three hydroelectric facilities, the first of which is Cady's Falls Hydro. Cady's Falls is located on the Lamoille River in Morrisville at the west end of Lake Lamoille. It was originally constructed in 1894, and was reconstructed in 1906, 1914, and 1947. It presently consists of two turbines that, in total, are rated at 1.3 MW. It operates in a run-of-river mode.

2. Fitchburg Landfill

MW&L holds a 15.65% (704 kW) entitlement to a landfill gas-fired generator at the Fitchburg Landfill in Westminster, MA. The 15-year PPA started in 2012 and provides 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. HK Sanders Hydro

The second of MW&L's hydroelectric facilities is the HK Sanders Hydro, which is located on the Green River, a tributary of the Lamoille River. It was constructed in 1947, and its dam forms the Green River Reservoir. It was designed as a water storage facility, and 1.89 MW of generation capacity was installed in 1984.

4. Hydro Quebec US (HQUS)

In 2010, a long-term, statewide Purchased Power Agreement (PPA) with Hydro Quebec was signed. MW&L's entitlement under the contract is 0.2% (420 kW) through 2030, and it steps down as the contract approaches expiration in 2038. 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.

5. Kruger Hydro

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 was purchased by VPPSA under three long-term purchased power agreements signed in February 2017. MW&L has an agreement with VPPSA to purchase 18.73% of their collective output. These contracts do not include RECs.

6. Lawrence Brook Solar

Lawrence Brook is a 2.2 MW solar facility that is being permitted for construction in spring 2020, and commercial operation by July 1st. It is wholly owned by MW&L, and once it is in operation, it will provide 3,500 MWH of energy. As a load reducer, it will also reduce MW&L's capacity requirements transmission costs.

7. McNeil

VPPSA is a joint owner of McNeil, a 54 MW wood-fired generator in Burlington, VT. MW&L is entitled to a 2.644% share of both the costs and output of the facility. McNeil is forecast to be available throughout the forecast period. Finally, McNeil is qualified under a number of state Renewable Portfolio Standards, and its renewable energy credits are sold to reduce MW&L's cost of service.

8. Morrisville #2 Hydro

MW&L's third hydroelectric facility is the Morrisville #2 Hydro, which is located on the Lamoille River in Morrisville upstream of Cady's Falls. Originally constructed in 1924, today it consists of two turbines that, in total, are rated at 1.8 MW. It operates in a run-of-river mode.

9. New York Power Authority (NYPA) – Niagara

NYPA provides power to utilities in Vermont under two contracts: Niagara and St. Lawrence. MW&L's share of the Niagara facility is 287 kW. While the current contract ends on September 1, 2025, we assume that it is renewed through 2039. The energy qualifies as a Vermont RES Tier 1 resource, but does not generate marketable RECs.

10. New York Power Authority (NYPA) – St. Lawrence

MW&L's share of the St. Lawrence facility is 19 kW. The contract ends on April 30, 2032, but we assume that it is renewed through the rest of the forecast period.

11. NextEra 2018-2022

MW&L has a PPA with VPPSA to purchase firm, fixed price energy from NextEra, which provides energy from Seabrook Station, a nuclear facility in Seabrook, New Hampshire. MW&L has an 3.4% (578 kW) share of the on-peak energy and a 3.2% (384 kW) share of the off-peak energy, which expires on December 31, 2022. This resource does not produce marketable RECs, but it is tracked separately due to its carbon-free emission profile.

12. Project 10

MW&L 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. MW&L's share of Project 10's is 9.0%, and we assume that Project 10 is available throughout the forecast period.

13. Public Utilities Commission (PUC) Rule 4.100

MW&L is required to purchase power from small power producers through Vermont Electric Power Producers, Inc. (VEPP Inc.), in accordance with PUC Rule 4.100. MW&L's share of VEPPI power in 2018 was 0.81%, 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, which is consistent with recent changes to Rule 4.100 that returned PURPA purchasing obligations to the host utility.

14. Public Utilities Commission (PUC) Rule 4.300

MW&L 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 defined as load-reducers, are not settled in the wholesale markets, and result in lower reported loads. MW&L's share of Standard Offer power in 2018 was 0.88%.

15. Ryegate Facility

MW&L receives power from the Ryegate biomass facility, a 20.5 MW generator in East Ryegate, Vermont. In 2018 MW&L received 0.867% of the energy from the plant. Under Vermont statutes, Ryegate is the only plant eligible to meet 30 V.S.A. § 8009, and we have assumed that the current contract is renewed through 2039. Currently MW&L is entitled to a portion of the RECs produced by the facility.

16. Seabrook Station

VPPSA entered into a long-term PPA with NextEra Energy Resources for energy, capacity, and associated carbon-free emissions attributes from the Seabrook Nuclear power plant in Seabrook, NH. The 20-year contract began in 2014 and expires on December 31st, 2034. It includes varying amounts of energy and capacity over the life of the contract, and employs a known price-escalating mechanism. As a result, it provides baseload energy at predictable prices, helping to reduce exposure to market volatility. MW&Ls entitlement to the PPA is 50% (0.3 MW).

17. Stonybrook Station

MW&L purchases 0.352% of the power from the Massachusetts Municipal Wholesale Electric Company's ("MMWEC") 352 MW Stony Brook Intermediate Project. The facility is located in Ludlow, Massachusetts and operates on natural gas or fuel oil.

18. Market Contracts

MW&L 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 designed to balance MW&L's supply resources with its load obligations in ISO New England's markets.

Table 11 summarizes MW&L's resources based on a series of important attributes. First the megawatt hours (MWH) and megawatts (MW) 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.

Hydro Relicensing

MW&L is near the end of the relicensing process for Cady's Falls, Morrisville #2, and HK Sanders. All three units are being permitted jointly under the same application and will be subject to additional requirements under the new permit. A three-part impact on the IRP is expected.

1. First, we expect that HK Sanders will be retired for the purpose of electrical generation on 1/1/2021. The dam itself is expected to remain to support the Green River Reservoir and State Park.

2. Second, the capacity factors for Cady's Falls and Morrisville are expected to drop under the new permit. We assume that this impact starts on 1/1/2025, and that:
    - Cady's Falls drops from 32% to 24%, and
    - Morrisville #2 drops from 30% to 23%.

3. Third, we anticipate that Cady's Falls and Morrisville #2 may qualify for Low Impact Hydro Institute (LIHI) certification on 1/1/25, which could qualify the units for Massachusetts Class II Renewable Energy Credits.

[4] Note that RECs are defined 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.

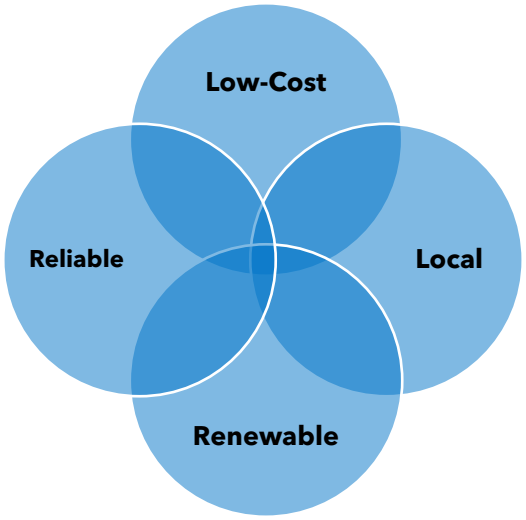
Table 11: Existing Power Supply Resources

Resource	2020 MWH	% of MWH	2020 MW	Delivery Pattern	Price Pattern	REC	Expiration Date	Renewal to 2039
1. Cady's Falls Hydro	3,609	7.3%		Intermittent	Fixed	✓	Life of unit	Yes
2. Fitchburg Landfill	5,282	10.6%	0.524	Firm	Fixed	✓	2031	No
3. HK Sanders Hydro	983	2.0%		Intermittent	Fixed	✓	Life of unit	Yes
4. Hydro Quebec US (HQUS)	2,383	4.8%		Firm	Indexed	✓	10/31/38	No
5. Kruger Hydro	4,744	9.5%	0.295	Intermittent	Fixed		12/31/37	No
6. Lawrence Brook Solar	1,770	3.6%		Intermittent	Fixed	✓	Life of unit	Yes
7. McNeil	7,036	14.1%	1.322	Dispatchable	Variable	✓	Life of unit	Yes
8. Morrisville #2 Hydro	4,751	9.5%		Intermittent	Fixed	✓	Life of unit	Yes
9. NextEra 2018-22	4,171	8.4%		Firm, Shaped	Fixed	✓	12/31/22	Yes
10. NYPA Niagara	3,604	7.2%	0.511	Baseload	Fixed	✓	04/30/32	Yes
11. NYPA St. Lawrence	99	0.2%	0.014	Firm	Fixed	✓	12/31/22	No
12. Project 10	53	0.1%	3.479	Dispatchable	Variable		Life of unit.	Yes
13. PUC Rule 4.100	232	0.5%	0.028	Intermittent	Fixed		2020	No
14. PUC Rule 4.300	1,127	2.3%	0.011	Intermittent	Fixed	✓	Varies	No
15. Ryegate Facility	1,439	2.9%	0.165	Baseload	Fixed	✓	10/31/21	Yes
16. Seabrook Station	2,419	4.9%	0.300	Baseload	Fixed	✓	12/31/34	No
17. Stonybrook Station	253	0.5%	1.246	Dispatchable	Variable		Life of unit	Yes
18. Market Contracts	5,822	11.7%		Firm, Shaped	Fixed		< 5 years.	N/A
Total MWH	**49,776**	**100.0%**	**7.90**					

Future Resources

MW&L 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 5: Resource Criteria



- ✓ **Low-Cost** resources reduce and stabilize electric rates.
- ✓ **Local** resources are located within the Lamoille County 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 MW&L to focus on a subset of generation technologies, and to exclude coal, geothermal and solar thermal generation which do not meet them. Resources that MW&L may consider fall into three categories: 1.) Existing resources in Table 11, 2.) Demand-side resources, and 3.) New resources.

Category 1: Extensions of Existing Resources

This plan assumes that three existing resources are extended past their current expiration date. These include NYPA, Project 10, and Ryegate. The most crucial of these is Project 10, which supplies over 95% of MW&L's capacity. 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, MW&L 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 MW&L's 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, MW&L will continue to welcome the work of the Efficiency Vermont (EVT) in its service territory. MW&L 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 MW&L 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, MW&L 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, MW&L 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, MW&L 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 continues 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 MW&L will continue to investigate solar developments both within its service territory and outside of it.

3.31 Net Metering

While net metering participation rates are presently modest and are forecast to grow modestly, MW&L 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[5]. 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

[5] 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

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.

3.5 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[6], 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 MW&L 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, MW&L 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.

[6] 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 Lamoille County Planning Commission (LCPC), MW&L is part of a Regional Energy Plan[7] that was amended in 2018. According to the Plan, the

"Lamoille County's Energy Plan is guided by two broad state energy goals. These goals - set for year 2050 – are to decrease the overall energy consumption in Vermont by 33% and transition the state's energy use from 75% non-renewable to 90% renewable. Meeting these energy goals will set the state on a path to meet its greenhouse gas emission reduction targets."[8]

The full plan is included in the appendix, and all future resource decisions will be made with this plan in mind. Specifically, MW&L will consult with the LCPC on resource decisions that involve potential siting of new resource in Vermont.

[7] The full plan can be found at https://www.lcpcvt.org/?SEC=77A0A7C5-D81B-4DAB-AC09-D59CA8D9A347.

[8] 2015-2023 Lamoille County Regional Plan, Section 3: Where We Live, LCRP 2018, Page 93

Resource Plan

III. Resource Plans

Decision Framework

MW&L 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 MW&L's retail cost of service per kWh over time. (i.e the effect on the rate trajectory)

When evaluating significant decisions, MW&L 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. MW&L 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.

Major Decisions

As the following sections will explain, MW&L faces a series of potential risks and accompanying resource decisions that can prudently fulfill its energy, capacity and RES obligations in the coming years. These include:

1. Energy and RECs

    a. **Contract Expirations:** The expiration of the NextEra contract on 12/31/2022 only represents about 8% of MW&L's energy supply, but 18 months later, other market-based contracts will also expire. These contracts represent an additional 12% of MW&L's supply. As a result, 20% of MW&L's energy supply will expire by 6/30/2024. These events represent the first major decision point in the IRP.

    b. **Contract Extension:** One way to manage the contract expirations is to extend the existing contract with NextEra, and continue to hedge the remaining energy market exposure with market contracts. This approach is modeled in the financial analysis.

    c. **Large Hydro Resource:** Because large hydro resources are dispatchable, they could hedge MW&L's energy requirements as effectively as a market contract. A large hydro resource could also supply Tier I RECs, which would be particularly attractive if Cady's and Morrisville #2 become LIHI certified, and start selling RECs from these resources to reduce rates. As a result, this approach is modeled in the financial analysis.

2. Owned Hydros

    As described in the Hydro Relicensing section, this IRP assumes that HK Sanders is retired for energy production purposes on 1/1/21, and the capacity factors for Cady's Falls and Morrisville #2 drop by 1/1/25. These events are built into the reference case of the IRP's financial analysis. In this context, the remaining decision with respect to the owned hydros is whether to seek LIHI certification for Cady's Falls and Morrisville #2, and this decision is modeled in the financial analysis.

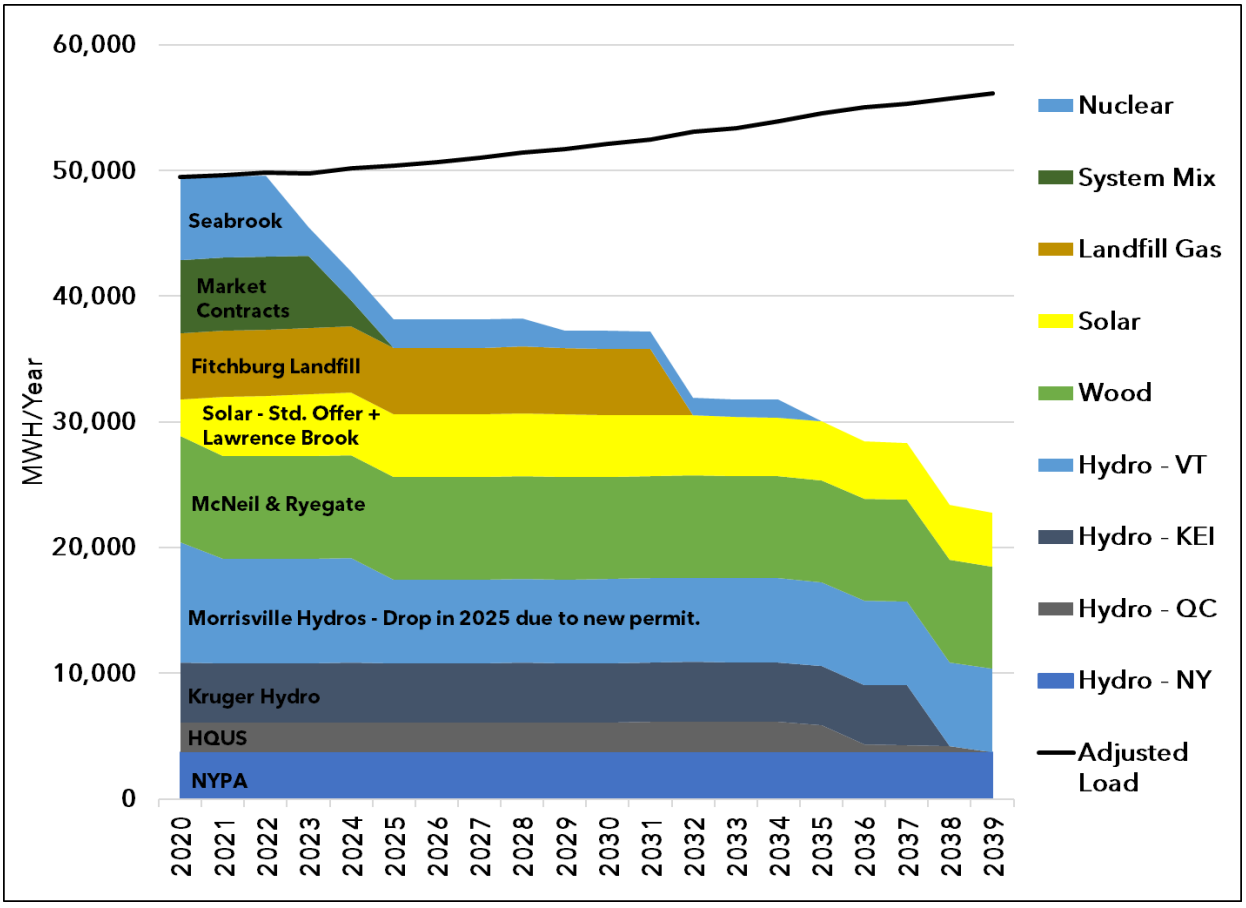
Energy Resource Plan

Figure 6 compares MW&L's energy supply resources to its adjusted load. There are two major resource decisions that, in total, will affect about 20% of MW&L's energy supply between 2020 and 2024. The first is the expiration of the NextEra contract on 12/31/2022, which represents about 8% of MW&L's energy supply. The second is the expiration of the current market contracts on 6/30/2024, which represent about 12% of MW&L's energy supply.

Leading options to replace these two contracts include:

- NextEra: Renegotiate the NextEra contract and extend its term,
- Existing Hydro: Sign a PPA for an existing, dispatchable hydro plant to provide energy and Tier I RECs, and
- Market Contracts: Sign a PPA for market energy supplies.

Figure 6: Energy Supply & Demand by Fuel Type



The impact of these two resource expirations on the portfolio is summarized in Table 12. Because the price of the NextEra contract is presently above the market price forecast, its expiration could potentially reduce rate pressure. It will have no impact on RES compliance, but because it includes emissions free nuclear attributes, it will increase MW&L's emissions rate if it is not replaced with another emissions free resource. The impact of the market

contracts' expiration is not expected to impact rates because they are priced very close to today's market price forecast.

Table 12: Energy Resource Decision Summary

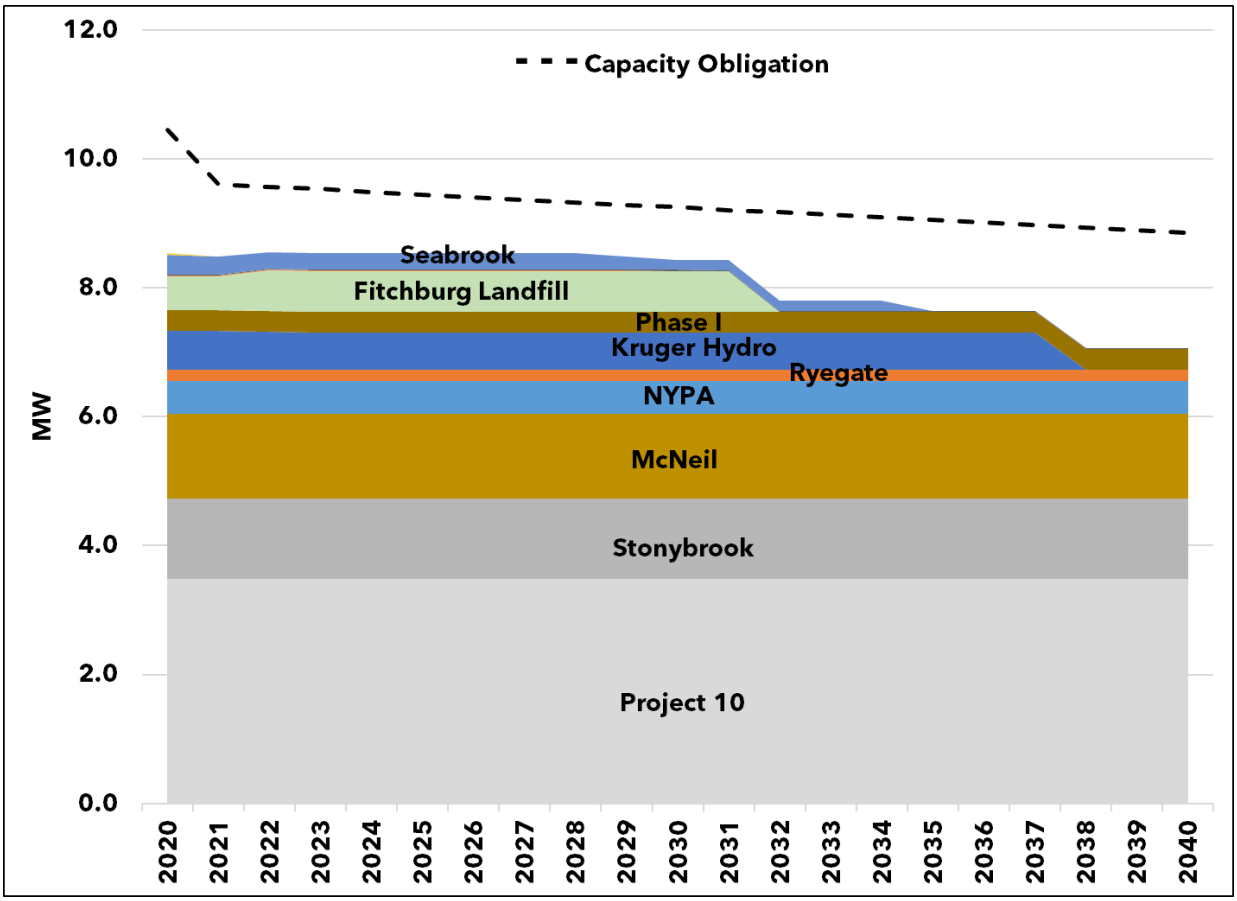
Resource	Years Impacted	% of MWH	Rate Impact	RES Impact
1. NextEra 2018-2022	2023+	8%	Beneficial	None
2. Market Contracts	2024+	12%	Neutral	None

Finally, we anticipate that MW&L will have an opportunity to reduce its power supply costs by seeking LIHI certification for Cady's Falls and Morrisville #2 when they come into compliance with their new Water Quality Certificate on 1/1/25. This was anticipated in the Hydro Relicensing section of the Electricity Supply chapter and is reiterated here because it is one of the decisions that is modeled in the Financial Analysis chapter.

