



# 2026 Long-Term Forecast Kick-Off Meeting June 16<sup>th</sup>, 2025

Mike Russo and Eric Fox



# Agenda

- Introduction
- Workplan and Schedule
- Forecast Method Overview
- Next Steps – Focus on the planning zones and substations
  - Weather response models
  - EV forecast
  - Heat pumps
  - Solar load modeling
  - New techs – battery storage, load control programs
  - Substation load forecasts
- Roundtable Discussion
  - What would you like to see this time around



# Workplan and Schedule

# Schedule: June to September 2025

## » Update forecast database and model inputs (currently, data through 2022)

- Update system, zonal hourly and known utility-scale solar generation data through June 2025
- Installed behind the meter solar capacity
- End-use intensities – Annual Energy Outlook 2025 for New England, Vermont survey data, VEIC historical and projected EE savings
- Woods & Poole 2025 forecast – county level, Moody Analytics September 2025 forecast – state level
- Monthly customer class sales and customer data
- AMI class hourly load data update – GMP and Burlington Electric
- EV and Heat Pump adoption data – by county and town
- Daily historical temperature data – Burlington, Rutland, and ?
- Normal daily and trended monthly normal HDD and CDD

## » Build out system and zone-level hourly load profiles

- Solar reconstitution, daily normal weather conditions
- Zonal weather response models, estimating with Artificial Neural Network (ANN) models
- Links/mapping to substations

## » Presentation – Data, model Inputs, distribution-level load forecasting

# Schedule: September – November 2025

## » Technology forecasts

- Update building electrification (heat pump and heat pump water heaters)
  - » Unit, energy, location, heat pump and water heat load profiles
- Update EV forecast
  - » Units, location, charging profiles
- Update utility scale and BTM solar generation forecast
- New technology and load control forecasts
  - » Utility scale and behind the meter utility scale battery storage
  - » Load control programs and rate design

## » Focus on the planning zones and subregions

- Improve zone-level forecasts of heat pumps and EVs
- Incorporate substation level load data – ideally hourly load

## » Presentation – Focus on technology forecasts

# Schedule: September – January 2026

## » Build baseline load forecasts

- State-level residential, commercial, and industrial energy demand forecasts
- System hourly load and peak forecasts – build-up from class sales forecasts
  - » Gross and Net (adjusted for solar) load forecasts
- Estimate and calibrate baseline zonal load forecasts
  - Incorporate zone-level data into model construction
    - » County-level economic projections, customer mix, known large customer activity
- Estimate baseline substation load forecasts (where data is available)
  - » Building relationship between substations and zones
  - » Understanding what is behind the substation – DERs, large customers, residential, commercial customer mix

## » Build adjusted load forecasts

- Layer technology level load forecast at the Zone level
- Aggregate zone-level adjusted forecast to system
- Allocate technology impacts to distribution substation (where possible)

## » Presentation – Preliminary Forecast Results

# Schedule: January - April 2026

## » Construct forecast scenarios

- Extreme weather conditions
- Higher and lower technology adoption paths
- Alternative EV charging profiles
- Alternative battery storage and load control strategies
- High and low economic outlook

## » Presentation – Scenario results

## » Complete project report

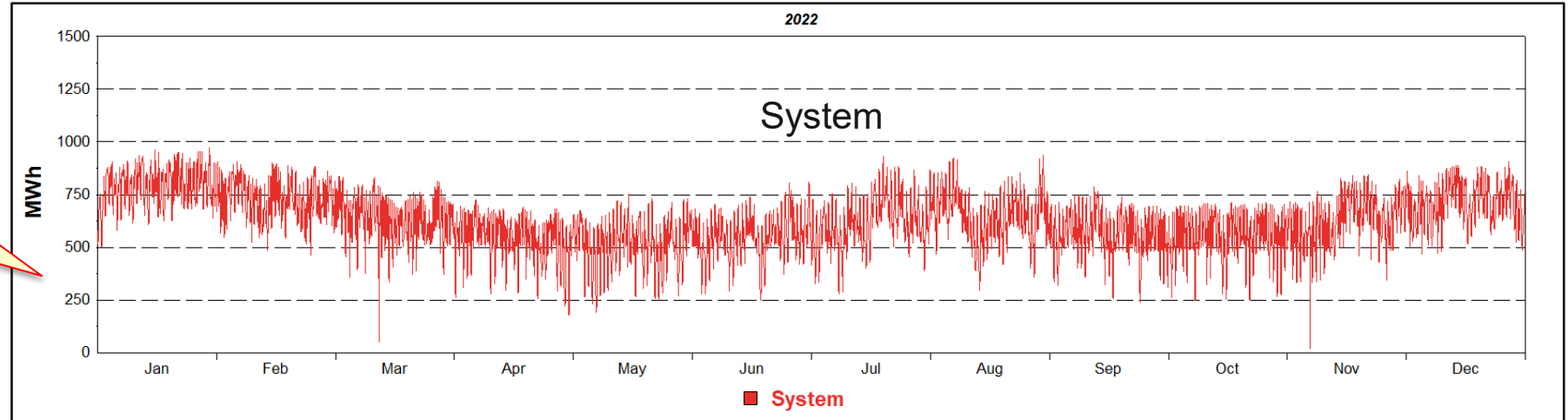
# Forecast Method Overview



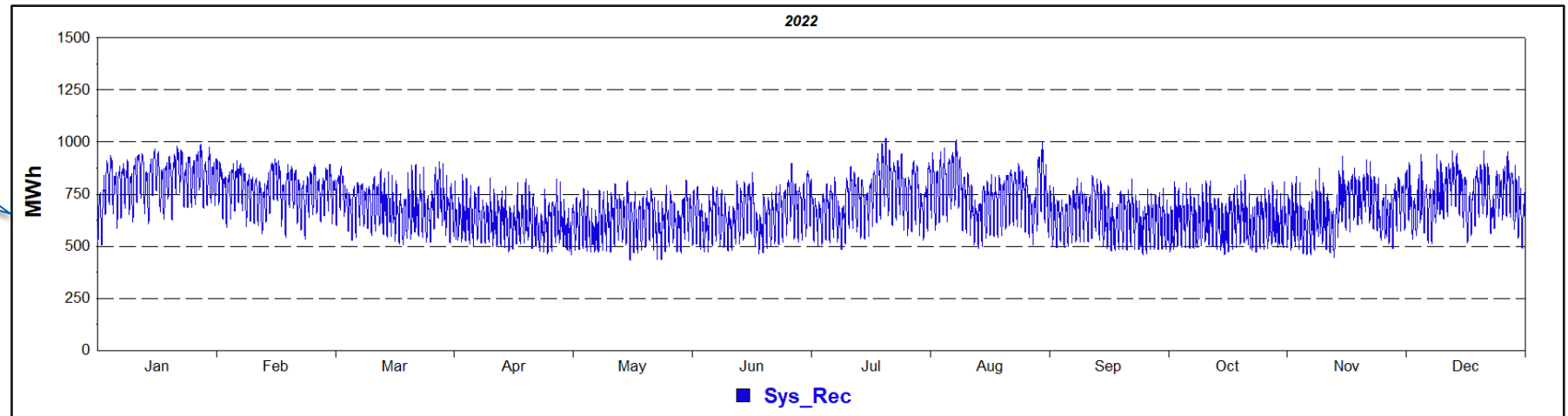
# 1. Reconstitute Sales and Load for Solar Generation

- » Forecast based on reconstituted class sales and system and zonal hourly loads (gross load)
  - Given the large amount of embedded solar, it's impossible to model net demand (what is measured by VELCO)

What we see

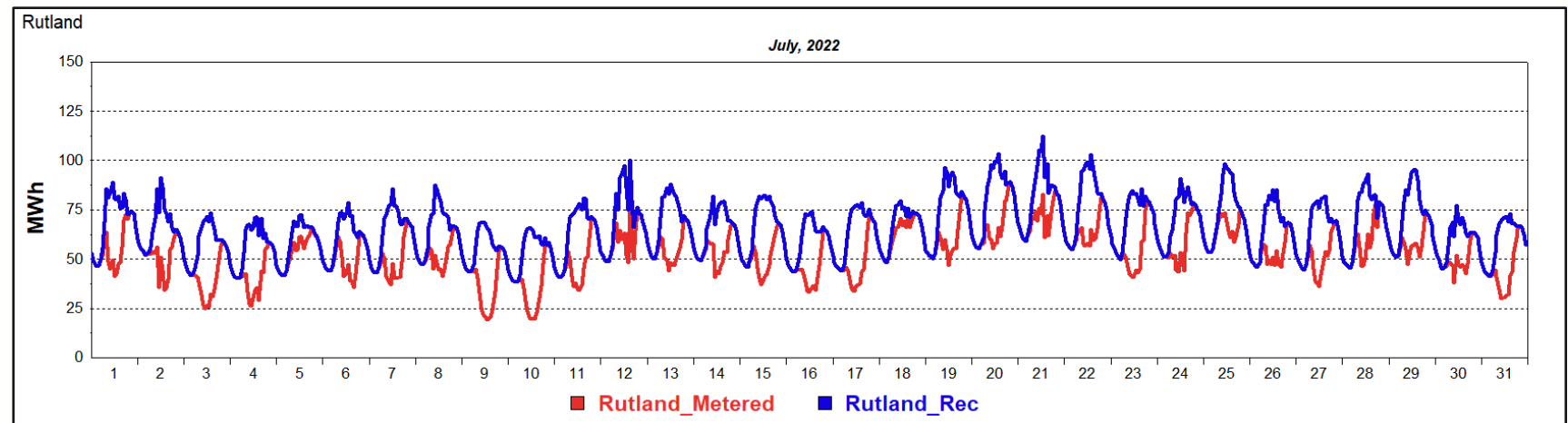
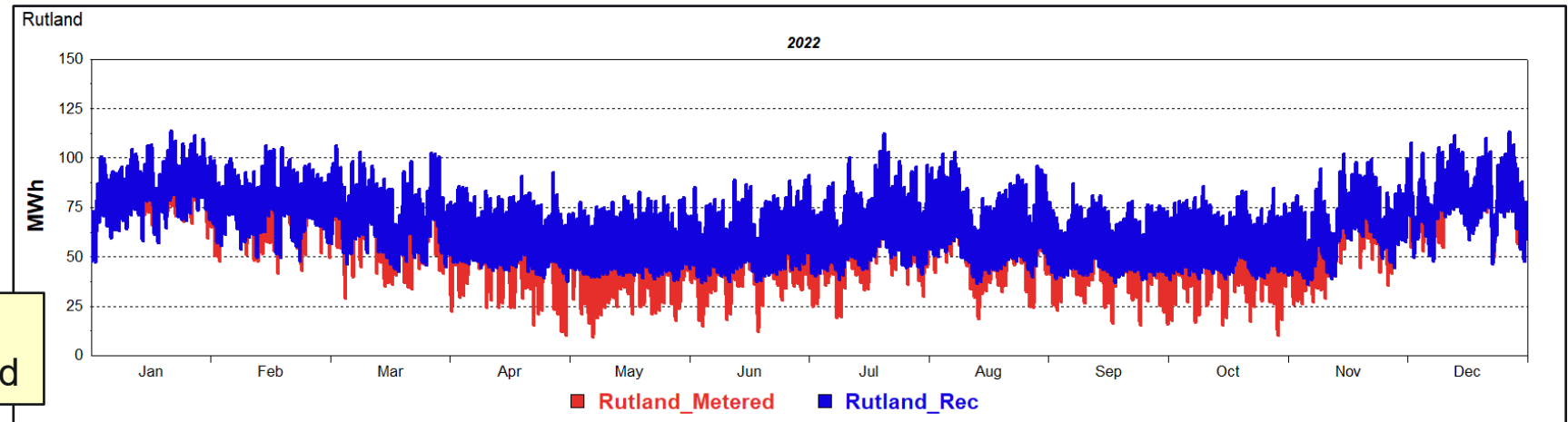


What we model



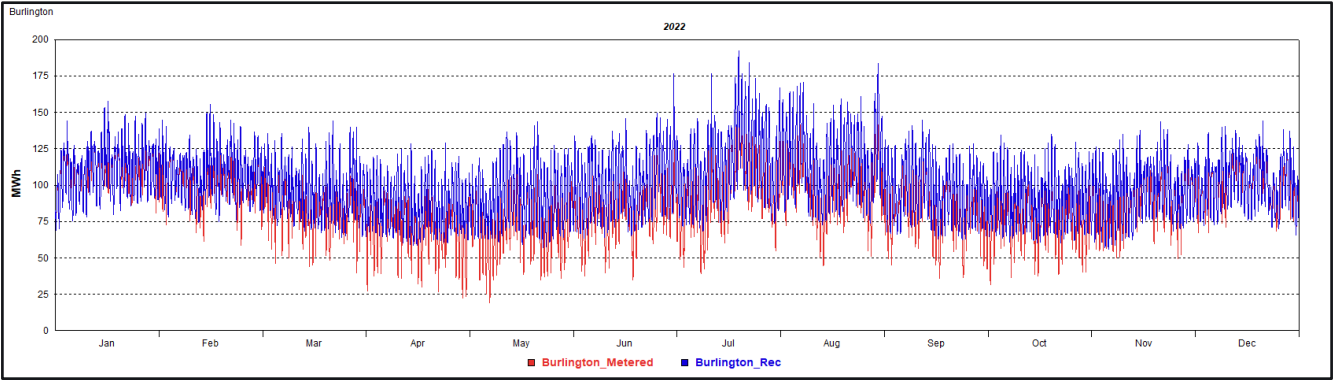
# Need to reconstitute loads for each zone

