Vermont Long-Term Forecast
Preliminary Results
June 22, 2023

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Agenda

1. Forecast Approach

2. Results

3. Solar, Heat Pumps, and EV Load Impacts

4. Questions

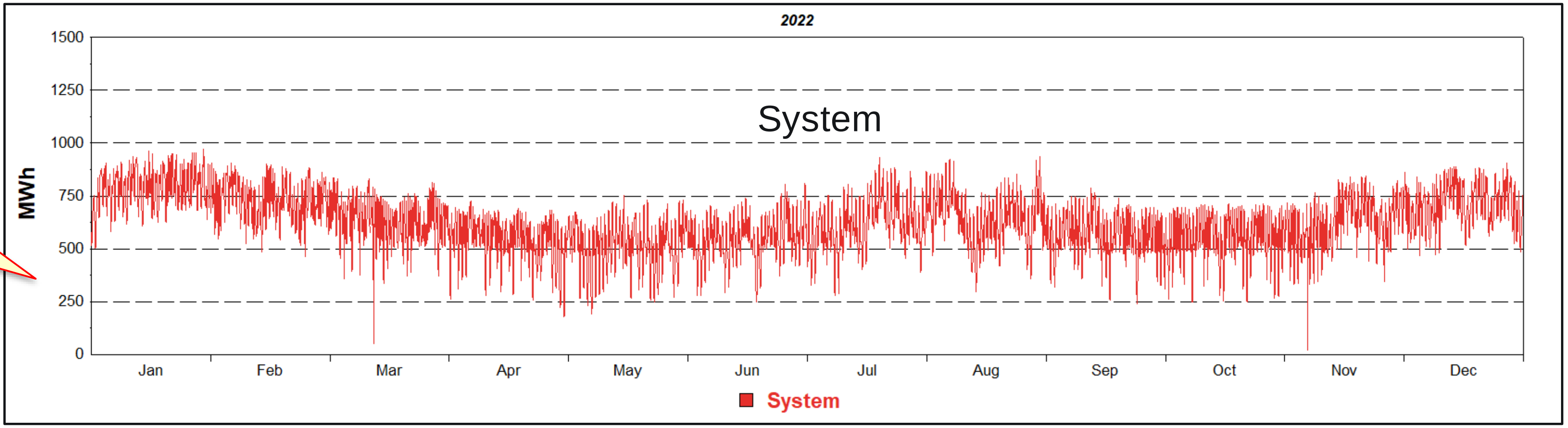
Approach

1. Reconstitute Sales and Load for Solar Generation

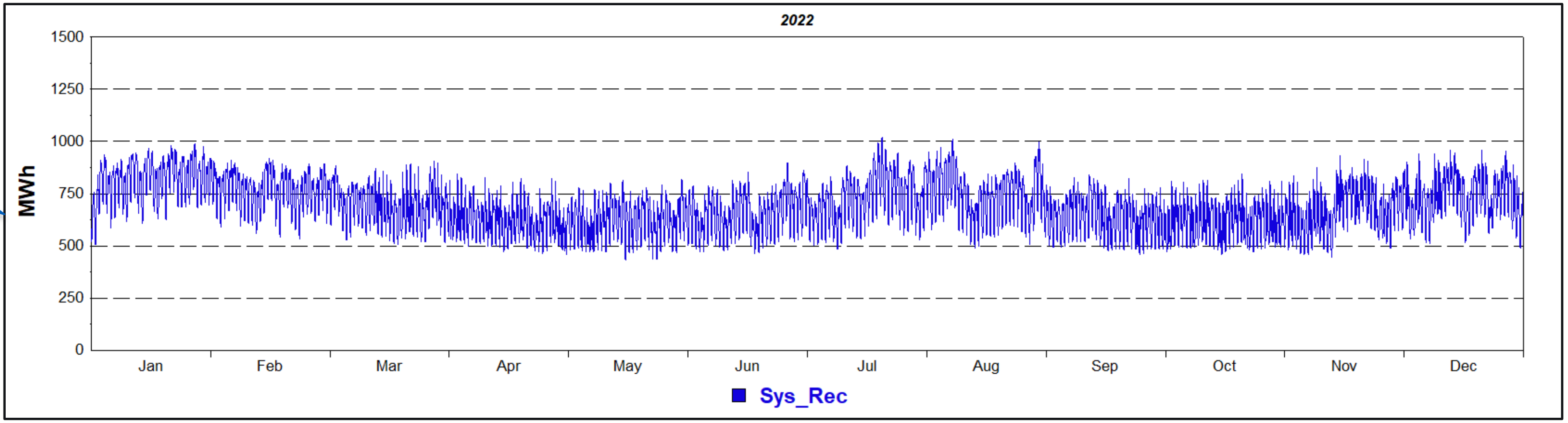
» Forecast based on reconstituted class sales and system and zonal hourly loads (gross load)

- Given the large amount of embedded solar, its impossible to model net demand (what is measured by VELCO)

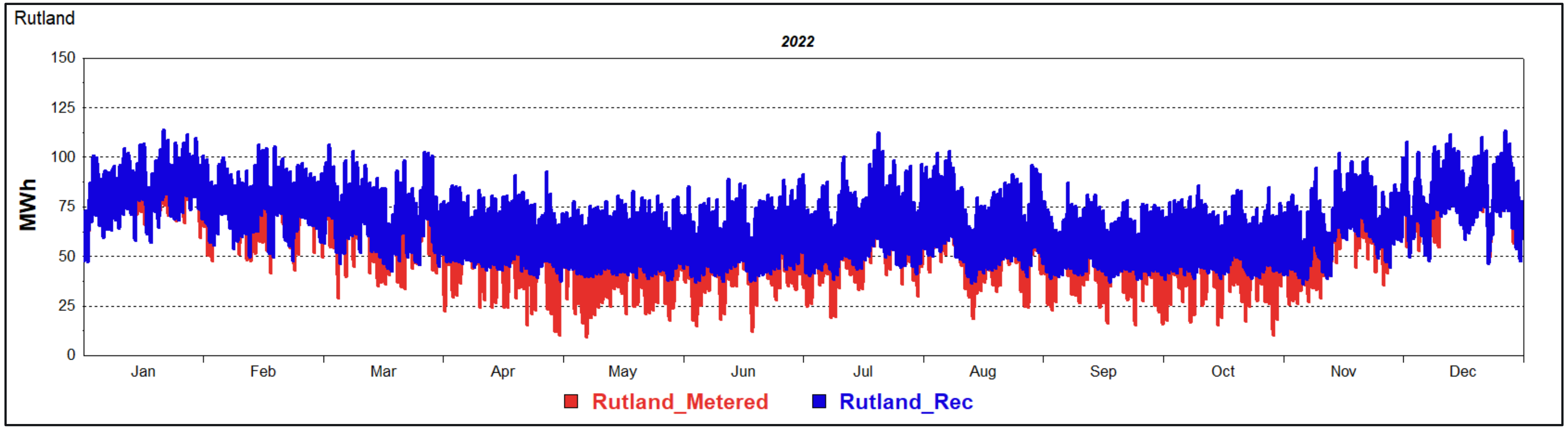
What we see

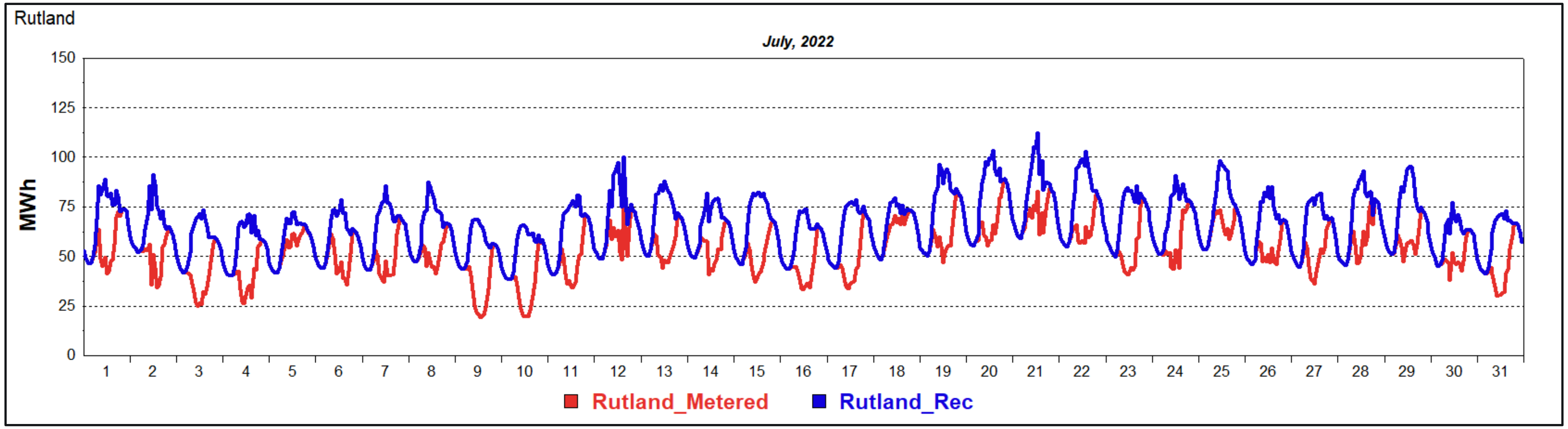


What we model



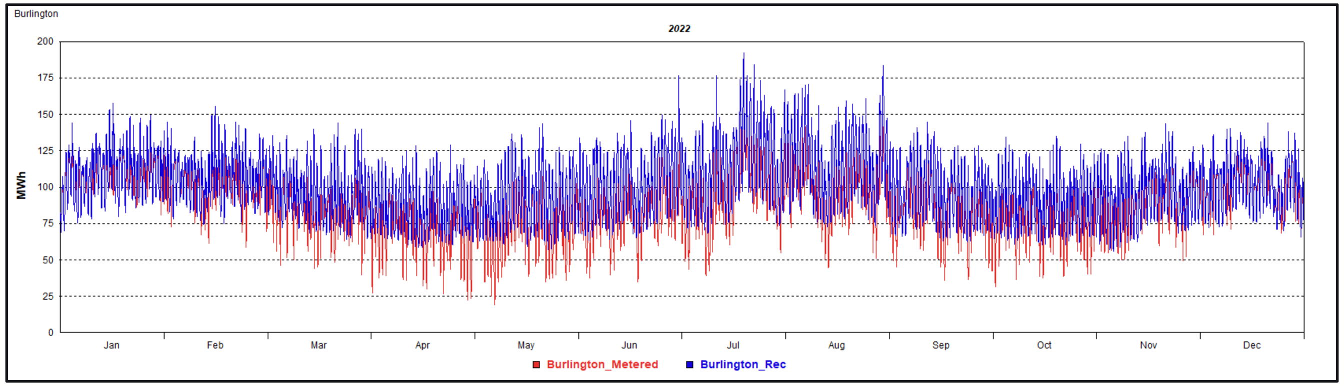
Need to reconstitute loads for each zone



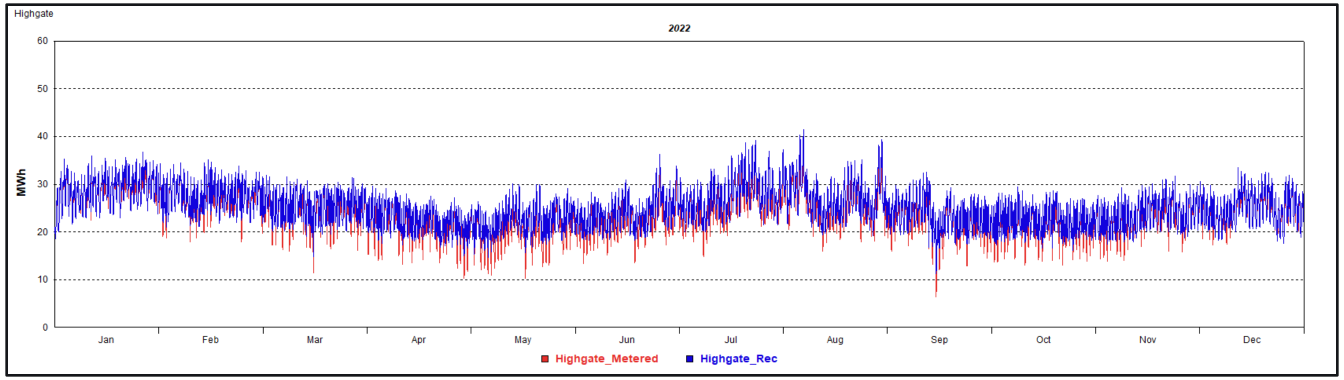


Reconstituted Load Examples

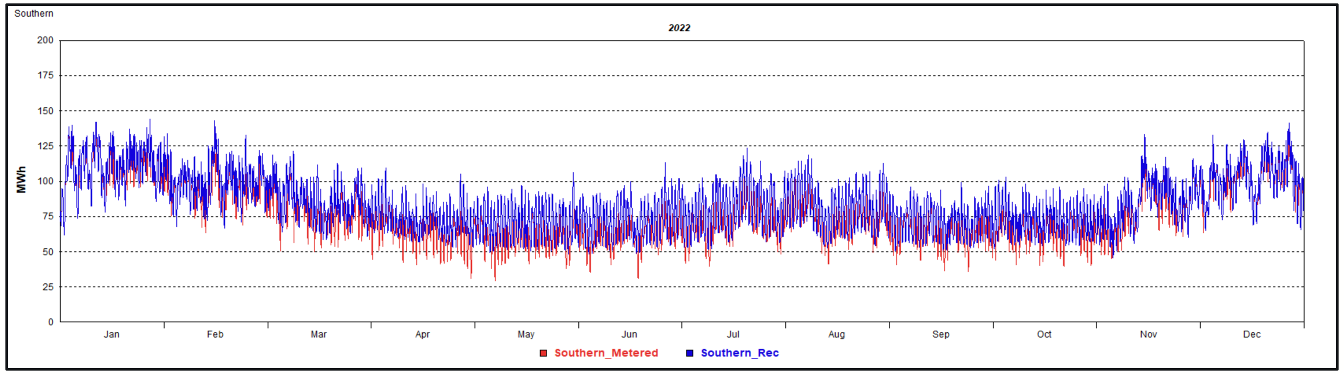
Burlington



Highgate



Southern



2. Develop Rate Class Energy Requirements Forecast

» Sales forecast based on state reported billed sales and customers through December 2022.
  - Reconstituted for solar own use

» Separate regression models estimated for residential, commercial, and industrial classes
  - Residential average use and commercial sales estimated using an SAE model specification

» Model variables incorporate:
  - Population/household growth
  - Economic growth – state income, employment, gross state output (real $)
    - Moody Analytics January 2023 state economic forecast
  - End-use and building shell efficiency and saturation trends
    - AEO 2023 New England forecast calibrated to state residential survey and NREL ResStock and ComStock simulations for Vermont
  - 2023 state energy efficiency savings projections (current Demand Resource Plan)
  - CDD and HDD reflect increasing temperature trend (0.9 degrees per decade)

Class Sales Models (reconstituted for solar)

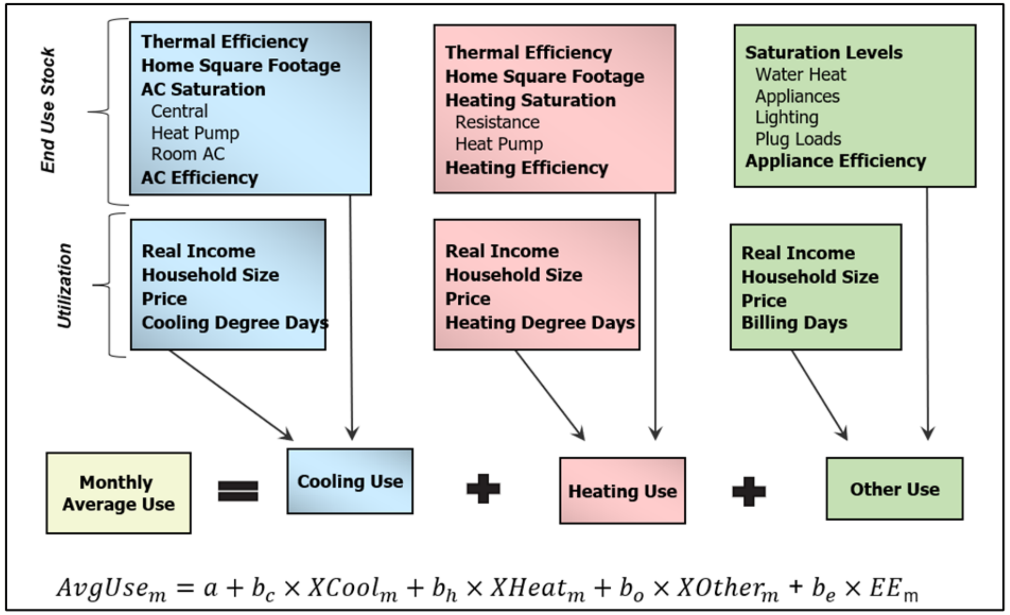
» Residential
- End-use intensity trends
  - Saturation (ownership)
  - Efficiency (both standards and EE programs)
- Square Footage
- Thermal shell efficiency
- Household size and income
- Weather (HDD and CDD)