Capacity Resource Plan

Figure 7 compares MW&L's capacity supply to its demand. Project 10 provides practically all of MW&L's capacity, with minor contributions from NYPA, Ryegate and the PUC 4.300 program.

Figure 7: Capacity Supply & Demand (Summer MW)



The gap between supply and demand is attributable to the intermittency of MW&L's behind-the-meter hydro units, Cady's Falls, Morrisville #2 and HK Sanders. These resources did not produce at the annual coincident peak in 2019, and MW&L's peak load was higher than expected as a result. In years when these resources are generating at the coincident peak hour, the load with ISO will drop, and this will close most of the gap through 2030. As a result, no capacity resource decisions are necessary.

As the largest part of the capacity supply, the reliability of Project 10 is the primary concern for MW&L. As a result, maintaining the reliability of Project 10 will be the key to minimizing MW&L's capacity costs, as explained in the next section.

ISO New England's Pay for Performance Program

Because MW&L 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 is not available, MW&L 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.

The following table illustrates the range of performance payments that MW&L's 9% 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, MW&L could receive up to a $1,200 payment or pay up to a $1,400 penalty during a one-hour scarcity event. This represents a range of plus or minus 2% of MW&L's monthly capacity budget. However, such events are not expected to occur more than a few times a year (if at all), and 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	-$600	$300	$1,200
15,000	$2,000/MWH	-$900	$100	$1,000
20,000	$2,000/MWH	-$1,100	-$200	$700
25,000	$2,000/MWH	-$1,400	-$500	$500

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

[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

MW&L's obligations under the Renewable Energy Standard[11] (RES) are shown in Table 14. Under RES, MW&L 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 10% in 2032. Note that this IRP assumes that these requirements are maintained at their 2032 levels throughout the rest of the study period.

Table 14: RES Requirements (% of Retail Sales)

Year	Tier I (A)	Tier II (B)	Net Tier I (A) - (B)	Tier III
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%	10.67%

Under RES, Tier II is a subset of Tier I. 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 2nd and 3rd year until the Tier I requirement increases. When these percentages are multiplied by the forecast of retail sales, the result is a seesaw effect where the Net Tier I requirement declines every 2nd and 3rd year. This 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 & 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 ten-years of the CCHP's expected useful life accrue to the 2020 Tier III requirement.

[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.

Table 15: Alternative Compliance Payment[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

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, II or 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).

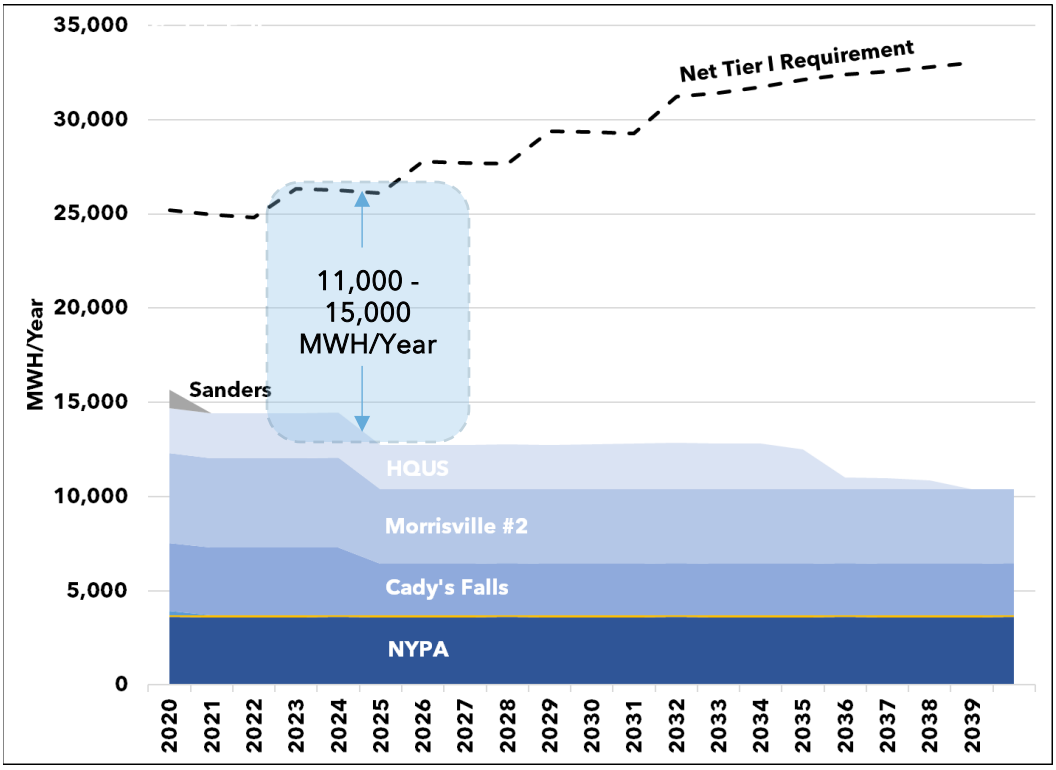
Finally, utilities with a RES deficit may also petition the Public Utilities Commission (PUC) for relief from the ACP. Alternatively, utilities may petition PUC to roll the deficit into subsequent compliance years. As a result, there are multiple ways to comply with RES requirements.

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

Tier I - Total Renewable Energy Plan

Between 2020 and 2024, MW&L's Net Tier I requirement is about 25,000 MWH per year. The resources that contributes to meeting it are shown in Figure 8. These resources represent about 14,000 MWH per year or 60% of MW&L's Net Tier I requirement. Through 2024, the Net Tier I deficit is about 11,000 MWH per year, but it rises to about 15,000 MWH per year after 2025 when Cady's Falls and Morrisville #2 come into compliance with their new water quality certification.

Figure 8: Tier I - Demand & Supply (MWH)



In the early years of the 2020s, MW&L 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 $1.5/MWH, the cost of complying with Net Tier I in the 2020 to 2024 period would be about $18,000 per year.

As mentioned in the Energy Resource Plan, the expiration of the NextEra 2018-2022 and Market PPAs creates an opportunity to purchase a resource that provides both energy and RECs. The 13,000 MWH per year deficit is equivalent to a 4 MW hydro facility[15], and if the output from a hydro resource of this size and capacity factor was purchased (including RECs),

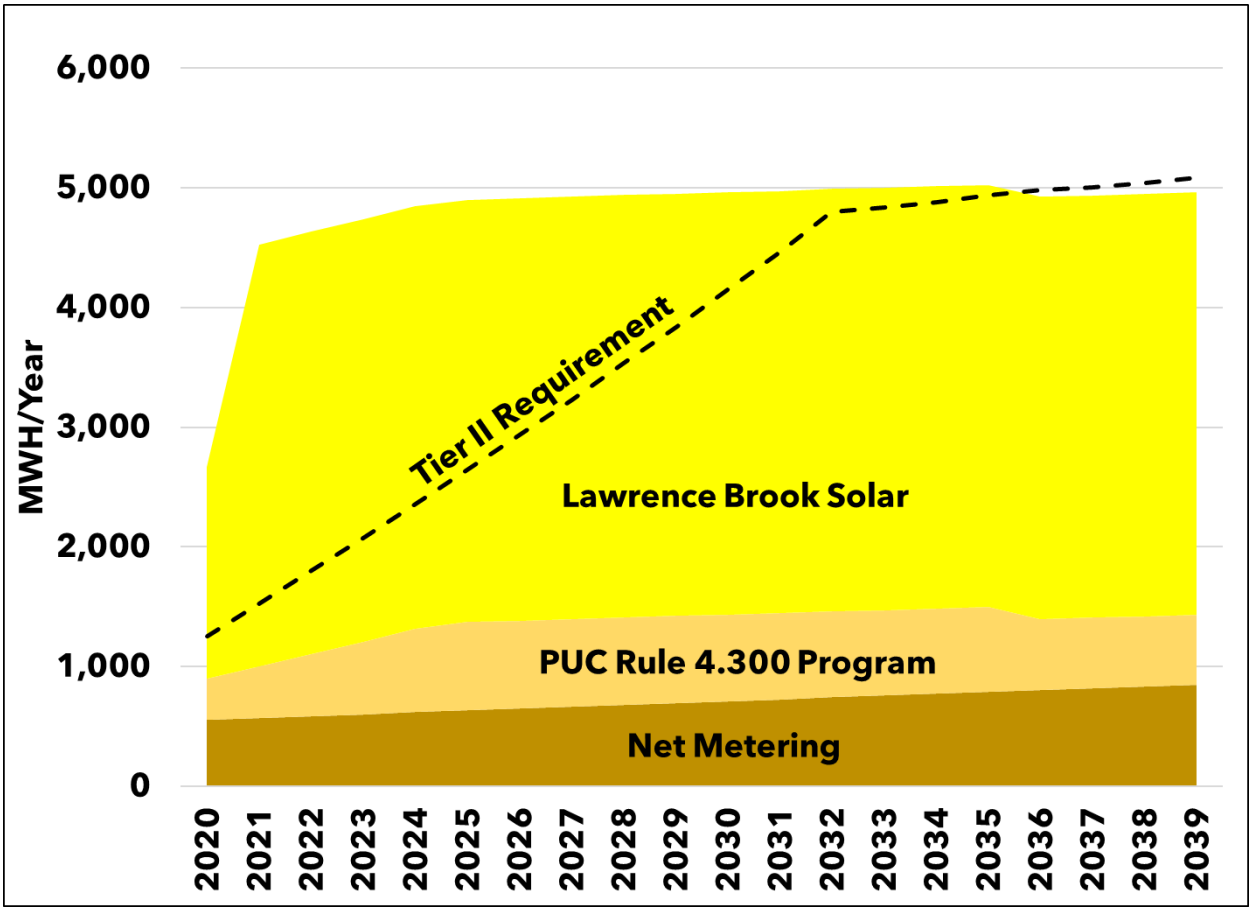
[15] We have assumed a 40% capacity factor, which results in roughly 13,000 MWH per year.

the Net Tier I deficit between 2020 and 2024 would be erased. This resource choice is one of the major resource decisions that is analyzed in this IRP.

Tier II - Distributed Renewable Energy Plan

The dashed line in Figure 9 shows MW&L's Distributed Renewable Energy[16] (Tier II) requirement, which rises steadily from 1,200 MWH in 2020 to 4,800 MWH in 2032. MW&L's supply exceeds the demand thanks to the Lawrence Brook solar, net metering program and the standard offer (PUC Rule 4.300) program. In the short-term, the excess MWH will be used to fulfill part of the Tier III requirement as shown in the following section. In the long-term, the supply is expected to about equal to the demand for Tier II. As a result, no additional Tier II resources are anticipated in this IRP.

Figure 9: Tier II – Demand & Supply (MWH)

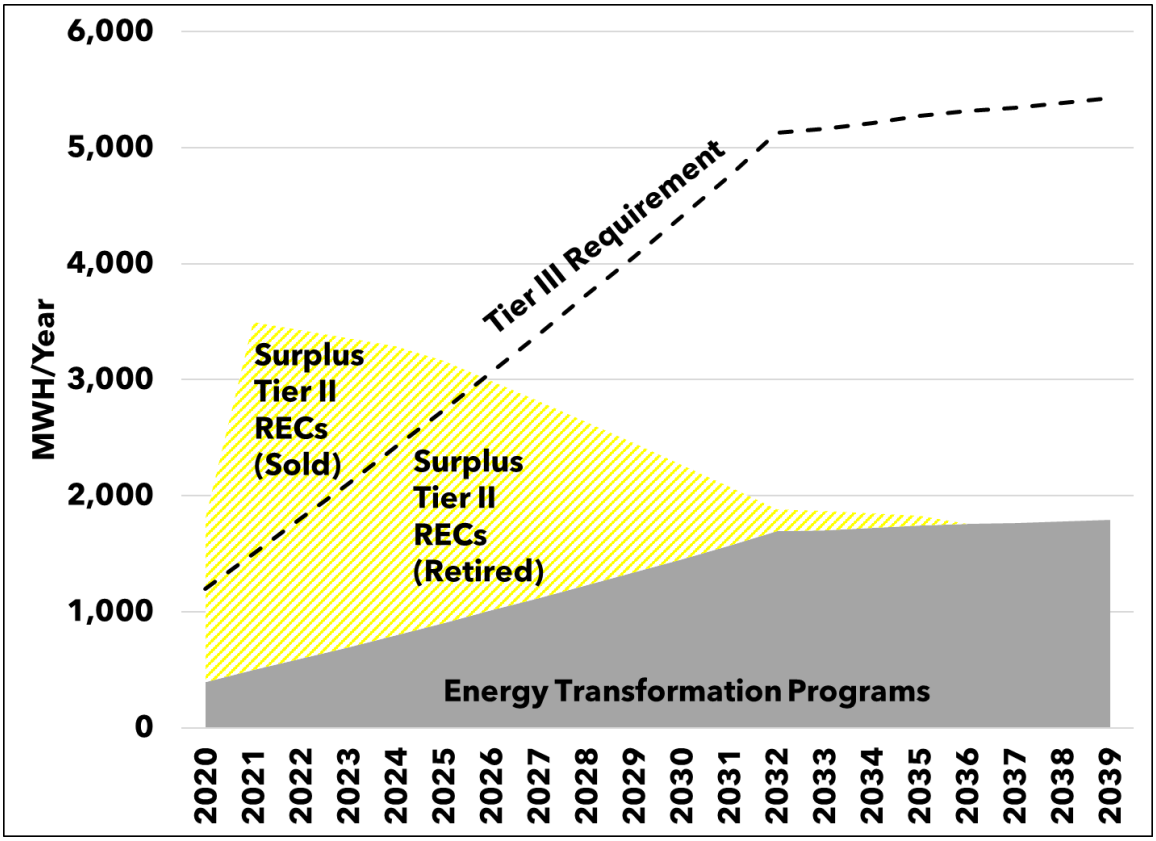


[16] The TIER II requirement is also known as "Tier 2".

Tier III - Energy Transformation Plan

The dashed line in Figure 10 shows MW&L's Tier III requirements, which rise from about 1,200 MWH in 2020 to about 5,100 MWH in 2032. Energy Transformation programs are presently budgeted to fulfill about a third of the requirement in the early 2020s,and are shown in the gray-shaded area of Figure 10. These programs[17] cover a range of qualifying technologies including EVs, CCHPs, and HPWHs. For perspective, the Tier III requirement is equivalent to installing 80-180 CCHP[18] per year between 2020 and 2025.

Figure 10: Energy Transformation Supplies



In the early and mid 2020s, MW&L is expected to have a substantial surplus[19] which is illustrated in Figure 10. This is a result of the Lawrence Brook project. After 2026, the surplus turns to a deficit, and by 2032, the deficit is large enough to call for the construction of

[17] More detail on these programs can be found in Appendix B (VPPSA's 2019 Tier 3 Annual Plan) and on VPPSA's website.

[18] This estimate is based on 15 MWH/CCHP of net lifetime savings, which is an average of all listed single-zone CCHP measures in the 'Act 56 Tier III Planning Tool FINAL PY2019.xls' spreadsheet.

[19] Figure 10 assumes that no banking occurs and that the surplus is simply sold in the year that is occurs.

another 1-2 MW of solar. Alternatively, the deficit could be fulfilled by a custom Tier III project.

Whatever the deficit or surplus position, MW&L will follow a four-part strategy to fulfill its Tier III requirements.

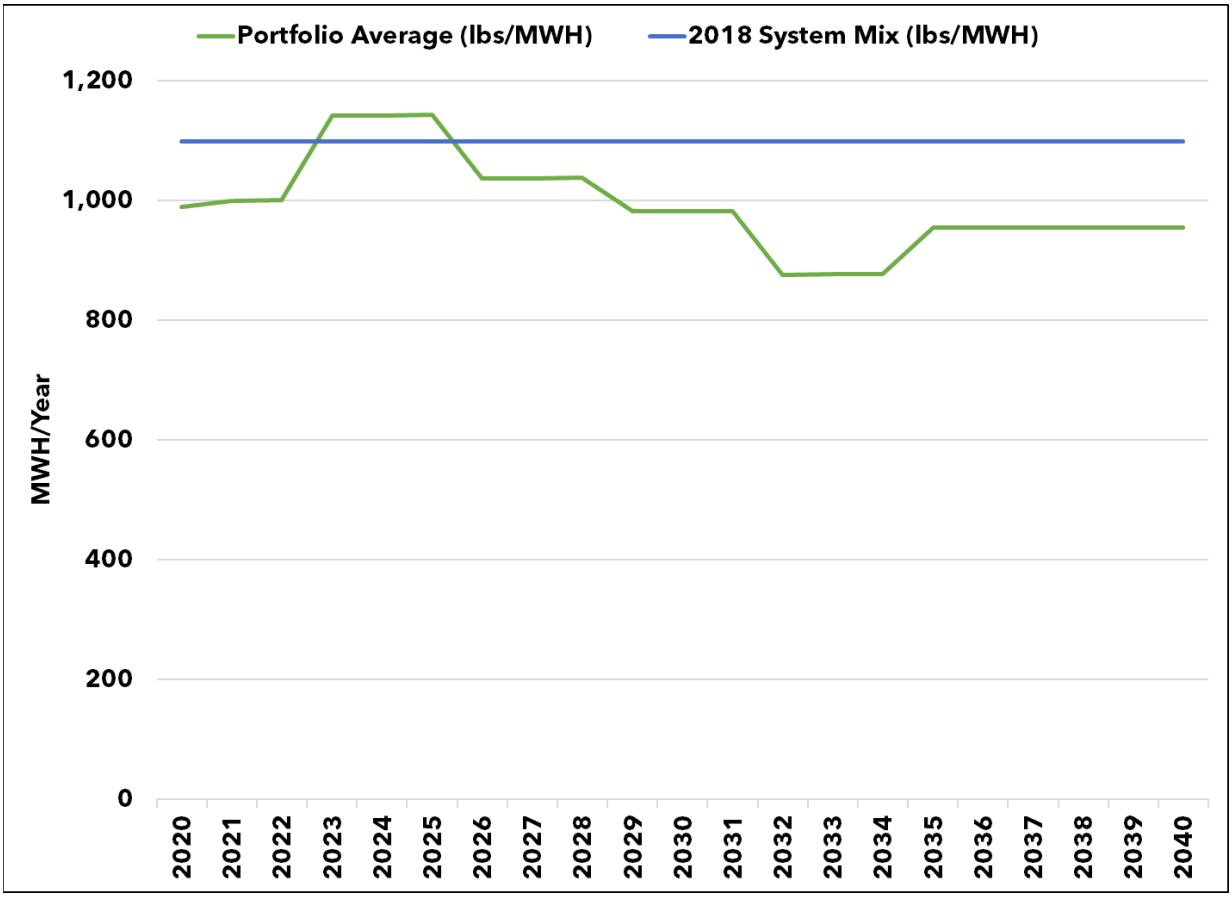
1. Identify and deliver *prescriptive* Energy Transformation ("Base Program") programs, and/or
2. Identify and deliver *custom* Energy Transformation ("Custom Program") programs, and/or
3. Develop and complete the Lawrence Brook Solar or a comparable, Vermont-based solar project, and/or
4. Purchase a surplus of Tier II qualifying renewable energy credits.

Carbon Emissions and Costs

Figure 11 shows an estimate of MW&L's carbon emissions rate compared to the 2018 system average emissions rate in the New England region[20]. The emissions rate between 2020 and 2022 is about 1,000 lbs/MWH, which is slightly below the 2018 system mix. The emissions level rises to a level that is slightly above the 2018 system mix in 2023. This is due to the expiration of the NextEra 2018-2022 contract, whose MWHs are being replaced 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.[21]

The carbon emissions rate declines until 2032 as the RES requirements increase. However, note that in 2034, the Seabrook PPA expires, which causes the emissions rate to increase slightly in 2035.

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



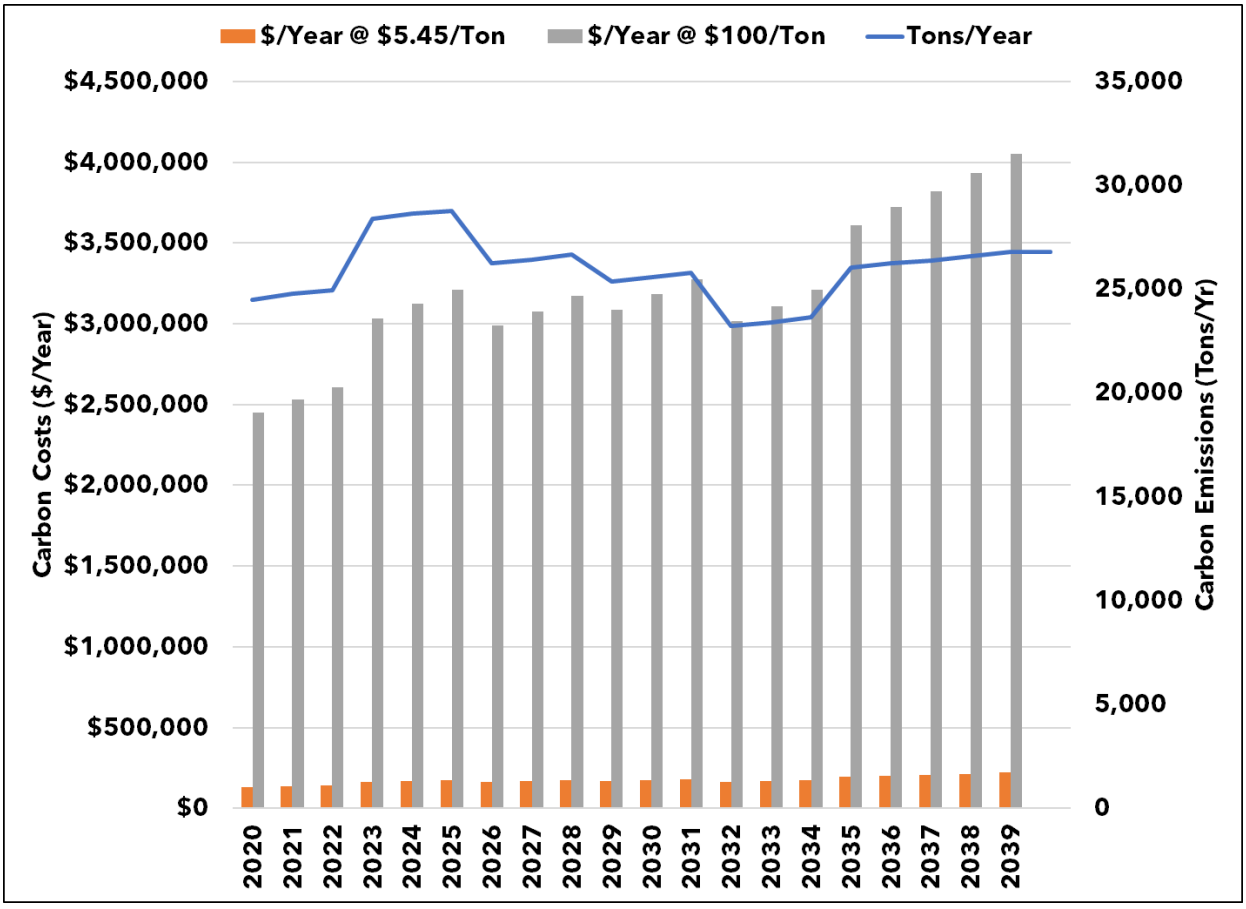
[20] The source of this data is the NEPOOL GIS. https://www1.nepoolgis.com/

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

These emissions rates were multiplied by the Adjusted Load Forecast from Section I. Electricity Demand to arrive at an estimate of carbon emissions in tons per year. The following figure shows that carbon emissions range from 25,000 tons/year in 2020 up to 29,000 tons/year in 2025, and then decline as the RES requirement increase through 2032.