Red is what we see.  
Blue is our best estimate of demand

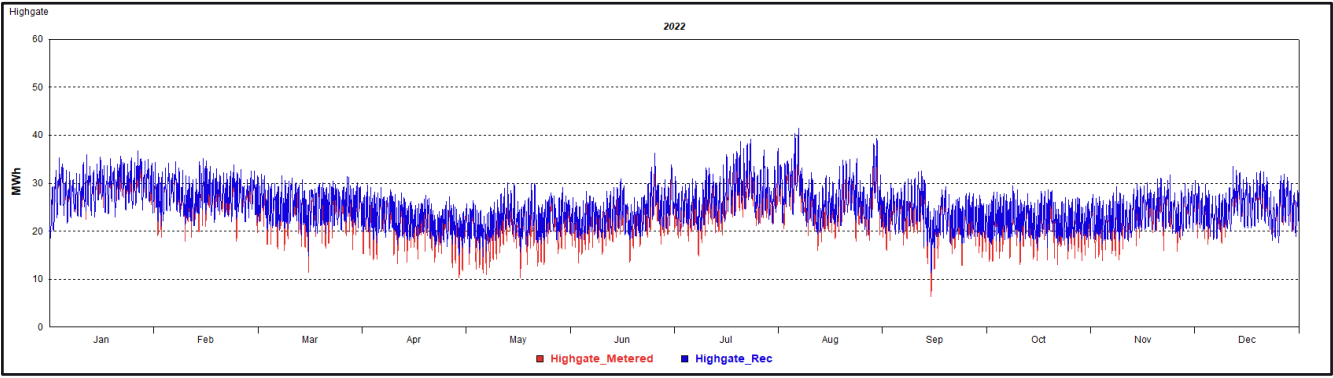


# Reconstituted Load Examples

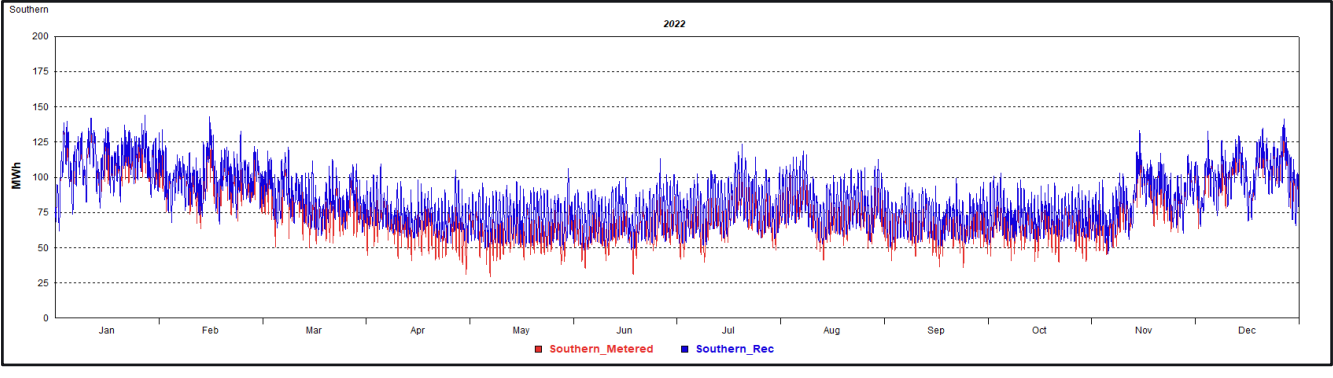
Burlington



Highgate



Southern



## 2. Develop Customer Energy Requirements Forecast

- » Sales forecast based on state reported billed sales and customers through December 2024.
  - 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:
  - Population and households
  - Household income, GSP, employment
    - Moody Analytics Fall 2025
    - Woods & Poole June 2025 (county forecasts calibrated to Moody's state forecast)
  - End-use and building shell efficiency and saturation trends
    - AEO 2025 New England forecast calibrated to state residential survey and NREL ResStock and ComStock simulations for Vermont
  - State energy efficiency savings projections (current Demand Resource Plan)
  - CDD and HDD reflect increasing temperature trend ( 0.9 degrees per decade)



# End-Use Model Framework (SAE)

## » 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)

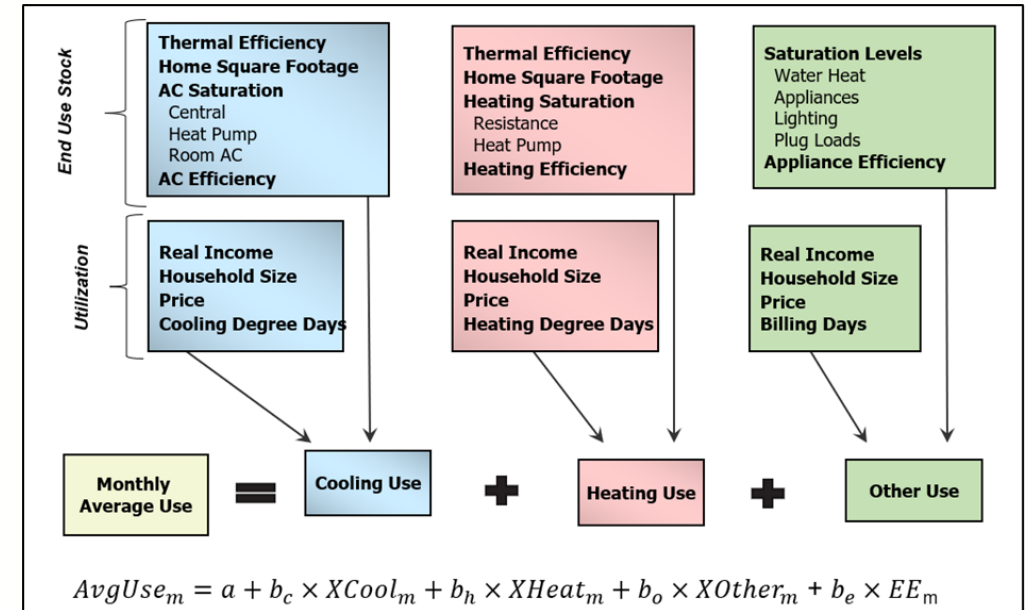
## » Commercial

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

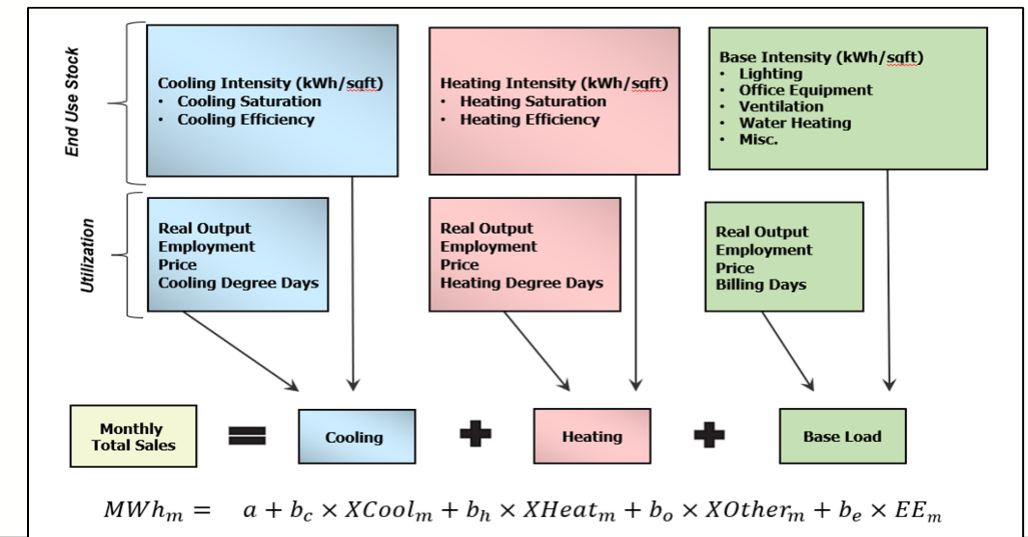
## » Linear regression used to estimate models

- Models estimated with billed sales and customer data
- Estimation statistically adjust end-use estimates to usage

### Residential Model



### Commercial Model

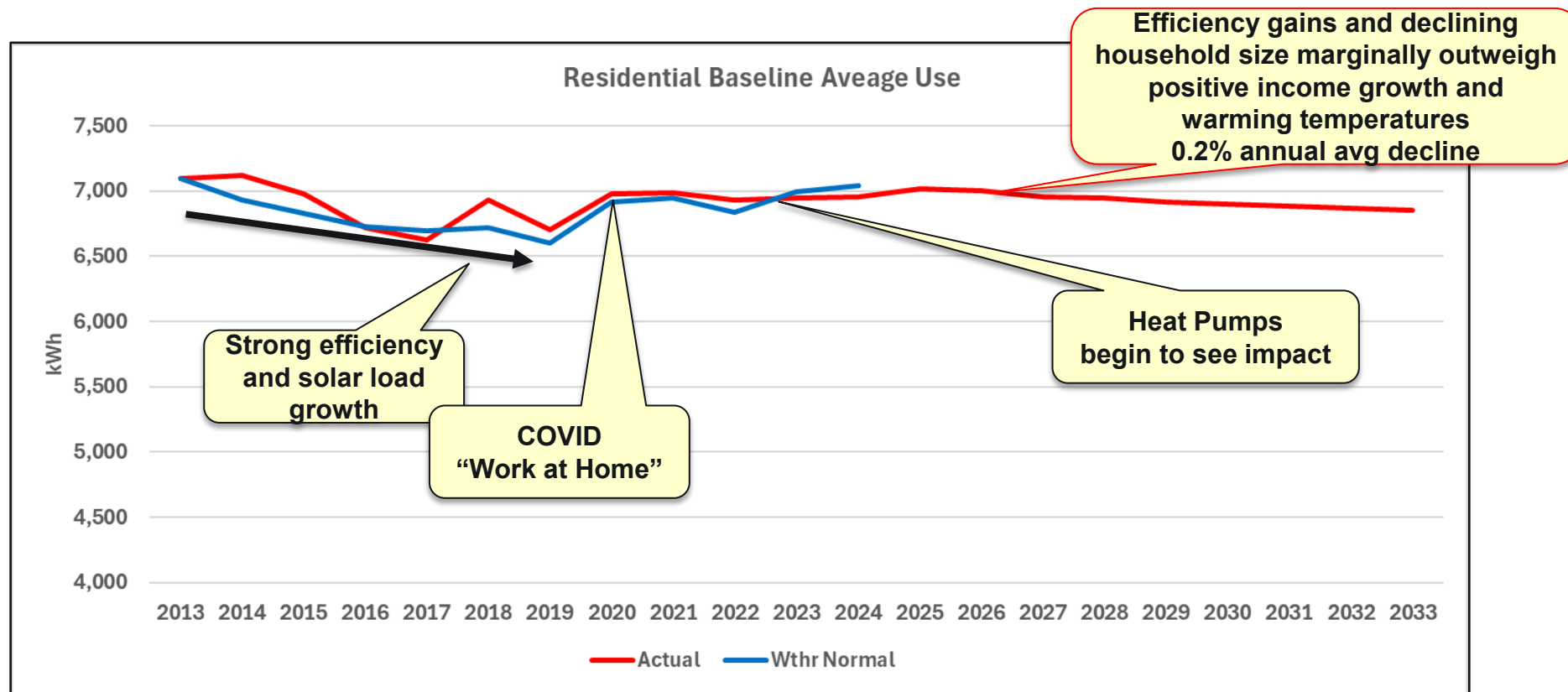


# Residential Baseline Average Use Model

- » Model residential average use (with solar own generation added back in)
- » Baseline average use (with no solar), captures
  - end-use saturation, efficiency, household size, household income, price, and temperature trends

Variable	Coefficient	StdErr	T-Stat
mStructRevRes.XHeat	1.143	0.046	24.896
mStructRevRes.XCool	1.110	0.064	17.422
mStructRevRes.XOther	0.966	0.013	74.363

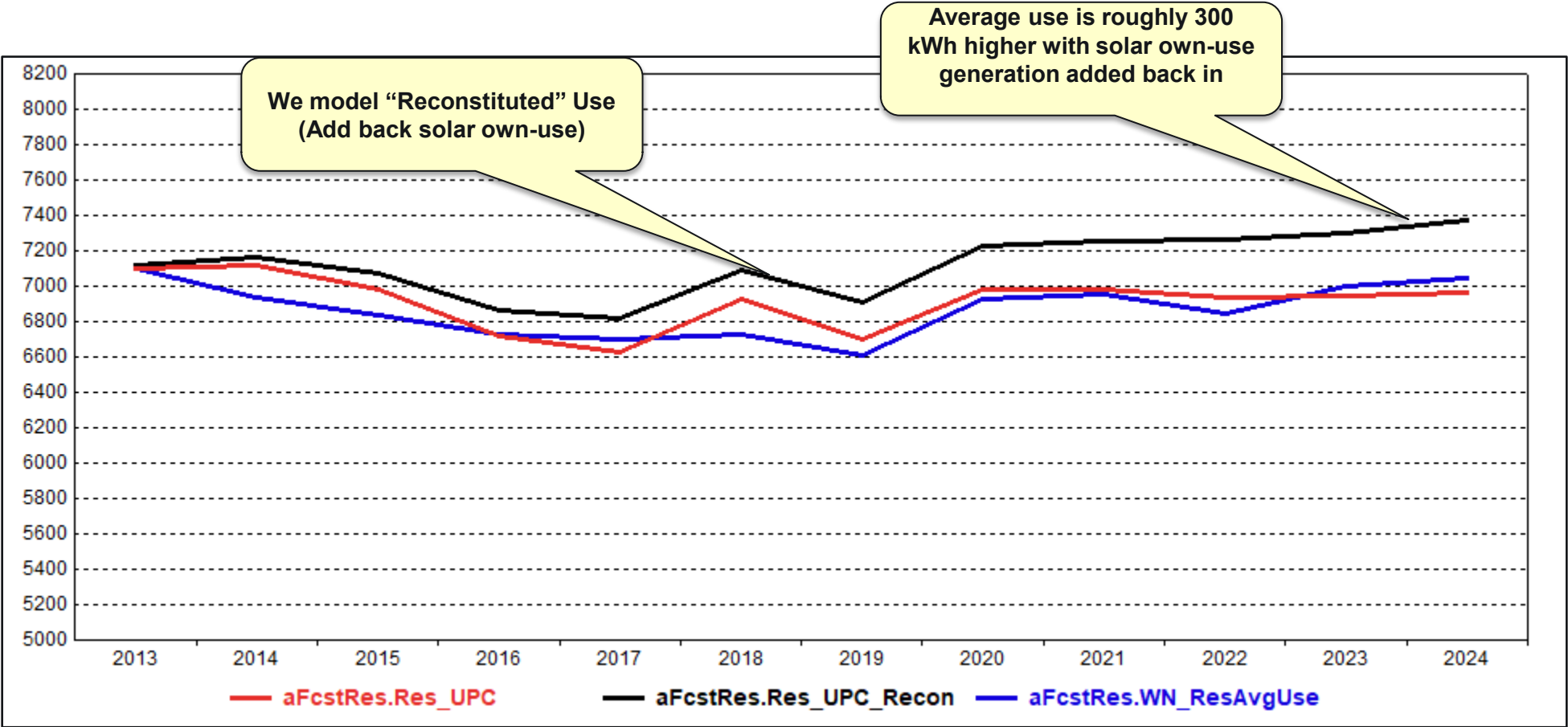
Adjusted Observations	156
Deg. of Freedom for Error	144
R-Squared	0.963
Adjusted R-Squared	0.960
AIC	5.677
BIC	5.911
F-Statistic	#NA
Prob (F-Statistic)	#NA
Log-Likelihood	-652.15
Model Sum of Squares	1,005,651.37
Sum of Squared Errors	39,059.48
Mean Squared Error	271.25
Std. Error of Regression	16.47
Mean Abs. Dev. (MAD)	12.03
Mean Abs. % Err. (MAPE)	1.98%
Durbin-Watson Statistic	1.683