» Commercial
- End-use intensities trends
  - Efficiency (both standards and EE programs)
- GDP and Employment
- Weather

» Construct estimates of monthly heating (XHeat), cooling (XCool), and non-weather sensitive (XOther) energy requirements

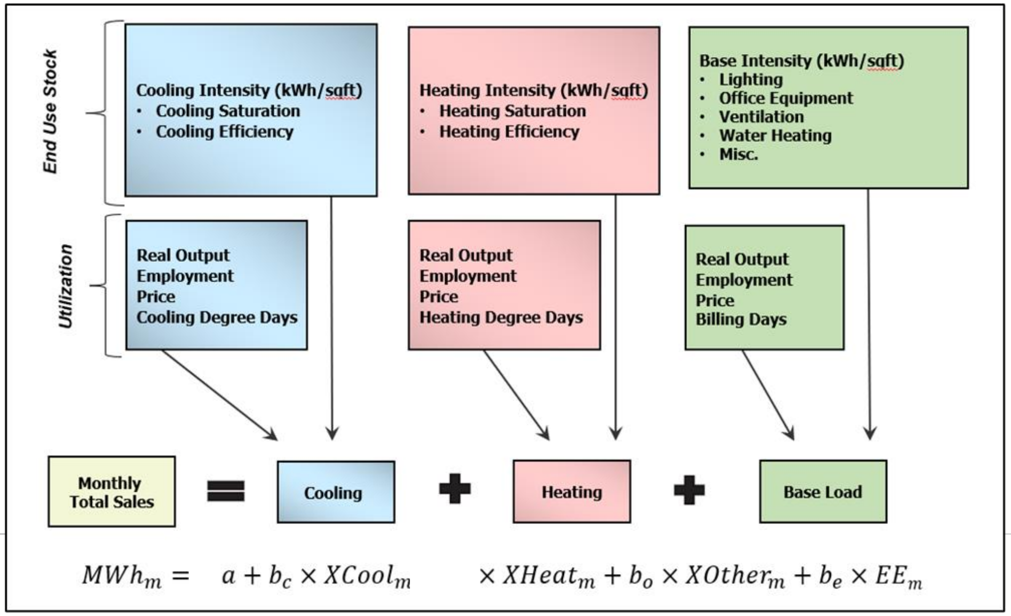
» Regression models used to estimate models
- Models estimated with billed sales data
  - January 2011 - December 2022

Residential Model



$$AvgUse_m = a + b_c \times XCool_m + b_h \times XHeat_m + b_o \times XOther_m + b_e \times EE_m$$

Commercial Model



$$MWh_m = \quad a + b_c \times XCool_m \qquad \times XHeat_m + b_o \times XOther_m + b_e \times EE_m$$

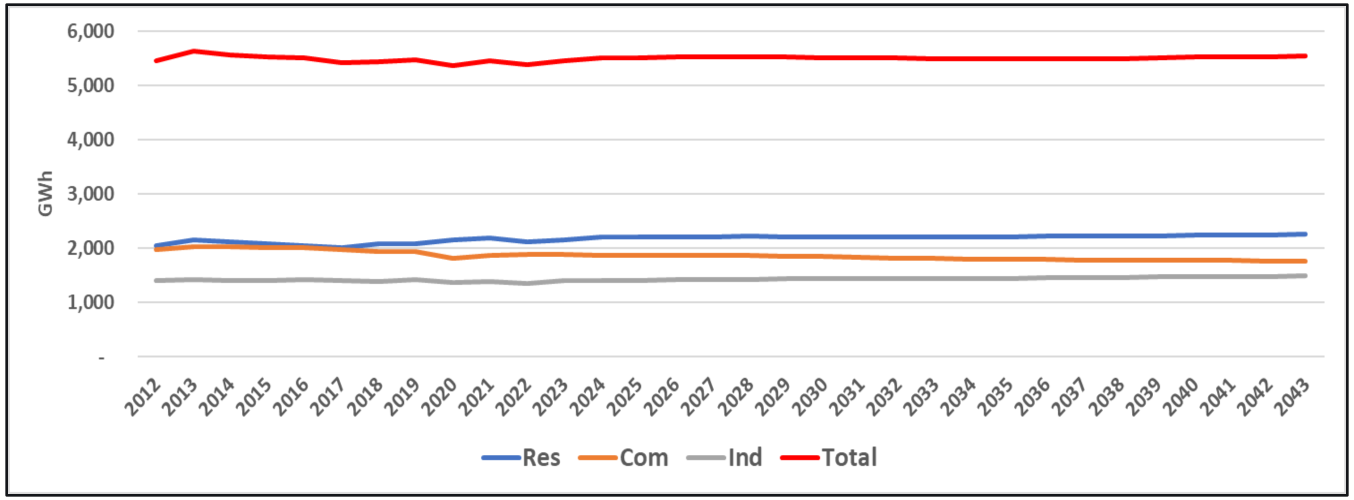
Baseline Sales Projection

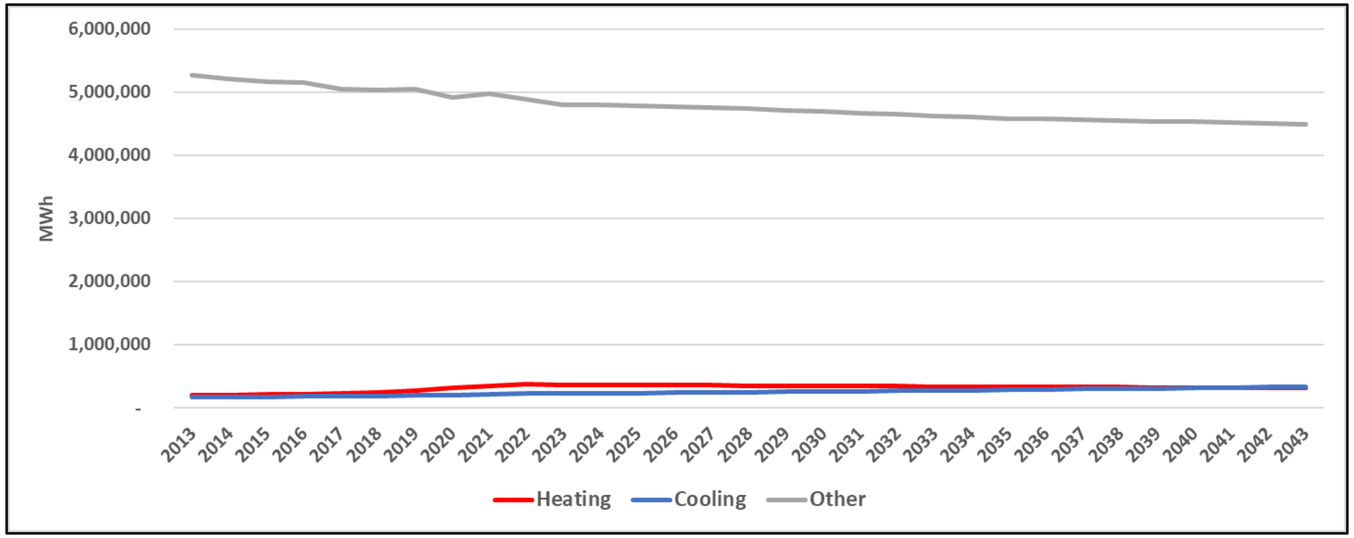
» Estimated from state reported sales and customer data through December 2022

» Forecast based on:
- Moody Analytics January 2023 state economic projections
- EIA 2023 Annual Energy Outlook
  - Calibrated to state survey and NREL ResStock data
- 2023 DRP energy efficiency savings projections
- Trended HDD and CDD based on temperature data through 2022

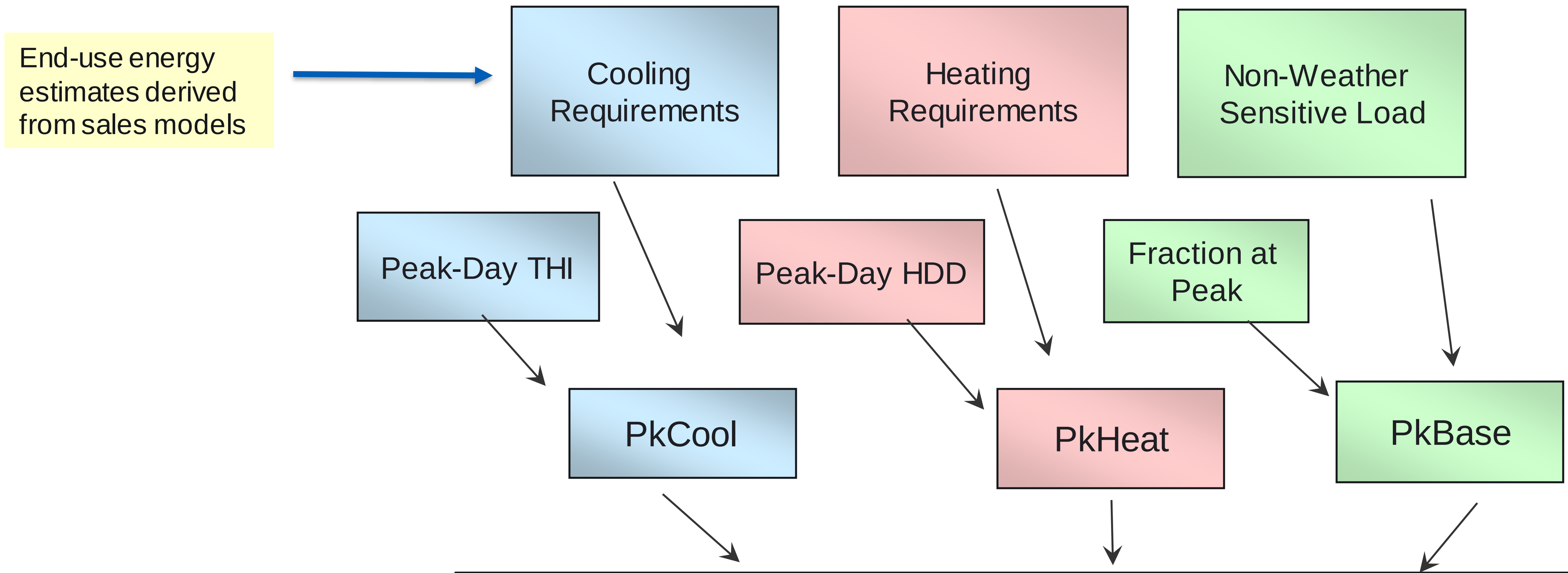
» Overall flat sales
- Impact from continued efficiency gains and solar adoption is about the same as positive impact from household and economic growth.

Period	Res	Com	Ind	Total
2012 - 2022	0.4%	-0.4%	-0.4%	-0.1%
2023 - 2033	0.3%	-0.4%	0.3%	0.3%
2033 - 2043	0.2%	-0.3%	0.3%	0.1%





3. Estimate System Baseline Peak Demand Model (Reconstituted Demand)



$$\text{Peak}_m = a + b_c \times PkCool_m + b_h \times PkHeat_m + b_o \times PkBase_m + e_m$$

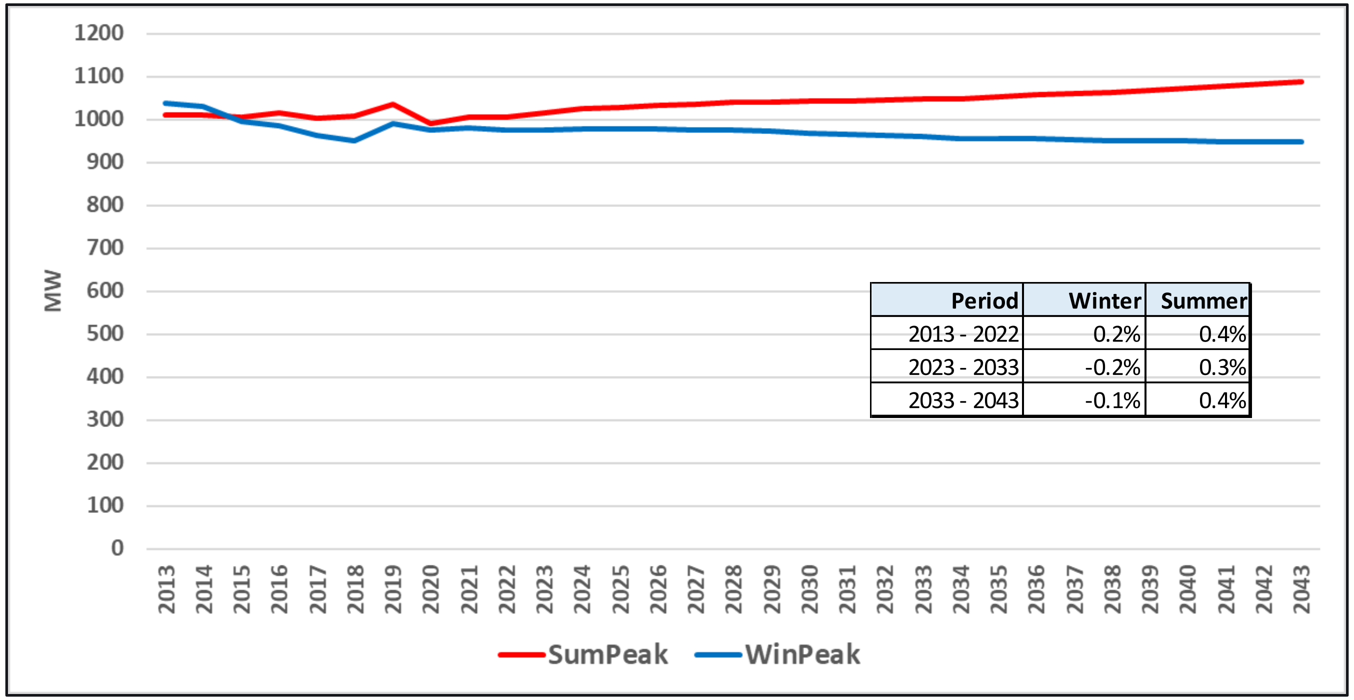
Estimate monthly model with reconstituted system peak

System Peak Forecast (Reconstituted)

» System peak demand with solar generation added back in

- Summer peak driven by cooling requirements – increase in air conditioning saturation and increasing CDD
- Winter peaks decline slightly – increase in end-use and building efficiency and declining HDD

» The system peak forecast is used to calibrate zonal hourly load and peaks



Period	Winter	Summer
2013 - 2022	0.2%	0.4%
2023 - 2033	-0.2%	0.3%
2033 - 2043	-0.1%	0.4%

Itron

4. Estimate zonal energy models

$$\text{MWh}_{Zm} = a + b_c \times CoolMWh_{Zm} + b_h \times HeatMWh_{Zm} + b_o \times Base\text{MWh}_{Zm} + e_{Zm}$$

Models based on reconstituted zonal energy

$$\text{CoolMWh}_{Zm} = ResCooling_{Zm} + ComCooling_{Zm}$$

$$\text{HeatMWh}_{Zm} = ResHeating_{Zm} + ComHeating_{Zm}$$

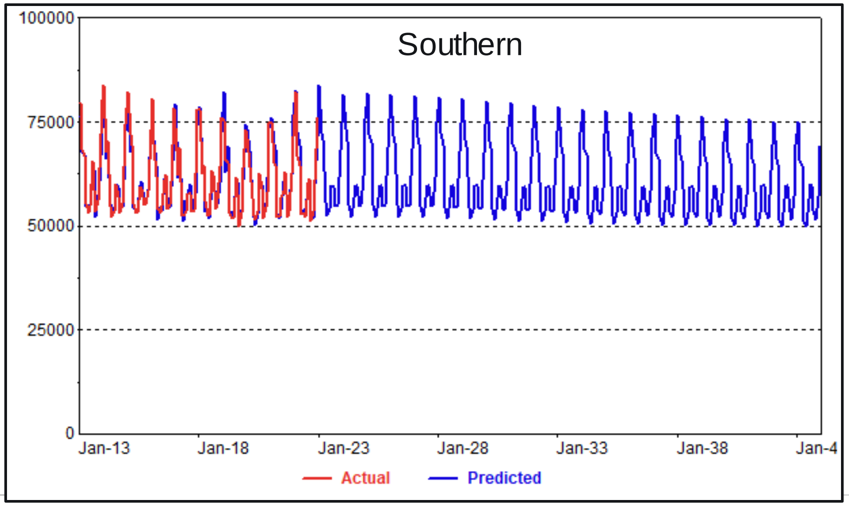
$$\text{BaseMWh}_{Zm} = ResBaseUse_{Zm} + ComBaseUse_{Zm} + IndBaseUse_{Zm}$$