The costs of these emissions were calculated using two sources, the 2019 Regional Greenhouse Initiative Auction[22] (RGGI) results ($5.45/ton) and the 2018 Avoided Cost of Energy Supply[23] (AESC) study ($100/ton). Using RGGI prices (plus inflation), the cost of carbon emissions in 2020 is $133,000/year and about $164,000/year in 2032. Using AESC prices, the range is $2.4 million per year in 2023 up to almost $4.0 million per year in 2032.

Figure 12: Carbon Emissions (Tons/Year) and Costs ($)



[22] https://www.rggi.org/auctions/auction-results/prices-volumes

[23] https://www.synapse-energy.com/sites/default/files/AESC-2018-17-080.pdf

Conclusions

There are three decisions facing MW&L that the financial analysis will quantify.

1. Extension of the NextEra PPA
   Q1: What are the costs and benefits of extending NextEra volumes through 2039?

2. New Long-Term Hydro PPA
   Q2: What are the costs and benefits of a dispatchable hydro PPA that includes both energy and Tier I RECs starting on 1/1/2025?

3. Low Impact Hydro Institute Certification for Cady's Falls and Morrisville #2
   Q3: What are the costs and benefits of getting LIHI certification effective 1/1/25?

In addition, we quantify one load-related question.

4. 1% CAGR

   Q4: What is the rate impact of 1% compound annual load growth?

Transmission & Distribution

IV. Electricity Transmission & Distribution

Transmission and Distribution System Description:

Detail regarding MW&L transmission supply, sub-transmission and distribution facilities is provided below.

Transmission System Description:

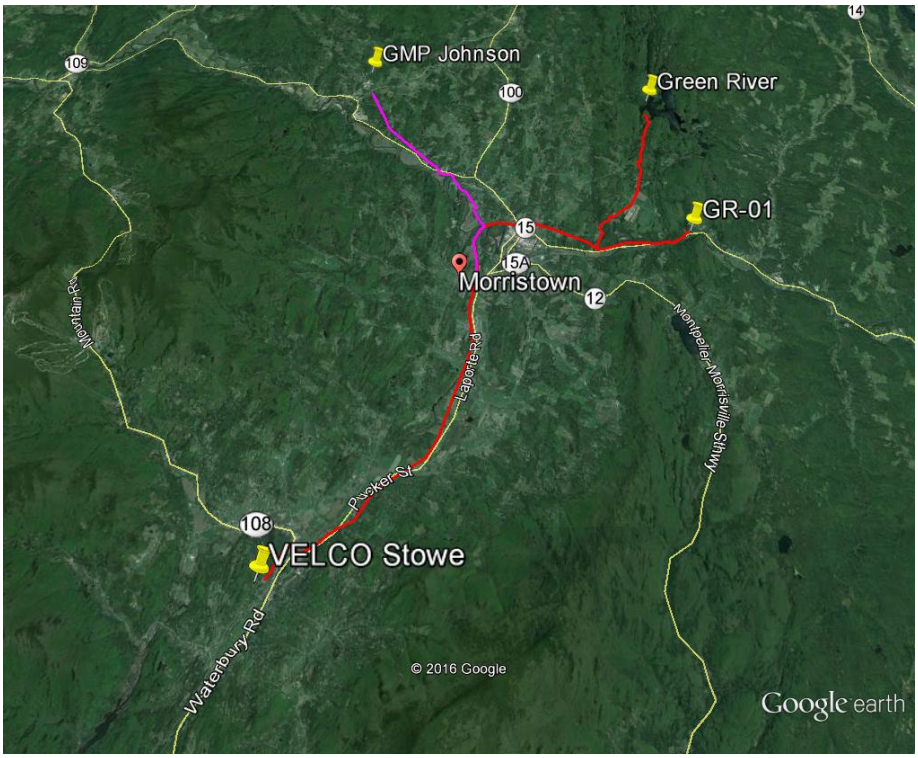
MW&L does not directly own any bulk transmission facilities. MW&L relies on VELCO for power deliveries over the state's bulk transmission facilities. MW&L has a direct connection to VELCO in Stowe and has indirect connections to VELCO through Green Mountain Power's 34.5 kV sub-transmission system at substations in Johnson and Marshfield supported by 115 to 34.5 kV interconnections at VELCO's East Fairfax, Irasburg, Middlesex, Berlin and Barre substations.

VELCO constructed a bulk transmission line extension from Middlesex to Stowe in 2009. In addition, VELCO constructed a 115 kV to 34.5 kV ring bus substation. MW&L connects to one section of the ring bus.

Sub-Transmission System Description:

MW&L also owns the 34.5 kV transmission facilities within its own service territory. The MW&L transmission system includes 33 miles of 34.5 kV line, interconnected to 1) GMP in Johnson, 2) VELCO in Stowe and 3) Hardwick in Wolcott (eventually GMP in Marshfield) as shown in the figure below.

Figure 13: MW&L Sub-transmission System Map



These three sources collectively provide MW&L with reliable deliveries of power for distribution to its customers.

The majority of the 34.5 kV lines are built with 336.4 MCM ACSR. The significant exceptions to this are the Cady's Falls to Johnson section of the B22, which is built with 626 MCM Hendrix spacer cable, the line from Substation #6 to Substation #7, which is built with 336 Hendrix spacer cable and a 1.5 mile section of the 3319 line from Sub. #3 to the Cady's Falls Plant which is built with 3/0 ACSR. Taps to Substation #2 is built with 1/0 AAAC.

These Facilities play an integral role in connecting the GMP system between Waterbury and Marshfield to the GMP system crossing the state from Fairfax to Irasburg. Changes to the MW&L transmission system affect GMP, VELCO, Stowe, Hardwick, Hyde Park, Johnson, Washington Electric Cooperative, Vermont Electric Cooperative and could have effects statewide under certain configurations of the bulk transmission system. Conversely, because MW&L's system is so tightly intertwined with its neighbors, it is very sensitive to any voltage swings or outages on those surrounding networks.

One item of interest is that MW&L's B22 line loading is showing significant flows from Johnson to MW&L after the Stowe VELCO Substation was put in service. MW&L was expecting to see flows from Stowe VELCO Substation to MW&L. That the opposite is occurring is attributable to large wind farms in the northern part of the State. The flows are increasing energy line losses for MW&L beyond what was expected when planning studies

were completed for the Stowe VELCO Substation. The increased loss situation could be alleviated if the B22 breaker was operated normally opened at GMP's substation in Johnson. However, analysis done by VELCO recommends keeping the B22 line operated in the normally closed position for system reliability purposes. MW&L continues to pursue a solution to the issue of increased power flows across its system.

Distribution System Description:

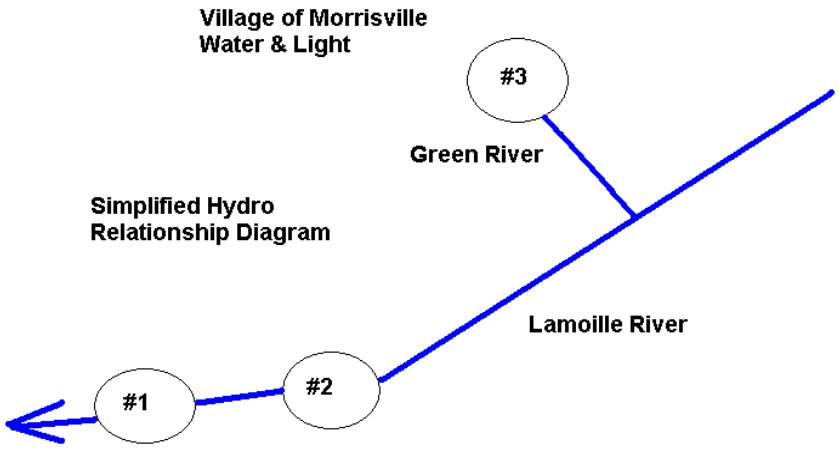
The distribution system includes 180 miles of line operating at 12.5 kV. A Distribution Study conducted by Economic and Engineering Associates in 1997 evaluated the long-term system performance and recommended conversion of the entire MW&L system to 12.5 kV. The conversion to 12.5 kV served three primary objectives. First, energy line losses are reduced. Secondly, it provides the opportunity to maximize feeder backup capabilities. Finally, it improves overall service quality for our customers. MW&L initiated the conversion work in the early 2000s and completed the voltage conversion effort in 2018.

MW&L-Owned Internal Generation:

MW&L owns and operates three generating stations known as Cady's Falls (Plant #1), Morrisville (Plant #2), and Green River (Sanders) (Plant #3). All three of MW&L's generating stations are hydroelectric plants with two turbine/generator units per plant. In total, these plants have a rated capacity of approximately 4.9 MW, produce an annual average of around 9,500,000 kWhs, and meet approximately 19% of MW&L's total power requirements.

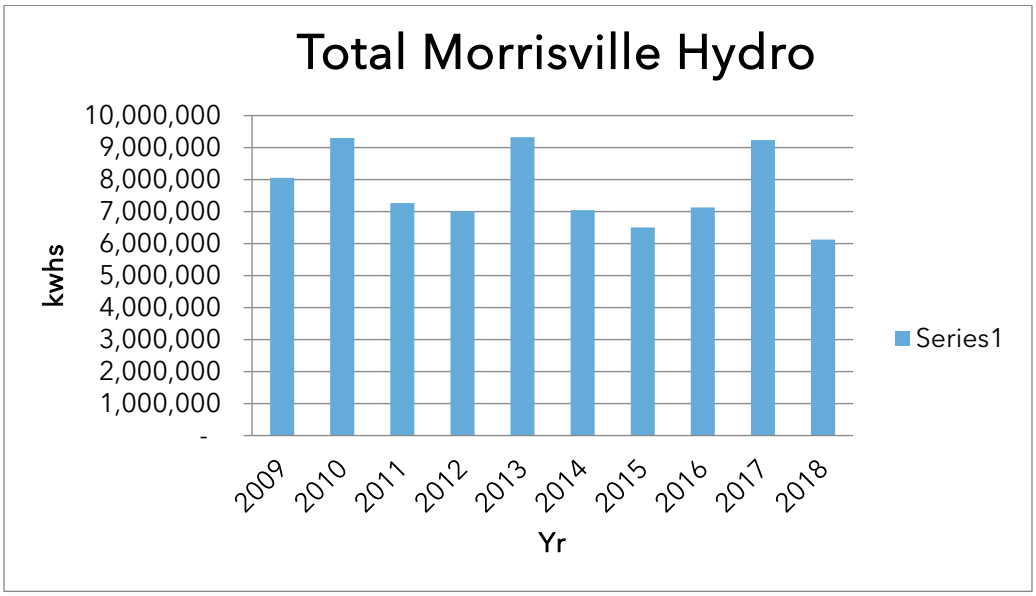
Two of the hydro plants are located on the Lamoille River. One is located on the Green River, a tributary that feeds into the Lamoille River. The relative relationship of each plant is shown in the following simplified diagram. In addition, each plant is discussed briefly below.

Figure 14: Simplified Diagram of MW&L Hydro Generation Plants



The following chart summarizes the actual total generation output for the past 10 years (2009-2018).

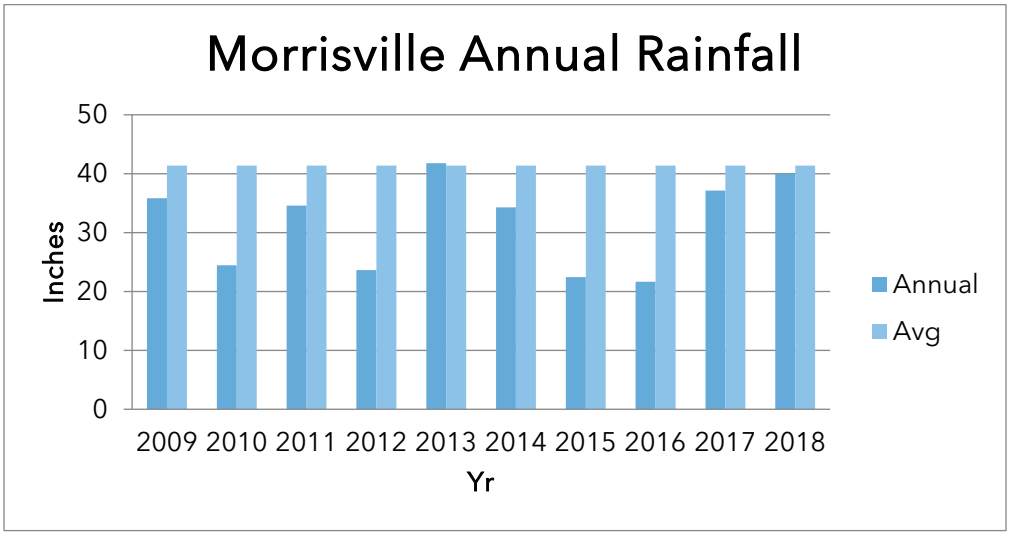
Figure 15: MW&L Historical Hydro Generation



MW&L's annual hydro generation is primarily dependent on the amount of precipitation received. The following chart shows precipitation recorded at the Morrisville/Stowe airport for 2009 through 2018. As can be seen in the chart, precipitation has been below average for

6 of the last 7 years with 3 of the years being significantly below average. Normalizing the hydro generation for the past 10 years yields an average annual generation of approximately 9,500,000 kWhs.

Figure 16: Historical Precipitation in Morrisville, VT



Cady's Falls (Plant #1)

The Cady's Falls Plant is located on the Lamoille River just downstream from the Morrisville Plant.

The Cady's Falls Plant consists of two turbines, an older horizontal unit installed in 1914 and a second, vertical unit installed in 1947. Unit #1 has an output of 600 kW while Unit #2 has an output of 700 kW. The output for both turbines is at 2.4 kV delta and presently connects to the MW&L sub-transmission System at 34.5 kV through a pad mounted transformer originating at Substation #1.

Morrisville Plant (Plant #2)

The Morrisville Plant is located on the Lamoille River just upstream from the Cady's Falls Plant.

The Morrisville Plant #2 consists of two vertical turbines installed in 1924. The units are rated 600 kW and 1,200 kW at 2.4 kV. The output is connected to a 2.4-34.5 kV step-up transformer that is connected to 1.29 miles of MW&L-owned sub-transmission line.

Green River Plant (Plant #3)

The Green River Plant is located on the Green River, a tributary of the Lamoille River and is about 5 miles upstream from the Morrisville and Cady's Falls plants. The Green River Plant structures include a concrete arch dam, an earth dike, a penstock and powerhouse. The plant is difficult to reach and is operated remotely.

The dam has a maximum height of 105 feet and a storage volume of approximately 17,400 acre-feet at spillway crest elevation 1,220 feet.

The Green River Plant consists of two vertical turbines powering two 900kW generators. The output is at 4.16 kV and steps up to 34.5 kV at Substation #7. Substation #7 interconnects to the MW&L transmission system at Substation #6 via a Hendrix spacer cable line.

Lake Elmore

Lake Elmore is included in Morrisville's hydro project boundary since natural outflow from the lake feeds into Elmore Pond Brook which feeds into the Lamoille River above the Morrisville and Cady's Falls hydro plants. MW&L does not impact the natural flow except when requested to do so by the Lake Association for the maintenance of docks on the lake.

Other General Generation Information

Both the Morrisville Plant and Cady's Falls Plant have black start capability. Both of these units operate at bus voltages of 2,300 V.

From an energy perspective, Cady's Falls Plant and Morrisville Plant are considered run-of-the-river though they have some storage capability through ponding and are available year-round. Green River has substantial storage capability, and a high head, but its output is reduced due to draw-down constraints and other factors, including maintaining reservoir levels for the Green River State Park and loon nesting.

MW&L operates its hydro plants under a license from the Federal Energy Regulatory Commission (FERC) which includes Water Quality Certificate conditions from the Vermont Agency of Natural Resources (VT ANR). The current 30-year License expired in April 2015. MW&L filed a new license application to operate its hydro for an additional 30 years in 2013. The VT ANR issued a new Water Quality Certificate (WQC) in 2016. MW&L appealed the WQC conditions to the VT Environmental Court in 2017. A decision from the Environmental Court in 2018 was appealed by the VT ANR to the VT Supreme Court. A decision from the VT Supreme Court was issued in November of 2019, overturning the decision from the Environmental Court. MW&L expects to have a new license issued from FERC in 2020. MW&L continues to operate under the conditions of its existing License. MW&L is evaluating options for the Green River hydro facilities based upon the final WQC conditions imposed. At this time, MW&L is assuming the Green River hydro facilities will be decommissioned in the reference case for this IRP.

MW&L Substations:

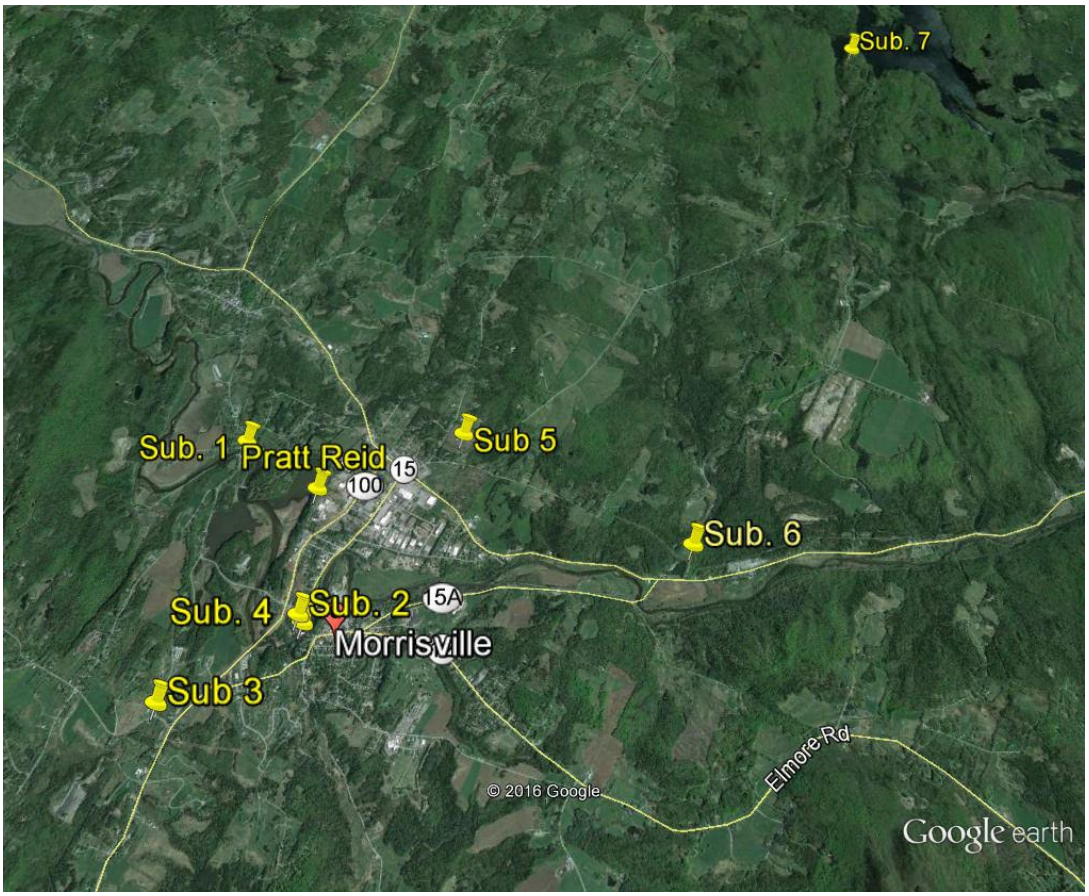
MW&L currently operates the substations shown in the following table. Each substation is briefly described below. All substations are in compliance with the National Electric Safety Code.

Table 16: MW&L Substation Description

Substation Name	Type	Outages 2018
1	Generation (Cady's Falls Hydro)	n/a
2	Generation (Morrisville Hydro)	n/a
3	Distribution Feeder Section 1 Feeder Section 2 Feeder Section 3 Feeder Section 4 Total	 25 24 11 18 78
5	Distribution Feeder 1 Feeder 2 Feeder 3 Feeder 4 Total	 9 32 26 33 100
6	Switching	n/a
7	Generation (Green River Hydro)	n/a
Johnson 1	Distribution	3
Johnson 2	Distribution	3
Johnson 3	Distribution	2
Pratt-Reid	Distribution	n/a

Figure 17: MW&L Substation Location Map

The approximate location of MW&L's major substation facilities are shown in the map below.