Model baseline excludes future solar, heat pumps, and EVs

# Solar Impact

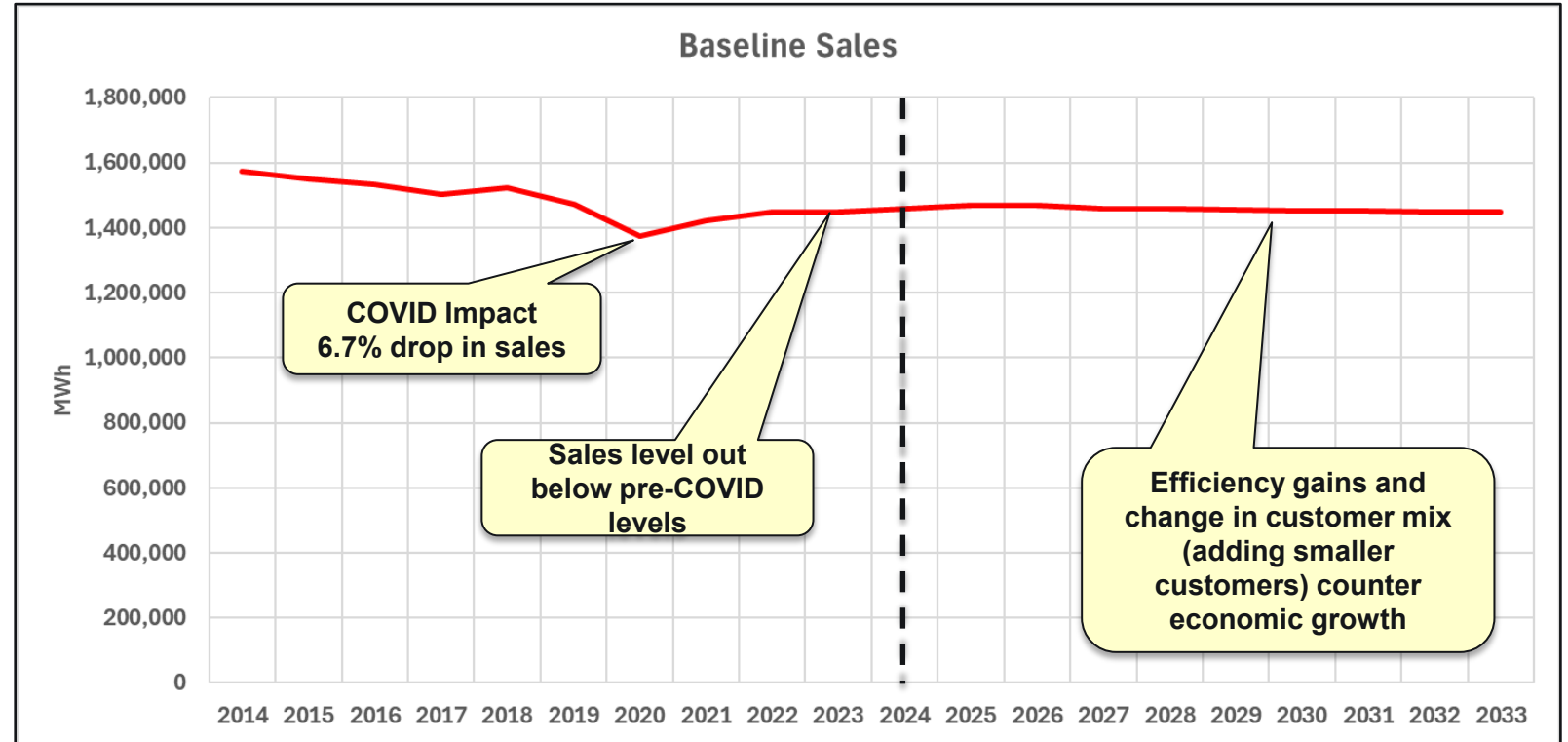
Impacts customer class sales as well as system and zonal hourly loads



# Small Commercial Baseline Sales Trend

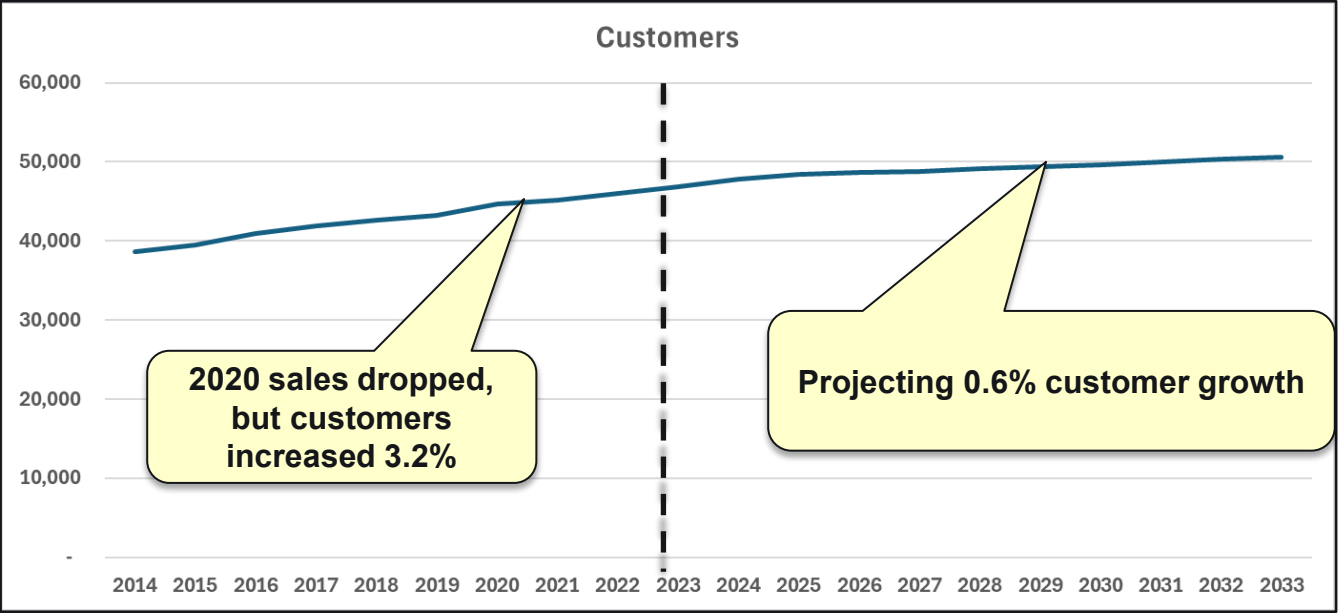
Variable	Coefficient	StdErr	T-Stat
CONST	21237.142	7664.796	2.771
mStructRevCom.XHeat	159926.247	10291.309	15.540
mStructRevCom.XCool	77089.833	3494.534	22.060
mStructRevCom.XOther	7737.154	618.948	12.500
Covid.NResIndex	-5494.170	1068.134	-5.144

Model Statistics	
Iterations	22
Adjusted Observations	168
Deg. of Freedom for Error	158
R-Squared	0.910
Adjusted R-Squared	0.905
AIC	16.016
BIC	16.202
F-Statistic	177.801
Prob (F-Statistic)	0.0000
Log-Likelihood	-1,573.76
Model Sum of Squares	13,645,455,321.50
Sum of Squared Errors	1,347,315,525.08
Mean Squared Error	8,527,313.45
Std. Error of Regression	2,920.16
Mean Abs. Dev. (MAD)	2,280.41
Mean Abs. % Err. (MAPE)	1.83%
Durbin-Watson Statistic	1.748



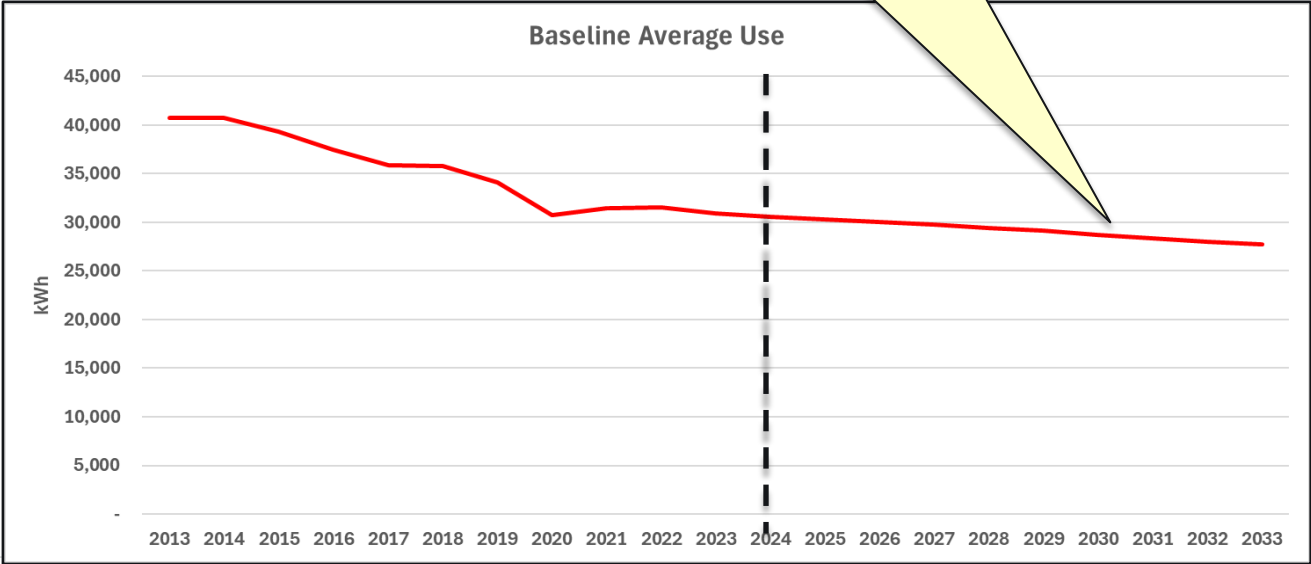


# Small Commercial Baseline Sales Trend



Strong growth in the number of “small businesses” contribute to the decline in aggregate class average use.

Average use decline 0.7% per year - strong efficiency gains and smaller use customers



# Small Businesses

76,787

SMALL BUSINESSES IN VT (FEWER THAN 500 EMPLOYEES) (US SMALL BUSINESS ADMINISTRATION, 2023)

86.7%

PERCENTAGE OF VERMONT'S \$2.4 BILLION IN TOTAL EXPORTS GENERATED BY SMALL AND MEDIUM SIZED BUSINESSES







98% of small businesses have less than 19 employees.

Nearly 80% have no employees.

Since 2019, averaging 0.8% annual growth in new businesses. (IBISWorld).

48,000 Small Commercial Customers

## Small business count by size and industry

				
Industry	No employees	1-19 employees	20-499 employees	All small businesses
Professional, Scientific, and Technical Services	9,730	1,765	126	11,621
Construction	8,662	2,519	132	11,313
Retail Trade	4,941	1,745	275	6,961
Other Services (except Public Administration)	4,853	1,882	81	6,816
Real Estate and Rental and Leasing	6,095	608	36	6,739
Health Care and Social Assistance	4,955	1,292	276	6,523
Administrative, Support, and Waste Management	5,294	1,008	64	6,366
Arts, Entertainment, and Recreation	5,103	398	50	5,551
Educational Services	2,578	298	84	2,960
Accommodation and Food Services	1,300	1,300	339	2,939
Manufacturing	1,761	747	193	2,701
Transportation and Warehousing	1,978	336	53	2,367
Agriculture, Forestry, Fishing and Hunting	1,814	134	3	1,951
Wholesale Trade	819	409	138	1,366
Finance and Insurance	935	317	52	1,304
Information	915	249	55	1,219
Utilities	155	13	7	175
Mining, Quarrying, and Oil and Gas Extraction	33	28	5	66
Management of Companies and Enterprises	*	11	25	36
Industries not classified	*	29	1	30
Total	61,921	15,074	1,888	78,883

\* Not reported by the Census Bureau

Sources: [Nonemployer Statistics](#), 2019 (Census); [Statistics of US Businesses](#), 2019 (Census)

# Vermont Economic Outlook

## Moody's Analytics January 2025 Forecast

1.7% real personal income growth  
1.5% gross state product growth  
0.0% employment growth?