Method captures differences in zonal customer mix and growth trends

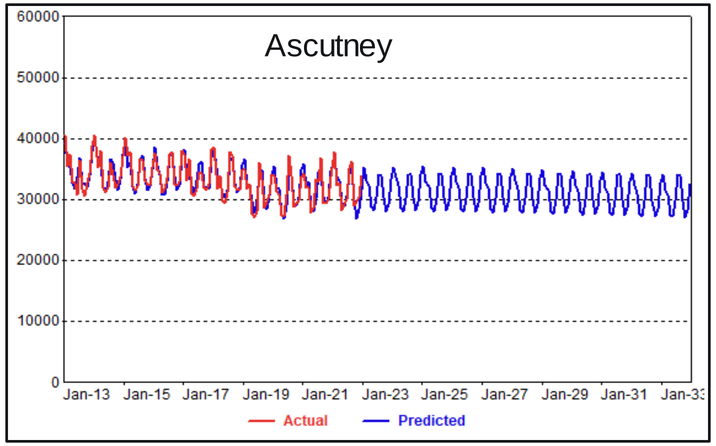
Residential sales allocated to zones base on zone percent of state households
C&I sales allocated to zones based on zone percent of state employment

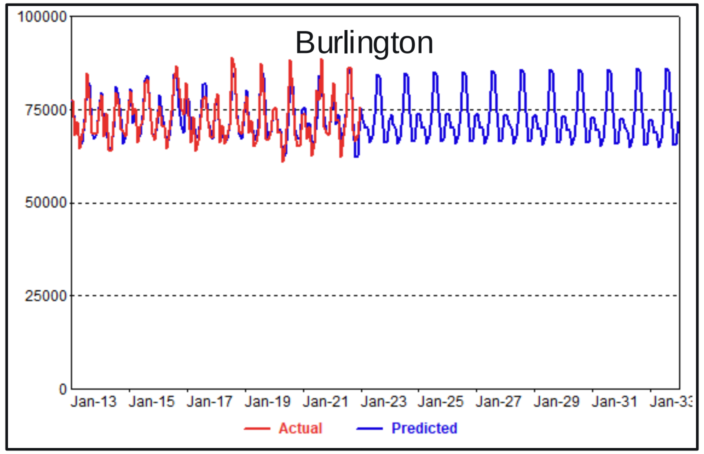
Variable	Coefficient	StdErr	T-Stat	P-Value
HeatMWh	2.918	0.179	16.325	0.00%
CoolMWh	0.74	0.12	6.181	0.00%
BaseMWh	0.961	0.015	65.313	0.00%
Feb	-3194.477	776.452	-4.114	0.01%
Apr	-2397.874	758.216	-3.163	0.20%
20-Jan	-5841.687	2372.531	-2.462	1.53%
20-Mar	-4669.998	2368.079	-1.972	5.11%
21-Jan	-7589.672	2245.472	-3.38	0.10%
MA(1)	0.608	0.079	7.742	0.00%

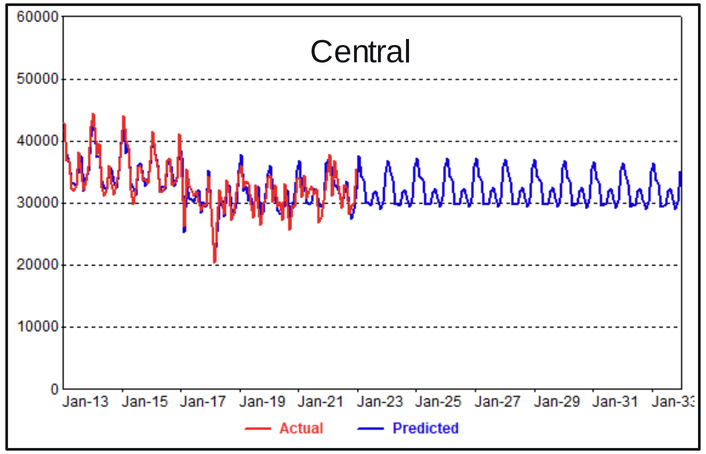
Model Statistics	
Iterations	14
Adjusted Observations	120
Deg. of Freedom for Error	111
R-Squared	0.91
Adjusted R-Squared	0.904
Std. Error of Regression	2,688.25
Mean Abs. Dev. (MAD)	2,007.39
Mean Abs. % Err. (MAPE)	3.18%
Durbin-Watson Statistic	1.916

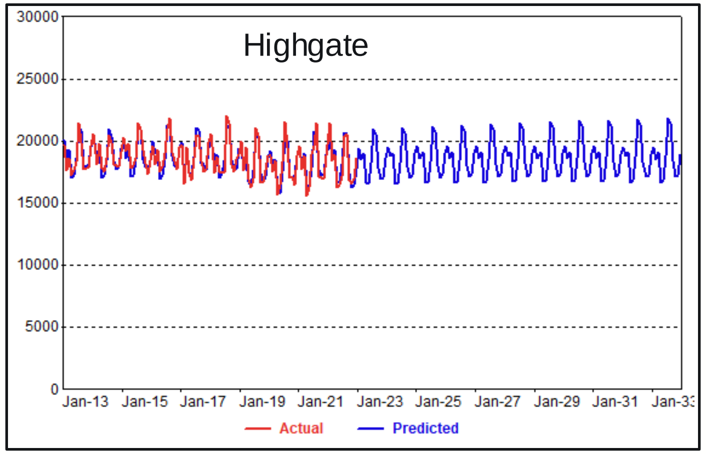


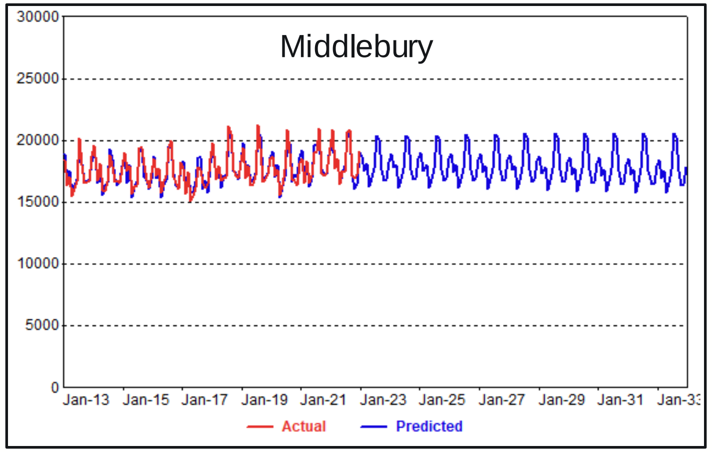
Zonal Energy Forecast

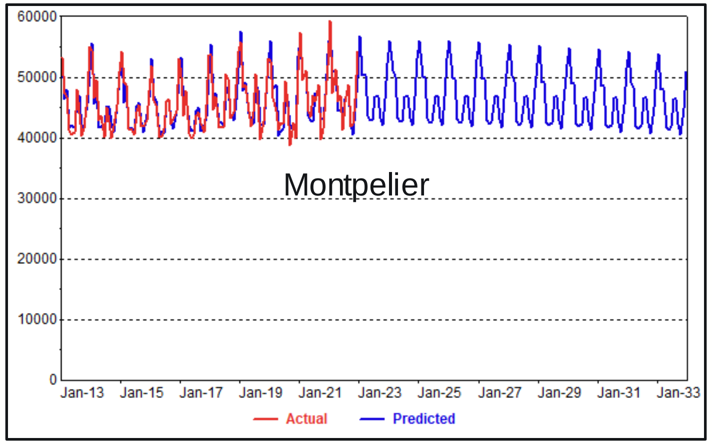




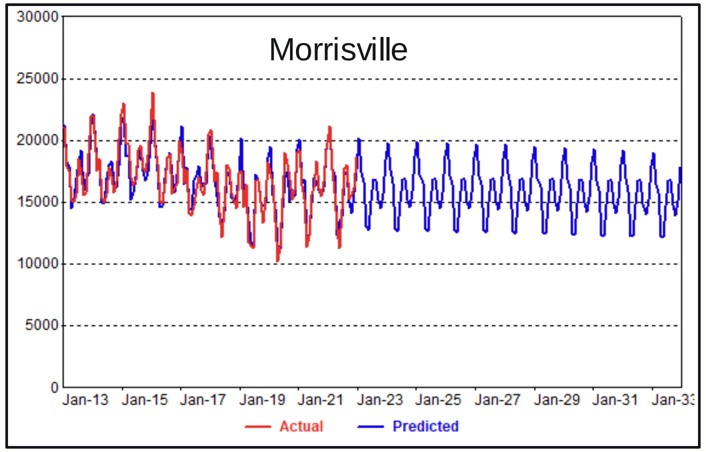


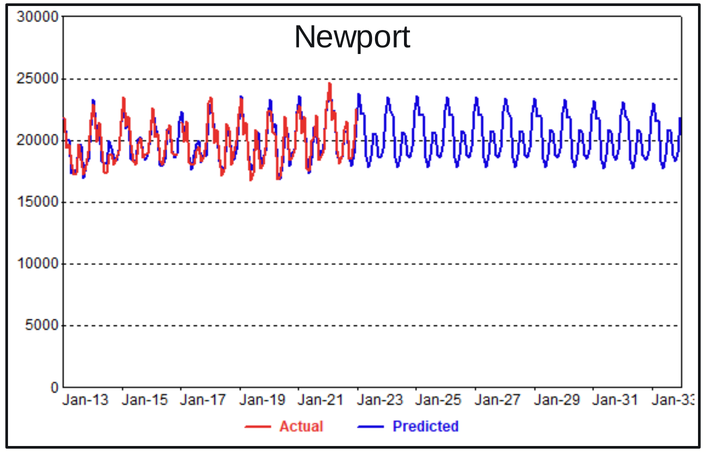


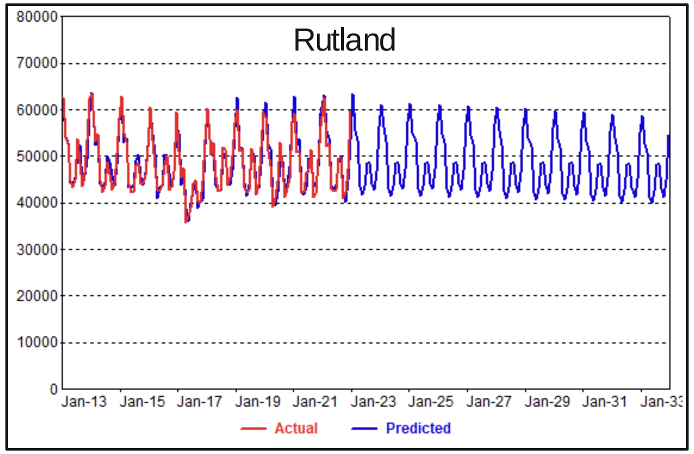


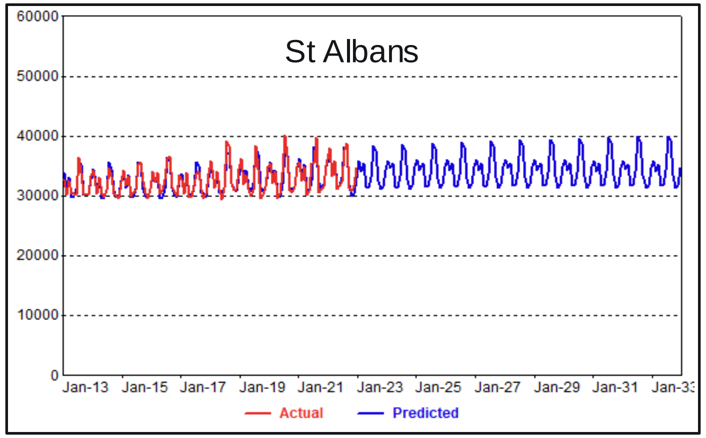


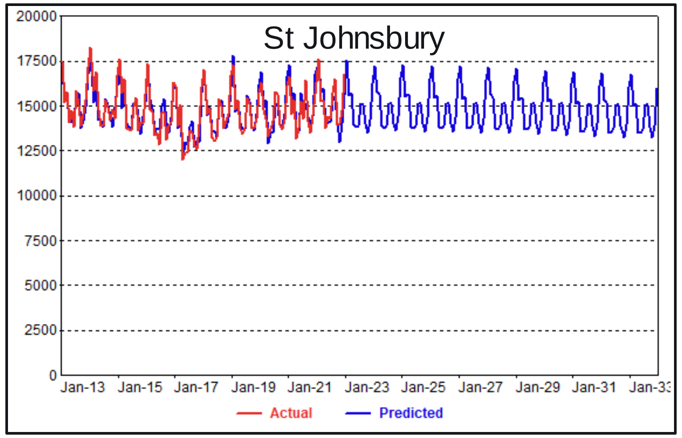
Zonal Energy Forecast

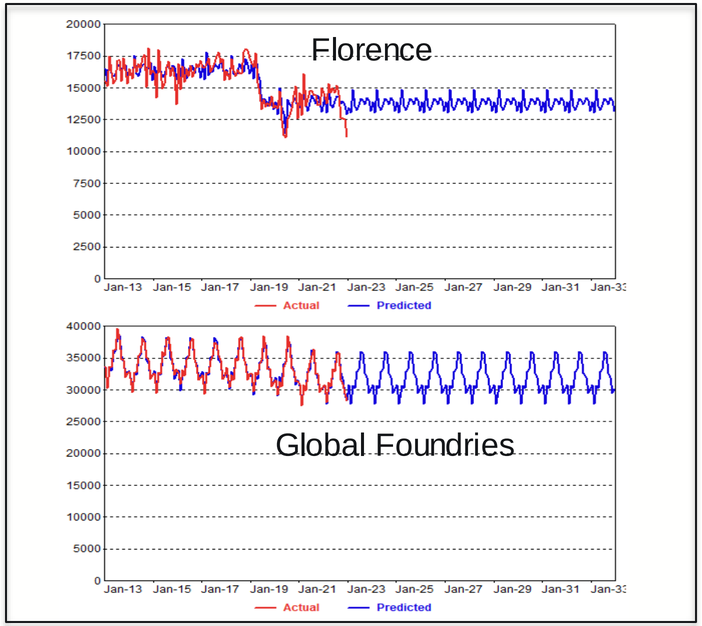










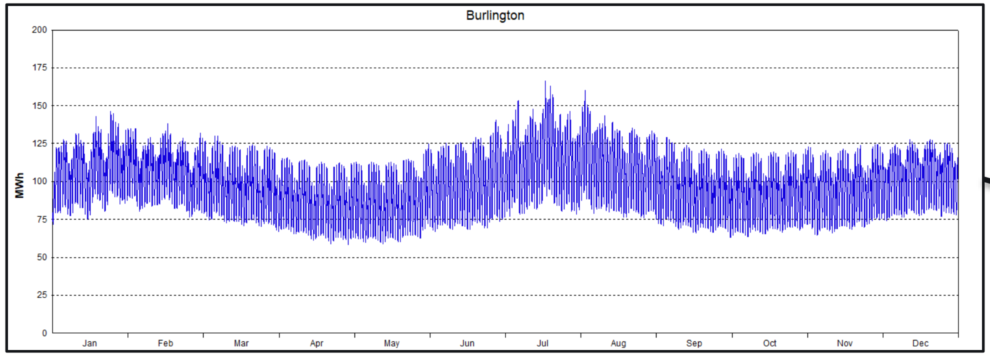


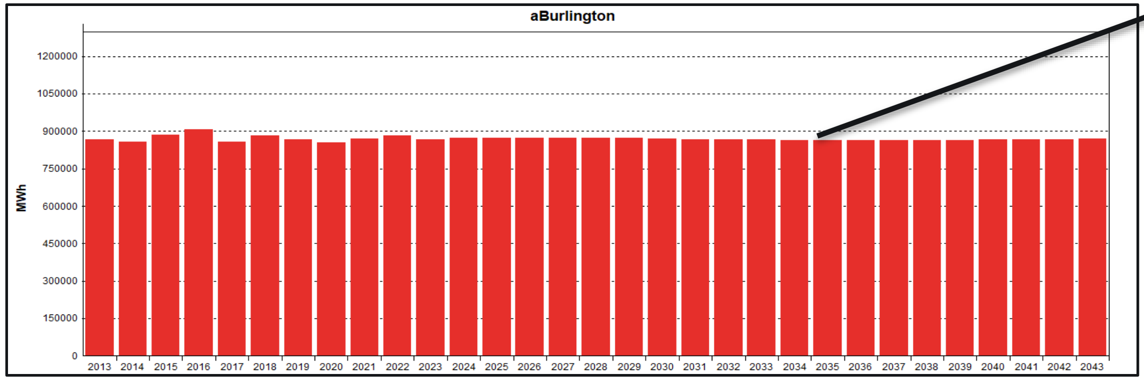
5. Generate Zonal Baseline Load Forecasts (Reconstituted)