Substation #1:

Substation #1 is the step-up substation for Plant #1. It consists of a 2,000 kVA 2.4-34.5 kV padmount transformer. This transformer connects to the B22 line via switch 345PL1 at 34.5 kV. The padmount transformer and switch pole are shown below.

Figure 18: MW&L's Substation #1

Substation #2:

Substation #2 is set up similar to Substation #1. MW&L installed a 2.4 kV to 34.5 kV 2,500 kVA pad mount transformer to connect generation to the sub-transmission facilities. Substation #2 no longer serves distribution customers. Presently Plant #2 generates at 2.4 kV, which is stepped up to 12 kV via 3-833 kVA transformers. Power at 12 kV is delivered to a 12 kV to 34.5 kV step-up transformerconnected to 1.29 miles of MW&L owned sub-transmission line. MW&L generation is connected to the Northern Loop and B22 bus at MW&L Substation #3. The work in Substation #2 to eliminate all equipment except a pad mount transformer was completed in 2017.

Figure 19: MW&L's Substation #2

Substation #3:

Substation #3 serves approximately 1,300 customers in the MW&L system. It consists of a 34.5 kV bus with four 34.5 kV circuits and a 2,500 kVA transformer with one three phase 12.5 kV distribution circuit. The distribution circuit serves the southern sections of the MW&L service territory with a main line that is underbuilt on the 3329 34.5 kV line. There are no problems anticipated on this circuit for the foreseeable future. An increase in the transformer capacity is recommended so the entire system load from Substations #5 and #3 can be carried from either substation. MW&L filed for and received a permit to increase the transformer size to 7,500 kva in 2019. The new transformer will be installed in 2020. The distribution breaker s-22 is a Cooper Nova 15 with a Form 5 control panel. MW&L has wireless communication with the distribution breaker, which allows remote operation and alarm notification. Transmission breakers have fault location and fiber connected communications for data monitoring only.

Figure 20: MW&L's Substation #3

Substation #5:

Substation #5 consists of a 7.5 MVA, 34.5-12.5 kV transformer. Three 12.5 kV circuits supply the MW&L customers in the Garfield section of Hyde Park, Elmore and all of the commercial load on the north end of Town as well as the Village and hospital circuits. In addition, a fourth circuit was added in 2019 to connect to the 855 kW solar project built in the proximity of Substation #5.

The substation includes a 3,600 kVAr capacitor bank which provides power factor correction and voltage support to the Lamoille County 34.5 kV system. Additional capacitors may be added to the 34.5 kV system at Substation #5 as the Lamoille County load continues to grow.

The substation originally included a 2,000 kVA, 12.0-2.4 kV transformer, but this transformer failed in 2004. The 2.4 kV load was transferred to Substation #2 but all of the 2.4 kV has been converted to 12.5 kV and transferred back to Substation #5. Substation #5 has been redesigned to improve the operations and safety of the substation. The significant upgrades are a new 34.5-12.5 kV transformer on a foundation that includes oil containment, new regulators and new circuit breakers. The design provides for four 12.5 kV circuits of which three are installed presently.

Work is in progress to reconductor distribution lines and create tie points so all Substation #3 customers can be carried on the 7.5 MVA transformer at Substation #5. This will make the upgrading of the Substation #3 transformer to a 7.5 MVA unit

possible. The substation has Cooper Nova 15 breakers with Form 5 control. MW&L has wireless communication with the distribution breaker which allows remote operation and alarm notification.

Figure 21: MW&L's Substation #5

Substation #6:

Substation #6 is a switching station and includes two 34.5 kV breakers. One breaker provides protection to the 3319 Line for faults between Substation #6 and Substation #7 at the Green River Plant. The second breaker (619) was installed to segment the 3319 line from Substation #3 to Marshfield. For a fault on the line between Substation #6 to Marshfield, the breaker will protect the MW&L section, keeping Substation #5 and Pratt and Reid Substation (currently not in service) from tripping off. The 619 breaker is an ABB OVR 3 phase vacuum breaker installed with an ABB control panel. Breaker 619 has remote reading ability to notify personnel of an operation. VELCO has a fiber interconnection at Substation #6 which presently monitors the 619 breaker status. Substation #6 does not have remote SCADA control.

Figure 22: MW&L's Substation #6

Substation #7:

Substation #7 is a step-up station for the Green River hydro generation. The plant output voltage is 4,160 volts. The plant output is stepped up to 34.5 kV through 3-833 kVA transformers connected delta on the low side and grounded wye on the high side. Substation #7 interconnects to Substation #6 with a 34.5 kV line. The line is protected by a recloser in Substation #7 and in Substation #6.

Figure 23: MW&L's Substation #7

Johnson Substations (3):

There are three small step-down substations located in the Town of Johnson. These substations were built to supply a small number of customers when the Villages of Johnson and Hyde Park and the Vermont Electric Cooperative had not yet served the area. The MW&L 34.5 kV line serving the Johnson talc mill and talc mine was the closest source of electric power. The step-down substations consist of a 100 kVA, 34.5-7.2 kV (single phase) transformer and a regulator mounted on pole-mounted platforms.

Pratt & Reid Substation:

Pratt and Reid Substation was originally a customer-owned substation. MW&L purchased the substation in 2002, when the customer's load dropped off significantly, and is able to serve distribution load to the west of Brooklyn Street when needed. The substation consists of a 2,000 kVA, 34.5-12.5 kV transformer and one 12.5 kV distribution circuit. Its proximity to the new commercial center of MW&L makes it a strong asset to the MW&L System; it being close to Substation #5 gives it the capability to provide significant backup to that substation. MW&L's long-term electrical infrastructure plan is to utilize the Pratt & Reid Substation in conjunction with Substations #3 and #5 to serve MW&L's load for the foreseeable future.

Circuit Description:

Table 17: MW&L Circuit Description

Circuit Name	Description	Length [24](Miles)	# of Customers by Circuit
5.4	Morrisville & Elmore	11.4	1,468
5.1	Hyde Park & Wolcott	7.4	398
3	Morristown & Stowe	7.3	1,300
5.3	Morrisville No. End and Cady's Falls	2.7	427
10	East Johnson	2.3	20
11	Collins Hill	1.2	45
5.2	Trombley Solar	0.1	n/a

There are 7 circuits in total. The voltage of the circuits is regulated at the substation bus. MW&L does not consider any of its circuits to be particularly long. MW&L operates its system to maintain 114 to 126 volts at the customer's outlets.

T&D System Evaluation:

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

Outage Statistics

MW&L evaluates T&D circuits on an ongoing basis in order to identify the optimum economic and engineering configuration for each circuit. The evaluations include the review of the Public Utility Commission Rule 4.900 Outage Reports and data collected from load loggers. In addition, MW&L periodically completes long term system

[24] Estimated from circuit maps

planning studies to develop overall strategies for improving the performance of the T&D facilities. The cost of the improvements recommended in the study are developed into a 5-year budget and approved by the Trustees based upon the financial position of MW&L's electric department.

Tree contact from severe weather event is the primary cause of service interruptions from the distribution facilities. To prevent future outages and maintain reliability, MW&L continues to trim trees and add animal guards to equipment. In addition, MW&L has wrapped up its voltage conversion work in order to connect and complete a tie between Substation #3 and #5 to avoid large number of customers out of service due to emergency or scheduled outages, particularly related to the loss of a substation transformer at either Substations #3 or #5. MW&L strives to complete trimming of its entire system on a 10 to 14 year rotation. MW&L also takes out danger trees as necessary subject to landowner approval.

MW&L's Public Utility Commission Rule 4.900 Electricity Outage Reports, reflecting the last five years (2014-2018) in their entirety, can be found in Appendix D, at the end of this document.

MW&L has committed to performance standards for reliability that measure the frequency and duration of outages affecting its customers. There are two primary measures for the frequency and duration of outages. The Public Service Board's Rule 4.900 defines them as:

> System Average Interruption Frequency Index ("SAIFI"): Customers Out, divided by Customers Served. SAIFI is a measure of the average number of times that the average customer experienced an Outage.
>
> Customer Average Interruption Duration Index ("CAIDI"): Customer Hours Out, divided by Customers Out. CAIDI is a measure of the average length of time, in hours, that was required to restore service to customers who experienced an Outage.

MW&L has committed to achieve performance levels for its distribution system below an index of 3.0 for SAIFI and 2.5 for CAIDI. MW&L maintains a record of and reports on all its system outages, including the root cause of an outage. While some outages cannot be prevented, there are a number of specific, cost-effective steps that can be taken to maintain or improve system reliability by working to eliminate the potential for some outages to occur and making changes that will promote reduced outage times when an unavoidable outage does occur.

The following table summarizes MW&L's SAIFI and CAIDI values for the years 2014 – 2018.

Table 18: MW&L Outage Statistics

	Goals	2014[25]	2015	2016	2017	2018
SAIFI[26]	3.0	0.6	0.9	3.8	2.7	2.2
CAIDI[27]	2.5	2.5	1.7	2.4	1.7	2.5

MW&L has a number of initiatives underway to improve reliability. Each of these initiatives is described below.

Animal Guards

MW&L has a number of animal contact events a year that have prompted it to implement a policy of installing animal guards on all new construction and line rebuilds. In addition, MW&L has changed out a number of porcelain cutouts and took the opportunity to install animal guards. MW&L believes that animal guards are a cost-effective means of reducing animal contact and the associated service interruptions and MW&L plans to continue the program of installing animal guards for the foreseeable future.

Fault Indicators

MW&L does not currently use fault locators on its distribution circuits since its circuits are relatively short and accessible. MW&L uses its outage management system, fuse location, dispatching and line crew knowledge of the system for locating faults.

Automatic reclosers/Fusing

MW&L has automatic reclosers installed on all of its distribution feeders which attempt to maintain service to the maximum extent possible for momentary interruptions caused by tree and animal contacts on the main line. In addition, MW&L fuses all of the tap lines off of the main distribution line to reduce the number of customers impacted by faults on the tap lines. MW&L has two remote operated motorized switches to provide loop feeds. MW&L has not completed a total system fuse coordination study. No study is presently contemplated since MW&L is not getting any indications that it is having coordination issues. Fuse coordination issues are minimal. Line workers have extensive experience with fusing the system and have

[25] SAIFI and CAIDI statistics shown are net of major storm outages

[26] System Average Interruption Frequency Index

[27] Customer Average Interruption Duration Index

successfully fused the system using industry rules of thumb. Fuse size adjustments are made if a fuse mis-coordination occurs.

Feeder back-up

In the past, MW&L had limited feeder back-up capabilities due to the multiple levels of distribution voltages on its distribution facilities. However, MW&L has completed its multi-year plan to convert all distribution voltages to 12.47 KV. Now that the voltage conversion work is completed, along with the update of system maps reflecting the work done, MW&L personnel will conduct a series of internal meetings with operations staff and our consultant engineer to determine the most cost-effective feeder back-up options to pursue. Recommendations will be made in the annual budgeting process to complete the projects needed to the extent possible within MW&L's financial constraints.

There is now a 12.5 kV tie between Substation #3 and Substation #5. While this tie allows either substation to carry the load of the other, the exposure to the hospital is high. Going forward, it is anticipated that additional ties will be constructed which will allow greater flexibility in providing back-up capability.

MW&L does not have many supplier-associated outages due to the three transmission sources to its system. MW&L's load can be served from any two of the three sources 100% of the time and can be served entirely from either the Stowe or Johnson source alone for over 95% of the time. In addition, the distribution transformer at Substation #3 is located on a 35 kV bus such that it does not drop out for line faults. With the addition of two 35 kV circuit breakers at Substation #5 in 2020 this will be true for this distribution transformer also.

Power Factor Measurement and Correction

MW&L lacks equipment needed to accurately measure power factor at various locations on its system. MW&L is investigating the cost of options with other VPPSA members to collect the data required to establish a program to improve its annual system power factor to 95%. This power factor value came from a model used for conducting distribution studies in the past and reflects a typical value based upon the consultant's experience from studies completed for other systems that had measured power factor.

Although MW&L's summer power factor approaches the 95% target, its winter power factor is estimated to be near unity with the 3.6 MVAR substation capacitor bank in service at its Substation #5. This bank is in service year-round for 34.5 kV voltage support and power factor correction based upon automatic voltage control. MW&L's hydro plants also provide power factor correction and volt amp reactive support when they are generating power.

A long-term planning study was completed for MW&L's distribution system in 2018. The planning study summarized the normal operating parameters of the distribution system. No parameter violations were identified.

MW&L relies on VELCO for completing load flow studies of the sub-transmission system (34.5 kV). The addition of the 115 kV substation in Stowe has significantly improved the normal and contingency performance for the Lamoille County utilities.

Other

Vegetation management and relocating country lines to roadside are also two important initiatives which MW&L uses in order to improve reliability. Both will be discussed in greater detail later in this document.

Distribution Circuit Configuration

Voltage Upgrades

MW&L's long-term strategy to improve system efficiency by converting the 2.4 kV and 4.16 kV portions of its system to 12.470 kV was completed in 2017.

Phase balancing

MW&L's loads are fairly stable and do not generally require reconfiguration to balance the load. Load data for each phase of each feeder is collected via recloser control panel data and reviewed periodically in order to check balance. This has been particularly important during the conversion work as major changes are being made to the paths power is delivered across the distribution facilities. Any additional load growth is connected to maintain load balance. Phase currents that are generally within 5% of each other are considered balanced.

As stated earlier, MW&L has positioned itself for improving its feeder back-up capabilities as the conversion work nears completion. Since the voltage conversion work was completed in 2018, along with the updates of the system maps, MW&L personnel will conduct a series of internal meetings with operations staff to determine the most cost-effective feeder back-up options to pursue. Reconductoring projects will be included in the 2020 to 2024 capital budget with the goal of creating multiple loops for alternate supply to minimize the number of customers impacted while repairs are made.

System Protection Practices and Methodologies;

Protection Philosophy

MW&L's system protection includes sub-transmission (34.5 kV), substation and distribution protection. Each is discussed briefly below.

34.5 kV Sub-transmission Protection:

The protection of MW&L 34.5 kV system is shared with GMP and VELCO. There are three main line sections from MW&L #3 Substation. These include the 3319 line to Hardwick/Marshfield, the 3329 line to the VELCO Substation in Stowe and the B22 line to GMP's substation in Johnson. These lines have breakers on both ends for fault protection. The status of the GMP and MW&L's breakers is monitored via SCADA. The status of the GMP breaker is monitored by GMP's SCADA. GMP is also able to operate its breakers via SCADA. MW&L's breakers at Substation #3 are not operable via SCADA. Any abnormal operation of the protection system is reviewed by VELCO, GMP and MW&L and relay settings are modified if required.

In addition, MW&L installed a breaker (619) at its Substation #6 to reduce the exposure to MW&L's customers for faults on the 34.5 kV line from its Substation #6 to Marshfield. This reduces outages to MW&L's Substation #5 customers for faults on the lengthy line section from MW&L's Substation #6 through Hardwick to GMP's substation in Marshfield.

MW&L contracted with VELCO to conduct a protection study of its sub-transmission system in 2016. MW&L has documented its relay and breaker settings for the VELCO study. VELCO completed its work in 2016. This included the review of settings of the 3310 breaker at Substation #3.

Substation Protection:

The substation equipment is protected by a combination of high side fuses and breakers. MW&L does not have any bus differential protection at its substations at this time. MW&L has not tested substation equipment for the past 10 years with the addition of new transformers and breakers. MW&L plans to ask GMP to help establish a testing program and schedule in 2020.

Distribution Protection:

The distribution system protection involves a combination of distribution circuit reclosers for each feeder and fuses. All side taps of the main line distribution feed are fused.

MW&L had an arc flash analysis completed in 2014; that analysis included data on all relay and breaker settings. A fuse coordination was not done at that time.

Smart Grid Initiatives

Existing Smart Grid

MW&L has installed 180 smart meters as a pilot program and continues to explore the prospective installation of dual water and electric AMI systems.

Planned Smart Grid

Beginning in 2018, MW&L 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 MW&L 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, MW&L will decide whether to proceed to the RFP phase of the process.

MW&L 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.

MW&L 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, MW&L 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, MW&L stays abreast of these developments and the strategies needed to maintain a safe, reliable, and economically viable distribution system.

MW&L is also mindful of the increasing importance of cybersecurity concerns, and the relationship of those concerns to technology selection and protection. While MW&L is not presently required to undertake NERC or NPCC registration, VPPSA is a registered entity, and MW&L's membership in VPPSA provides MW&L with knowledge and insight regarding ongoing cybersecurity developments and risks. On a more local level, MW&L 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. MW&L 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

MW&L has been gradually replacing small conductor over the last twenty years and completed this program in 2017. The work included the upgrading of 3/0 lines. MW&L also re-conductored nearly a mile of #1 stranded copper to 4/0 aluminum wire. MW&L has not determined the loss savings or pay-back for replacing small conductor for individual projects. The conductor was replaced to avoid bottlenecks from backing up Substation #3 with Substation #5 and vice versa.

Transformer Acquisition

Historically, MW&L has purchased used transformers at a fraction of the cost of new transformers. MW&L does not currently use an economic model to evaluate the life cycle cost of low loss transformers since the cost of used transformers always results in the lowest life cycle costs. The transformer supplier does provide loss data for the transformers purchased. MW&L will consider using a spreadsheet-based tool in the future, developed in collaboration with the Department of Public Service to select lowest life-cycle cost equipment.

Conservation Voltage Regulation

All circuits are bus regulated at the substation. All reports of low voltage are investigated. No voltage complaints have been reported since the upgrade was

completed at Substation #5. This substation has the largest circuit distance. Bus regulation is set to deliver 117 to 126 volts.

MW&L participates in the ISO-New England voltage reduction tests twice a year, in the spring and fall. MW&L periodically monitors customer voltage on last customers of a circuit being fed from each substation to make sure proper voltage is supplied. MW&L does this by installing a voltage recorder at the meter and downloads the information to review.

Distribution Transformer Load Management (DTLM)

MW&L does not have a DTLM program. MW&L plans to pursue a DTLM program after smart meters are installed.

Substations within the 100- and 500-YEAR Flood Plains

MW&L currently has three substations that fall within the 100-year and 500-year flood plains. Those substations are: Substation #1, Substation #2, and Substation #3. Substation #1 is located at the Cady's Falls hydro plant. Substation #2 is located at the Morrisville Hydro plant. Substation #3 located at Morristown Corners. Morrisville's goal is to be able to serve its customer load from either Substation #3 or Substation #5. In case of the flooding of Substation #3, switching would be done to isolate the flooded equipment and feeder ties would be closed to restore customer load from Substation #5. Two substations (Substation #1 and Substation #2) were replaced with step-up transformer on a pad at the Cady's Falls and Morrisville Hydro plants.

The Utility Underground Damage Prevention Plan (DPP)

The majority of MW&L's lines are overhead lines. As the quantity of MW&L's underground lines increase, MW&L will become increasingly more involved with the Damage Prevention Plan. MW&L requires inspection of all underground lines prior to burial. This will be performed by MW&L employees. MW&L has collaborated with the Department of Public Service and VPPSA to develop a draft Damage Prevention Plan and filed it with the Department of Public Service in May 2018.

MW&L participates in Dig Safe and responds with line personnel to mark all utility owned underground lines. All primary underground is installed per MW&L's specifications. MW&L pulls all wire with its line crews. All underground is located on MW&L's Outage Management System/GIS and gets updated as needed.

Selecting Transmission and Distribution Equipment

When replacing transmission and distribution equipment, MW&L solicits three different quotes before making a purchase. MW&L installs equipment that has proven to be effective or reliable based upon experience. These purchases are based on pricing and reliability. Equipment purchases are evaluated based upon actual experience of MW&L staff and the experience of other utilities in Vermont at periodic meetings of the MEAV (Municipal Electric Association of Vermont).

Maintaining Optimal T&D Efficiency

System Maintenance

System maintenance includes a number of components. Each is discussed briefly below. MW&L plans to draft and implement a system maintenance plan in 2020.

Substation Maintenance

MW&L has an unwritten substation maintenance program. MW&L performs annual oil checks on transformers, and monthly substation inspections. MW&L currently only does a visual check of transformer oil levels. There has been a lapse in testing oil. MW&L plans to reinstitute annual transformer oil tests in 2020. Meter readers and line crews report maintenance issues as they find them in the field. Much of MW&L's substation and distribution system has been upgraded in recent years and is in the beginnings of its scheduled maintenance.

Figure 24: MW&L's Substation Maintenance Checklist:

Substation Monthly Check List			Date:		Checked By:				
Sub #3	Battery Volts				Temp:				
	High	Low	Counter	Oil Level	Winding	Liquid	Buck	Boost	Neutral
S22									
Reg 1									
Reg 2									
Reg 3									
34.5 Trans.									
34.5 Battery									
Betta Alams									

	Drained	Running	Water	Oil Level	Heaters
3329 Compressor					
3319 Compressor					
Notes:					

Sub #4			
Gate Locked:	Broken Glass:	Notes:	

Sub #5	Battery Volts				Temp:				
	High	Low	Counter	Oil Level	Winding	Liquid	Buck	Boost	Neutral
Breaker 1									
Breaker 2									
Breaker 3									
Breaker 4									
34.5 Trans.									
Reg 1									
Reg 2									
Reg 3									
	on/off		status		status				
Trans. Fans:		Cap Bank:		Fuses:					
Notes:									

Sub #6	Battery Volts		
	High	Low	Counter
622			
619			
Notes:			

Sub #7				
	Spot check			
Notes				

Sub #10	Counter	Buck	Boost	Neutral	Notes:	

Sub #12	Counter	Buck	Boost	Neutral	Notes:	

Pratt Reed				
	Spot check			
Notes				

Pole Inspection

MW&L does not currently inspect or treat its transmission and distribution poles. Many of the distribution poles have been replaced due to voltage conversion, roadside relocation or re-conductoring projects. MW&L has a goal to replace 10 transmission poles annually, as the transmission poles are in the most need of attention. MW&L has completed the mapping of its entire system. Pole age data was included in the scope of the project and allows MW&L to determine the age profile of its existing plant. Morrisville is considering the potential for a group or shared pole inspection/treatment program that may include other VPPSA or MEAV members.

Equipment

MW&L does not have a maintenance program for its substation transformers, line breakers, switches, or protective relays. MW&L has aggressively replaced porcelain cutouts with polymer cutouts system wide. It is MW&L's intent to implement a written maintenance plan in 2020.