Implies productivity alone drives  
GSP growth

- » Income, households, and GDP used in driving the residential forecast
- » GDP and households drive the commercial sales forecast
- » Industrial sales forecast based on GDP and manufacturing employment

Year	Households (Thou)	Chg	RPI (Mil \$)	Chg	GDP (Mil \$)	Chg	Emp (Thou)	Chg
2015	272.9		31,425		32,090		312.1	
2016	275.1	0.8%	31,632	0.7%	32,296	0.6%	313.3	0.4%
2017	276.6	0.5%	31,921	0.9%	32,586	0.9%	315.0	0.5%
2018	277.5	0.3%	32,524	1.9%	32,846	0.8%	316.1	0.3%
2019	276.0	-0.5%	33,647	3.5%	33,202	1.1%	315.4	-0.2%
2020	271.3	-1.7%	35,860	6.6%	32,389	-2.5%	289.3	-8.3%
2021	271.2	0.0%	35,855	0.0%	33,690	4.0%	294.5	1.8%
2022	272.7	0.5%	35,393	-1.3%	34,664	2.9%	304.1	3.3%
2023	273.6	0.3%	35,994	1.7%	35,219	1.6%	309.5	1.8%
2024	275.0	0.5%	36,892	2.5%	35,974	2.1%	314.2	1.5%
2025	276.0	0.3%	37,672	2.1%	36,603	1.8%	316.6	0.8%
2026	276.7	0.3%	38,312	1.7%	37,052	1.2%	317.1	0.2%
2027	277.2	0.2%	38,879	1.5%	37,518	1.3%	316.8	-0.1%
2028	277.5	0.1%	39,441	1.4%	38,069	1.5%	316.5	-0.1%
2029	277.7	0.1%	40,165	1.8%	38,683	1.6%	316.4	0.0%
2030	278.3	0.2%	40,935	1.9%	39,321	1.7%	316.2	-0.1%
2031	278.8	0.2%	41,681	1.8%	39,941	1.6%	315.9	-0.1%
2032	279.3	0.2%	42,429	1.8%	40,568	1.6%	315.7	-0.1%
2033	279.6	0.1%	43,154	1.7%	41,200	1.6%	315.4	-0.1%
2034	279.8	0.1%	43,821	1.5%	41,779	1.4%	315.1	-0.1%
15-24		0.1%		1.8%		1.3%		0.1%
24-34		0.2%		1.7%		1.5%		0.0%

Slightly lower economic growth projections compared with last year

# 2023 State Baseline Sales Projection

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

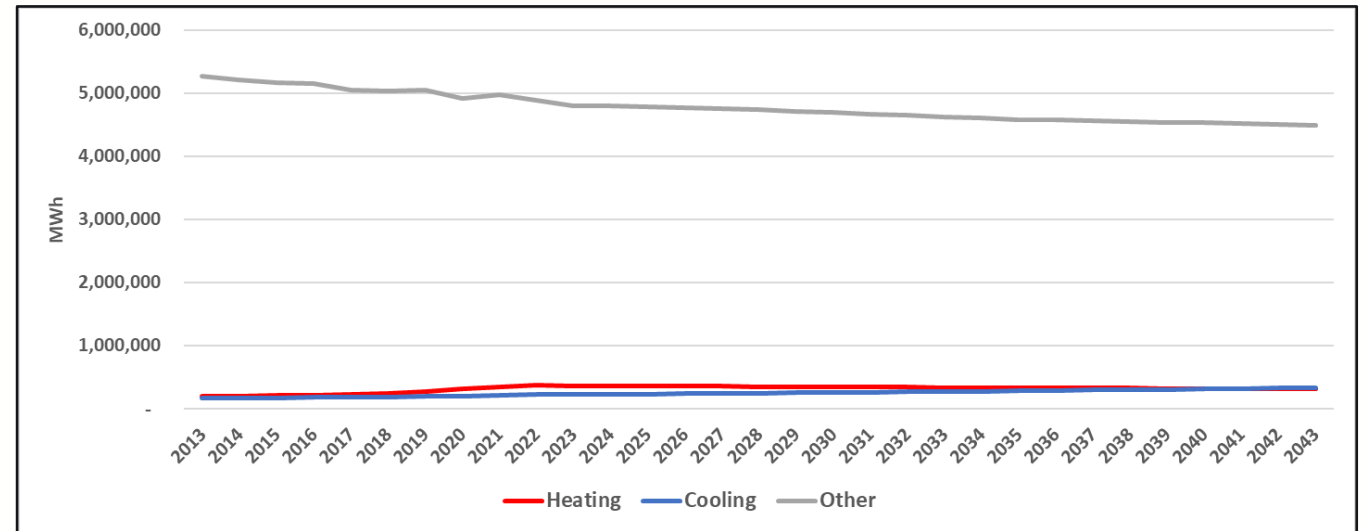
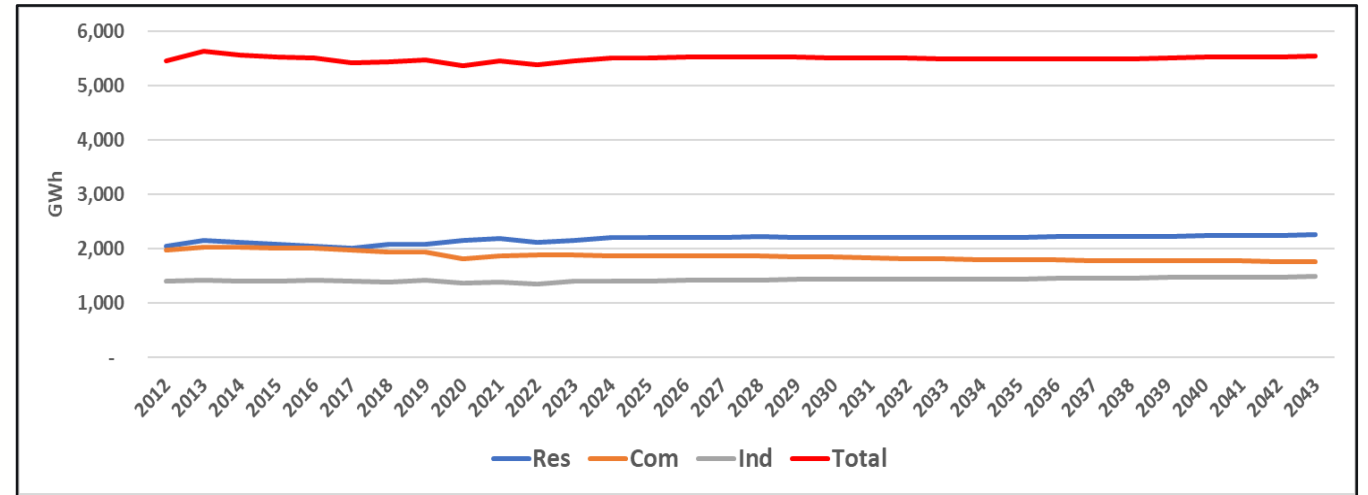
» Forecast based on:

- 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.

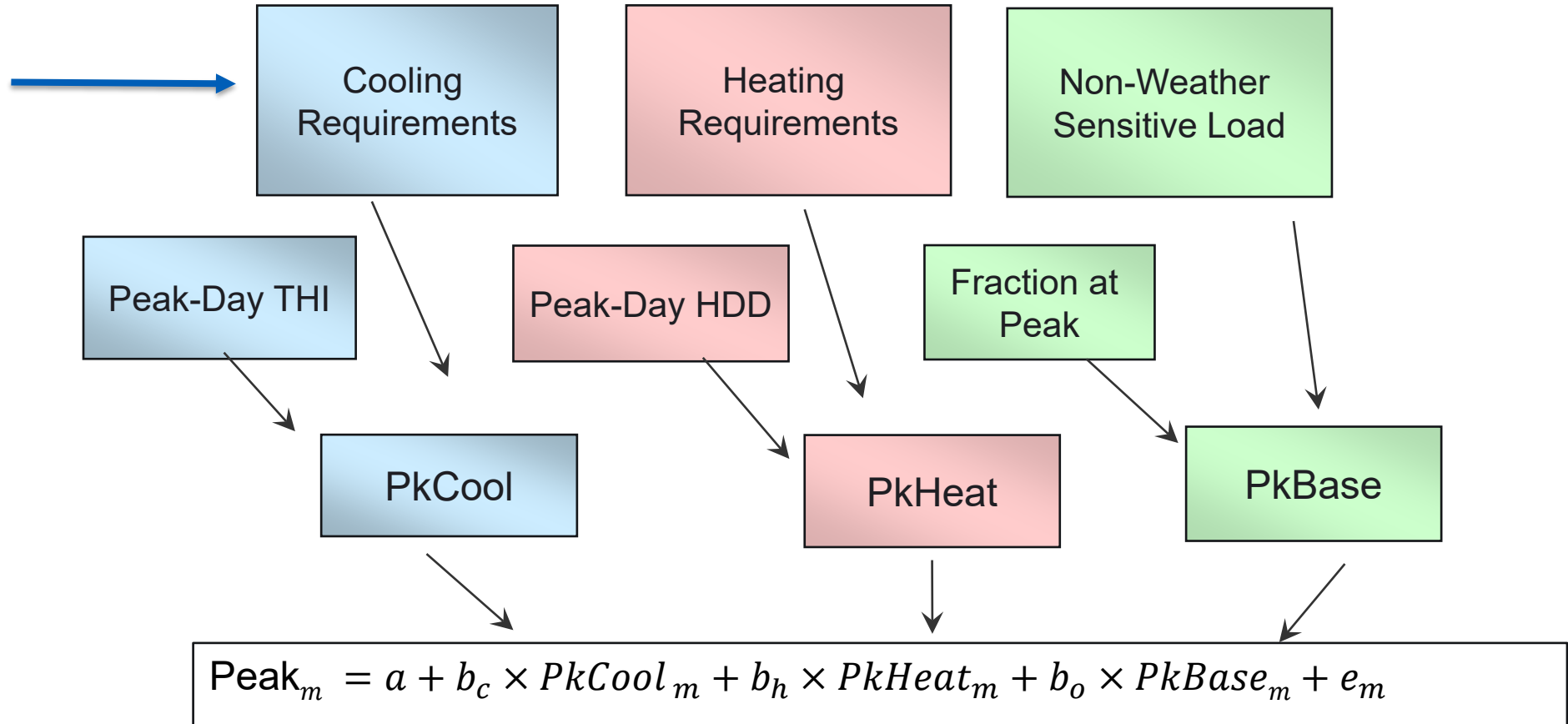
Period	Res	Com	Ind	Total
2012 - 2022	0.4%	-0.4%	-0.4%	-0.1%
2023 - 2033	0.3%	-0.4%	0.3%	0.3%
2033 - 2043	0.2%	-0.3%	0.3%	0.1%





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

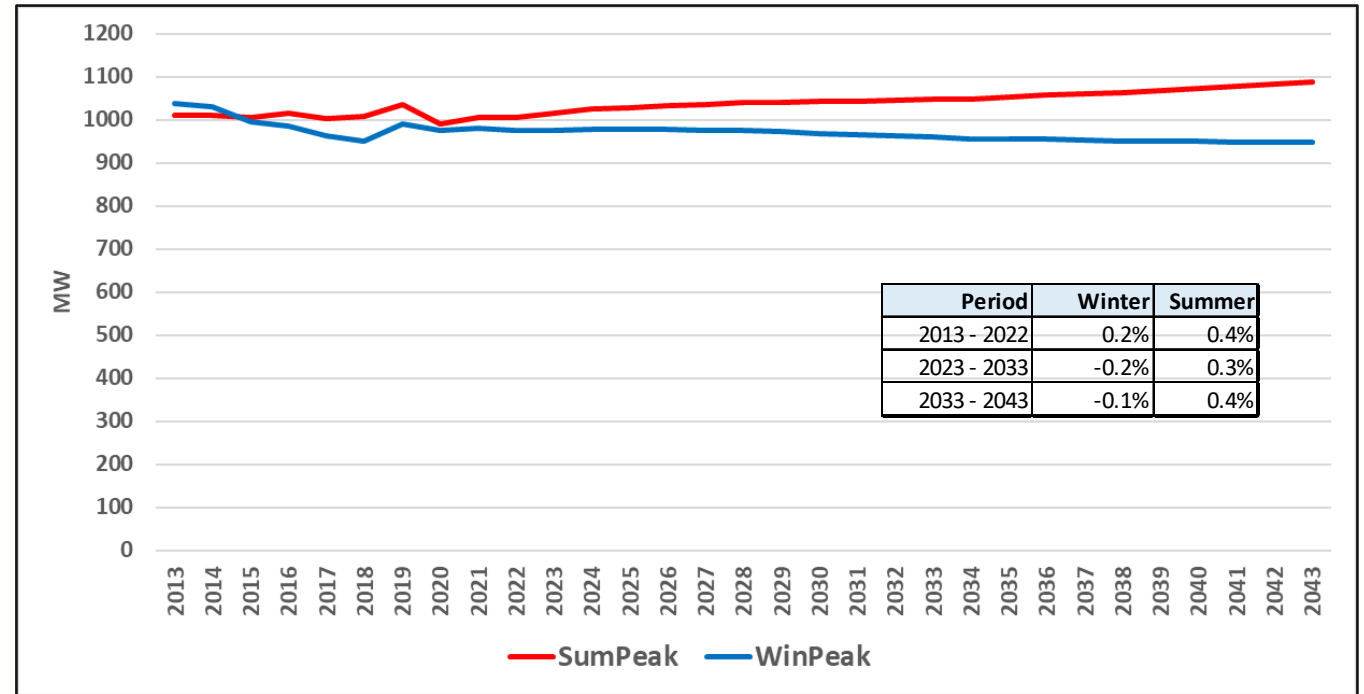
End-use energy estimates derived from sales models



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



## 4. Estimate Zonal Energy Models

$$MWh_{Zm} = a + b_c \times CoolMWh_{Zm} + b_h \times HeatMWh_{Zm} + b_o \times BaseMWh_{Zm} + e_{Zm}$$

Models based on reconstituted zonal energy

$$CoolMWh_{Zm} = ResCooling_{Zm} + ComCooling_{Zm}$$

$$HeatMWh_{Zm} = ResHeating_{Zm} + ComHeating_{Zm}$$

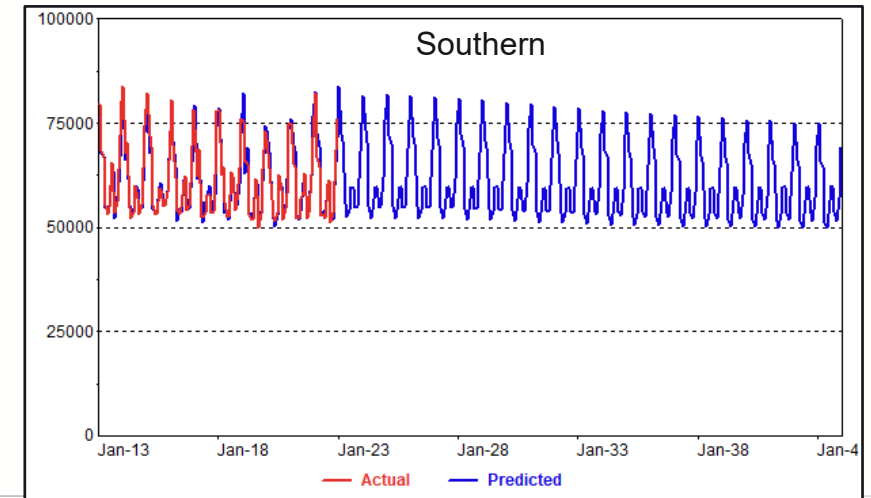
$$BaseMWh_{Zm} = ResBaseUse_{Zm} + ComBaseUse_{Zm} + IndBaseUse_{Zm}$$