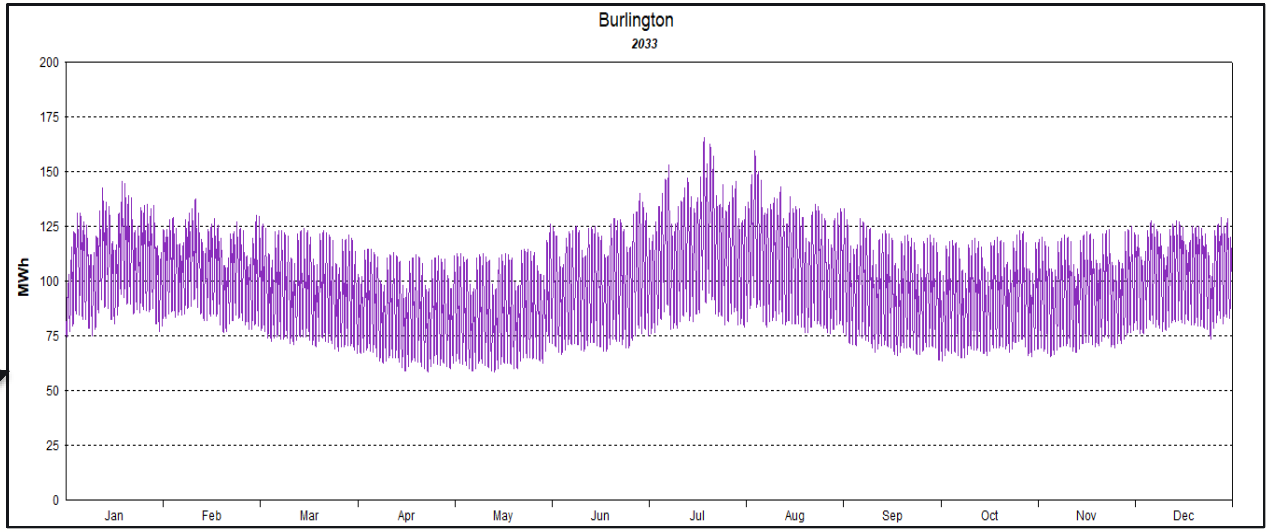
» Energy forecasts combined with zone hourly load profiles forecasts

- Profiles reflect expected weather conditions, day of the week, holidays, hours of light, seasons

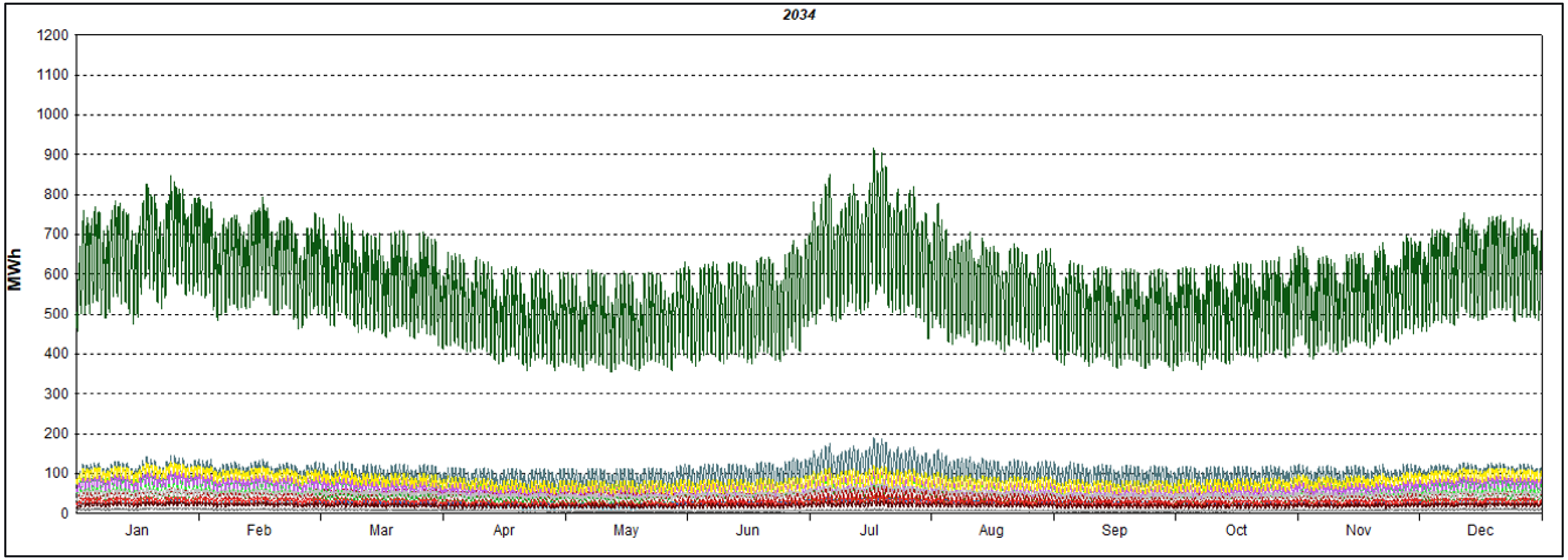
» Baseline forecast derived by combining zone-level energy forecast with zone-level profile







One last touch: calibrate baseline zonal load forecasts



» Calibrate zonal profiles to system baseline peak forecast

- Excluding BED, Florence, and Global Foundries
- BED based on current BED IRP forecast
- Florence (primarily Omya) and Global Foundries are flat production loads.

6. Develop Net Load Zonal (and System) Hourly Load Forecast

» Net Load = Baseline Load + Heat Pump Load + Electric Vehicle Charging Load – Solar Generation Load

» Policy Case:

- Meet state electric vehicle electrification target (both non-fleet and fleet) (VEIC high case)
  - Using ISO New England fleet electrification forecast
- Heat pump unit sales continue to increase reaching 17,500 (net) units per year by 2029 (VEIC mid-case forecast)

» Business as Usual:

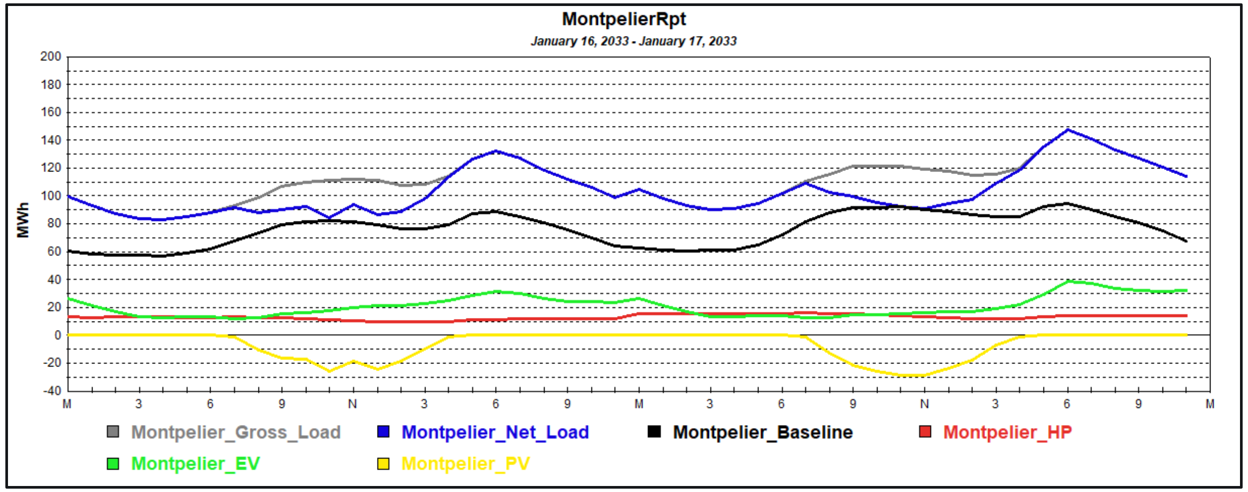
- Lower electric vehicle market penetration
  - VEIC nonfleet mid-case (consistent with the Bloomberg NEF forecast)
  - Slower fleet electrification after the first ten years
- Lower heat pump penetration continues at 2022 level – 10,500 per year through 2029

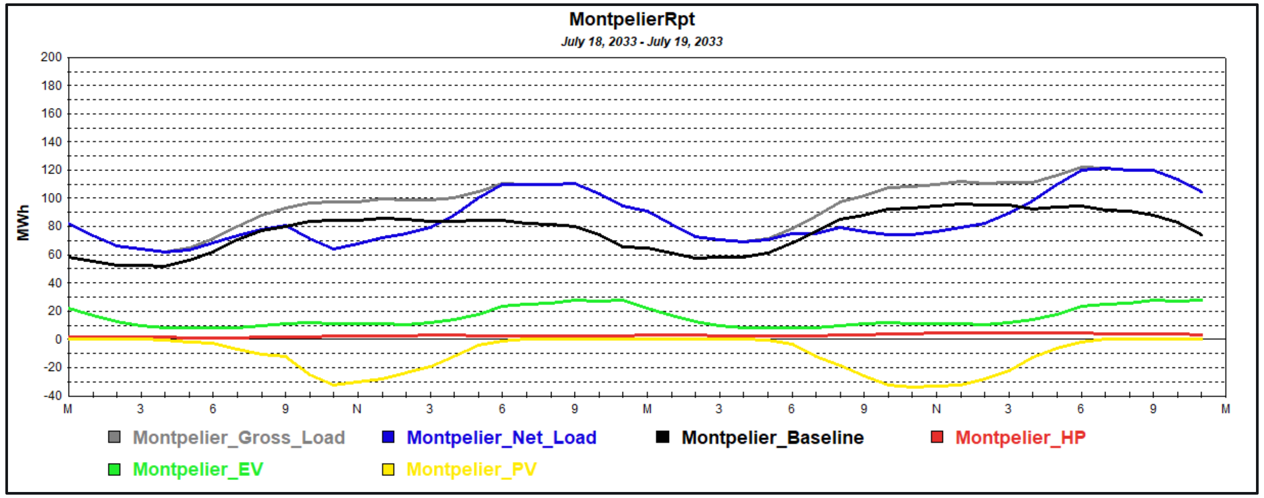
Zone Load Forecasts Forecast

» Technology loads allocated to zones

- Heat pump units based on number of households
- Electric vehicles allocated based on number of existing electric vehicles
- Fleet vehicles allocated using same allocation as nonfleet
- Solar adoption models estimated for each zone

» Baseline zonal hourly load forecasts combined with technology hourly load forecast





System Load Forecast

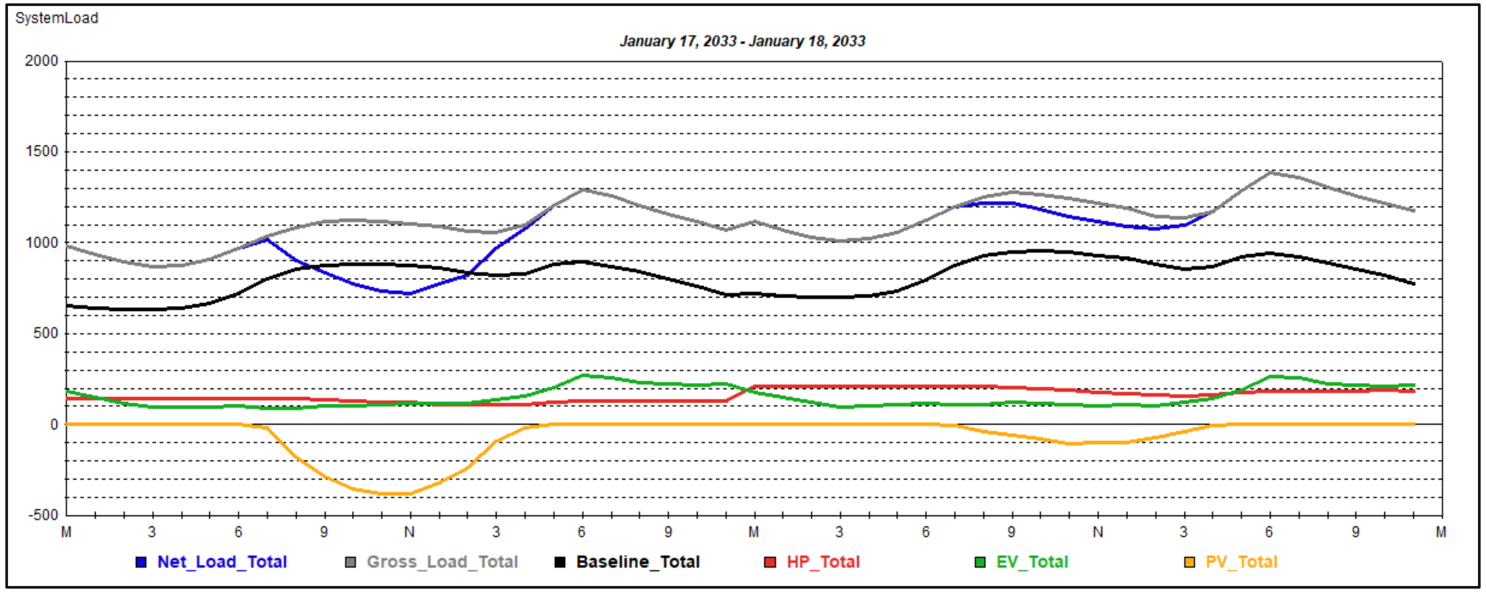
» Add zonal loads or load components

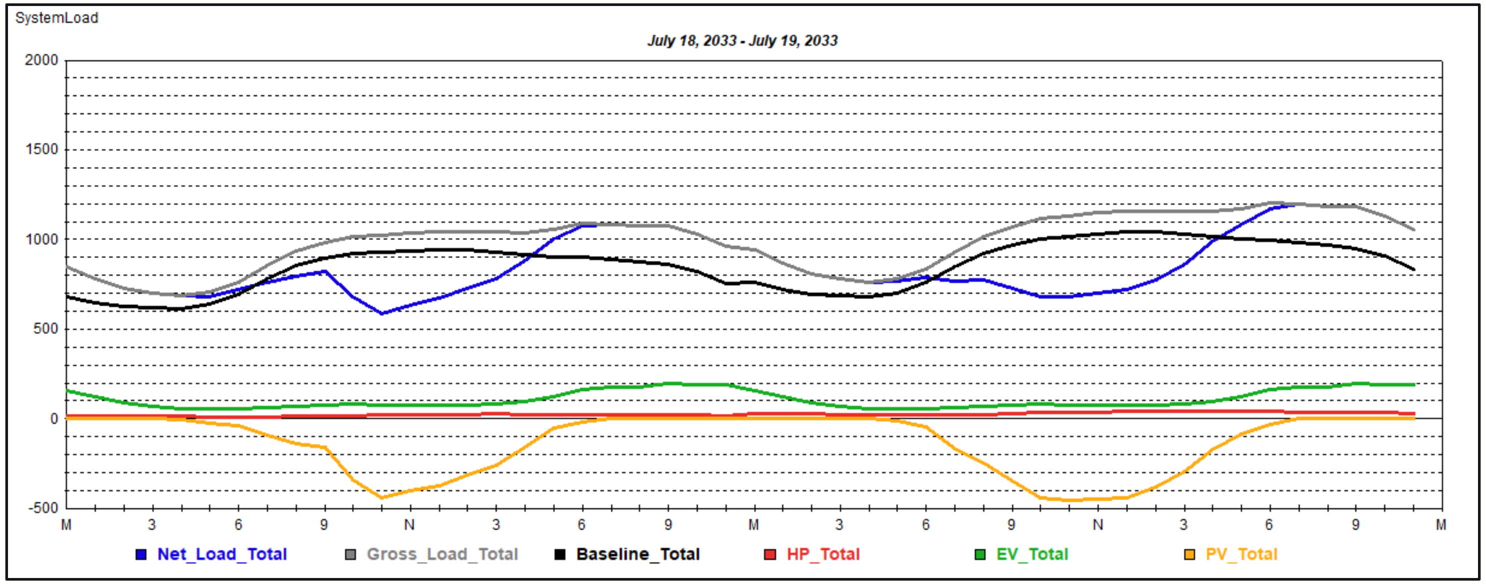
» Peak days

- Winter: January 18 (Tuesday)
- Summer: July 19 (Tuesday)