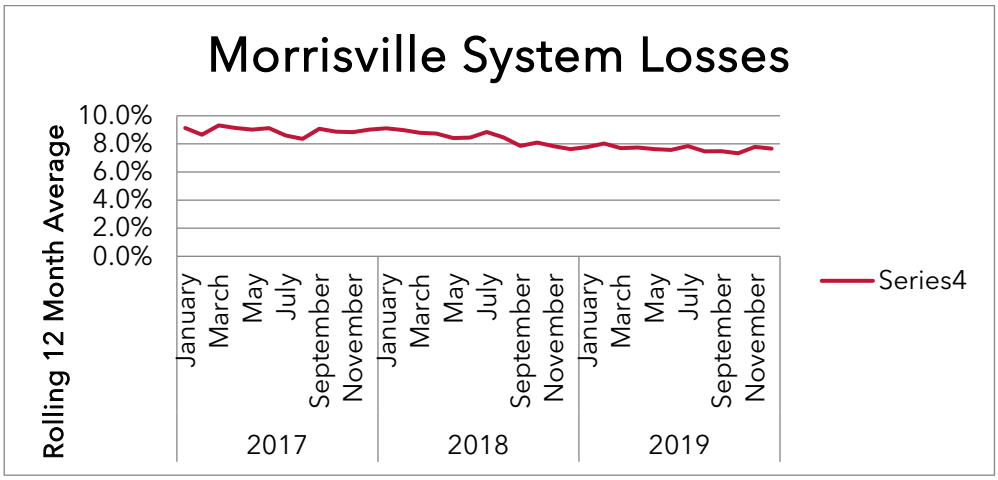
System Losses

MW&L is committed to providing efficient electric service to its customers. MW&L's plan for improving system efficiency involves two actions. The first action involves monitoring actual system losses. The second action is to complete projects to reduce system losses. Each of these tasks is discussed briefly below.

Actual System Losses:

MW&L monitors system energy losses by tracking metered system load at its interconnections to GMP, VELCO and Hardwick and comparing it to metered energy sales to its customers. The calculation is done on a rolling 12-month basis to minimize the impact of unbilled energy resulting from meter reading cycles not corresponding with the system load meters that run from the first to the last hour of the month.

Figure 25: MW&L's Historic System Losses:



Efforts to Reduce Losses:

MW&L's primary effort to reduce line losses is increasing distribution system voltages, re-conductoring and reducing power flows on the 34.5 kV system. Each of these efforts is discussed in more detail below along with other miscellaneous topics. MW&L was expecting to reduce losses into the 6% to 8% range by converting its distribution voltage to 12.47 kV. MW&L cannot separate distribution and transmission losses. MW&L still has through flows over its 34.5 kV facilities that need to be addressed. MW&L had a system study conducted in 2018 now that MW&L has reached the end of its conversion work. The study will help identify where losses are occurring and steps that can be taken to reduce losses further.

Transmission Losses:

MW&L has an issue involving real line losses associated with incremental power flows beyond what is required for MW&L across MW&L's system. The average hourly north to south power flows have increased since VELCO completed its Northern Loop Upgrades in Stowe. The flows are attributable to the large wind projects in the northern portion of Vermont.

MW&L is looking to either reduce the losses by opening the B-22 line or be compensated for the losses by others (GMP). The study completed by VELCO shows the B-22 line is critical and needs to be kept in the closed mode.

Tracking Transfer of Utilities and Dual pole Removal (NJUNS)

MW&L does not use the NJUNS database. MW&L's staff has attempted to use the database but has found it not to be user friendly, which has discouraged MW&L's use

of the program. NJUNS is not the preferred means of tracking pole transfers. MW&L does utilize an exchange of transfer of notifications with Consolidated Communications which Consolidated Communications enters into NJUNS, but the bulk of the transfer work is completed due to interaction with local TELCO engineers.

Relocating cross-country lines to road-side

MW&L takes every opportunity during line rebuilds to relocate cross-country lines to roadside. Once its system mapping is completed, its progress will be documented and remaining cross-country line sections will be considered as future line rebuilds are approved in the budget.

Distributed Generation Impact:

MW&L presently has 106 residential scale (< 15 kW) net metered customers with a total installed capacity of about 720 kW. In addition, there are nine customers who have arrays between 15 and 150 kW, and the total 614 kW.

Interconnection of Distributed Generation

MW&L recognizes the unique challenges brought on by increasing penetration levels of distributed generation. MW&L 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 MW&L 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, MW&L will maintain detailed records of installed generation including location, type, and generating capacity. This information will allow MW&L 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). MW&L continues to monitor trends for interconnection protection for abnormal conditions. 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 MW&L's service territory, MW&L 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 borne by MW&L. As a reasonable compromise, MW&L 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, MW&L 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. MW&L recognizes the need to standardize efforts aimed at certifying

inverter compliance with the ISO SRD and will work with VPPSA and the PSD to achieve use of common forms and process in this regard.

Vegetation Management/Tree Trimming:

MW&L has about 180 miles of distribution and 30 miles of transmission. It estimates about 20% of the lines run through fields that do not require tree trimming; the other 80% of the lines require tree trimming. MW&L has a target to complete tree trimming for all of its distribution and transmission on a 14-year cycle. MW&L uses several local contractors for doing trimming on its system. The following table summarizes the amount of line trimmed and the cost of the trimming over the past few years. While MW&L has not conducted an analysis, it believes the combined use of the local contractors along with its own personnel provides a cost-effective approach to tree trimming. However, MW&L is looking at ways to reduce the tree trimming expenses. MW&L does not inventory tree species, but its line people have significant logging experience and they take into account the species of tress while trimming and trim accordingly.

MW&L has a layer in its mapping system that shows where and when it trims. MW&L's outage reports show tree contact being the primary cause of outages. MW&L's outage reports show that the trimming plans need to be aggressively pursued.

All lines are trimmed to the edge of the legal right-of-way. The trimming width on either side of the line varies depending on the voltage and right-of-way easement.

In addition to its vegetative and brush management program, MW&L has a program to identify danger trees within its rights-of-way and to either prune or remove those trees. Again, the success of this program is measured by whether danger trees are a root cause of system outages. Danger trees are identified by utility personnel while patrolling the lines, reading meters, or inspecting the system and our customers. Once a danger tree is identified, it is promptly removed if it is within MW&L's right-of-way. For danger trees outside of the right-of-way, MW&L contacts the property owner, explains the hazard, and, with the owner's permission, removes them. Where permission is not granted, MW&L will periodically follow up with the property owner to attempt to obtain permission.

The data in the tables is a little misleading for trying to determine the trimming cycle. MW&L experienced a number of major storms over the past five years that resulted in significant tree contact from trees toppling over into the rights-of-way. The cutting done for these storms is not reflected in the numbers. Going forward, absent disruptions of this type, MW&L anticipates trimming approximately 12 miles per year. In addition, MW&L's Trustee's made a commitment to maintaining the tree right of way clearing budget in 2020 to improve reliability.

One of MW&L's goals for 2020 is to refine the documentation of trimming to develop a detailed plan rather than a generic plan based upon total miles. MW&L has been documenting the trimming cycle on system maps showing the trimming to be done each year with the miles of line involved in each year.

MW&L's analysis of tree trimming expenses shows MW&L is currently on a 14-year cycle with using outside contractors. Moving to a 10-year cycle is estimated to cost $250,000 per year compared to $130,000 per year spent for the last 4 years, roughly doubling the amount of dollars to be spent each year.

Tree trimming competes with other projects for limited financial resources for operating and maintaining the electrical facilities and capital improvements needed. MW&L is looking at options for reducing tree trimming expenses and still moving to a 10-year cycle. Options include hiring two full time employees to focus on trimming year-round and using State Corrections services that allows the State to recover some of the costs of inmates with services they provide that benefits MW&L's customers. Also, MW&L is looking at methods used by some contractors using "brontosaurus" equipment that efficiently cuts and mulches trees/brush in the right of way to ground level. MW&L does not intend to consider using herbicides.

Tree trimming expenses provides an unquantifiable benefit in customers satisfaction from lower service interruptions. When compared to other projects that offer a tangible and quantifiable benefits, the inclination of staff and the Trustees is to reduce the tree trimming budget and fund other projects to reduce upward pressure on rates. This decision making increases the cycle time for tree trimming.

The emerald ash borer has not yet become an active issue in MW&L's territory. MW&L 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 MW&L's territory, affected trees will be cut down, chipped and properly disposed of.

Table 19: MW&L Vegetation Trimming Cycles

	Total Miles	Miles Needing Trimming	Trimming Cycle
Transmission	Approximately 33 miles	20	14-year average cycle
Distribution	Approximately 180 miles	150	14-year average cycle

Table 20: MW&L Vegetation Management Costs

	2016	2017	2018	2019	2020	2021
Amount Budgeted	$110,000	$100,000	$100,000	$125,000	$150,000	$150,000
Amount Spent (FY)	$109,000	$125,300	$140,600	$146,200	Deliberately left blank	Deliberately left blank
Miles Trimmed	7 miles	8 miles	9 miles	12 miles	12 miles to be trimmed	12 miles to be trimmed

Table 21: MW&L Tree Related Outages

	2014	2015	2016	2017	2018
Tree Related Outages	45	15	44	53	124
Total Outages	107	100	130	110	186
Tree-related outages as % of total outages	42%	15%	34%	48%	67%

Storm/Emergency Procedures:

Like other Vermont municipal electric utilities, MW&L is an active participant in the Northeast Public Power Association (NEPPA) mutual aid system, which allows MW&L to coordinate not only with public power systems in Vermont, but with those throughout New England. A MW&L representative is also on the state emergency preparedness conference calls, which facilitate in-state coordination between utilities, state regulators and other interested parties. MW&L uses the www.vtoutages.com site during major storms especially if it experiences a large outage that is expected to have a long duration. MW&L believes it is beneficial to inform the Public Service Department if it is experiencing these types of outages. MW&L partners with neighboring municipals and cooperative when extra crew power is required. MW&L does not typically use contract crews.

Previous and Planned T&D Studies:

Fuse Coordination Study

MW&L has completed fuse coordination studies in house using data collected from load loggers and breaker data. Existing fusing is done by general rules of thumb and actual operating experience. Fuse size changes are made to up-stream fuses when fuse sizes are increased for load increases or other reasons. Historical data from voltage conversion work and system mapping from the outage management system have all been included to maintain fuse coordination.

System Planning and Efficiency Studies

System Operation

The reliability of MW&L's electric system has been greatly enhanced by the addition of the VELCO 115 kV substation in Stowe in 2009 served by the new 115 kV line extension

from Middlesex. MW&L relies on VELCO for evaluating electrical system configurations when MW&L needs to take portions of its 34.5 kV lines out of service. In addition, MW&L has given GMP authority for monitoring the condition of the 34.5 kV system and scheduled line outages on the MW&L 34.5 kV lines are coordinated with GMP's dispatch center including the review of MW&L's planned switching procedures.

Distribution System Planning

MW&L commissioned a system planning study in 2017 with Crocket Engineering LLC. The study period was 2019 to 2028. The study was completed in 2018. MW&L's Trustees approved the plan and MW&L is currently implementing the recommendations.

The objective of this study was to analyze the MW&L distribution system and provide a plan of system upgrades over the next ten years. To accomplish this goal, a 2018-2028 load forecast was developed. The results of this forecast were then used in the MilSoft distribution circuit analysis program, along with substation and line data, to model the entire MW&L system. By using this model, present and future problems were identified. The model was then modified to reflect various system upgrades, which were then compared with respect to system performance, loss reduction and cost, to obtain the best overall plan.

The planning criteria considered in this analysis are:

1. Maintain the primary voltage on all line sections between 117 volts and 125 volts
2. Operate all lines below their thermal rating.
3. Load all transformers below their nameplate rating. MW&L uses the self-cooled transformer nameplate rating.
4. Complete conversion of the system to 12.5 kV is a long-term goal.
5. Complete elimination of the 12.0 kV system (12 kV delta) is a long-term goal.

Options considered in meeting these goals included:

1. Voltage conversions
2. Capacitor additions
3. Adding phase wires
4. Re-conductoring
5. Regulator installations
6. Load transfers
7. Step-bank installations
8. Phase balancing
9. New substations

The final plan incorporates all of these elements into a systematic approach to improving the service to existing customers while providing capacity to allow for continued growth.

The significant system changes recommended by this study include:

1. Expansion of Substations #3 and #5.
2. Construction of stronger ties between Substation #3 and Substation #5 to allow back-up capability for both substations.

3. Relocation of the distribution underbuild on the 3329 34.5 kV line to Stowe.
4. Extension of three phase construction along various line sections to improve load balance.
5. Installation of capacitors for loss reduction.
6. Revitalization and energization of the Pratt Reid substation.

In addition, Morrisville filed a joint permit application with GMP for:

7. Rebuild B-22 Line.

The results of the Work Plan for the previous ten years is summarized below.

Table 22: MW&L Projects Summary 2005-2017

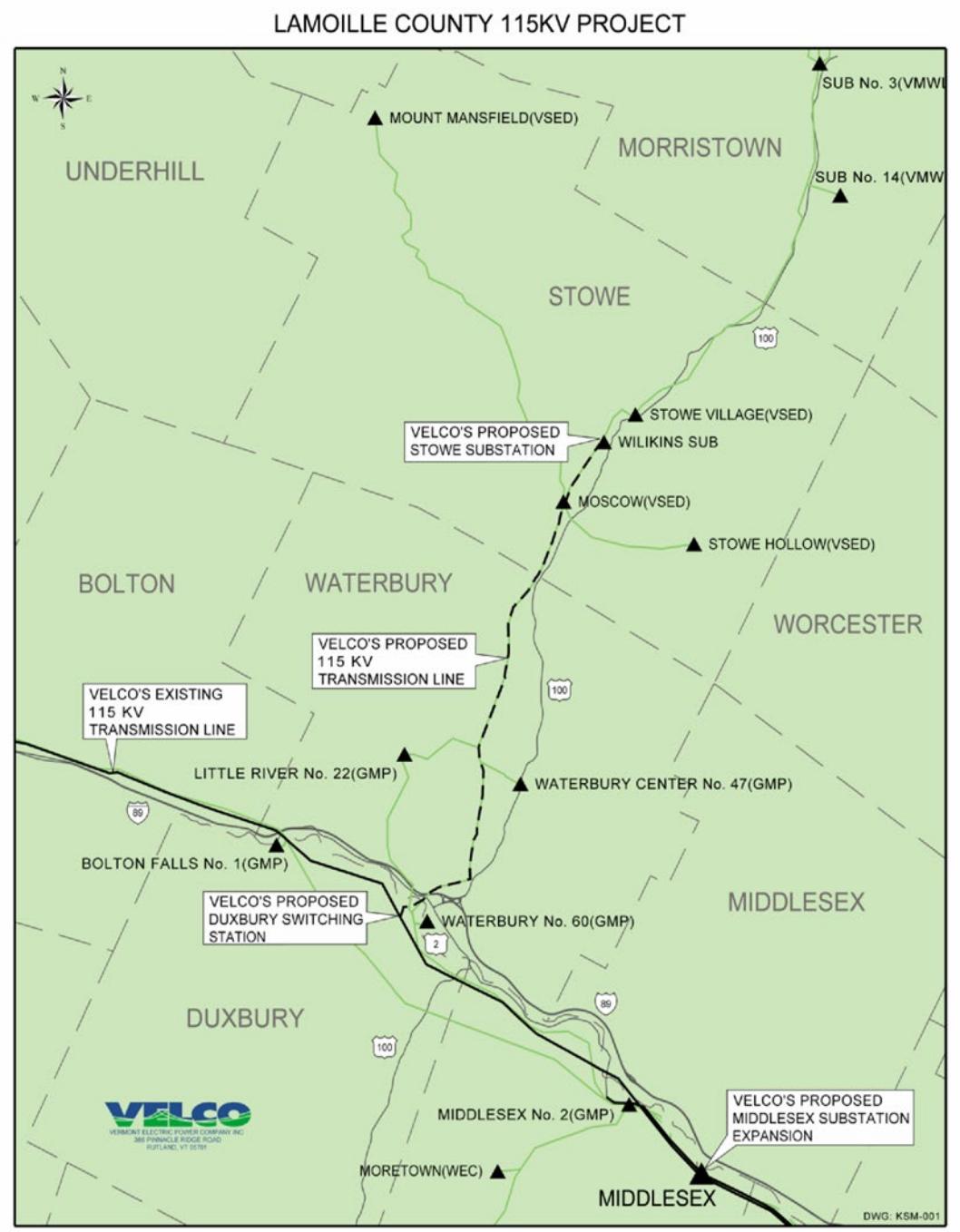
Year	Project Description	Estimated Cost	Status
2005	Convert Brooklyn Street to 12.5kV, transfer loads to reduce losses	$ 1,200	Done
2005	Reconnect transformers on Randolph Road to wye and transfer to Substation #3 & #5	$ 1,200	Done
	Total 2005	$ 2,400	
2006	Extend neutral on Randolph Road to Goeltz Road and convert to wye operation	$ 6,000	Done
2006	Substation #5-Rebuild Substation	$ 174,000	Done
2006	12.0kV Regulators (use Substation #5 Regulators)	$ 1,880	Done
	Total 2006	$ 180,880	
2007	Construct a three phase tie along Elmore Road	$ 112,500	Done
2007	Convert Section of Substation #2 to 12.5kV	$ 30,000	Done
2007	Convert Goeltz/Bliss Hill Roads	$ 21,650	Done
2007	Retire Substation #14 Equipment	$ 5,000	Done
	Total 2007	$ 169,150	
2008	Rebuild Substation #1	$ 70,000	Done
2008	Convert Randolph Road to 12.5kV	$ 42,500	Done
2008	Convert Route 100 from Sub #3 to Randolph Road	$ 29,050	Done
2008	Convert 12.0kV Circuit	$ 20,000	Done
	Total 2008	$ 161,550	
2009	New Transformer/foundation Substation #3	$ 80,000	Future
2009	Convert Washington Highway to 12.5kV	$ 33,500	Done
	Total 2009	$ 113,500	
2010	Substation #14 Underbuild Tie to Substation #3	$ 108,000	Done
2010	Construct Tie Along Washington Highway	$ 45,000	Done
2010	Convert Section of Elmore Road	$ 29,750	Done
	Total 2010	$ 182,750	
2011-2017	Substation #14 Conversions	$ 44,750	Done

2011-2017	Lower Elmore Road Conversions	$	25,500	90% Done
2011-2017	Upper Elmore Mountain Road Conversion	$	34,000	Done
2011-2017	Cady's Falls Conversion	$	63,350	Done
2011-2017	Convert Substation #4	$	36,250	2017
2011-2017	Convert Substation #2	$	127,400	2017
2011-2017	Rebuild Substation #2	$	50,000	2017
2011-2017	Remove Substation #4	$	25,000	2017
2011-2017	Rebuild Bliss Hill Road-3 Phase	$	135,000	Done
	Total 2011-2017	$	541,250	

Transmission System Planning

MW&L relies on VELCO for recommending improvements needed to the transmission facilities. Currently, MW&L has no transmission planning issues pending after the completion of the 115-kV line into Stowe along with a new 115/34.5 kV substation to improve the reliability of the power supply to the Lamoille County area. The new project was completed in 2009 as shown below.

Figure 26: Lamoille County 115KV Project Map



Capital Spending:

Construction Cost (2016-2018):

Table 23: MW&L Historic Construction Costs

Morrisville Water & Light Department	Historic Construction		
Historic Construction	**2016**	**2017**	**2018**
Functional Summary:			
Production	$ 757,179	$ 50,520	$ 392,609
General	$ 52,779	$ 104,488	$ 262,078
Distribution	$ 180,547	$ 167,294	$ 164,956
Transmission	$ 11,644	$ 32,609	$ 5,898
Total Construction	**$ 1,002,149**	**$ 354,911**	**$ 825,541**

Projected Construction Cost (2020-2022):

Table 24: MW&L Projected Construction Costs

Morrisville Water & Light Department	Projected Construction		
Projected Construction	**2020**	**2021**	**2022**
Functional Summary:			
Production	$ 150,000	$ 253,300	$ 356,673
General	$ 40,000	$ 285,220	$ 40,445
Distribution	$ 160,000	$ 163,520	$ 167,117
Transmission	$ 89,250	$ 166,080	$ 15,667
Total Construction	**$ 439,250**	**$ 868,120**	**$ 579,902**

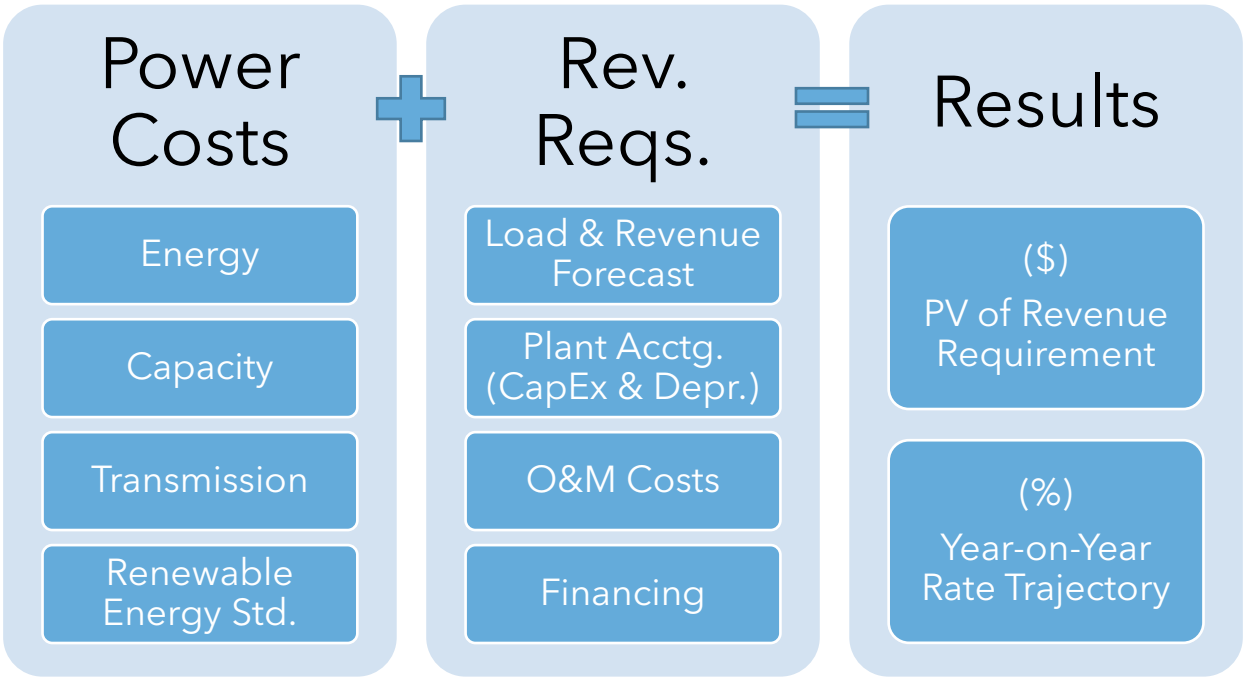
Financial Analysis

V. Financial Analysis

Components

The financial analysis represents an integrated analysis of MW&L's power supply costs and its revenue requirements. The results include the present value of MW&L's revenue requirements (a proxy for least cost) and the annual change in retail rates. The following figure illustrates the primary components of the analysis.