Method captures differences in zonal customer mix and this year growth trends

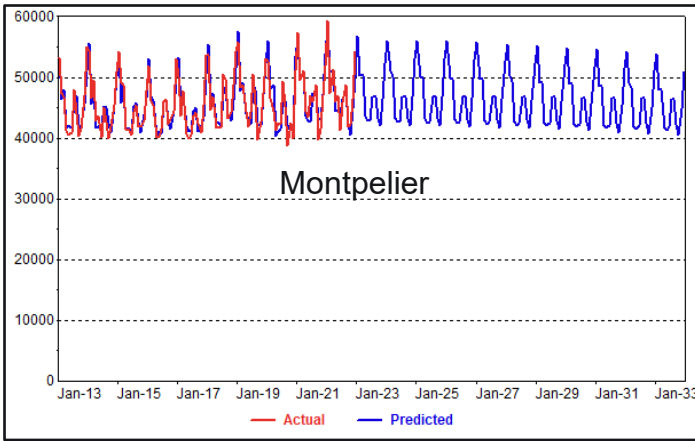
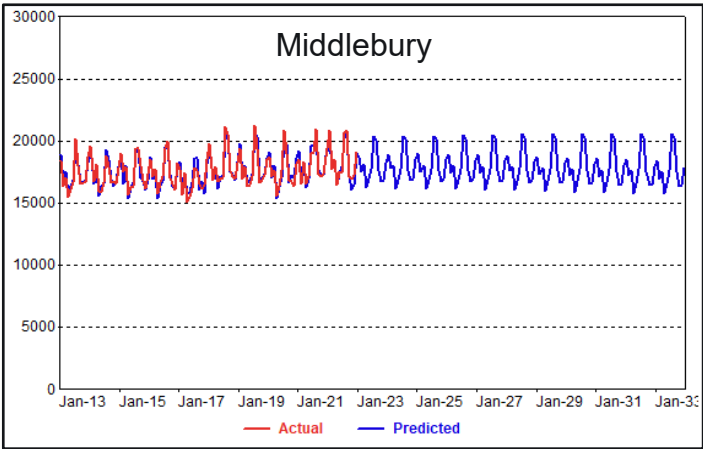
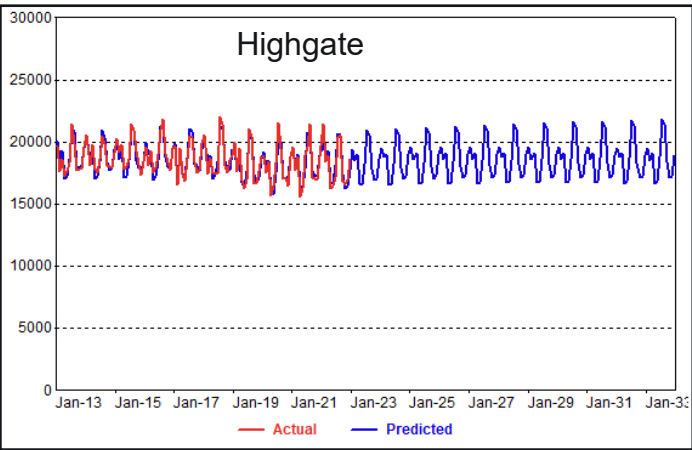
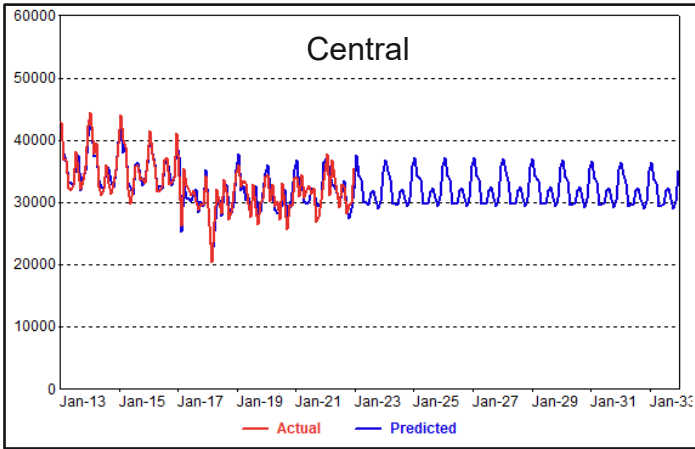
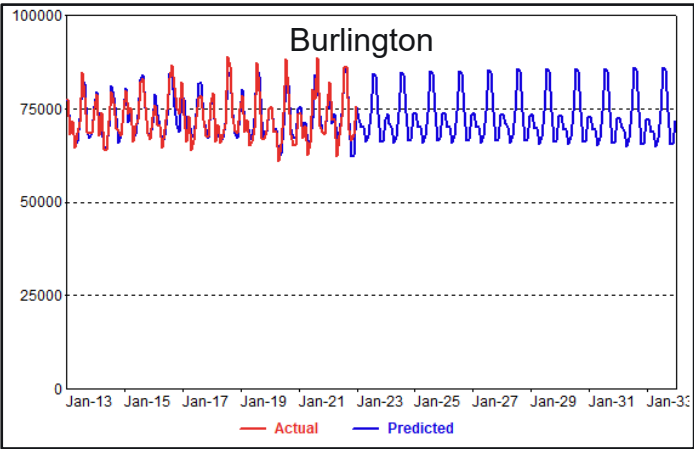
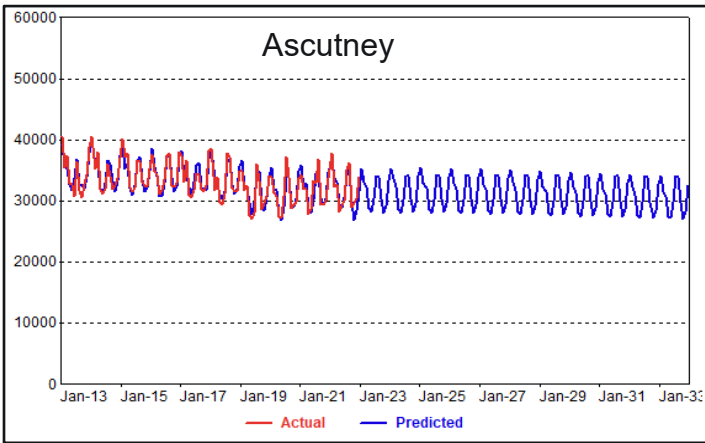
Residential sales allocated to zones base on zone percent of state households  
C&I sales allocated to zones based on zone percent of state employment

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

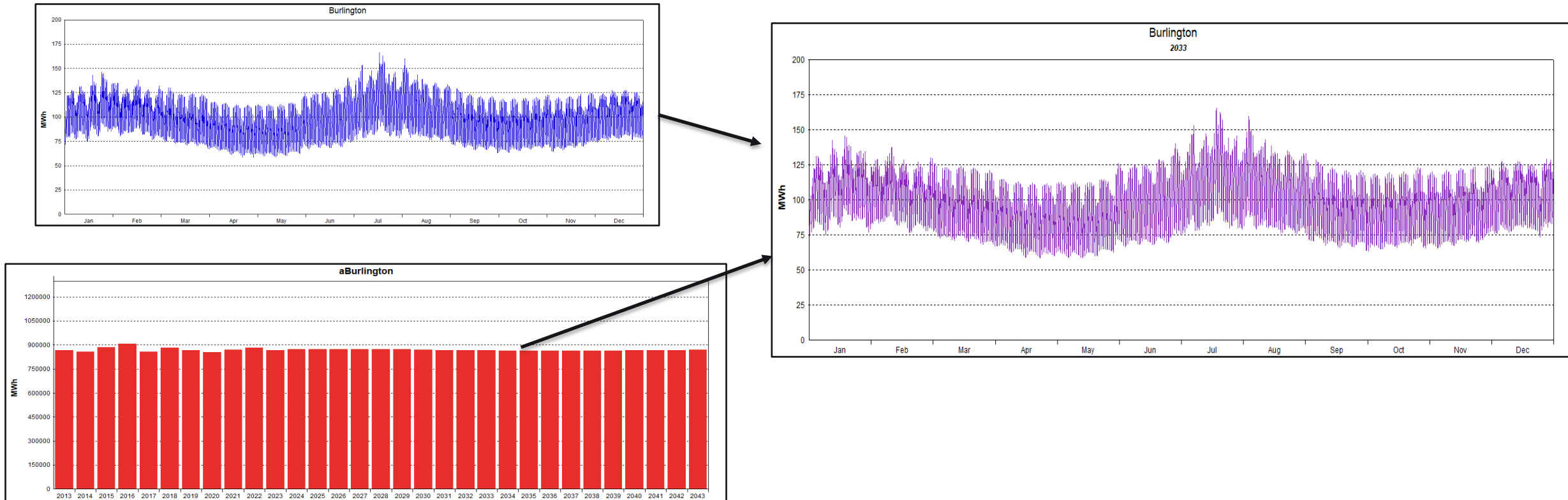


# Zonal Energy Forecast



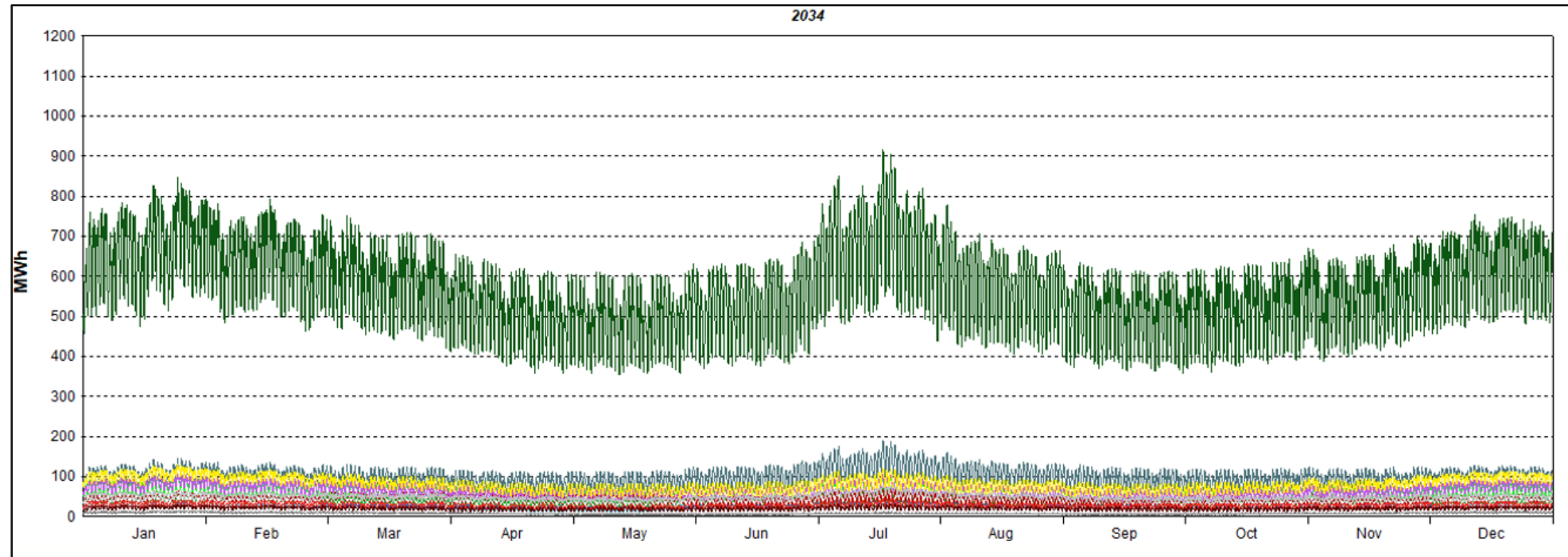
## 5. Generate Zonal Baseline Load Forecasts (Reconstituted)

- » 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 baseline load forecasts to system baseline load forecast

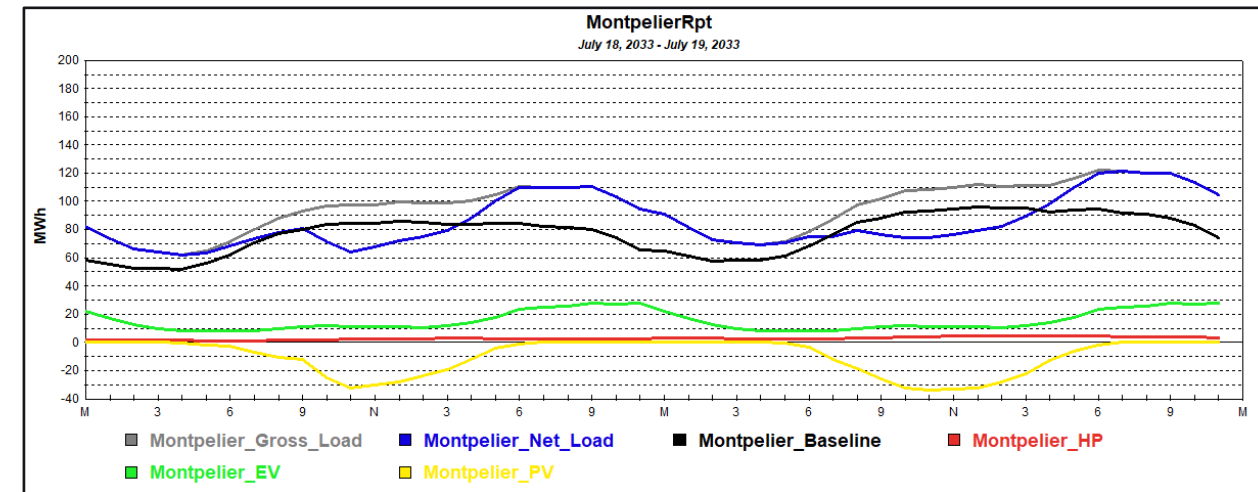
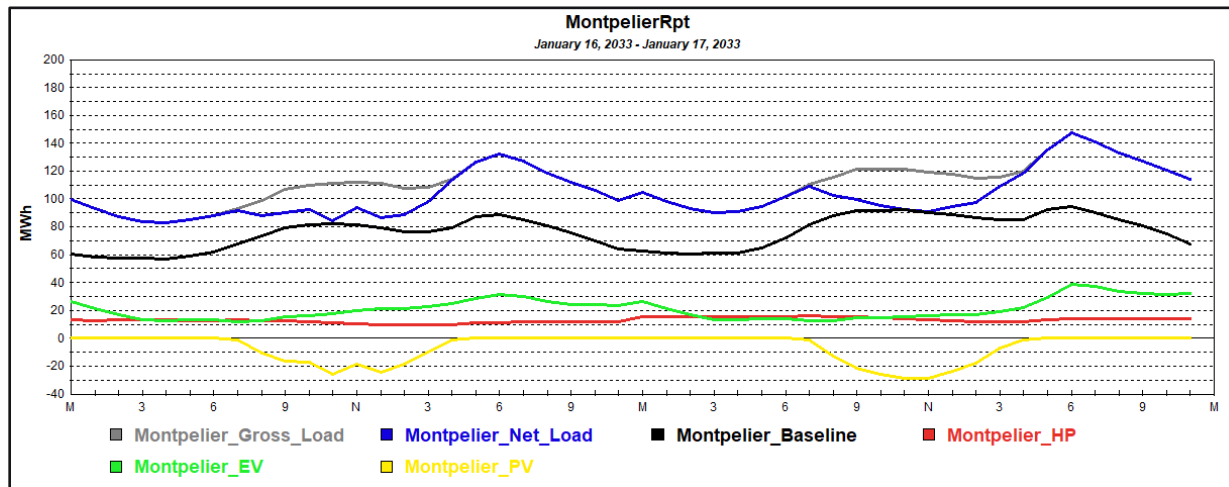
## 6. Develop Zone Adjusted Hourly Load Forecast Net – includes solar impact