» Load Components

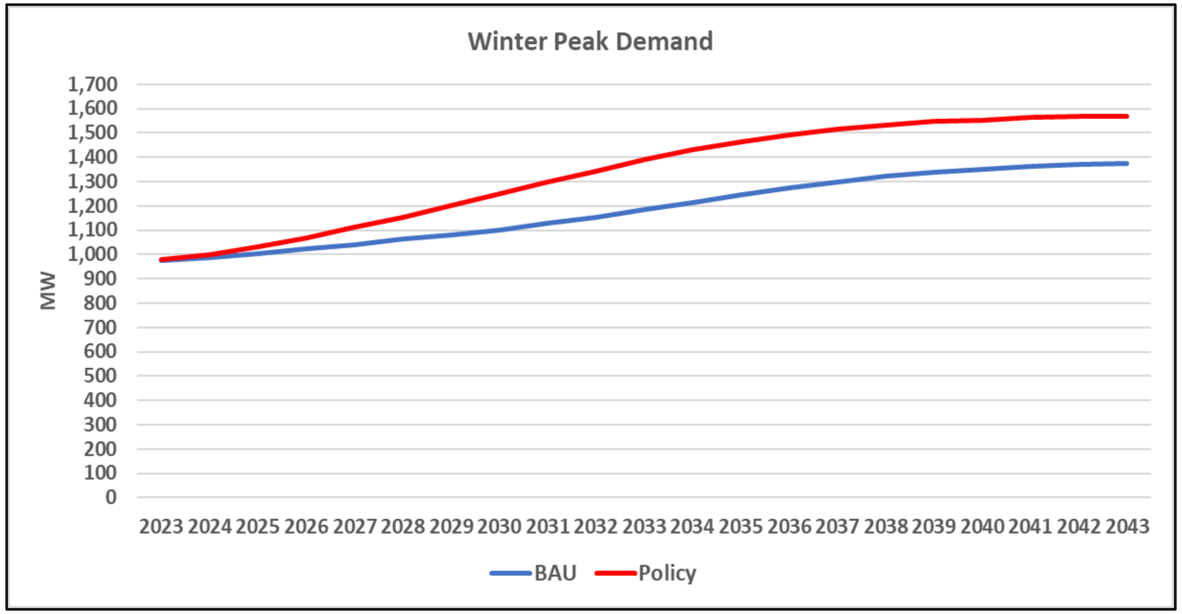
- Net load (final results)
- Gross load (before solar adjustment)
- Baseline (before tech adjustments)
- Tech forecasts
  - Electric vehicle
  - Heat Pump
  - Solar

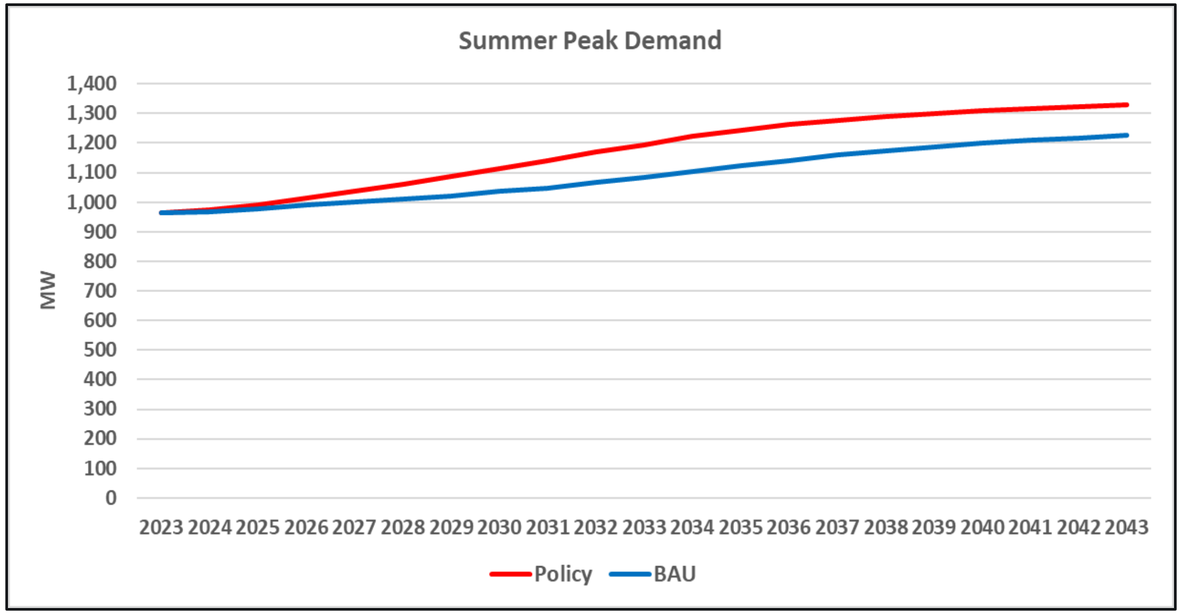




Results

Net Peak Demand Forecast





	Policy (MW)				BAU (MW)			
Date and Time	Peak	Base	HeatPmp	EV	Peak	Base	HeatPmp	EV
1/24/23 6:00 PM	978.4	960.6	12.6	5.3	974.3	960.6	11.4	2.4
1/18/28 6:00 PM	1,154.4	960.5	94.3	99.6	1,062.2	960.5	69.4	32.3
1/18/33 6:00 PM	1,388.8	943.9	182.5	262.4	1,184.9	943.9	126.7	114.3
1/19/38 6:00 PM	1,533.0	938.4	228.9	365.8	1,321.0	938.4	171.9	210.7
1/20/43 6:00 PM	1,568.7	933.8	250.4	384.4	1,374.8	933.8	193.8	247.2
Grwth								
2023 - 33	**3.6%**				**2.0%**			
2023 - 43	**2.4%**				**1.7%**			

	Policy (MW)					BAU (MW)				
Date and Time	Peak	Base	HeatPmp	EV	PV	Peak	Base	HeatPmp	EV	PV
7/18/23 6:00 PM	965.6	970.7	2.8	3.3	(11.3)	963.5	970.7	2.5	1.5	(11.3)
7/18/28 7:00 PM	1,061.6	976.4	19.6	66.4	(0.9)	1,011.5	976.4	14.4	21.5	(0.9)
7/19/33 7:00 PM	1,194.9	983.2	37.8	174.9	(0.9)	1,084.5	983.2	26.2	76.1	(0.9)
7/20/38 7:00 PM	1,288.9	999.2	47.4	243.4	(1.1)	1,173.9	999.2	35.6	140.2	(1.1)
7/21/43 7:00 PM	1,329.3	1,022.8	51.9	255.5	(0.9)	1,226.3	1,022.8	40.1	164.3	(0.9)
Grwth										
2023 - 33	**2.2%**					**1.2%**				
2023 - 43	**1.6%**					**1.2%**				

Winter policy peak: 1,389 MW in ten years
1569 MW in twenty years.

Summer policy peak: 1,195 MW in ten years
1329 MW in twenty years.

Preliminary Zone Summer Coincident Peak Forecast (Policy Case)

Net Summer Peak (MW)																		
Year	Ascutney	Burlington	Central	Florence	Highgate	Johnson	Middlebury	Montpelier	Morrisville	Newport	Rutland	StAlbans	Southern	StJohnsbury	BED	GF	System	Peak Date/Time
2023	68.3	157.3	56.9		41.2	11.5	35.3	92.4	32.6	40.4	92.1	73.3	108.6	26.6	57.2		965.6	7/18/23 6:00 PM
2024	69.0	159.5	58.1		42.4	12.1	35.7	92.5	33.5	40.4	93.7	75.0	107.9	27.0	56.8		974.8	7/16/24 7:00 PM
2025	70.0	164.2	59.1		42.9	12.3	36.1	94.5	33.9	41.0	94.9	76.0	109.6	27.3	58.1		991.4	7/15/25 7:00 PM
2026	71.5	170.7	60.3		43.6	12.5	36.6	97.3	34.5	41.8	96.4	77.5	112.3	27.7	59.9		1,014.1	7/21/26 7:00 PM
2027	73.0	177.5	61.6		44.2	12.8	37.2	100.3	35.1	42.5	98.0	78.8	114.9	28.1	61.8		1,037.2	7/20/27 7:00 PM
2028	74.6	184.8	63.0		45.0	13.1	37.8	103.4	35.7	43.3	99.7	80.2	117.6	28.5	63.7		1,061.6	7/18/28 7:00 PM
2029	76.3	192.7	64.1		45.6	13.4	38.3	106.8	36.2	44.0	101.2	81.4	120.4	28.9	66.0		1,086.7	7/17/29 7:00 PM
2030	78.1	201.2	65.6		46.4	13.7	38.9	110.4	36.9	44.8	103.0	83.0	123.5	29.3	68.3		1,114.5	7/16/30 7:00 PM
2031	79.9	209.4	66.8		47.0	13.9	39.4	113.9	37.5	45.5	104.5	84.2	126.3	29.7	70.6		1,140.2	7/15/31 7:00 PM
2032	81.8	218.4	68.2		47.7	14.2	40.1	117.7	38.2	46.4	106.4	85.8	129.8	30.2	73.0		1,169.2	7/20/32 7:00 PM
2033	83.5	226.6	69.3		48.3	14.5	40.6	121.1	38.8	47.1	107.9	87.2	132.7	30.5	75.3		1,194.9	7/19/33 7:00 PM
2034	85.4	235.2	70.8		49.1	14.8	41.3	124.7	39.4	47.9	109.8	88.7	135.8	30.9	77.6		1,222.9	7/18/34 7:00 PM
2035	86.8	241.6	71.6		49.6	15.0	41.7	127.5	39.9	48.5	111.0	89.7	138.0	31.2	79.4		1,243.1	7/17/35 7:00 PM
2036	88.1	247.3	72.7		50.2	15.2	42.2	129.7	40.3	49.1	112.3	90.9	140.1	31.5	80.8		1,261.7	7/15/36 7:00 PM
2037	89.1	252.1	73.3		50.7	15.4	42.6	131.7	40.8	49.6	113.2	92.0	142.0	31.8	82.2		1,277.9	7/21/37 7:00 PM
2038	89.8	255.4	73.9		51.2	15.5	42.9	133.0	41.0	50.0	113.9	92.8	143.0	32.0	83.1		1,288.9	7/20/38 7:00 PM
2039	90.5	258.4	74.6		51.7	15.5	43.2	134.1	41.3	50.4	114.7	93.7	144.0	32.2	83.8		1,299.5	7/19/39 7:00 PM
2040	91.1	260.9	75.4		52.2	15.6	43.5	135.0	41.5	50.7	115.4	94.6	144.8	32.4	84.3		1,308.7	7/17/40 7:00 PM
2041	91.6	263.1	75.9		52.6	15.7	43.7	135.8	41.7	51.0	115.9	95.4	145.4	32.6	84.8		1,316.8	7/16/41 7:00 PM
2042	91.9	264.3	76.2		53.1	15.7	43.9	136.2	41.8	51.3	116.1	96.0	145.6	32.6	85.1		1,321.3	7/15/42 7:00 PM
2043	92.3	266.4	76.8		53.5	15.8	44.2	136.8	42.0	51.6	116.6	97.0	146.4	32.9	85.4		1,329.3	7/21/43 7:00 PM
% Change																		
23-33	2.0%	3.7%	2.0%	0.0%	1.6%	2.3%	1.4%	2.7%	1.7%	1.5%	1.6%	1.8%	2.0%	1.4%	2.8%	-0.1%	2.2%	
33-43	1.0%	1.6%	1.0%	0.0%	1.0%	0.9%	0.8%	1.2%	0.8%	0.9%	0.8%	1.1%	1.0%	0.7%	1.3%	0.0%	1.1%	
23-43	1.5%	2.7%	1.5%	0.0%	1.3%	1.6%	1.1%	2.0%	1.3%	1.2%	1.2%	1.4%	1.5%	1.1%	2.0%	0.0%	1.6%	

Preliminary Zone Winter Coincident Peak Forecast (Policy Case)

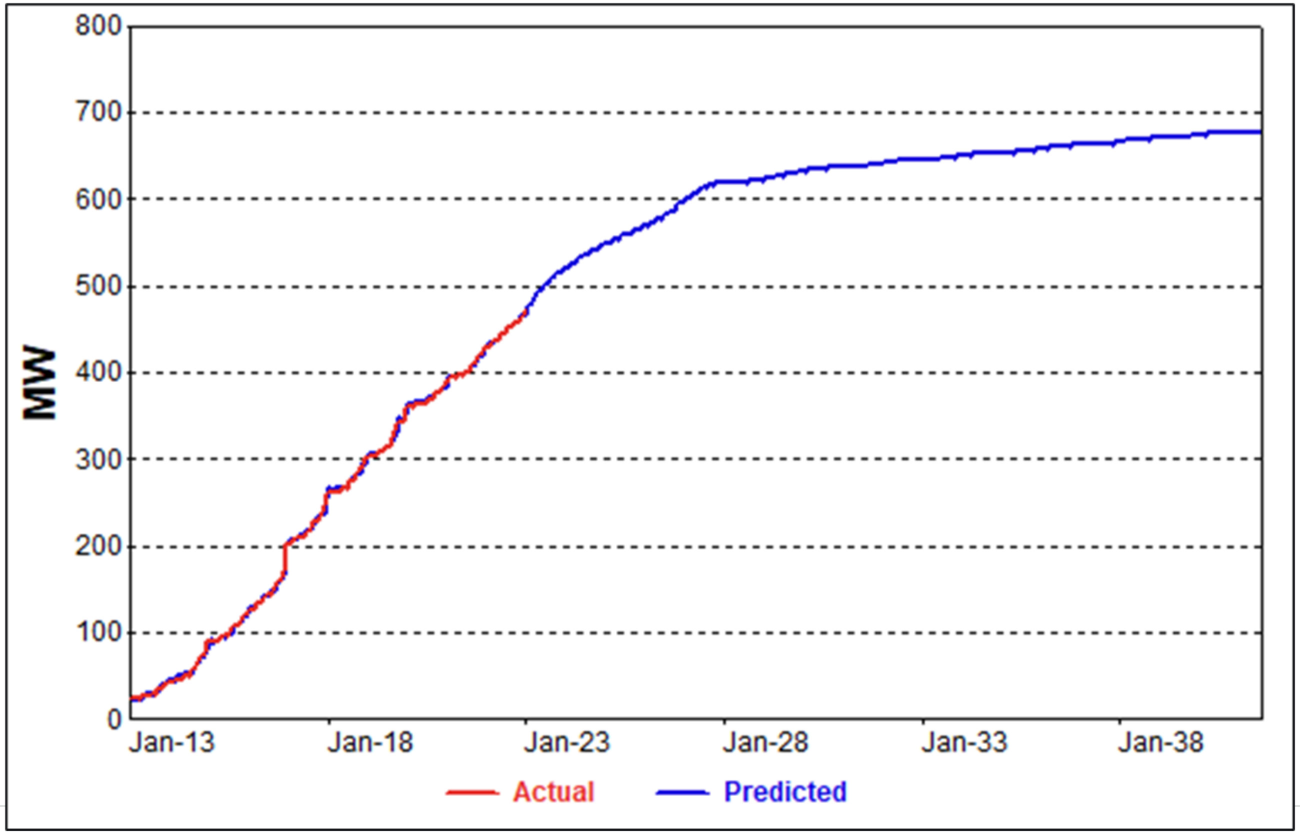
Net Winter Peak (MW)																	
Year	Ascutney	Burlington	Central	Florence	Highgate	Johnson	Middlebury	Montpelier	Morrisville	Newport	Rutland	StAlbans	Southern	StJohnsbury	BED	GF	System	Peak Date/Time
2023	64.5	132.6	67.1		36.6	15.1	33.9	106.1	33.7	42.4	105.2	63.5	136.1	29.8	50.2		978.4	1/24/23 6:00 PM
2024	65.7	138.8	69.0		37.4	15.4	34.6	108.8	34.4	43.3	106.9	65.0	138.4	30.4	51.9		1,001.4	1/23/24 6:00 PM
2025	67.3	146.8	71.0		38.3	15.8	35.4	112.5	35.2	44.5	109.3	66.7	141.9	31.1	54.6		1,032.0	1/21/25 6:00 PM
2026	69.4	156.7	73.3		39.3	16.2	36.3	117.0	36.2	45.8	112.1	68.7	146.1	31.9	57.9		1,068.6	1/20/26 6:00 PM
2027	71.8	168.4	75.8		40.5	16.8	37.3	122.3	37.4	47.2	115.3	71.0	150.9	32.8	61.6		1,110.6	1/19/27 6:00 PM
2028	74.3	180.5	78.5		41.6	17.4	38.4	127.9	38.6	48.7	118.6	73.3	156.0	33.7	65.4		1,154.4	1/18/28 6:00 PM
2029	76.8	193.8	81.2		42.8	17.9	39.4	133.8	39.6	50.2	121.8	75.5	161.0	34.6	69.8		1,199.9	1/23/29 6:00 PM
2030	79.7	208.0	84.0		44.0	18.5	40.5	140.1	40.9	51.8	125.3	78.0	166.6	35.5	74.3		1,248.9	1/22/30 6:00 PM
2031	82.5	222.3	86.6		45.2	19.1	41.6	146.4	42.2	53.3	128.5	80.4	172.1	36.4	78.7		1,297.0	1/21/31 6:00 PM
2032	85.3	236.1	89.0		46.3	19.7	42.6	152.3	43.4	54.7	131.6	82.7	177.4	37.2	83.1		1,342.8	1/20/32 6:00 PM
2033	88.0	249.9	91.4		47.4	20.2	43.6	158.3	44.5	56.1	134.7	85.0	182.6	38.0	87.5		1,388.8	1/18/33 6:00 PM
2034	90.5	262.6	93.6		48.4	20.7	44.4	163.8	45.4	57.4	137.4	86.9	187.1	38.7	91.4		1,430.0	1/24/34 6:00 PM
2035	92.7	273.3	95.4		49.2	21.1	45.2	168.3	46.3	58.4	139.7	88.6	191.1	39.2	94.7		1,464.9	1/23/35 6:00 PM
2036	94.3	281.5	96.8		49.9	21.4	45.8	171.6	47.0	59.2	141.4	90.0	194.1	39.7	97.3		1,491.4	1/22/36 6:00 PM
2037	95.7	288.7	98.0		50.5	21.7	46.3	174.6	47.6	60.0	142.9	91.4	196.6	40.1	99.7		1,515.4	1/20/37 6:00 PM
2038	96.6	294.0	99.1		51.1	21.9	46.8	176.6	48.0	60.6	144.0	92.5	198.4	40.4	101.5		1,533.0	1/19/38 6:00 PM
2039	97.3	298.1	99.9		51.5	22.0	47.1	178.1	48.4	61.0	144.8	93.5	199.7	40.7	103.0		1,546.8	1/18/39 6:00 PM
2040	97.4	300.1	100.4		51.8	22.0	47.2	178.6	48.3	61.2	145.0	93.8	199.8	40.7	103.7		1,551.5	1/24/40 6:00 PM
2041	97.9	303.3	101.1		52.2	22.1	47.4	179.7	48.6	61.6	145.5	94.7	200.6	40.9	104.9		1,562.3	1/22/41 6:00 PM
2042	98.0	304.8	101.4		52.5	22.2	47.5	179.9	48.7	61.7	145.5	95.1	200.6	41.0	105.5		1,566.2	1/21/42 6:00 PM
2043	98.0	305.9	101.7		52.7	22.2	47.6	180.0	48.7	61.8	145.4	95.5	200.5	41.0	106.0		1,568.7	1/20/43 6:00 PM
% Change																		
23-33	3.2%	6.5%	3.1%	0.0%	2.6%	3.0%	2.5%	4.1%	2.8%	2.8%	2.5%	3.0%	3.0%	2.5%	5.7%	0.0%	3.6%	
33-43	1.1%	2.0%	1.1%	0.0%	1.1%	0.9%	0.9%	1.3%	0.9%	1.0%	0.8%	1.2%	0.9%	0.8%	1.9%	0.0%	1.2%	
23-43	2.1%	4.3%	2.1%	0.0%	1.8%	1.9%	1.7%	2.7%	1.9%	1.9%	1.6%	2.1%	2.0%	1.6%	3.8%	0.0%	2.4%	