Figure 27: Primary Components of the Financial Analysis



The power supply cost models consist of four primary spreadsheets that estimate the cost of energy, capacity, transmission, and the costs of complying with the Renewable Energy Standard. The power supply models are monthly and roll up to annual numbers for integration with the revenue requirements model. The revenue requirements model contains annual estimates of MW&L's load, revenue, plant accounting activity (including capital expenditures and depreciation), O&M costs, and ultimately, a profit and loss statement. Its outputs are annual revenue requirements, average rates, and the annual change in rates.

Importantly, the power cost spreadsheets are the same models that are used to create MW&L's annual power cost budget and are formatted to be consistent with the spreadsheets that are used for monthly budget to actual analysis. As a result, they are operational as well as planning tools.

Methodology

The financial analysis estimates the costs and benefits of three major decisions that were identified in Section III. Resource Plans, and one load-related uncertainty. These include:

Decisions

There are three decisions facing MW&L that the financial analysis will quantify.

1. Extension of the NextEra PPA
   Q1: What are the costs and benefits of extending NextEra volumes through 2039?

2. New Long-Term Hydro PPA
   Q2: What are the costs and benefits of a dispatchable hydro PPA that includes both energy and Tier I RECs starting on 1/1/2025?

3. Low Impact Hydro Institute Certification for Cady's Falls and Morrisville #2
   Q3: What are the costs and benefits of getting LIHI certification effective 1/1/25?

In addition, we quantify one load-related question.

4. 1% CAGR

   Q4: What is the rate impact of adding 1% compound annual load growth to the load forecast?

There are six relevant combinations of the three decisions, as shown in Table 25.

- Pathway 1 is the reference case.
- Pathway 2 shows the costs and benefits of extending the NextEra PPA to hedge energy costs through 2039.
- Pathway 3 shows the cost and benefits of a new long-term hydro PPA to hedge MW&L's short position in RECs and energy through 2039.
- Pathway 4 shows the benefits of seeking LIHI certification for Cady's Falls and Morrisville #2.
- Pathways 5 and 6 show the benefits of combining:
  - Pathways 2 and 4, and
  - Pathways 3 and 4.

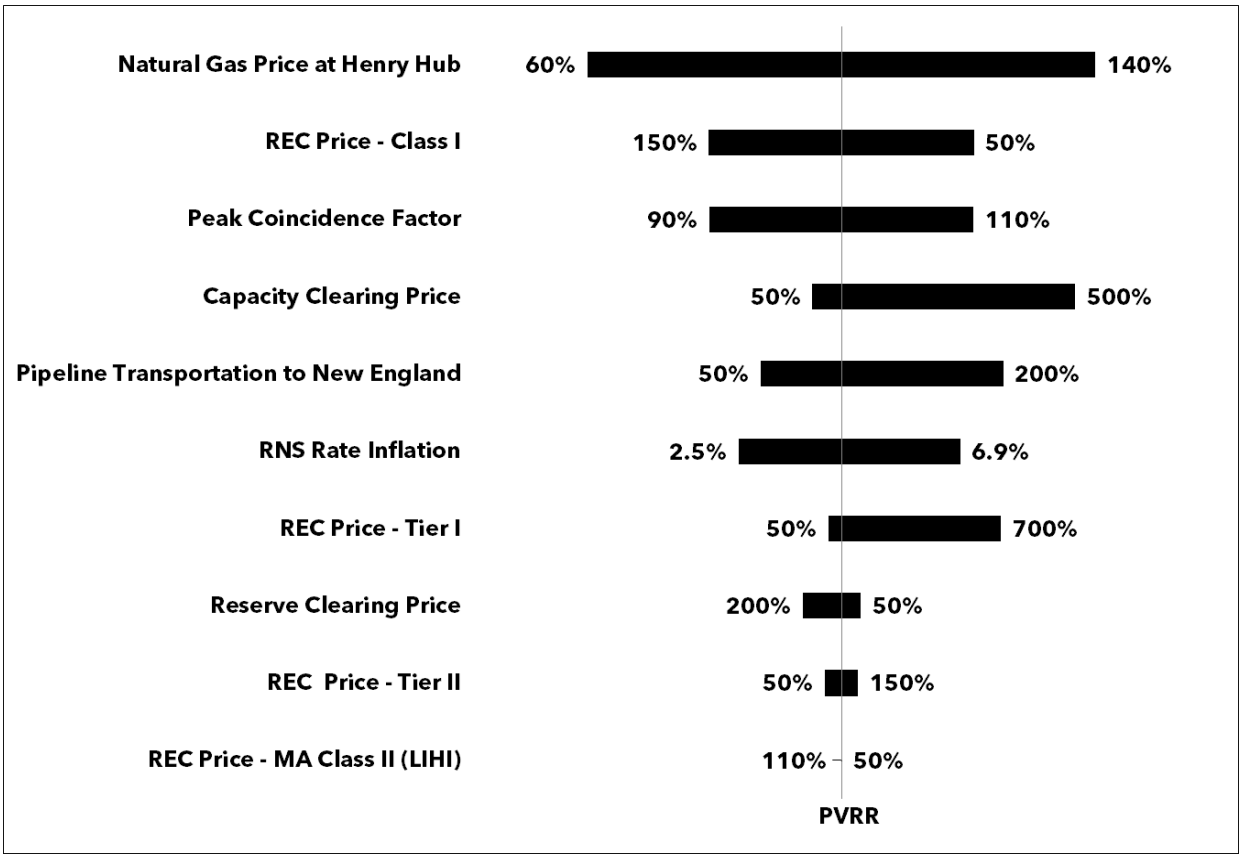
Table 25: Event / Decision Pathways

Pathway	Name	Extend NextEra PPA to 2039	Long-Term Hydro PPA in 2025	LIHI Certification in 2025
1	Reference Case			
2	Extend NextEra to 2039	✓		
3	Hydro PPA		✓	
4	LIHI Certification			✓
5	LIHI + Extend NextEra	✓		✓
6	LIHI + Hydro PPA		✓	✓

Not all combinations of each scenario are of interest. For example, making the decision to both extend the NextEra PPA and sign a new long-term hydro PPA would make MW&L significantly and chronically long on energy. VPPSA's energy hedging policy explicitly seeks to hedge energy to within +/-5% of 100%, and such a combination of decisions would be contrary to that policy.

The financial analysis estimates the cost of each of these pathways, and then runs sensitivity analysis on ten different variables that are known to have a material impact on MW&L's revenue requirements. Low, base and high ranges were set up using historical data for each of these variables, as shown in Figure 28.

Figure 28: Sensitivity Analysis of Key Variables – Pathway 1 (Reference Case)



Note that changes in load and the rate of load growth are not included in the sensitivity analysis. This is due to the fact that these two variables were always at the top of the tornado chart, regardless of the decision being analyzed. Furthermore, these two variables effectively masked the impacts of the other ten variables on Figure 29, the scatter plot of financial outcomes.

The conclusion is that +/-10% changes in load and +/-1% changes in load growth are the biggest variables impacting MW&L's cost of service, as measured by the Present Value of its Revenue Requirement (PVRR). Because MW&L has few large customers and its customer base is well diversified across rate classes, neither of these risks are likely to present themselves in the short term. However, they remain within the realm of possibility over the long-term, in part because the energy transformation (Tier III) requirements in Renewable Energy Standard imply 1% load growth in the early 2030s. With this conclusion established, we decided to omit load growth and large changes in load from the sensitivity analysis in order to draw out the impacts of the remaining ten variables.

With this in mind, the number one risk facing MW&L is the price of natural gas. Number two is the price of Class I Renewable Energy Credits (RECs). These outcomes are intuitive because price of natural gas and RECs are known to change quickly and competing alternatives (supplies) are limited in the short-term.

The peak coincidence with monthly and annual load in New England is the third most important variable because it determines transmission and capacity costs, and is subject to a high degree of uncertainty. As load reducers, the hydroelectric generation from Morrisville #2 and Cady's Falls have a direct impact on MW&L's peak coincidence, and if they are generating at the coincident peak hour, they can and do reduce transmission and capacity costs.

Number four on the list is the price of capacity. Because MW&L's capacity supply is forecast to be about 1 MW less than its requirements, increases in capacity prices can increase its costs. However,

in today's market environment, capacity prices have been falling, which has reduced MW&Ls costs. This level of market price risk is not a concern, but there is an opportunity to use demand response and/or new capacity supplies to manage these costs.

Number five on the list is the price natural gas transportation to New England. New England's pipeline infrastructure is known to be inadequate to supply the gas-fired generation fleet during winter cold spells, and this variable captures this risk.

The last variable of note is the cost of Tier I RECs. Although the cost of these RECs is quite low right now, the Alternative Compliance Payment (ACP) is about 700% higher than market prices, and this presents a significant risk to MW&L's costs.

Revenue Requirement Results

The high-level results of the financial analysis appear in Figure 29.

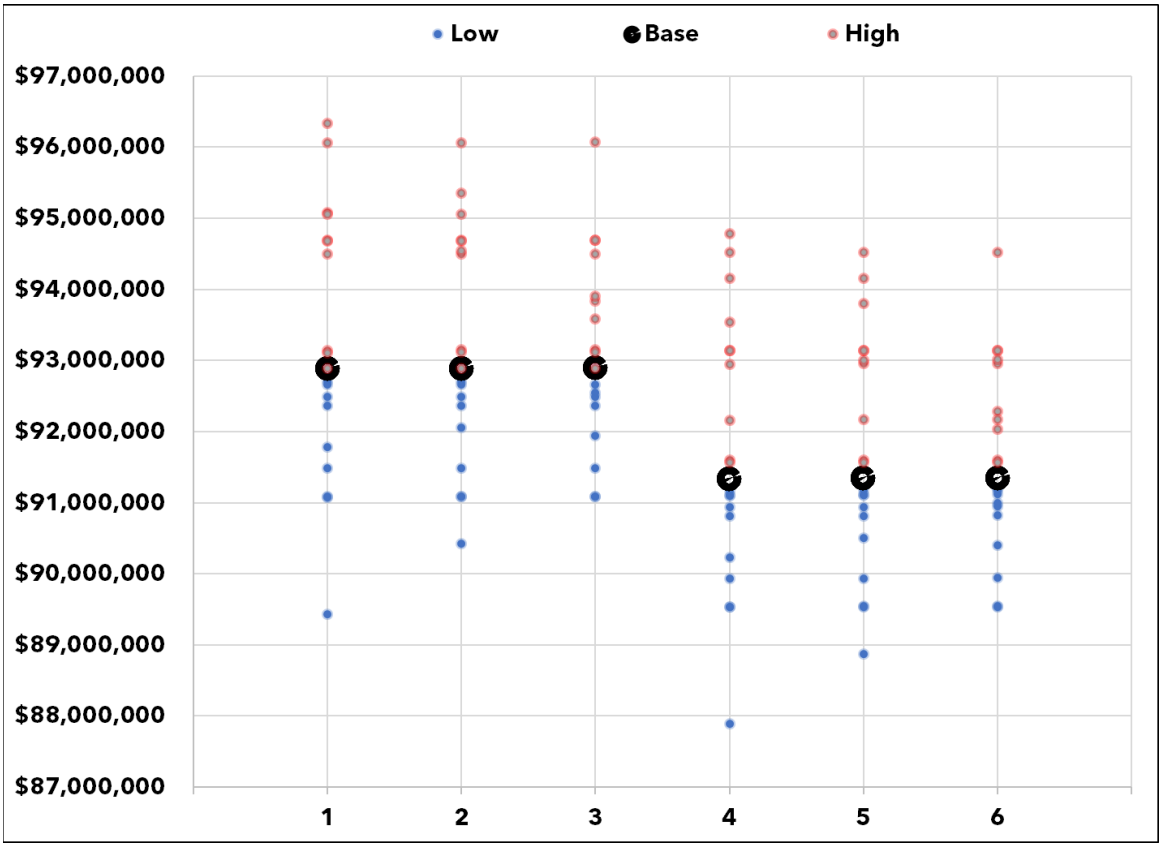
- **Pathway 1:** This range of outcomes is the reference case and it shows how much variability MW&L can expect from changes in market conditions over time.

- **Pathway 2**: Extending the NextEra PPA has little impact on MW&L's revenue requirements but it does reduce risk as shown by the narrower range of financial outcomes.

- **Pathway 3:** This pathway is slightly more costly because we assumed that the long-term PPA would be bundled with Tier I RECs at a slight premium to present-day REC prices. Note that the range of financial outcomes is narrower than in Pathways 1 or 2.

- **Pathways 4-6:** This pathway shows how LIHI certification could drop MW&L's cost of service, and that impact also carries into Pathways 5 and 6 where the LIHI certification is combined with each of the decisions in Pathway 2 and 3.

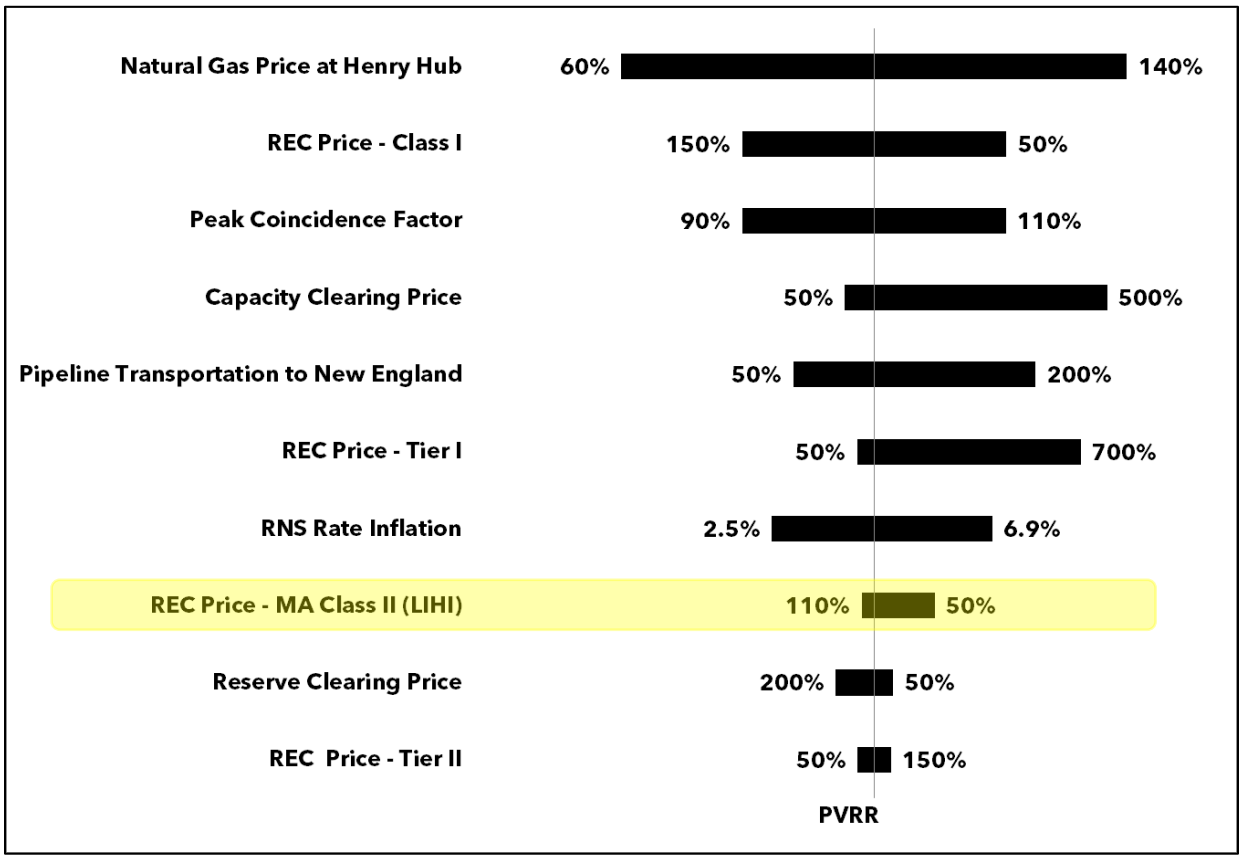
Figure 29: Scatter Plot of Financial Analysis Results (PV of Revenue Requirement)



The lowest cost outcomes occur when MW&L seeks LIHI certification for Cady's Falls and Morrisville #2. These outcomes are about 1-2% less costly than the reference case. This is one of the major conclusions of this chapter. LIHI certification can materially lower MW&L's costs. The other major conclusion is that the range of financial outcomes narrows when the cost of energy is hedged, as in Pathways 2, 3, 5 and 6.

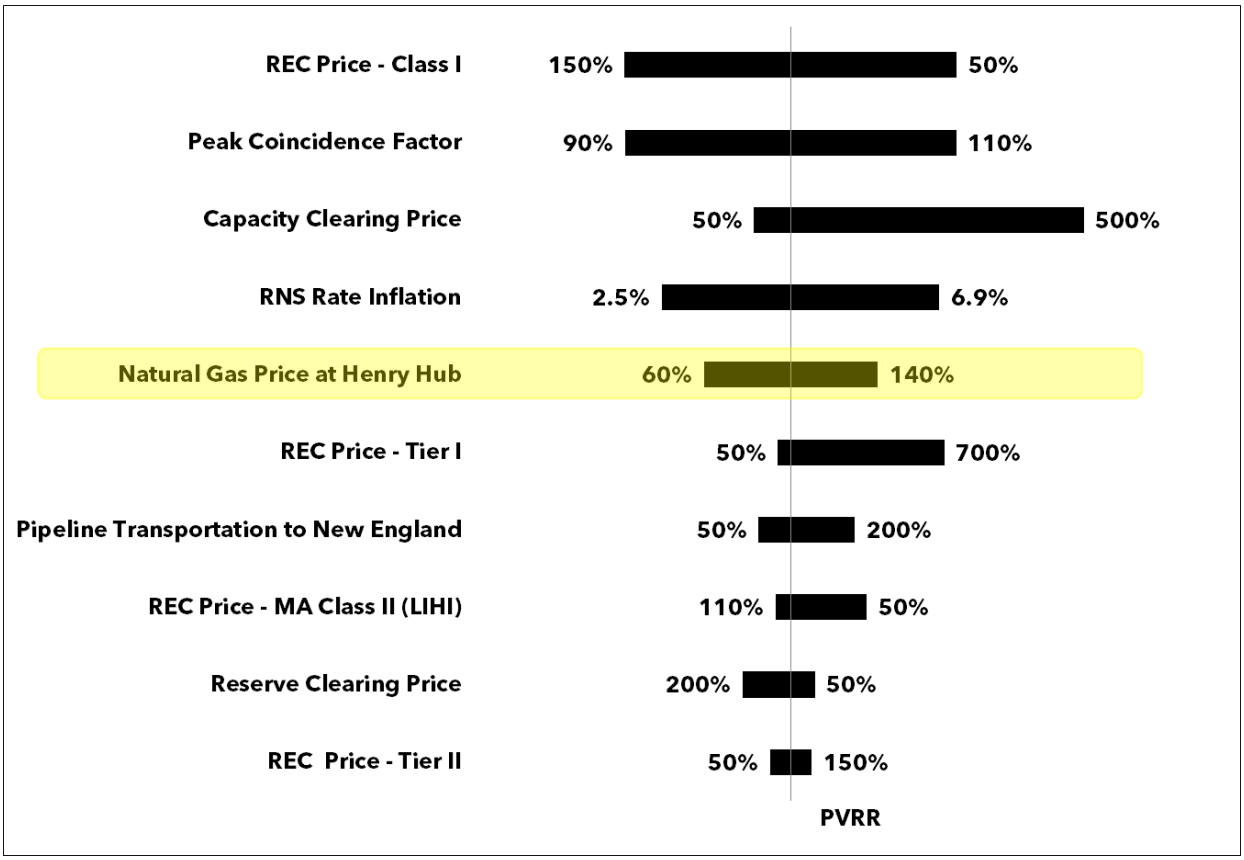
Figure 30 shows how the decision to seek LIHI certification changes the financial risks that MW&L faces. The primary change is highlighted in yellow. Pathway 4 shows that MA Class II REC prices become a minor financial risk, when before it was not present. In return for this risk, MW&L gets a significant, $1.5 million (1.7%) decrease in its cost of service. As a result, this is one of the preferred pathways in the analysis.

Figure 30: Sensitivity Analysis of Key Variables – Pathway 4 (LIHI Certification)



Pathway 6 (LIHI + Hydro PPA) is shown in Figure 31 and its risk profile is distinct from the other pathways. Class I REC prices rise into the top spot on the chart. However, this is not because REC price risk increases, but because natural gas price risk is so well hedged by the hydro PPA that it drops down into the middle of the chart.