### » Technology loads allocated to zones

- State heat pump units allocated based on zone-level household estimates
- 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 based on historical BTM capacity estimates

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

## Montpelier 2033 Load Forecast

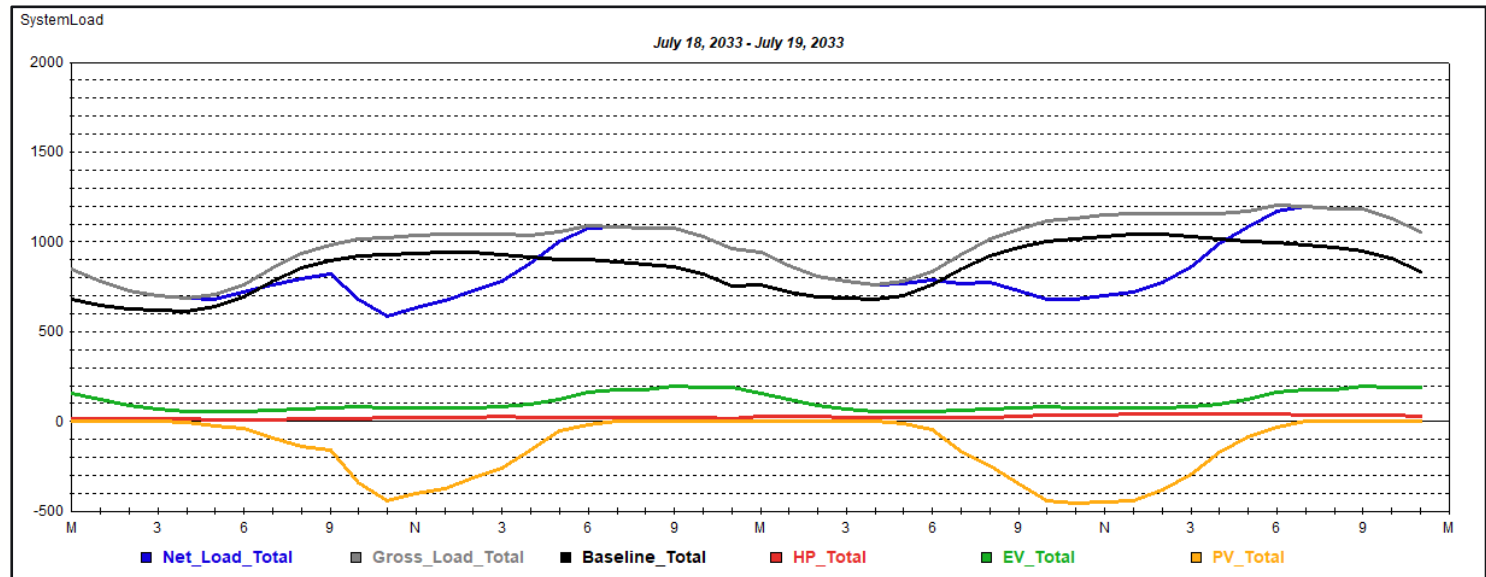
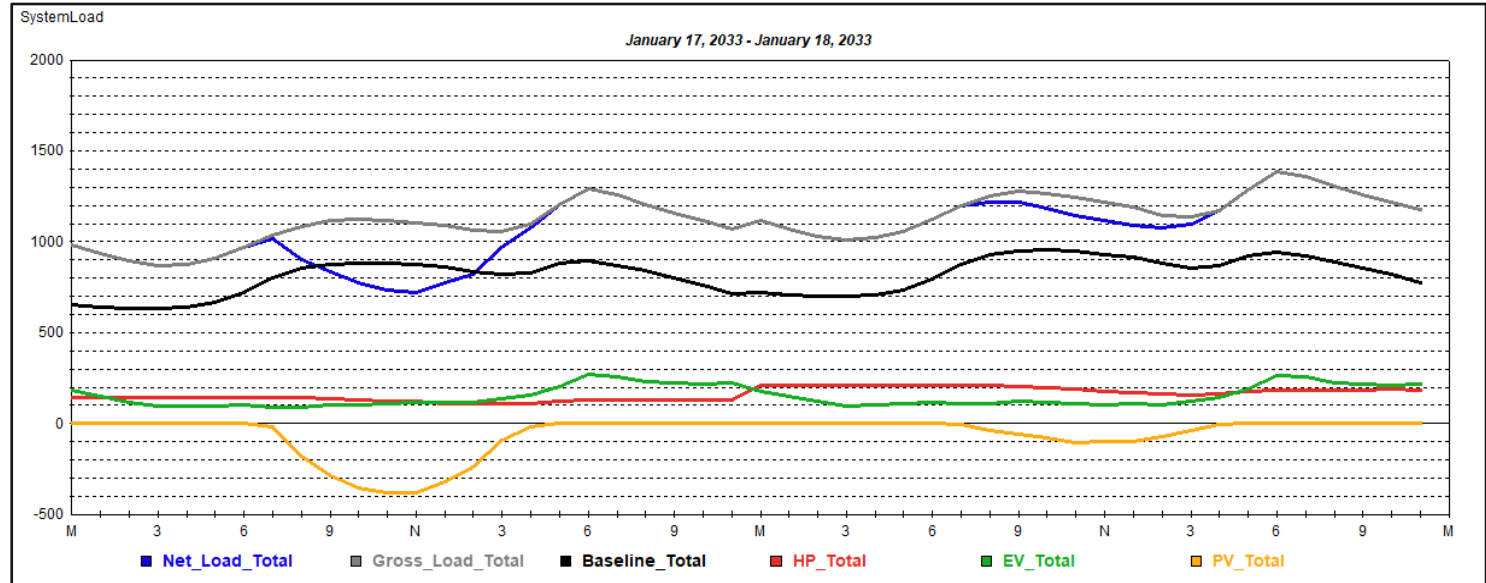


# Adjusted System Load Forecast

Sum of the adjusted zone hourly load forecasts

## » Load Components

- Net load (final result)
- Gross load (before solar adjustment)
- Baseline (before tech adjustments)
- Tech forecasts
  - Electric vehicle
  - Heat Pump
  - Solar
- Forecast reflects “non-controlled” customer loads
- Possible actions
  - EV charging control or pricing
  - End-use controls – air conditioning, water heat
  - Utility and behind the meter battery storage and operation schema
  - Large C&I interruptible load programs

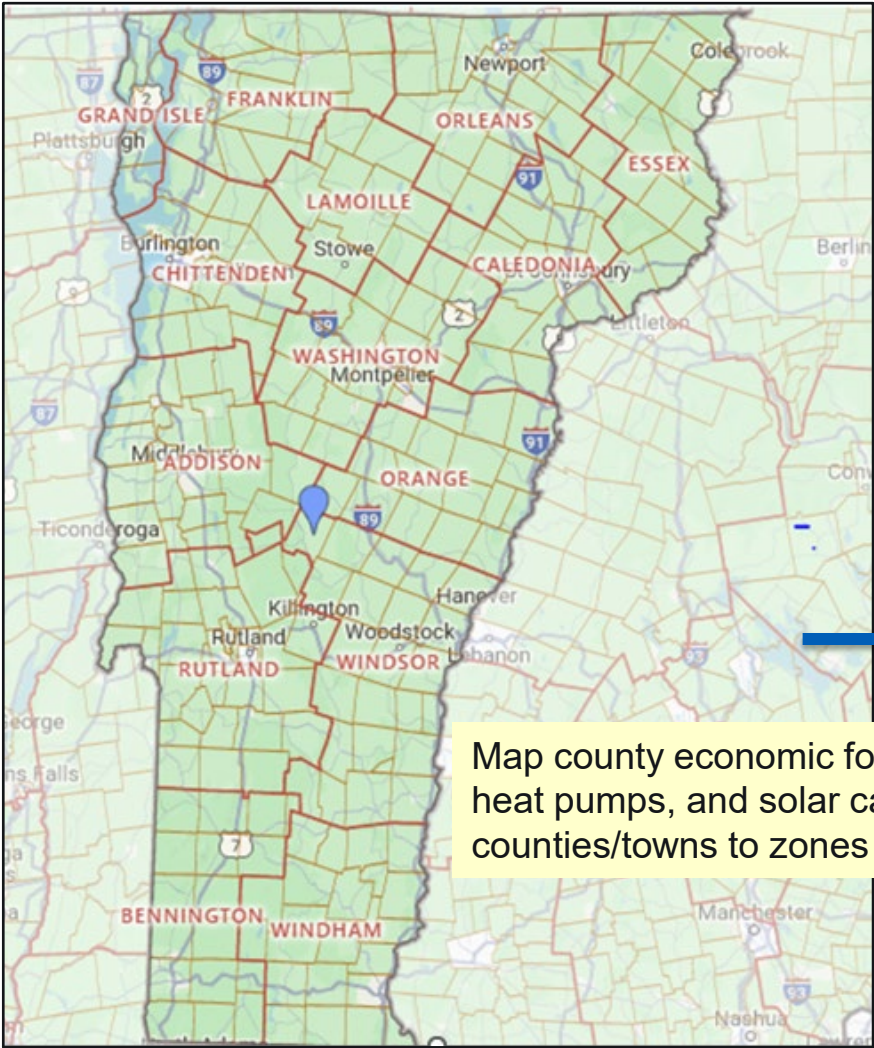


# Next Steps - Focus on the planning zones, substations, technologies

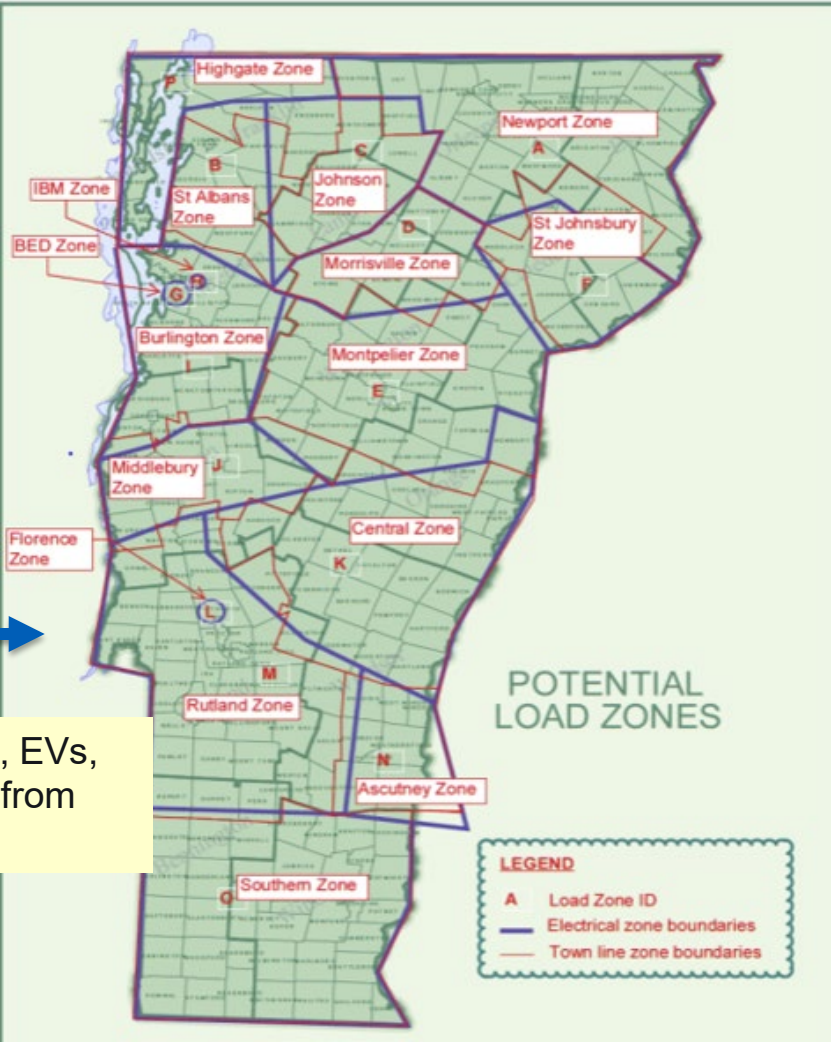
# Enhancements to Forecasting Methodology

1. Capture differences in economic growth across the zonal planning areas
2. Develop zone specific weather response models
3. Develop more accurate zonal level technology forecasts
4. Explore substation level forecasting