Solar, Heat Pump, and EV Load Impacts

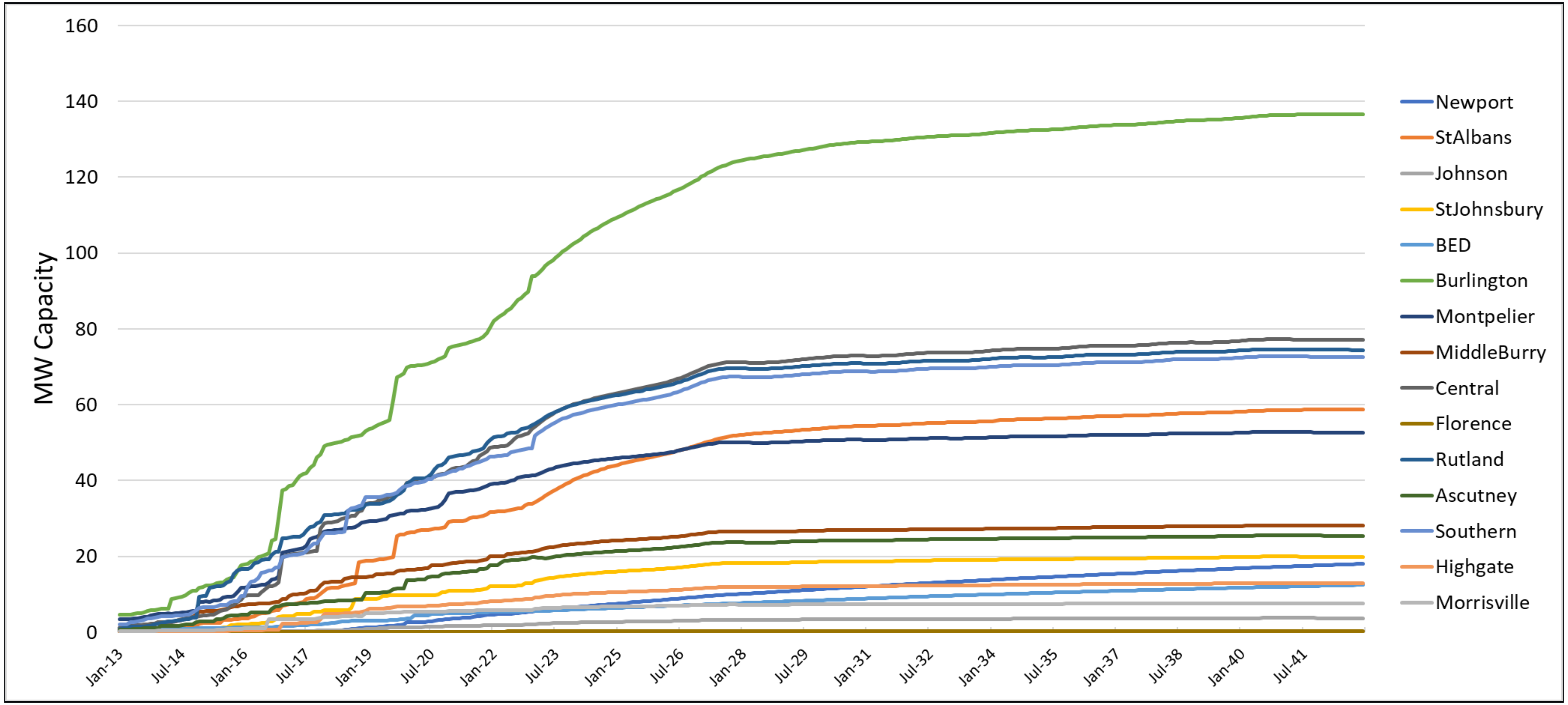
Forecasting Solar Capacity

» Capacity (excluding utility scale and standard offer) modeled as a function of simple payback.

- Payback incorporates:
  - system costs, incentives, electric rates, and payments for excess generation.
- Cubic model specification used to impose S-shaped curve.



Zonal Solar Capacity

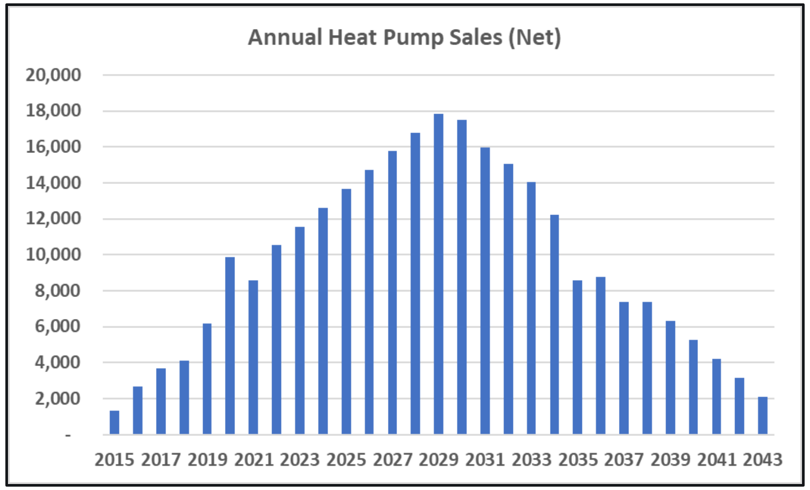


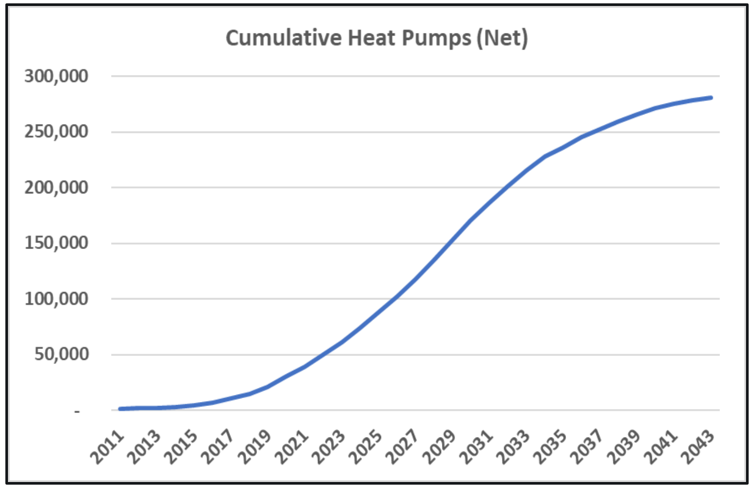
» Solar capacity model for each zone, calibrated to state capacity model

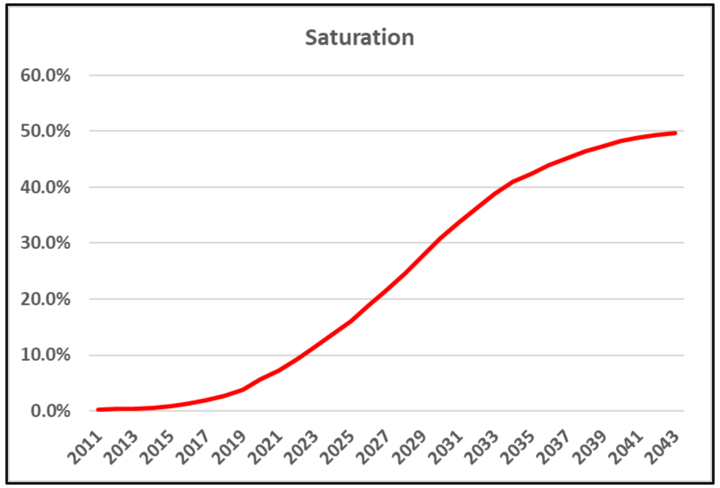
Heat Pump Forecast

» Policy Case – VEIC medium projection

• Number of heat pumps increases from 10,500 units in 2022 to 17,850 units (net) by 2029





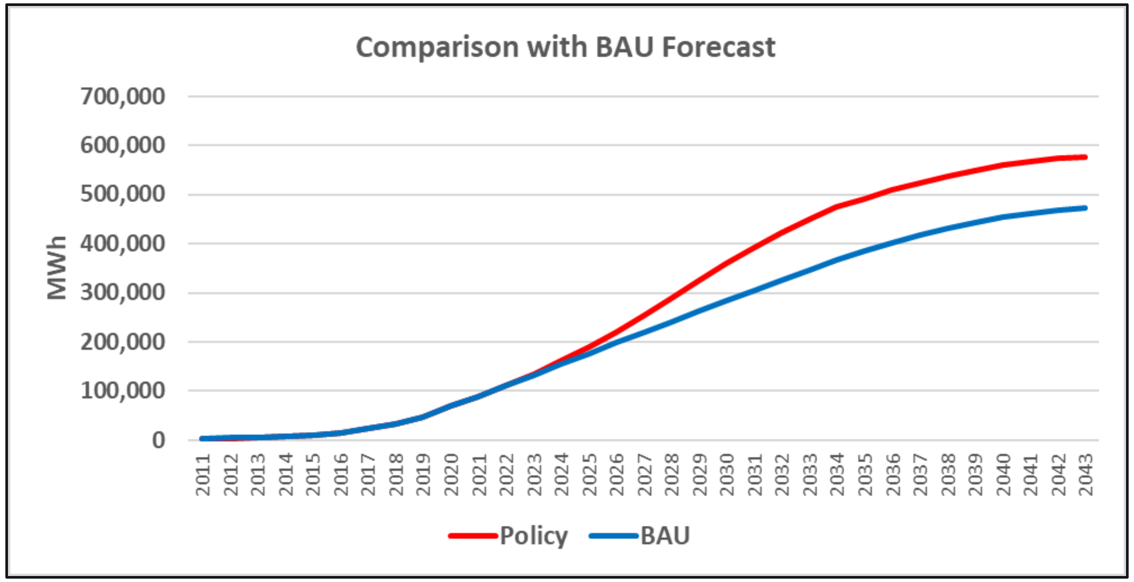


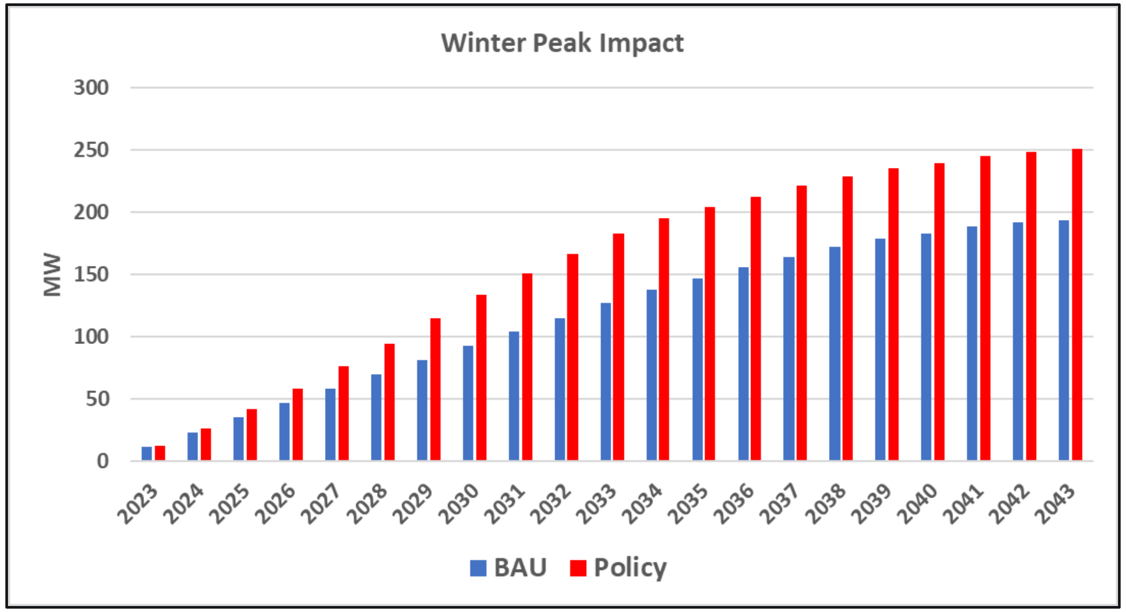
Saturation based on sales of 1.7 units per site

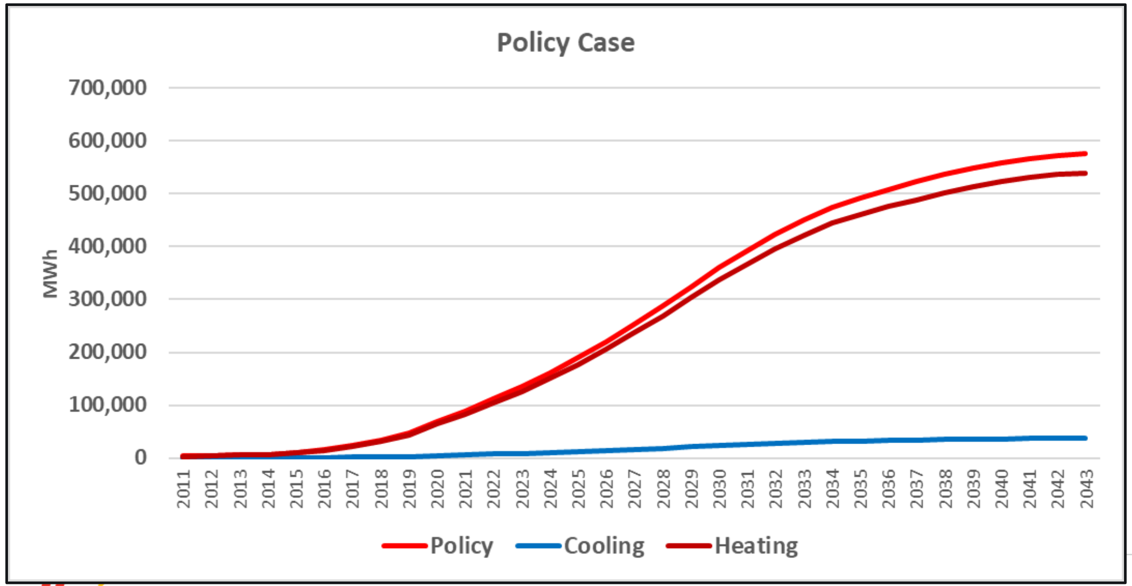
» Business as Usual Case – Heat Pumps held at 2022 sales level of 10,500 units per year