Figure 31: Sensitivity Analysis of Key Variables – Pathway 6 (LIHI Certification + Hydro PPA)



This is a key conclusion of the analysis. The hydro PPA was modeled using monthly on and off-peak volumes that precisely matched up to the load forecast. As a result, it is a measurably superior hedge to the NextEra PPA, whose volumes were simply extended at their current levels. The conclusion is that any effort to more precisely forecast the load and shape the supply to match it is well spent. Precise matching of supply and demand reduces risks considerably compared to either the status quo or the extension of NextEra PPA.

Preferred Pathway = Pathway 6 – LIHI + Hydro PPA

The pathway with the lowest cost and least risk combination appears to be Pathway 6 – LIHI + Hydro PPA. This pathway lowers costs with LIHI certification and lowers risk with a well-shaped hydro PPA that hedges both energy and Tier I risks at the same time. However, the outcome of this strategy depends on MW&L's ability to negotiate energy and REC prices that are similar to or less than those that were assumed in this analysis. Similar outcomes can be had by purchasing these products separately, but it is rare to be able to sign long-term contracts for unbundled REC and energy.

Importantly, similar outcomes can be found in Pathways 4 and 5. Pathway 4 is attractive because it lowers costs and maximizes flexibility (the ability to contract for shorter terms at potentially lower market prices). Pathway 5 could also be equally attractive simply by renegotiating both the price and the volume of the NextEra contract such that it more precisely matches the electricity demand.

Impact of Supply – Demand Imbalances

The impact of supply-demand imbalances are summarized in Figure 32. Any time the supply of energy is less than the demand, lower market prices also lower MW&L's cost of service. Conversely, any time the supply is greater than the demand, higher market prices lower MW&L's cost of service. As a result, the financial impact of supply-demand imbalances are indeterminant, and depend on the market price of energy. Said differently, we cannot say with certainty that an imbalance (surplus or deficit of energy) is cost minimizing.

However, as we just learned in the previous section, the *size* of the imbalance has a direct impact on the price risk that MW&L faces. As a result, minimizing supply-demand imbalances is definitely *risk* minimizing.

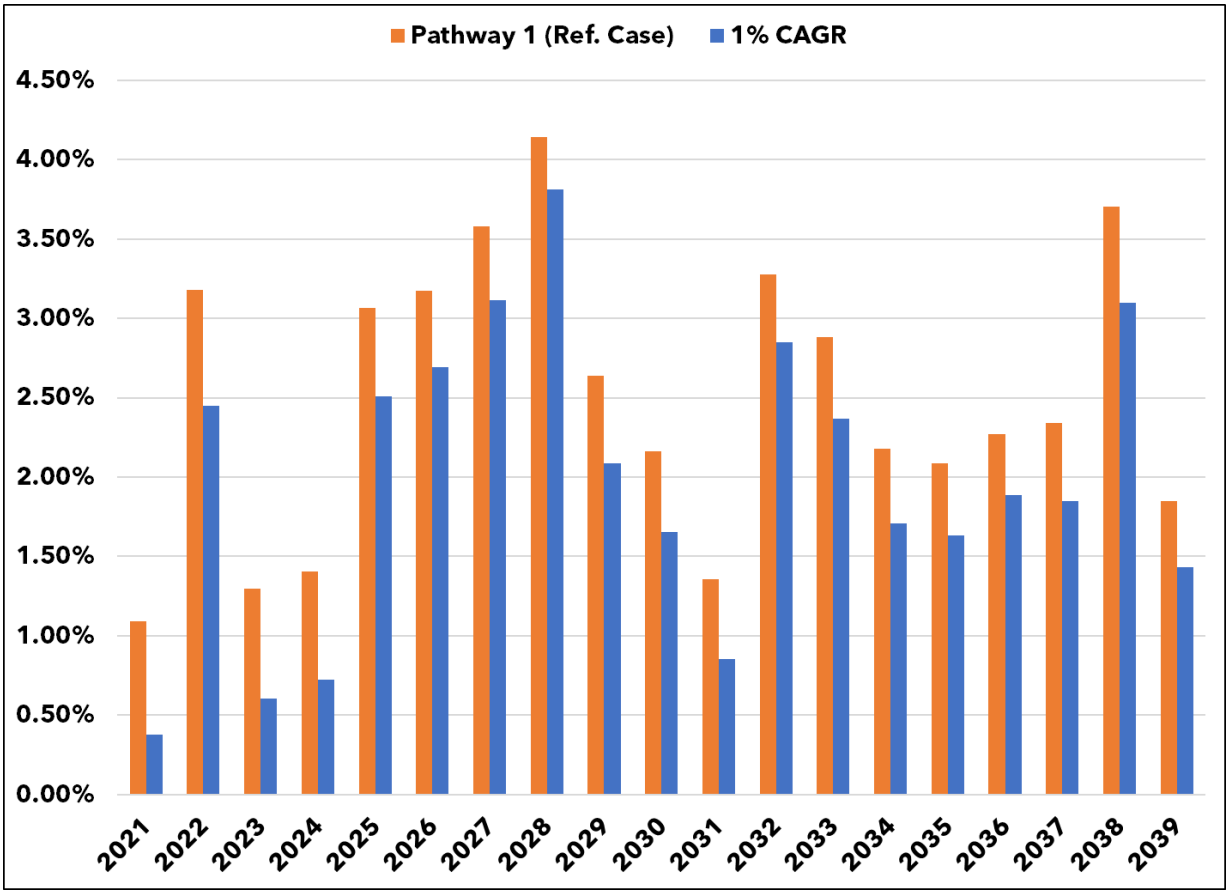
Figure 32: Quadrant Analysis of Market Price & Energy Length Outcomes

	Long MWH	Short MWH
Market Energy Prices HIGHER than Contract Price	**Cost of Service DECREASES**	**Cost of Service INCREASES**
Market Energy Prices LOWER than Contract Price	**Cost of Service INCREASES**	**Cost of Service DECREASES**

Impact of 1% Compound Annual Load Growth (CAGR)

Promoting energy-efficient load growth is an implied goal of the RES's Energy Transformation (Tier III) requirements. This section quantifies the impact that a 1% increase in annual load growth would have on retail rates. As Figure 33 shows, the impact is uniformly to lower rates. This is intuitive but is an important outcome to quantify. If this level of load growth were to occur between 2020 and 2032, for example, the 1% compound annual load growth could reduce rates by about 7% in 2032 as compared to the reference case.

Figure 33: Rate Impact of 1% CAGR Load Growth



Summary and Conclusions

The answers to the questions that were posed at the beginning of this chapter are now evident.

Decisions

1. Extension of the NextEra PPA
   Q1: What are the costs and benefits of extending NextEra volumes through 2039?
   A1: Extending the NextEra PPA simply continues the status quo in terms of the cost and risk that MW&L faces. However, the cost could be lowered by renegotiating the volumes to more precisely match the electricity demand.

2. New Long-Term Hydro PPA
   Q2: What are the costs and benefits of a dispatchable hydro PPA that includes both energy and Tier I RECs starting on 1/1/2025?
   A2: This decision represents an excellent hedge against the energy market, especially as compared to a small-hydro PPA whose volumes are seasonal. If Tier I RECs can be bundled into the PPA at an attractive price, this decision would also fulfill a large part of MW&L's Tier I requirements and reduce Tier I price risk.

3. Low Impact Hydro Institute Certification for Cady's Falls and Morrisville #2
   Q3: What are the costs and benefits of getting LIHI certification effective 1/1/25?
   A3: LIHI certification is the clearest path to reducing MW&L's costs and should be pursued as soon as possible after compliance with the new water quality certificate is achieved.

4. 1% CAGR
   Q4: What is the rate impact of adding 1% compound annual load growth to the load forecast?
   A4: 1% compound annual growth in load could reduce rates in 2032 by 7% compared to the reference case.

These and other conclusions are carried into the Action Plan in the following section.

Action Plan

VI. Action Plan

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

1. Automated Metering Infrastructure (AMI)

- MW&L 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, MW&L will have the information needed to examine the business case and make a decision to commit to implementation of an AMI system, or not. MW&L 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 MW&L 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. MW&L also notes that unanticipated initiatives may emerge over time that positively impact the perceived value of having an AMI system in place. MW&L is considering the potential benefit of a staged implementation that would initially focus on limited areas of high load or customer concentration.

2. Energy Resource Actions

- Manage year to year energy market requirements using fixed-price, market contracts that are less than five-years in duration.
- Negotiate a firm hydro PPA that includes bundled energy and Tier I renewable energy credits to reduce both energy and Tier I costs and risks.

3. Capacity Resource Actions

- Manage and monitor the reliability of Project 10 to minimize Pay-for-Performance (PFP) risk and maximize capacity, reserves, and PFP benefits.

4. Tier I Requirements

- Negotiate a firm hydro PPA that includes bundled energy and Tier I renewable energy credits to reduce both energy and Tier I costs and risks.
- Make forward purchases of qualifying RECs on the regional market to manage REC price and ACP risk.

5. Tier II Requirements

- Commission the Lawrence Brook Solar project, bank surplus RECs for future compliance years to the extent allowed.
- Make forward purchases of qualifying RECs on the Vermont market to manage REC price and ACP risk.
- Investigate adding storage to upcoming solar projects to increase their value and decrease overall project costs.

6. Tier III Requirements

- Identify and deliver prescriptive and/or custom Energy Transformation programs, and/or
- Commission the Lawrence Brook solar project and retire surplus RECs to fulfill Tier III to the extent allowable.
- Purchase a surplus of Tier II qualifying renewable energy credits.

7. Active Load Control Pilot Program

- 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. 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.

10. 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: Lamoille County Regional Plan

This appendix is provided separately in a file named:

Appendix A – Lamoille County Regional Plan.pdf

Appendix B: 2020 Tier 3 Annual Plan

This appendix is provided separately in a file named:

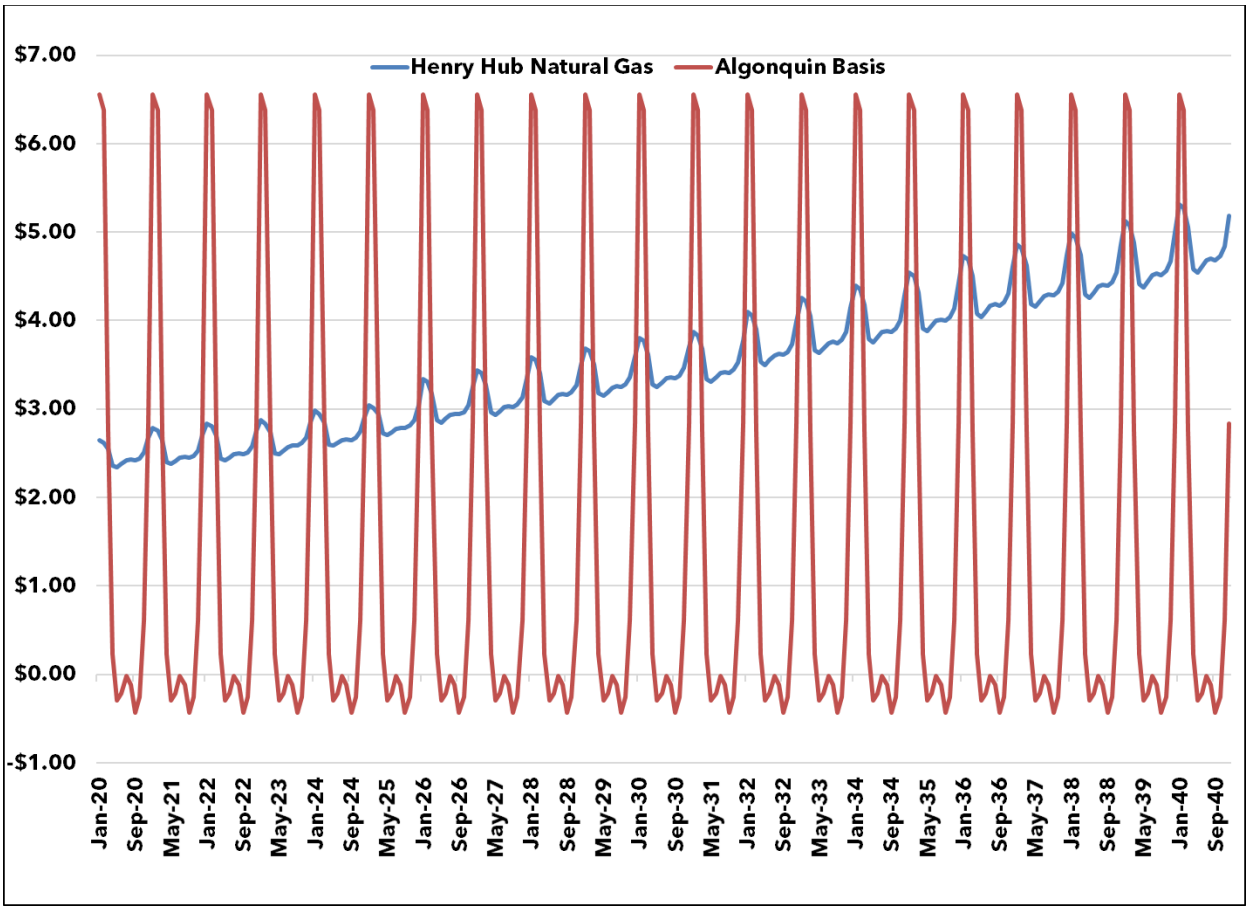
Appendix B - VPPSA Tier 3 2020 Annual Plan.pdf

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 34.

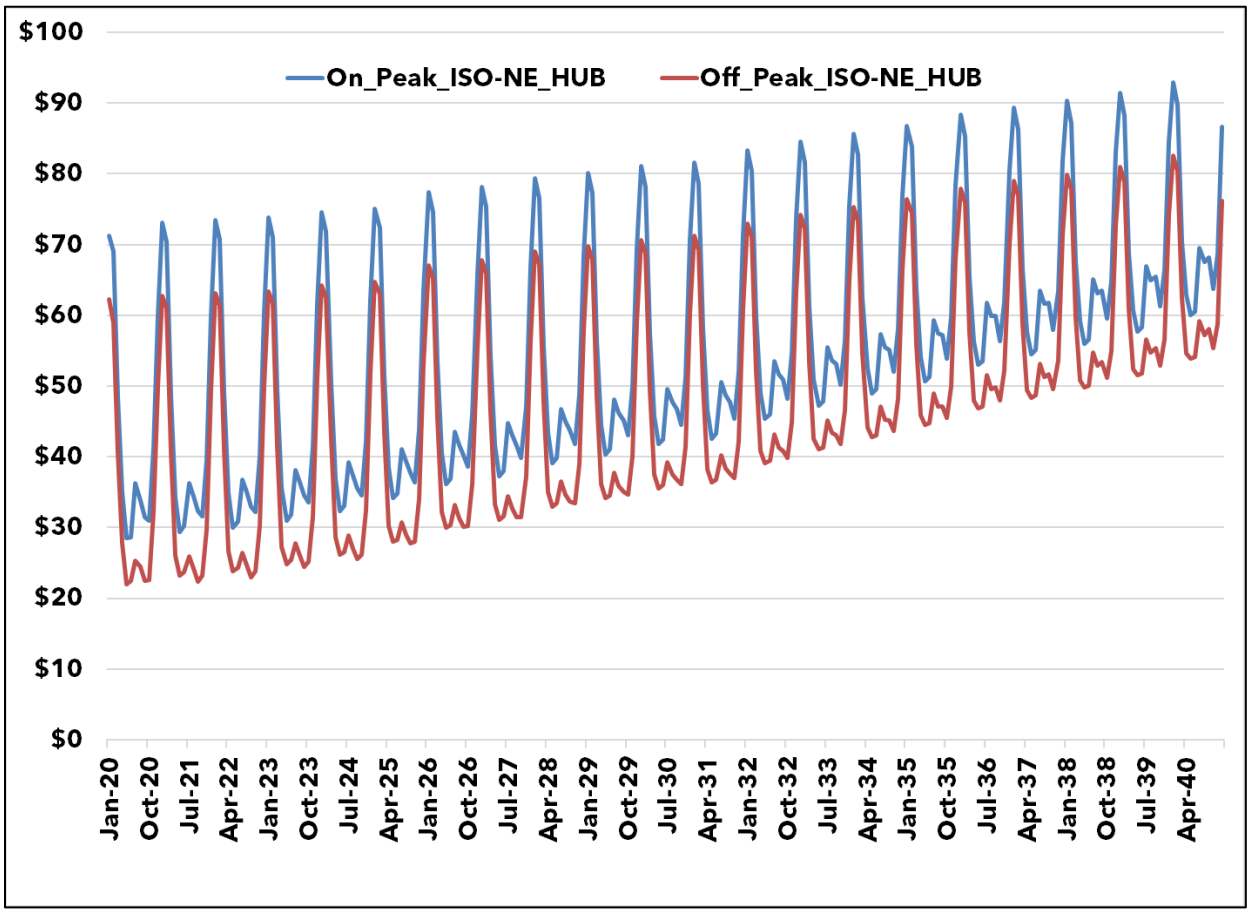
Figure 34: Henry Hub Natural Gas Price Forecast (Nominal $/MMBtu)



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 35.

Figure 35: Electricity Price Forecast (Nominal $/MWH)

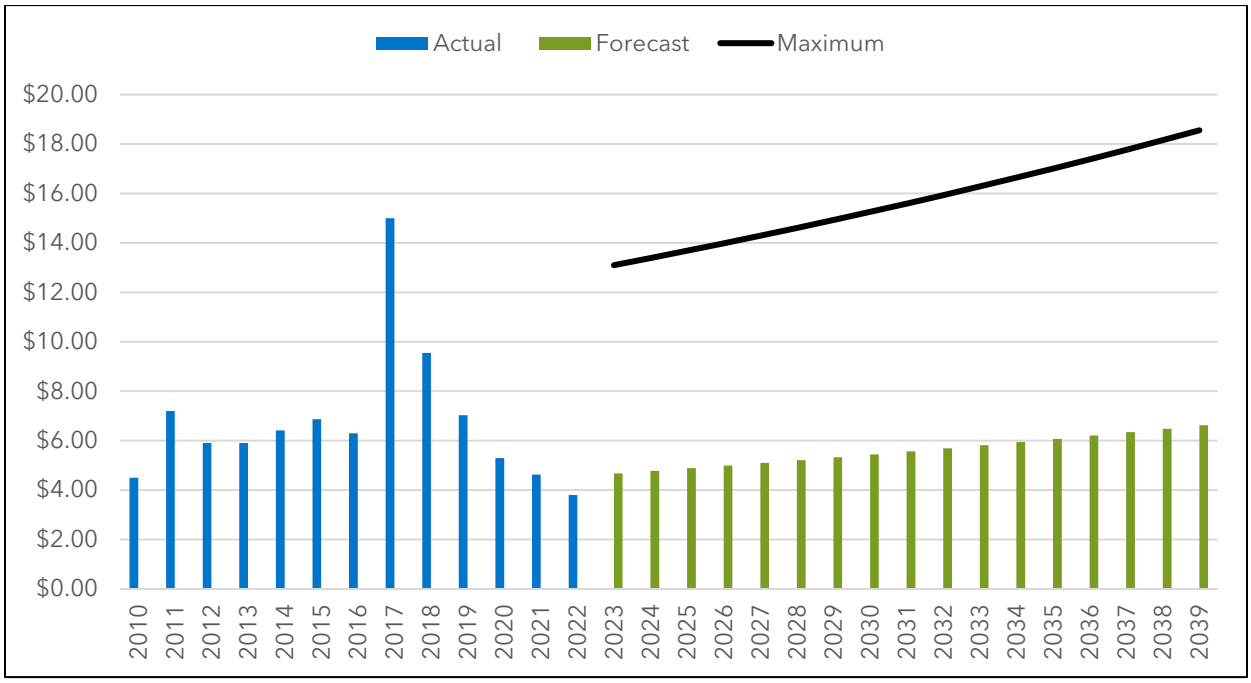


Finally, and in keeping with the function of ISO-NE's Standard Market Design, we use a five-year average basis between LMP nodes to adjust the price forecast at the MA Hub to the location of MW&L's load and resources.

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 36. This line represents the Forward Capacity Auction Starting Price plus inflation.

Figure 36: Capacity Price Forecast (Nominal $/kW-Month)



Appendix D: PUC Rule 4.900 Outage Reports

Morrisville Water and Light **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	Morrisville Water and Light
Calendar year report covers	2014
Contact person	Craig Myotte
Phone number	888-3348
Number of customers	3,979

System average interruption frequency index (SAIFI) = 0.6
Customers Out / Customers Served

Customer average interruption duration index (CAIDI) = 2.5
Customer Hours Out / Customers Out

	Outage cause	Number of Outages	Total customer hours out
1	**Trees**	45	3,801
2	**Weather**	11	313
3	**Company initiated outage**	12	906
4	**Equipment failure**	15	478
5	**Operator error**	0	0
6	**Accidents**	5	69
7	**Animals**	10	64
8	**Power supplier**	0	0
9	**Non-utility power supplier**	3	4
10	**Other**	0	0
11	**Unknown**	6	44
	Total	107	5,679

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.

Morrisville Water and Light 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	Morrisville Water and Light
Calendar year report covers	2015
Contact person	Craig Myotte
Phone number	888-3348
Number of customers	4,025

System average interruption frequency index (SAIFI) = Customers Out / Customers Served	**0.9**
Customer average interruption duration index (CAIDI) = Customer Hours Out / Customers Out	**1.7**

	Outage cause	Number of Outages	Total customer hours out
1	**Trees**	15	2,416
2	**Weather**	11	1,529
3	**Company initiated outage**	24	351
4	**Equipment failure**	17	589
5	**Operator error**	3	121
6	**Accidents**	11	355
7	**Animals**	6	229
8	**Power supplier**	0	0
9	**Non-utility power supplier**	2	4
10	**Other**	1	5
11	**Unknown**	10	366
	Total	100	5,964

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.

Morrisville Water and Light Reliability

March 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 calender year.