# From County to VELCO Load Zones

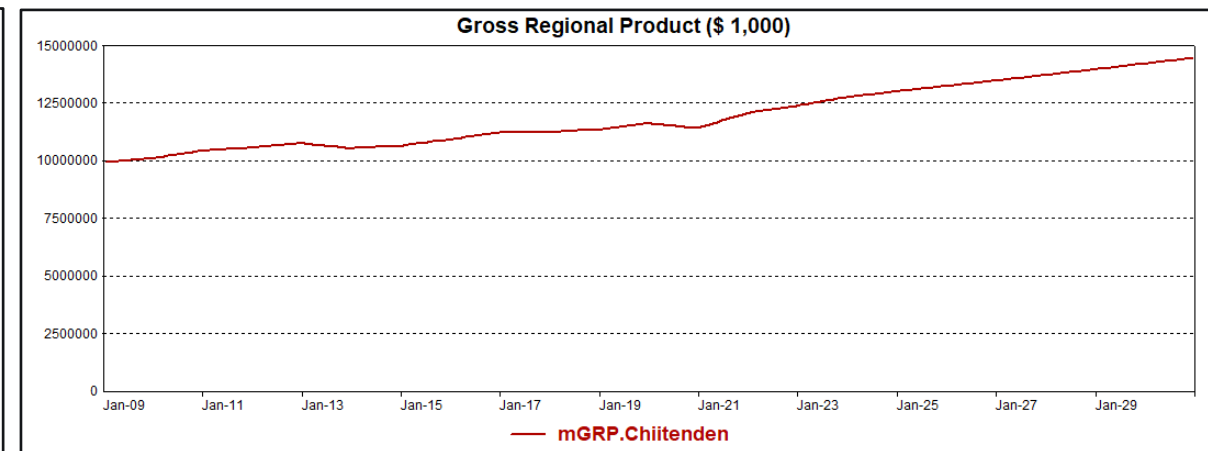
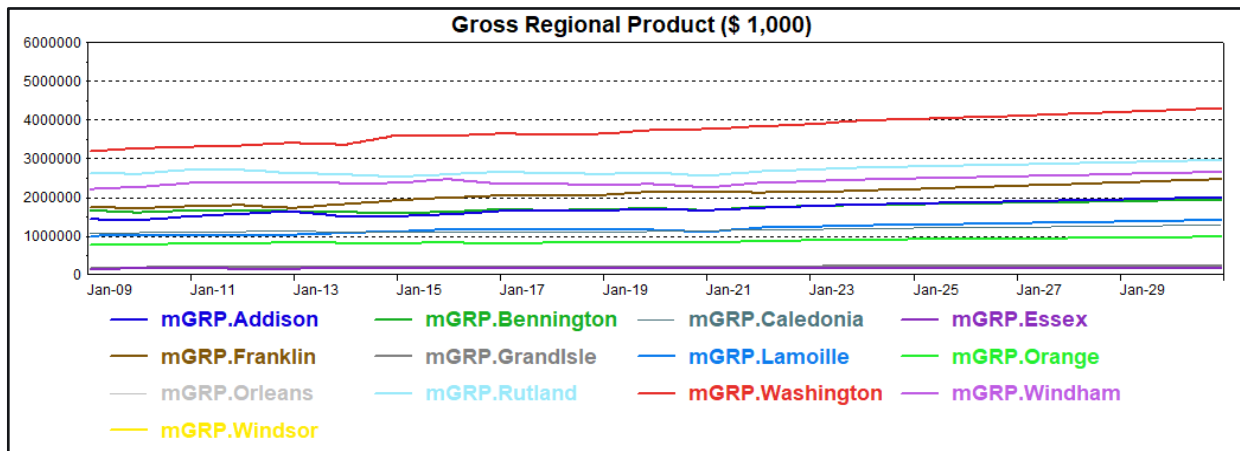
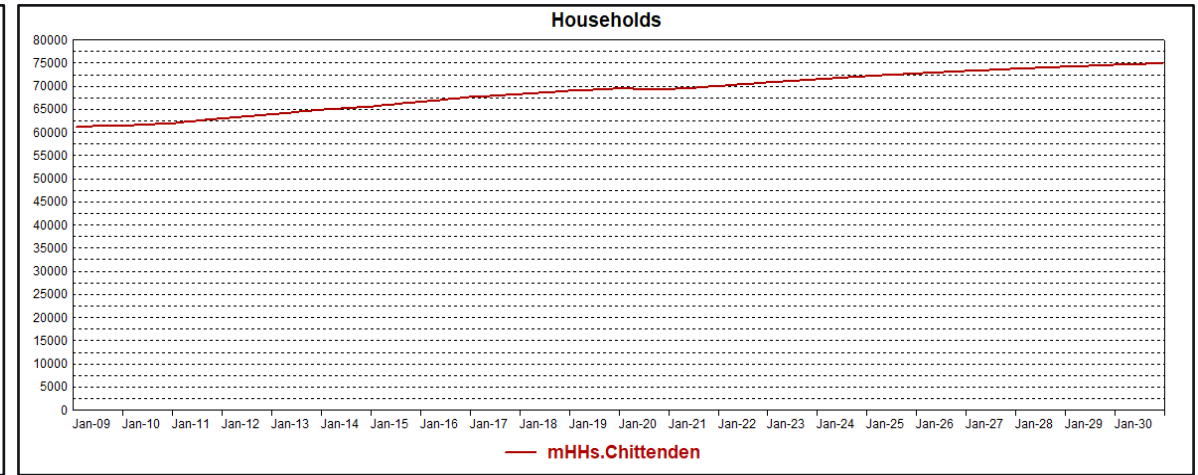
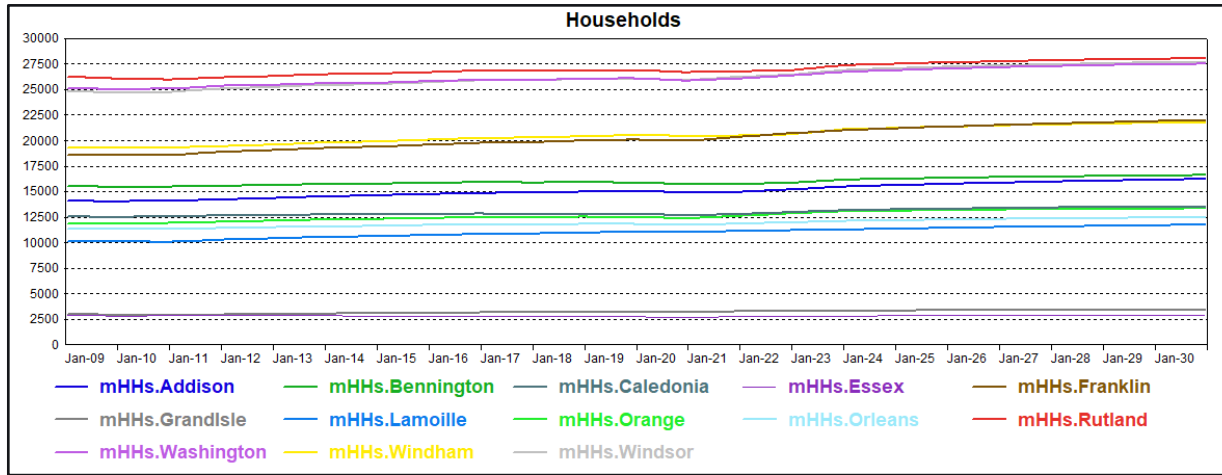


Map county economic forecasts, EVs, heat pumps, and solar capacity from counties/towns to zones





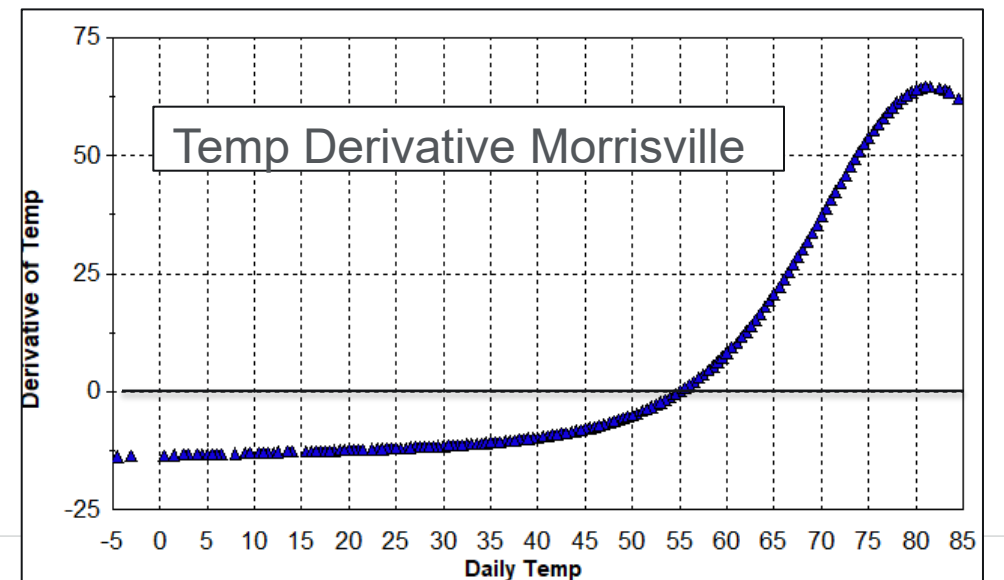
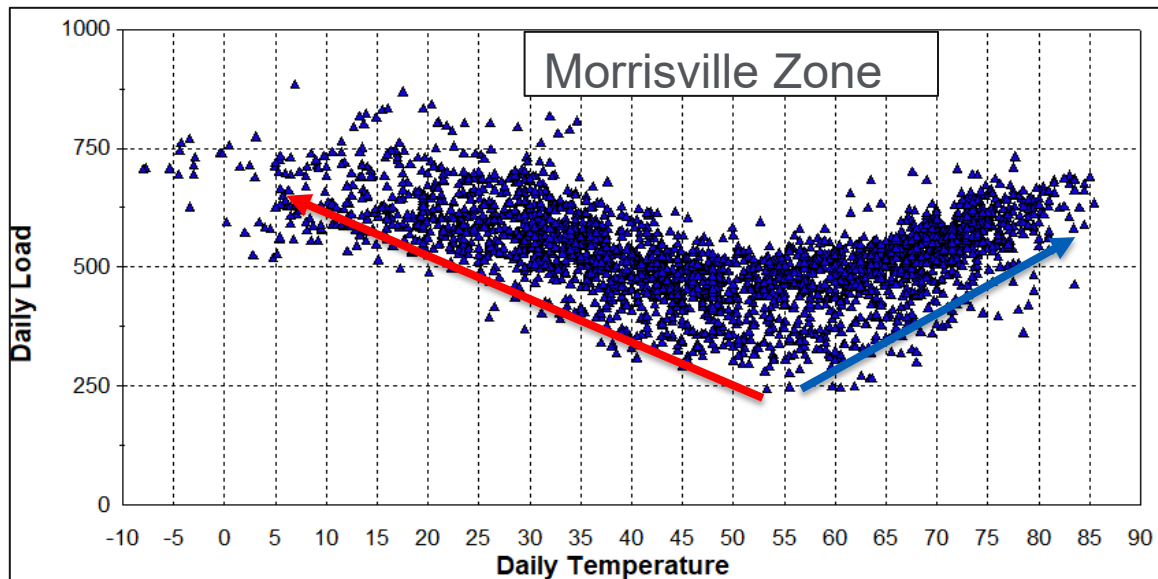
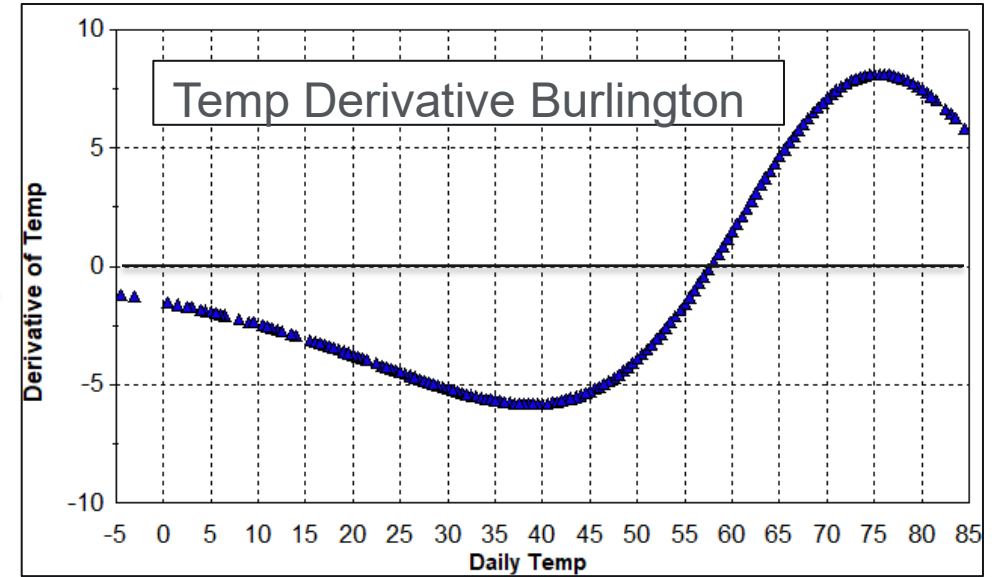
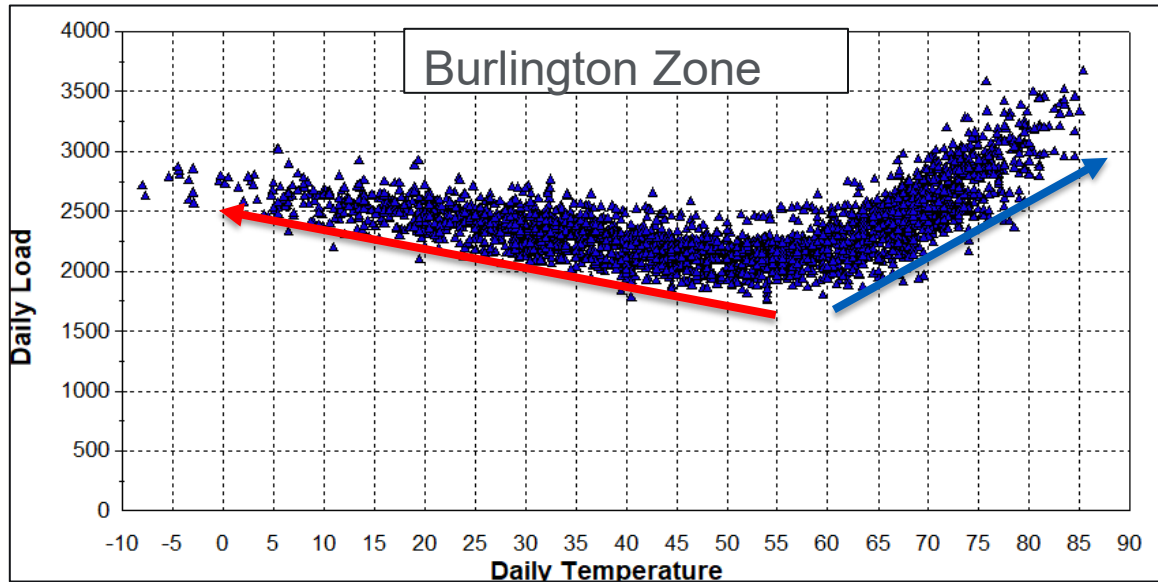
# Woods & Poole County Economic Forecast Annual (interpolated to months)



# Estimate Weather Responses by Zone

- » VELCO is comprised of 16 zones, each with its own mix of customer classes which can impact the zones sensitivity to weather.
  - Zones with a greater share of residential customers will be more weather sensitive.
  - Varying mixes of electric heating saturation can vary impact this sensitivity
- » Machine learning Artificial Neural Network (ANN) models will be used to develop accurate non-linear daily response functions by zone.