• From November 2022 to April 2023 running at an 8,400 annual run rate

Heat Pump Loads







Policy Case: Adds an additional 180 MW of load by 2033 and 250 MW by 2043

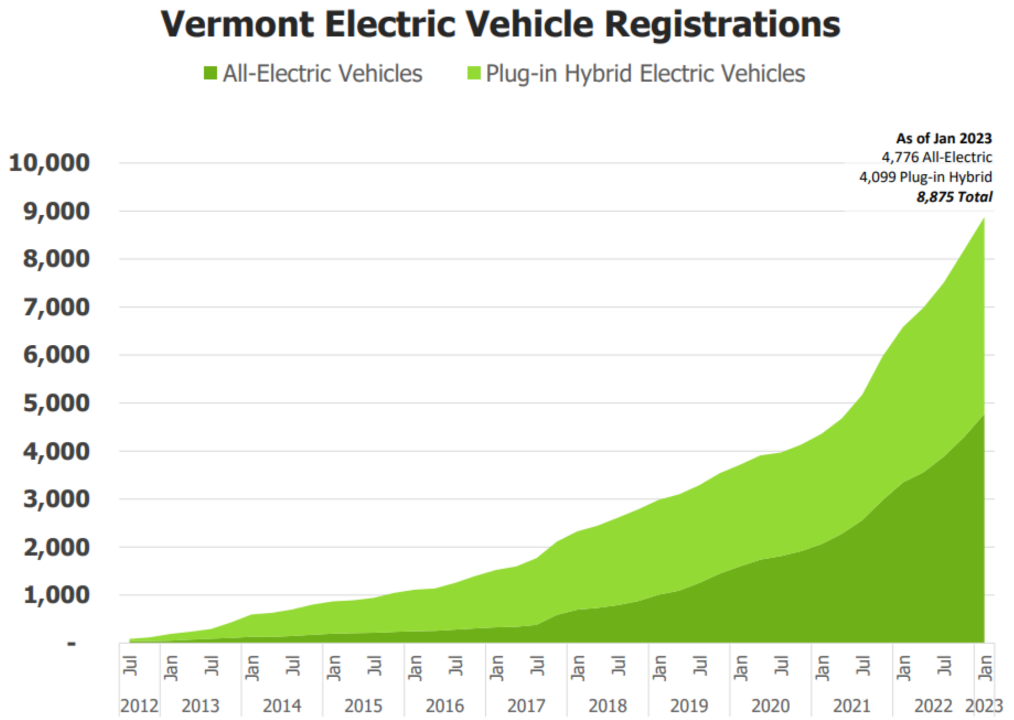
BAU: Adds an additional 130 MW of load by 2033 and 195 MW by 2043

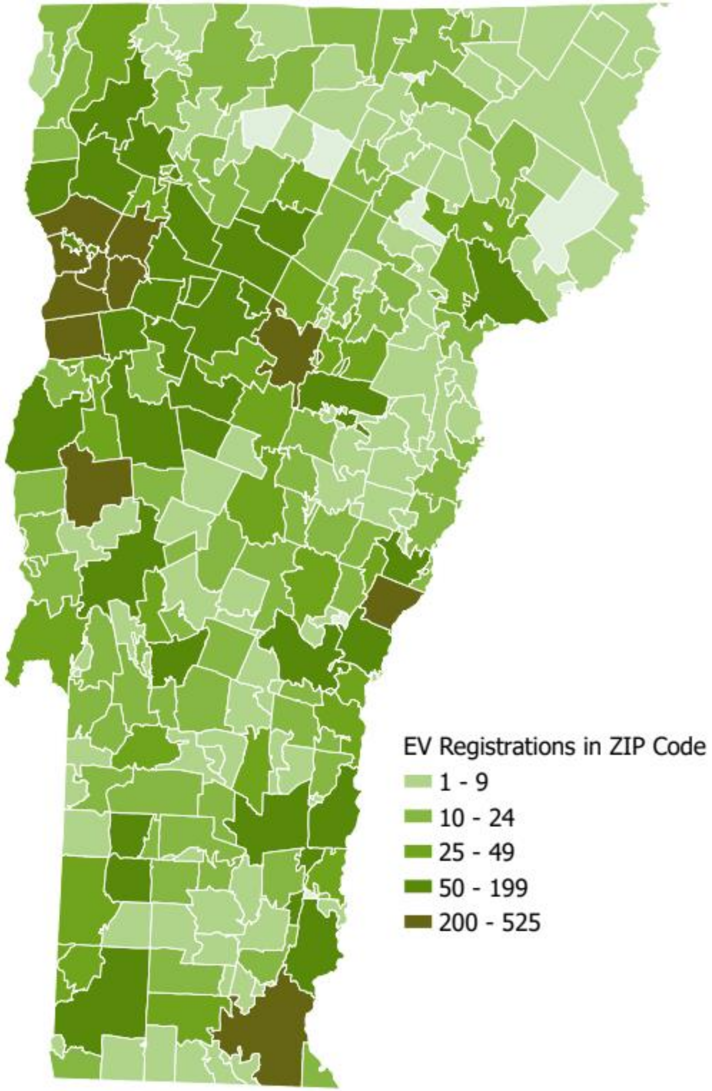
» Assumes heat pumps are operating on typical peak winter day(not peaking in November at 30 degrees)

Current EV Market: Vermont

» 8,875 registered EV in the state
  - 35% growth over the past year

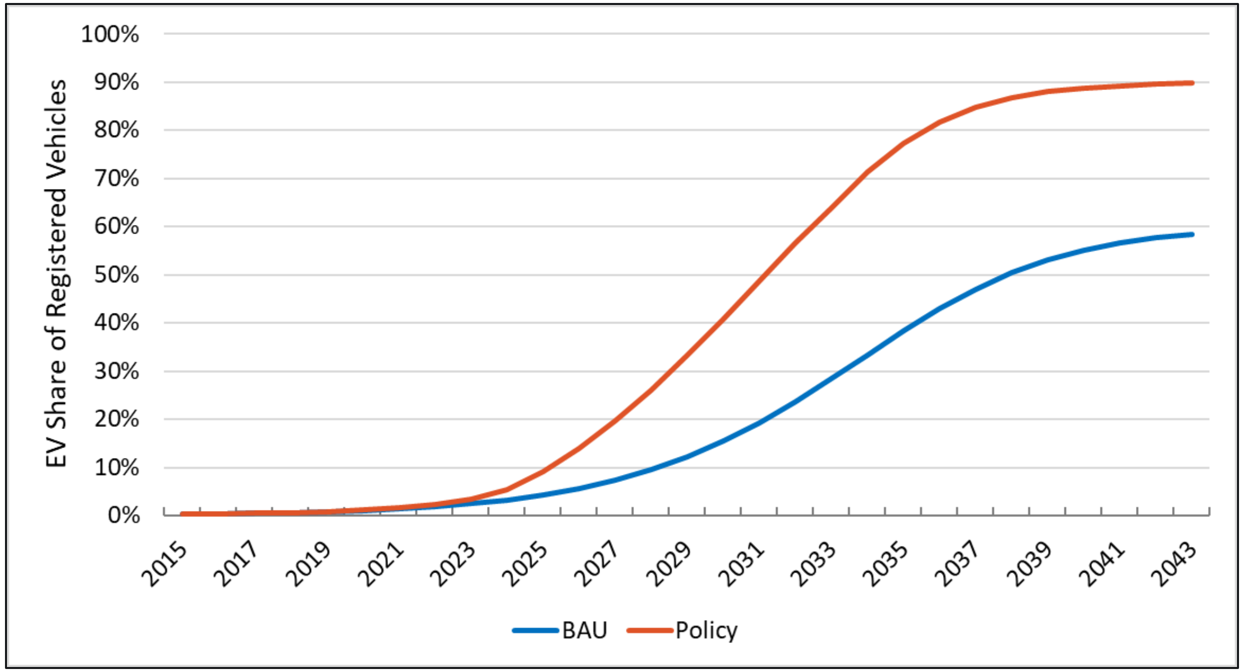
» Electric vehicles constituted 6.9% of all new light duty vehicle sales in 2022
  - Higher than the U.S. average of 5.8%





Source: Drive Electric Vermont, January 2023 EV Registration Updates

Non-Fleet Electric Vehicle Forecasts



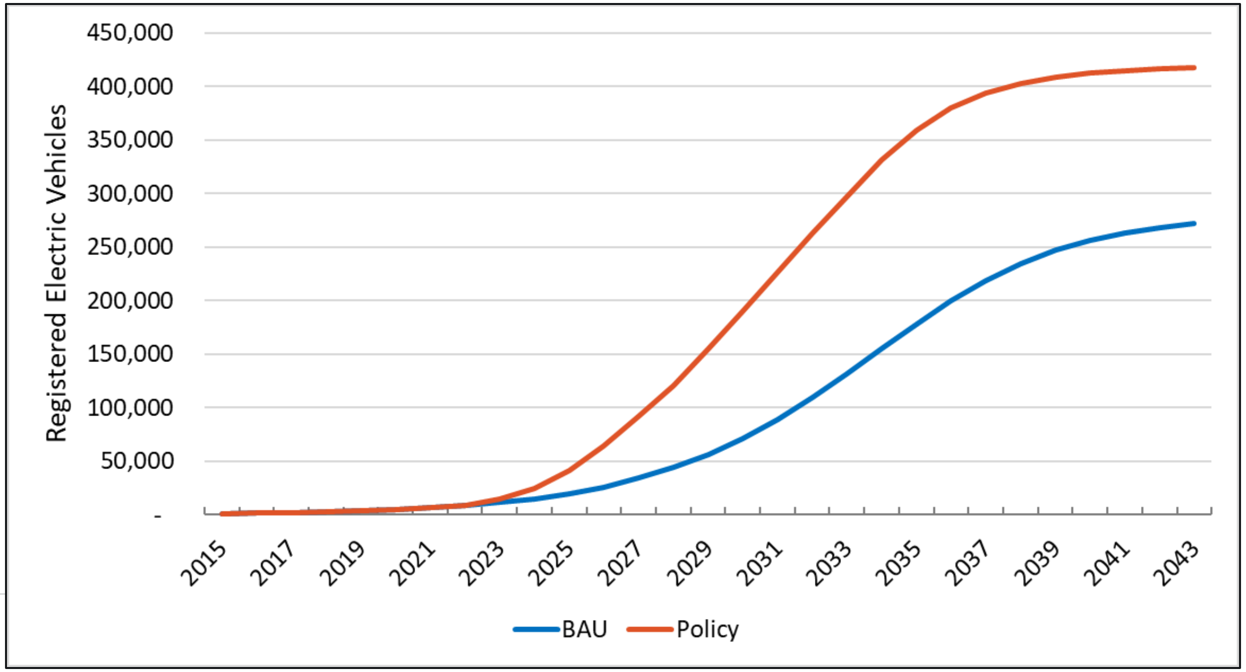
» Based on the 2020 VEIC medium and high electric vehicle forecast, calibrated into 2023 registrations

Assumptions

» 12,000 miles driven annually

» PHEV account for approx. 50% of EVs currently, declining to 25% by 2043

» PHEV operate in all electric drive mode for approx. 55% of miles currently, increasing to 75% by 2043



Fleet Electric Vehicle Forecasts Assumptions

- Based on ISO New England's 2023 Transportation Electrification Forecast for Vermont
  - State-level forecast of light-duty fleet, medium-duty fleet, school bus, and transit bus
- Forecast for 2023-2032
- BAU forecast assumes the incremental increases remain at 2032 level through 2043
- Policy forecast assumes 100% electrification by 2038-2045, depending on fleet electric vehicle type

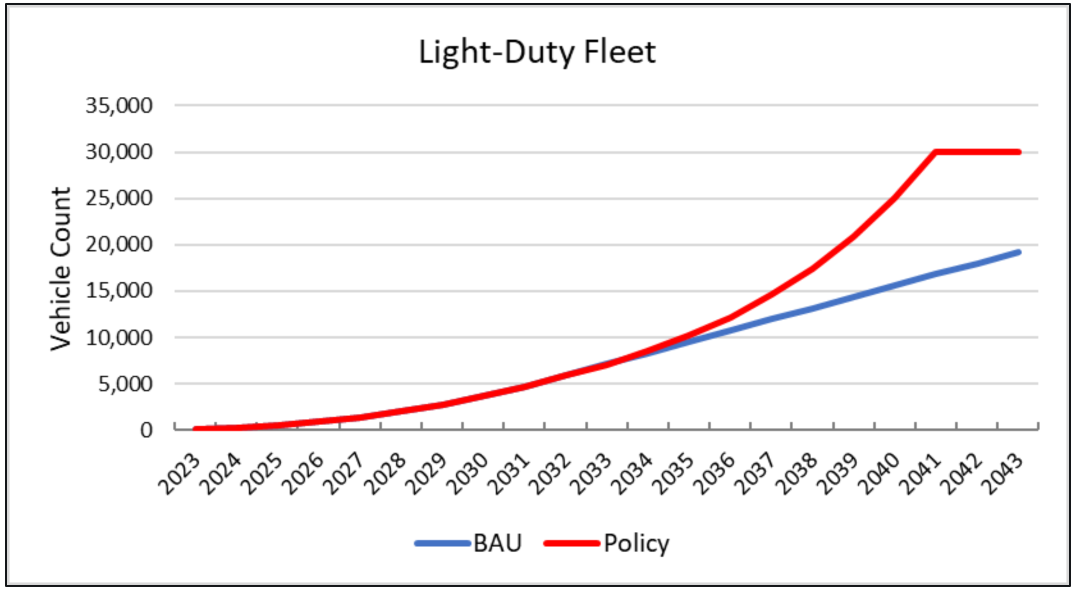
FEBRUARY 24, 2023 | WEBEX

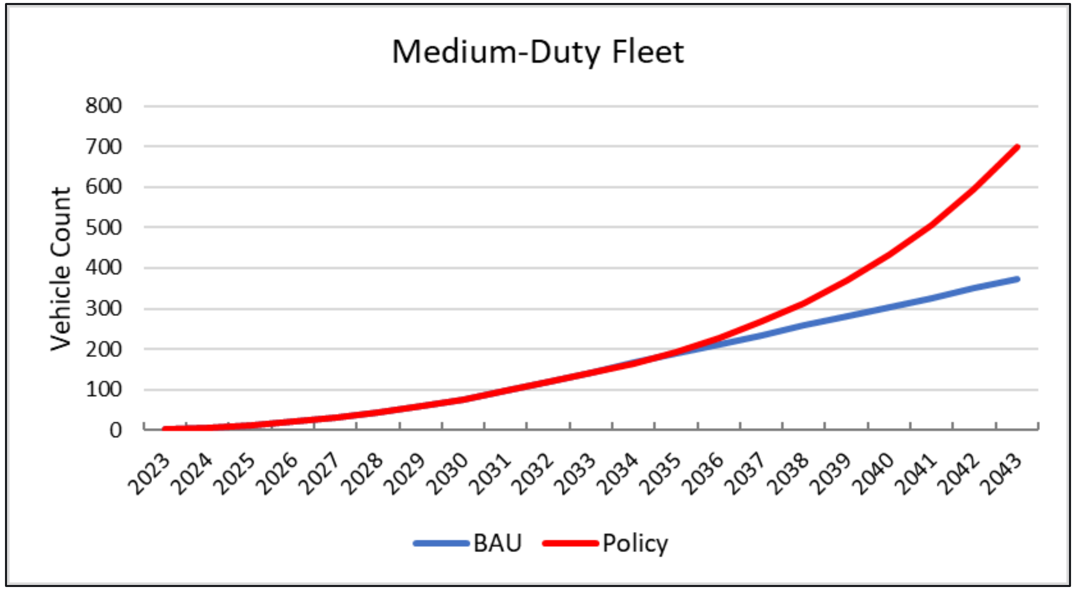
ISO new england

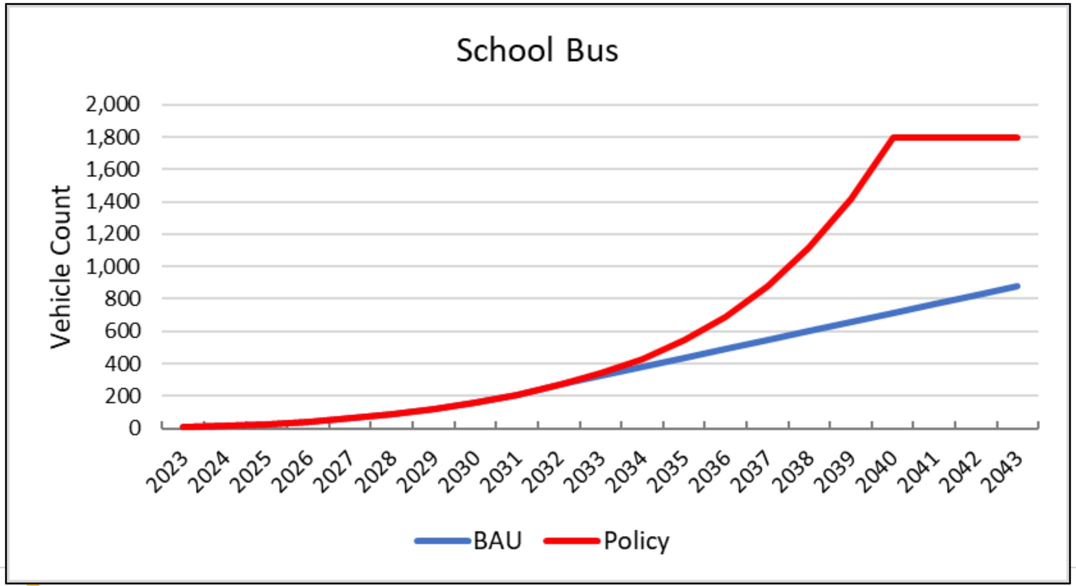
Draft 2023 Transportation Electrification Forecast