Electricity Outage Report -- PSB Rule 4.900

Company: Morrisville Water and Light
Calender Year: 2016
Contact Person: Craig Myotte
Phone Number: (802)888-3348
Customers Served: 4025

System average interuption frequency index (SAIFI) = **3.76**
Customers out / Customers served

Customer average interuption duration index (CAIDI) = **2.39**
Customer hours out / Customers out

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

Outage Cause	Number of outages	Total customer hours out
Accident	7	760.07
Animal	9	384.97
Company initiated	20	13249.83
Equipment Failure	18	7476.38
No Outage	2	24.30
non-utility	2	5.33
Operator Error	2	13.05
other	1	7.00
Power Supplier	9	7226.18
Trees	44	4985.80
Unknown	10	2336.98
Weather - Wind	6	162.62
Total	130	36632.51

Morrisville Water and Light Reliability
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 calender year.

Electricity Outage Report -- PSB Rule 4.900

Company: Morrisville Water and Light
Calender Year: 2017
Contact Person: Craig Myotte
Phone Number: (802)888-3348
Customers Served: 4179

System average interuption frequency index (SAIFI) = **2.71**
Customers out / Customers served

Customer average interuption duration index (CAIDI) = **1.69**
Customer hours out / Customers out

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

Outage Cause	Number of outages	Total customer hours out
Accident	4	522.53
Animal	10	250.57
Company initiated	12	361.23
Equipment Failure	9	1694.18
Operator Error	1	10.87
other	1	6.63
Trees	53	15037.73
Unknown	11	1222.10
Weather - Wind	9	44.82
Total	110	19150.66

Morrisville Water and Light Reliability Report

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 calender year. Electricity Outage Report -- PSB Rule 4.900

Electricity Outage Report -- PSB Rule 4.900

Company: Morrisville Water and Light
Calendar Year: 2018
Contact Person: Craig Myotte
Phone Number: (802) 888-3348
Customers Served: 4179

System average interuption frequency index (SAIFI) = Customers out / Customers served	2.21
Customer average interuption duration index (CAIDI) = Customer hours out / Customers out	2.50

Outage Code	# of Outages	Total Hours Out
Accident	5	17.13
Animal	29	28.85
Company initiated	3	7.97
Equipment Failure	20	57.42
Trees	124	545.31
Unknown	4	8.57
Weather - Wind	1	1.40
Total	186	666.65

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

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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ISO-NE PUBLIC **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		
	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
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	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.)
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

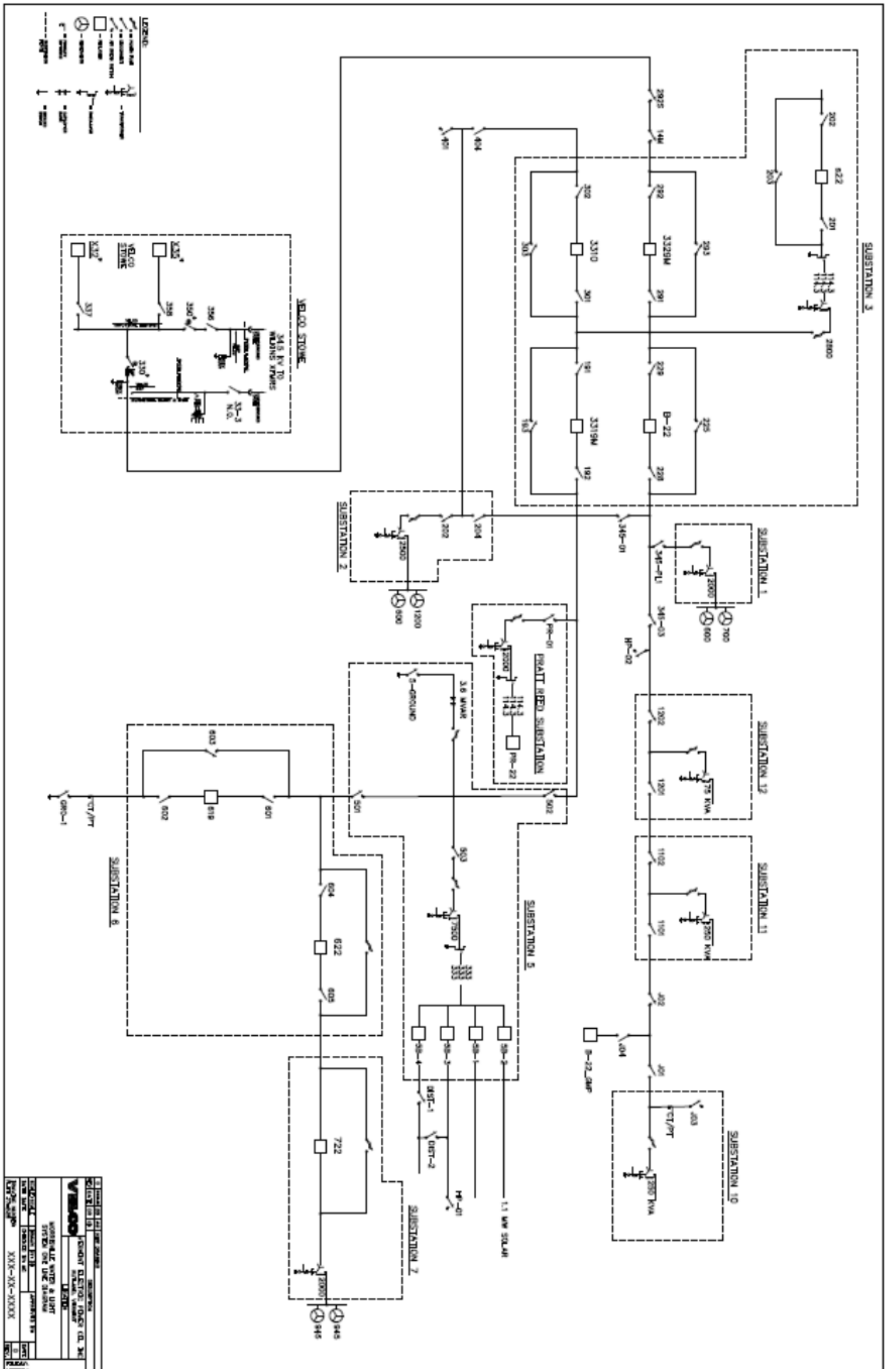
Table V: Grid Support Utility Interactive Inverter Functions Status

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

2

with unity PF.

Appendix F: One-Line Diagrams


SUBSTATION 3
SUBSTATION 2
SUBSTATION 1
SUBSTATION 12
SUBSTATION 11
SUBSTATION 10
SUBSTATION 5
SUBSTATION 6
SUBSTATION 7
VELCO STONE

Glossary

Glossary

ACP	Alternative Compliance Payment
ACSR	Aluminum conductor steel-reinforced
APPA	American Public Power Association
CAGR	Compound Annual Growth Rate
CAIDI	Customer Average Interruption Duration Index
CC	Combined Cycle (Power Plant)
CCHP	Cold Climate Heat Pump
CEDF	Clean Energy Development Fund
CEP	Comprehensive Energy Plan
DPS	Department of Public Service or "Department"
EIA	Energy Information Administration
ET	Energy Transformation (Tier III)
EV	Electric Vehicle
EVT	Efficiency Vermont
FERC	Federal Energy Regulatory Commission
GMP	Green Mountain Power
HPWH	Heat Pump Water Heater
IRP	Integrated Resource Plan
ISO-NE	ISO New England (New England's Independent System Operator)
kV	Kilovolt
kVA	Kilovolt Amperes
kW	Kilowatt
kWh	Kilowatt-hour
LCPC	Lamoille County Planning Commission
LIHI	Low Impact Hydro Institute
MAPE	Mean Absolute Percent Error
ME II	Maine Class II (RECs)
MEAV	Municipal Association of Vermont
MSA	Master Supply Agreement
MVA	Megavolt Ampere
MW	Megawatt
MWH	Megawatt-hour
MW&L	Morrisville Water & Light Department
NEPPA	Northeast Public Power Association
NYPA	New York Power Authority
PFP	Pay for Performance
PUC	Public Utility Commission
PPA	Power Purchase Agreement
R^2	R-squared
RES	Renewable Energy Standard
RTLO	Real-Time Load Obligation
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
TIER I	Total Renewable Energy (Tier I)
TIER II	Distributed Renewable Energy (Tier II)
TIER III	Energy Transformation (Tier III)
TOU	Time-Of-Use (Rate)

VEC	Vermont Electric Cooperative
VELCO	Vermont Electric Power Company
VEPPI	Vermont Electric Power Producers, Inc.
VFD	Variable Frequency Drive
VSPC	Vermont System Planning Committee
VT ANR	Vermont Agency of Natural Resources
WQC	Water Quality Certificate

Vermont Public Power Supply Authority

Putting the Public in Power.
www.vppsa.com

P.O. Box 126 • 5195 Waterbury-Stowe Rd. • Waterbury Center, VT 05677 • 802.244.7678 • Fax: 802.244.6889

Lamoille County Regional Plan:
https://www.lcpcvt.org/vertical/Sites/%7B3C01460C-7F49-40F5-B243-0CA7924F23AF%7D/uploads/2015-2023_Regional_Plan_as_amended_on_May_22_2018.pdf

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Vermont Public Power Supply Authority
2020 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 2020 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 ("Tier 3") projects or purchase additional Renewable Energy Credits ("RECs") from small, distributed renewable generators ("Tier 2").

VPPSA's Requirement

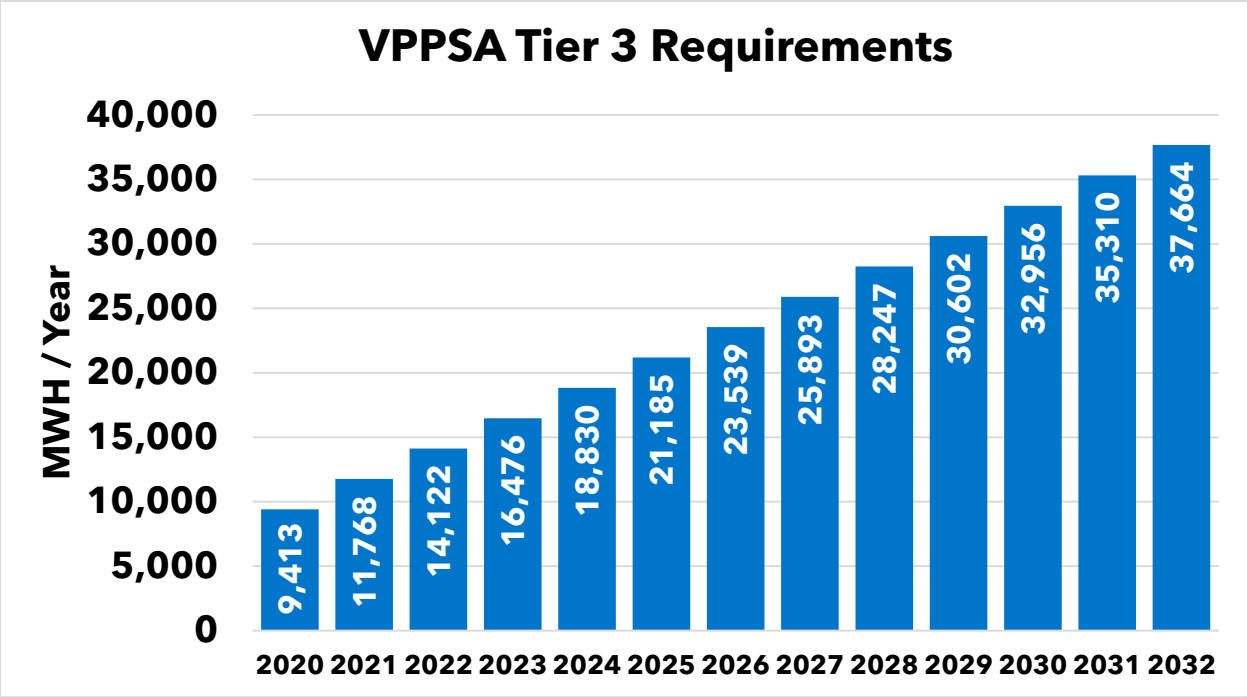
Utilities' Tier 3 requirements are established by 30 V.S.A. § 8005(a)(3)(B), which states that "in the case of a provider that is a municipal electric utility serving not more than 6,000 customers, the required amount shall be two percent of the provider's annual retail sales beginning on January 1, 2019.[1]"

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 11 VPPSA member utilities plan to meet Tier 3 requirements in aggregate. In 2020, VPPSA's aggregate requirement is estimated to be 9,413 MWh equivalent in savings, representing 2.67% of annual retail sales.

VPPSA Members:
- **Barton Village**
- **The Village of Enosburg Falls**
- **Hardwick Electric Department**
- **Village of Jacksonville**
- **Village of Johnson**
- **Ludlow Electric Light Department**
- **Lyndonville Electric Department**
- **Morrisville Water & Light**
- **Northfield Electric Department**
- **Village of Orleans**
- **Swanton Village**

[1] 30 V.S.A. § 8005(a)(3)(B)

Tier 3 requirements increase by .67% annually. The below chart represents VPPSA's projected annual MWh equivalent in savings through 2032.



Summary of 2019 Projects

VPPSA expects to meet its 2019 Tier 3 requirements of 7,059 MWh through a combination of prescriptive and custom measures and through employing excess Tier 2 RECs as needed.

Prescriptive measures included post-purchase rebates for:

1. Cold Climate Heat Pumps
2. Heat Pump Water Heaters
3. Electric and Plug-In Hybrid Vehicles

Of the three prescriptive measures, we found cold climate heat pumps to be the most successful. We additionally found that custom measures, while providing a greater return in MWh savings at a lower cost, tend to have a longer ramp-up time. We identified and began working on multiple custom measures in 2019, but completion will likely not take place until a later date. Because the pricing of Tier 2 RECs was lower than the cost of implementing Tier 3 programs, purchasing excess Tier 2 was an effective strategy for keeping the Tier 3 compliance cost low. However, to accommodate the changing REC market prices, we have preemptively employed a Tier 3 marketing strategy to raise customer awareness around Energy Transformation Projects and increase uptake in the coming years.

2020 Program Overview

VPPSA proposes employing a similar strategy to meet the 2020 Tier 3 requirements while mitigating costs that could put upward pressure on rates. This includes a combination of prescriptive and custom measures and use of excess Tier 2 RECs.

Prescriptive Measures

VPPSA intends to expand its prescriptive measures offerings. Savings are estimated using measure characterizations created by the Tier 3 TAG. VPPSA's budget and estimated savings for prescriptive Tier 3 Programs is summarized below.

Cold Climate Heat Pumps

VPPSA will continue to offer customer rebates for the purchase of cold climate heat pumps ("CCHP".) In 2020 the rebate amount will be increased to $400. For customers that can demonstrate a defined level of building performance, the CCHP rebate will be increased to $500. The additional incentive serves to highlight the importance of overall building performance. 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 TAG.

Heat Pump Water Heaters

VPPSA will provide rebates to customers that install heat pump water heaters ("HPWH") to replace fossil-fuel fired water heaters. In 2019, VPPSA's post-purchase incentives were provided in conjunction with Efficiency Vermont's ("EVT") upstream rebates, which are paid to the equipment distributor. Because EVT and VPPSA were both claiming fossil fuel savings in 2019 for HPWH that replaced fossil-fuel water heaters, it was necessary to split savings and costs between the two entities. VPPSA continues to urge EVT to avoid using Thermal Energy and Process Fuels ("TEPF") funds for incentives on electrification measures. For 2020, VPPSA and EVT have agreed that VPPSA will fund 100% of the upstream rebate for HPWH that replace fossil fuel systems and thus will claim 100% of the fossil fuel savings in the form of Tier 3 credits. Efficiency Vermont will fund the upstream rebate and claim the associated savings for HPWH that are installed to replace *electric* water heaters.

Electric Vehicles and Plug-In Hybrids

Despite lower operating and maintenance costs associated with electric vehicles ("EVs") 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 676 vehicles, or 26%, over the past year. These vehicles comprised 4.1% of new passenger vehicle registrations over the past quarter. Nonetheless, there were only 3,288 plug-in vehicles registered in Vermont as of July 2019.

VPPSA is 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 and raise the rebate levels in 2020. The customer incentive for purchasing or leasing a new electric vehicle will be $1000 and the customer incentive for purchasing or leasing a new plug-in hybrid electric vehicle will be $500. Low-income customers[2] will receive an additional $400 towards the purchase or lease of an EV or PHEV.

To further expand on this program, VPPSA is adding incentives for purchasing used EVs and PHEVs. The customer incentive will be $500 for the purchase of a used EV and $250 for the purchase of a used PHEV. We are also adding a $500 incentive for the purchase of a Level 2 Charger.

Forklifts

Several industrial customers in VPPSA Members' territories utilize forklifts in their operations. Because the potential fossil fuel savings from converting diesel forklifts to those powered by electricity is significant VPPSA will actively work with these customers to determine whether a conversion is feasible. We are adding a rebate incentive of $3000.

Golf Carts

VPPSA has identified opportunities to switch golf carts from fossil fuel to battery powered. We are adding a rebate incentive of $50.

Lawn Mowers

VPPSA will be adding both commercial and residential lawn mower incentives. A rebate of $25 for a residential lawn mower and $1,000 for a commercial lawn mower will be available in 2020.

E-Bikes

Utility customers have expressed interest in e-bikes, which has led VPPSA to add a rebate incentive of $100 for the purchase of a new e-bike or e-bike conversion kit.

[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.

Measure	Savings/Unit (MWh)	Incentive Amount	Admin Cost	Total Cost	Volume	Cost/MWh	Credit (MWh)	Budget
EV	31.88	$1,000	$403	$1,403	16	**$44.00**	510	$22,443
PHEV	24.55	$500	$310	$810	18	**$33.00**	442	$14,582
EV (Low Income)	31.88	$1,400	$403	$1,803	5	**$56.55**	159	$9,013
PHEV (Low Income)	24.55	$900	$310	$1,210	5	**$49.29**	123	$6,050
EV (Used)	15.94	$500	$201	$701	4	**$44.00**	64	$2,805
PHEV (Used)	12.27	$250	$155	$405	4	**$33.01**	49	$1,620
CCHP	21.74	$400	$275	$675	42	**$ 31.03**	913	$28,333
CCHP (Weatherized)	26.84	$500	$339	$ 839	8	**$31.26**	215	$6,712
HPWH	14.23	$650	$180	$830	10	**$58.31**	142	$8,297
Level 2 Charger	16.75	$500	$212	$ 712	4	**$42.48**	67	$2,805
Forklift	89.64	$3,000	$1,132	$4,132	3	**$46.10**	269	$12,397
Golf Cart	3.24	$50	$41	$91	25	**$28.06**	81	$2,273
Lawn Mower (Residential)	1.51	$25	$19	$44	20	**$29.19**	30	$881
Lawn Mower (Commercial)	52.35	$1,000	$814	$1,814	2	**$28.15**	129	$3,628
E-Bike	5.3	$100	$67	$167	10	**$31.57**	53	$1,667
TOTAL					**176**	**$38.06**	**3,246**	**$123,549**

Custom Measures

Commercial and industrial ("C&I") customers will be served on an individual, custom basis in 2020. 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 ski resorts, a furniture maker, a quarry, and a candy manufacturer. Due to the long ramp-up time expected for these projects, completion will likely take place after 2020. The Tier 3 savings would be claimed in the year the project is completed. VPPSA will continue to work with the DPS on custom projects to ensure savings claims are valid and able to be evaluated.

Tier 2 RECs

To the extent that there is a shortfall in savings from the prescriptive and custom measures, VPPSA will 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. For VPPSA members that own Tier 2 eligible generating resources, Tier 2 RECs may be the primary strategy for Tier 3 compliance.

Should REC prices increase, VPPSA will reevaluate its incentive levels and potentially increase the rebate value. In that situation, VPPSA would re-file its annual Tier 3 planning document.

Demand Management

Over the long-term, Tier 3 programs 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.

VPPSA has established a partnership with Virtual Peaker, allowing us to assist our members in demand-response programming. In 2020, VPPSA will be piloting the following demand-response programs to keep peak load and the cost of electricity at a minimum:

1. Internal utility behavioral demand-response program to strategically maximize load-reducing generation
2. Active demand-response programs to control electric devices including CCHPs, HPWHs, and Level 2 chargers

VPPSA is also exploring partnerships outside of Virtual Peaker to best deploy demand-response programming.

Equitable Opportunity

The Tier 3 incentives described above will be available to all VPPSA member utility 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. 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.

Partnership, Collaboration, and Marketing

VPPSA plans to continue actively working with both public and private partners to best execute our Tier 3 plan in the most cost-effective way.

VPPSA is participating in administering the VTrans electric vehicle incentive. The VTrans incentive is offered on the sale of any vehicle registered in Vermont. The value of the VTrans incentive is dependent upon the owner's household income level. Participating car dealers will sell the vehicle at a price reduced by the statewide incentive. The dealer will then submit the customer's information and vehicle details to VPPSA. VPPSA will batch the incentives on a monthly basis and send the information to VTrans with a summary report and invoice. VTrans will pay VPPSA for the state incentive, which VPPSA will then remit to the dealer. We anticipate that stacked incentives and collaboration with car dealers will help to increase participation in VPPSA's electric vehicle rebate program.

VPPSA and EVT are working together to define how the two entities can provide holistic efficiency services to residential, commercial, and industrial customers. In many cases, this partnership involves VPPSA providing incentives for electrification measures, which can provide benefits to all VPPSA utility customers, while EVT provides incentives for thermal and electric efficiency measures.

VPPSA and EVT are also working closely on the Energy Savings Account pilot, which involves Ethan Allen and the Village of Orleans. This pilot allows Ethan Allen to engage in

electrical efficiency measures and helps to identify opportunities for strategic energy transformation projects.

Two VPPSA member utility areas have been selected for EVT's 2020 Targeted Communities. The Village of Johnson and the Village of Orleans will both receive enhanced services from EVT for efficiency. This is yet another opportunity to explore strategic electrification for customers while reducing overall energy burden. The 2020 Targeted Communities effort is designed to have the greatest impact on low-income households.

VPPSA is taking on a greater role in utility customer interaction. Historically, the individual VPPSA member utilities were responsible for customer outreach. With the addition of Tier 3 projects, VPPSA will educate utility customers on the available incentives through use of the following:

- VPPSA website
- VPPSA member utility websites
- Social media
- Front Porch Forum
- Collaborative events and workshops
- Car dealer outreach
- EVT contractor and distributor outreach