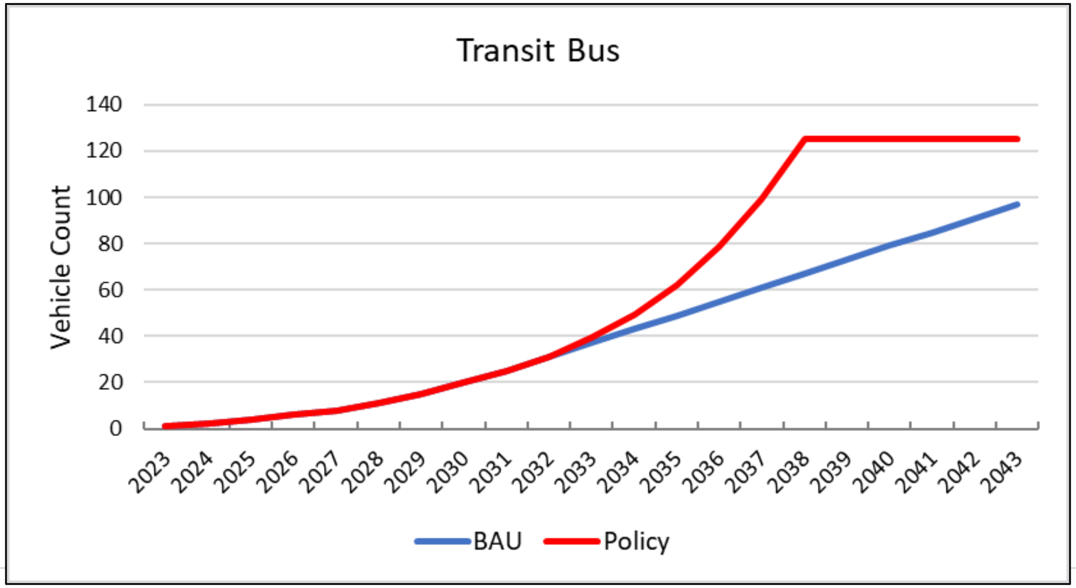
Load Forecast Committee

Fleet Electric Vehicle Forecasts

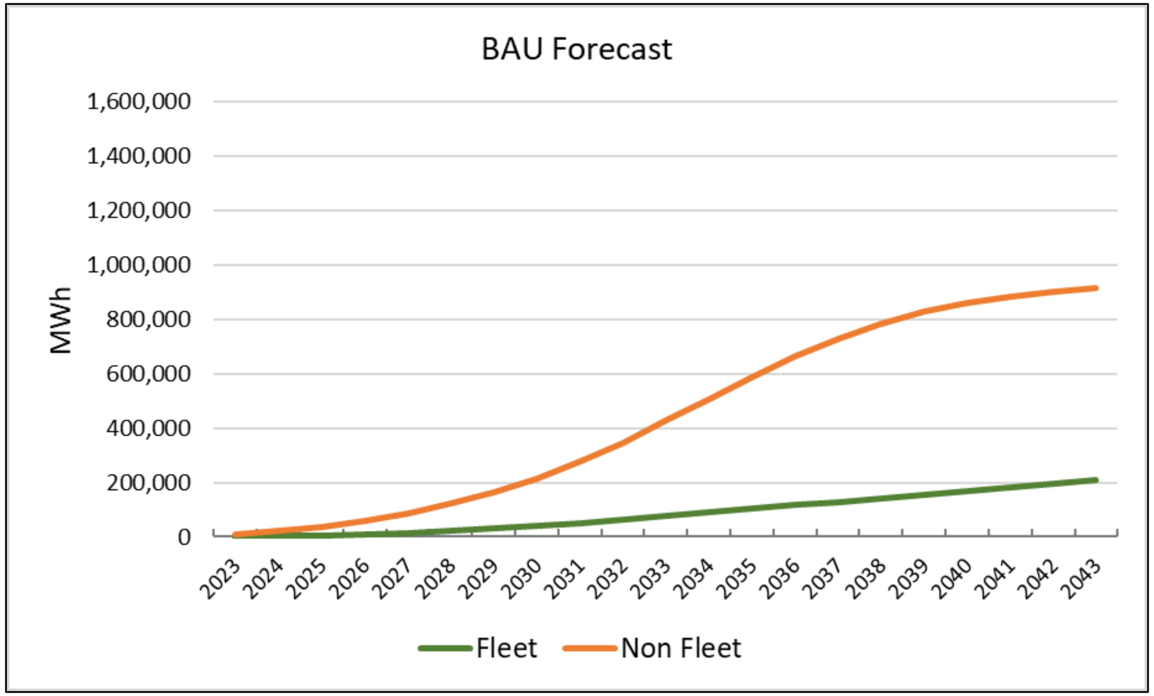


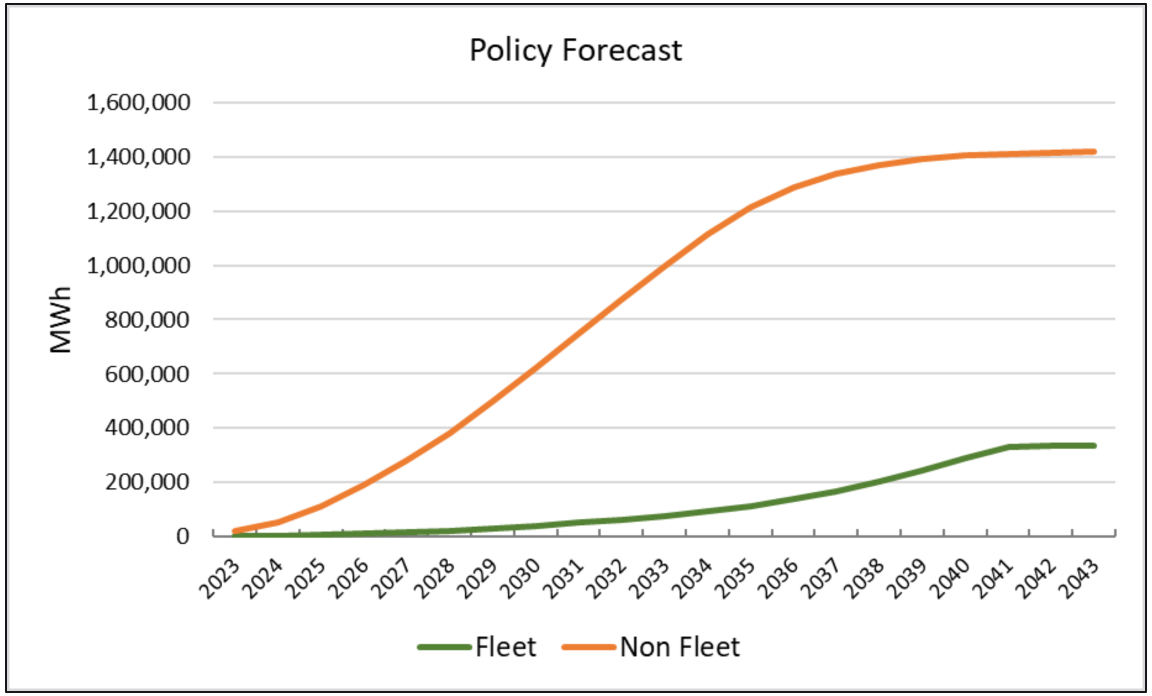






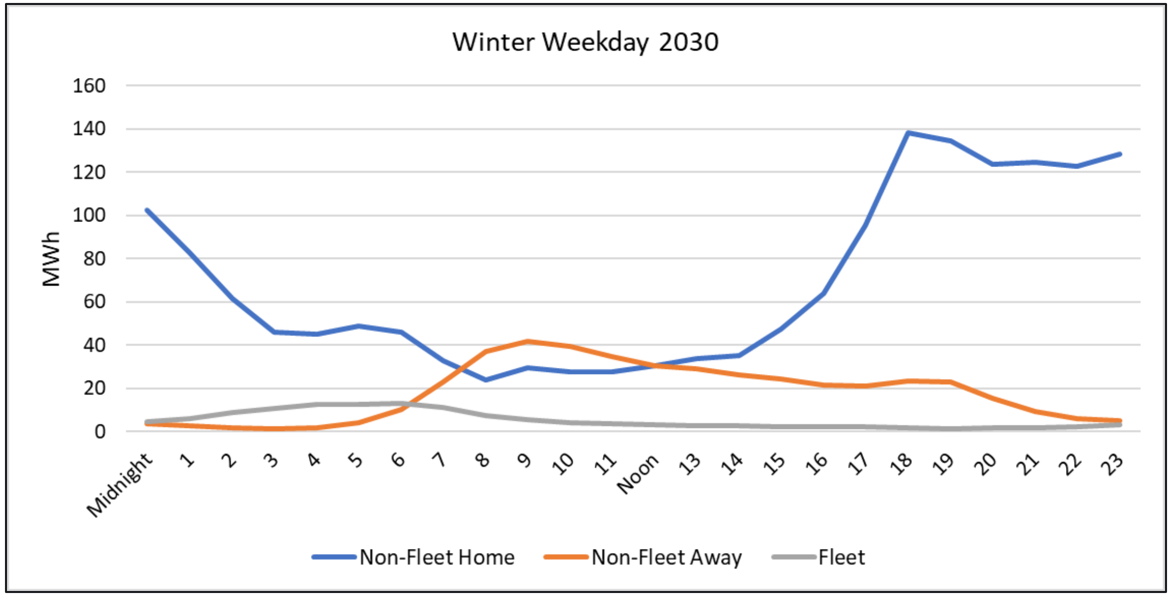
Electric Vehicle Charging Energy





- Fleet EVs are approx. 1/3 the impact of non-fleet
- Allocated to zones based on January 2023 county EV registration data

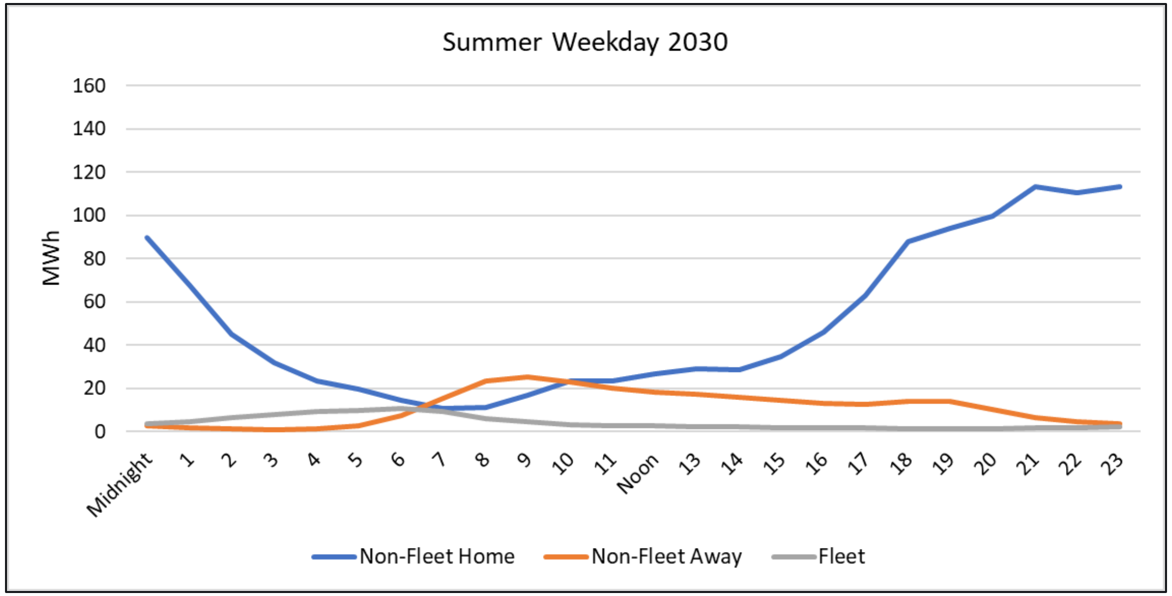
Charging Profiles



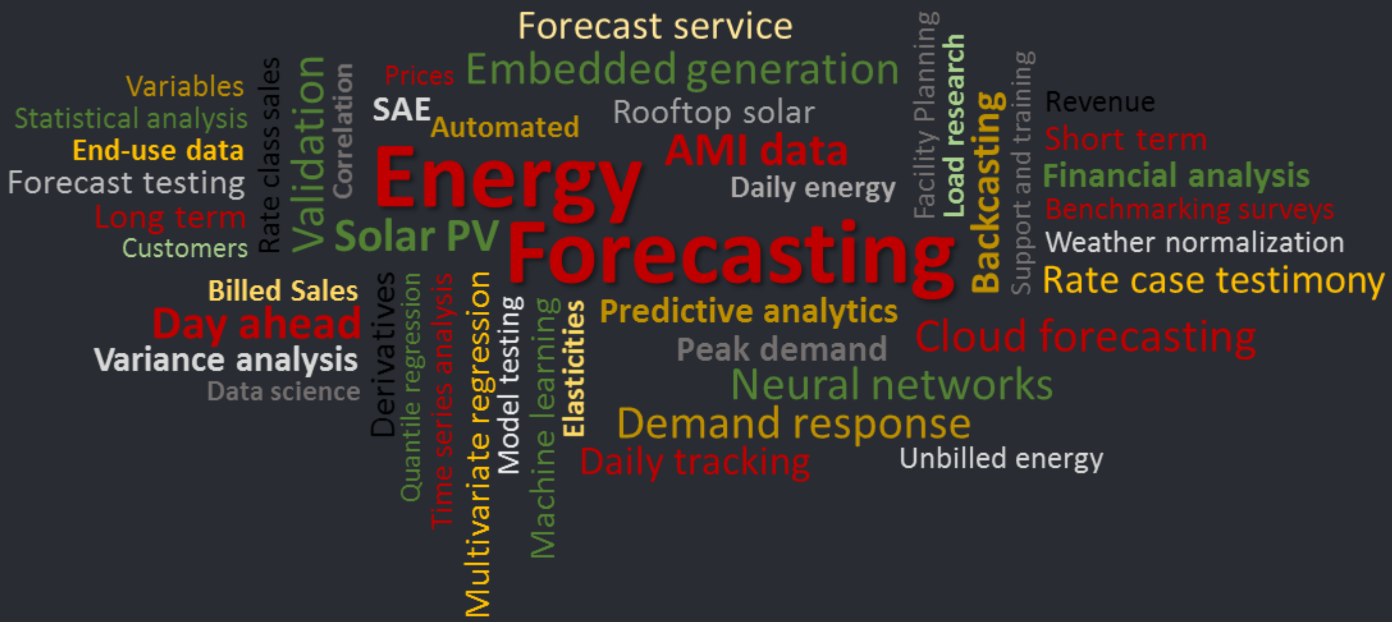
» Non-fleet at home charging profile based on measured GMP EV charging data

» Non-fleet away from home and Fleet charging profile based on the National Renewable Energy Laboratory's Electric Vehicle Infrastructure Projection Tool

- Incorporates workplace and public level two and three charging
- Seasonal patterns to capture the impact of temperature



Questions ?



Thank You

http://www.itron.com/forecasting

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