# Unique Weather Response by Zone

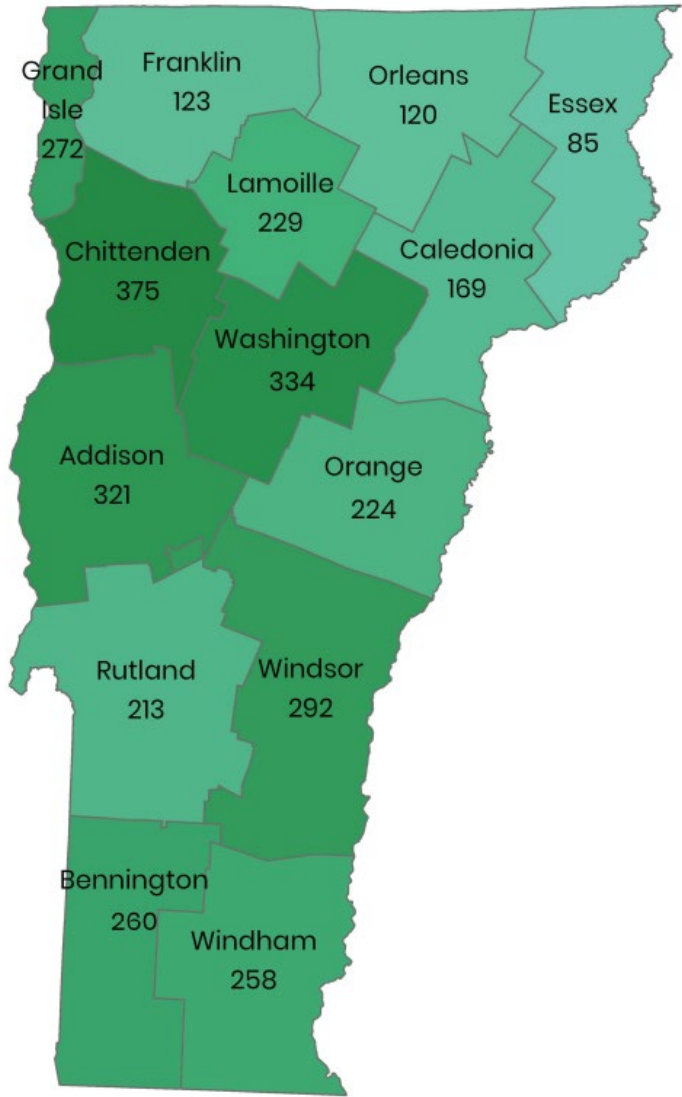


# Current Electric Vehicle Market Information: Vermont

- » As of January 2025, there were 17,939 registered electric vehicles in the state, comprised of all electric (BEV) and plug-in hybrid electric (PHEV).
  - 60% BEV and 40% PHEV
- » 5,8185 additional EV were added over the past year, a 41% increase.
- » 12.4% of all light-duty vehicle sale were electric in the 4<sup>th</sup> quarter of 2024.
- » Most population BEV registered vehicles include the Chevy Bolt, Tesla Model Y, and Nissan Leaf.
- » Most population PHEV registered vehicles include the Toyota RAV4 Prime, Toyota Prius Prime, and Jeep Wrangler.

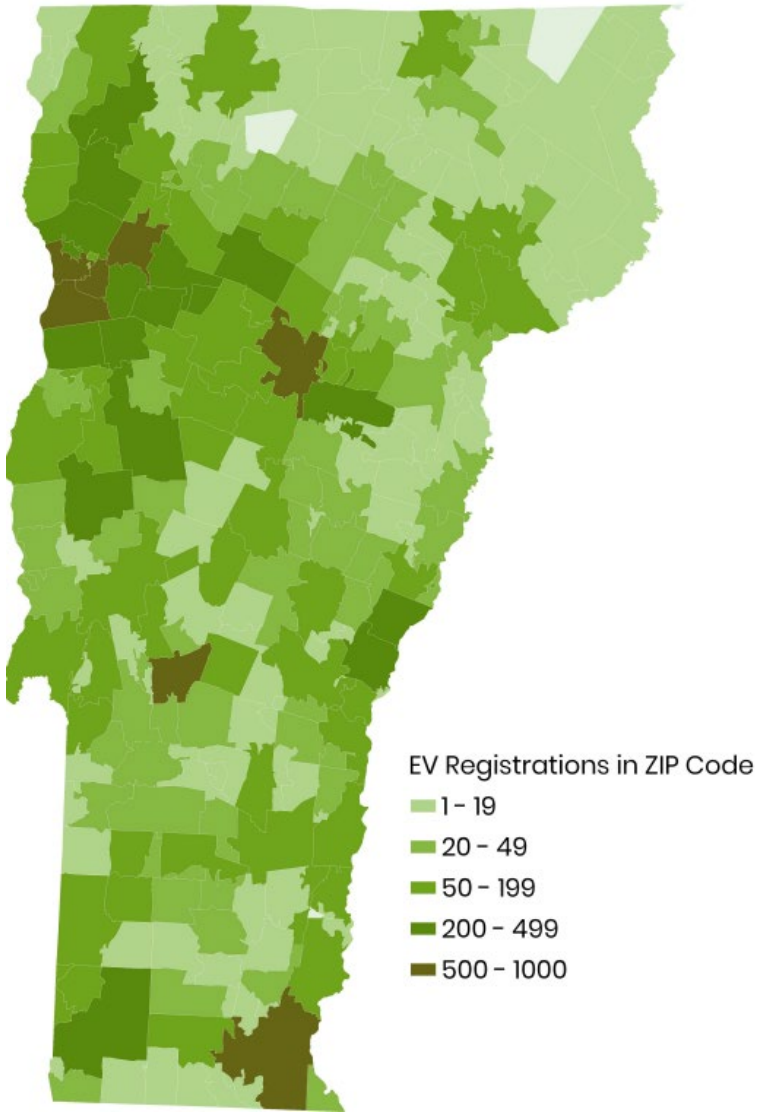
# Distribution of EV

County EV Per 10,000



County	Registered EV
Addison	1,198
Bennington	970
Caledonia	511
Chittenden	6,309
Essex	50
Franklin	616
Grand Isle	198
Lamoille	593
Orange	657
Orleans	328
Rutland	1,289
Washington	1,995
Windham	1,183
Windsor	1,686

EV by Zip Code

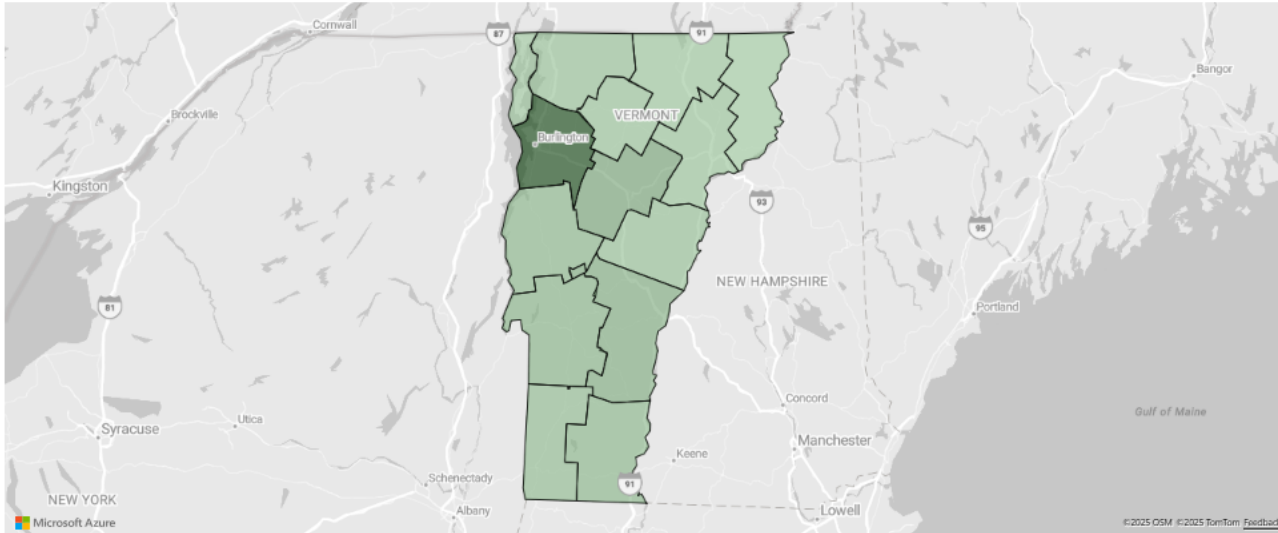


# Additional Data Source: Atlas Public Policy EValuate



R&D ▾ Products ▾ Strategic Advising Newsroom ▾ About ▾

Electric vehicles on the Road Map



View EV registrations by county, zip code, and utility.

Utility View

County	EV Original Registrations	EVs on the Road	LDVs on the Road	EV Share of Light-Duty Vehicles on the Road
Addison County	1,398	1,224	30,723	3.93%
Bennington County	1,184	973	33,724	2.78%
Caledonia County	627	516	25,817	1.95%
Chittenden County	7,828	6,638	132,920	4.85%
Essex County	57	55	6,133	0.90%
Franklin County	811	662	42,957	1.50%
Grand Isle County	239	219	7,549	2.78%
Lamoille County	725	604	22,576	2.54%
Orange County	801	688	26,518	2.52%
Orleans County	405	345	24,550	1.38%
State of Vermont	22,377	18,780	578,963	3.14%

Original EV Registrations

EV Registrations by Make and Tech

Top 10 EVs on the Road

EVs on the Road by Vehicle Make and Drivetrain

BEV PHEV

7K

Original EV Registrations by Top Makes

7K

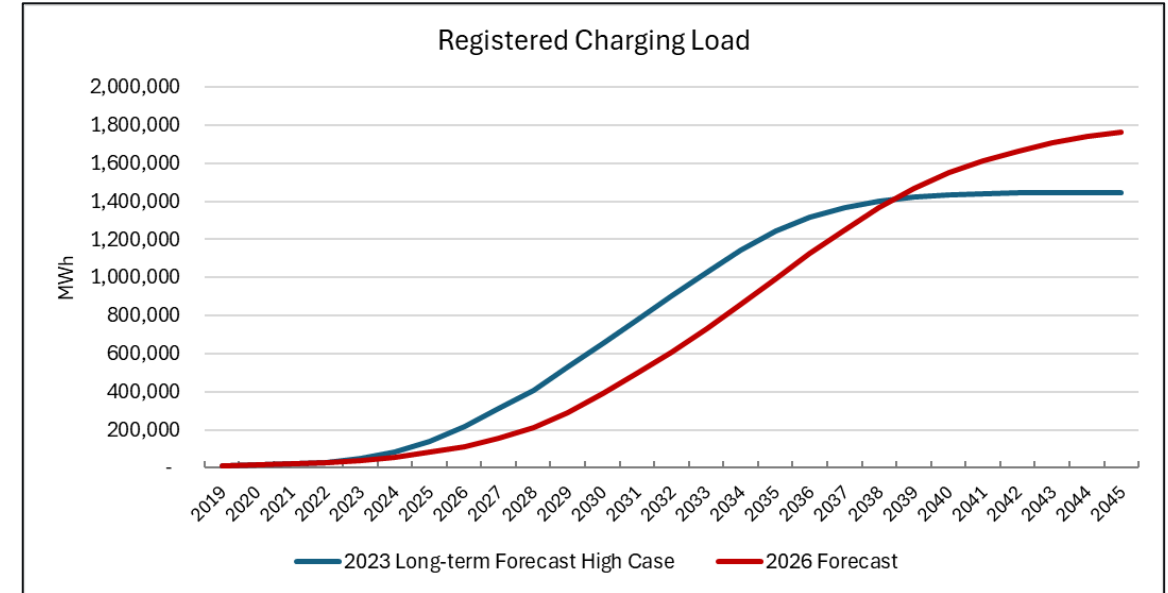
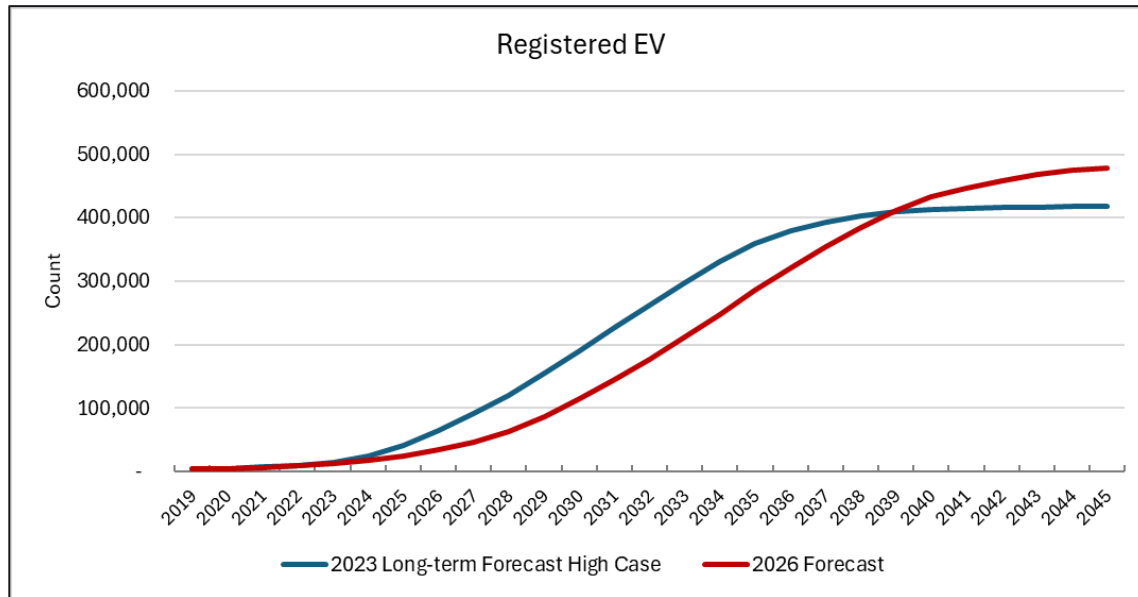
- » Detailing breakdown of registered EV by county and zip code
- » Make and models
- » Charging locations
- » Regularly updated: last update April 2025
  - 18,780 registered EV
- » Prior updates are available allowing the construction of a time series of EV adoption by county.
  - Enabling modeling of EV adoption at the county level



# Electric Vehicle Forecast Model

1. Develop a state-level EV forecast using a stock accounting model based on EV sales targets.
  - I. Starting with the most recent EV sales and EV registrations
  - II. EV sales targets based on state mandates; ~~35% by 2026~~, 68% by 2030, 100% by 2035
  - III. Assumptions regarding BEV/PHEV splits, annual miles, kWh per mile, average vehicle life
2. Forecast county EV registrations as a function of county household income.
  - i. Calibrate county EV forecast to state EV forecast
  - ii. Validate reasonableness of county allocation
3. Combine EV MWh forecast with hourly charging profiles
  - i. Home charging versus public charging
  - ii. Uncontrolled home charging versus controlled or TOU rates

# Preliminary 2026 Forecast Compared to the Prior Long-term Forecast

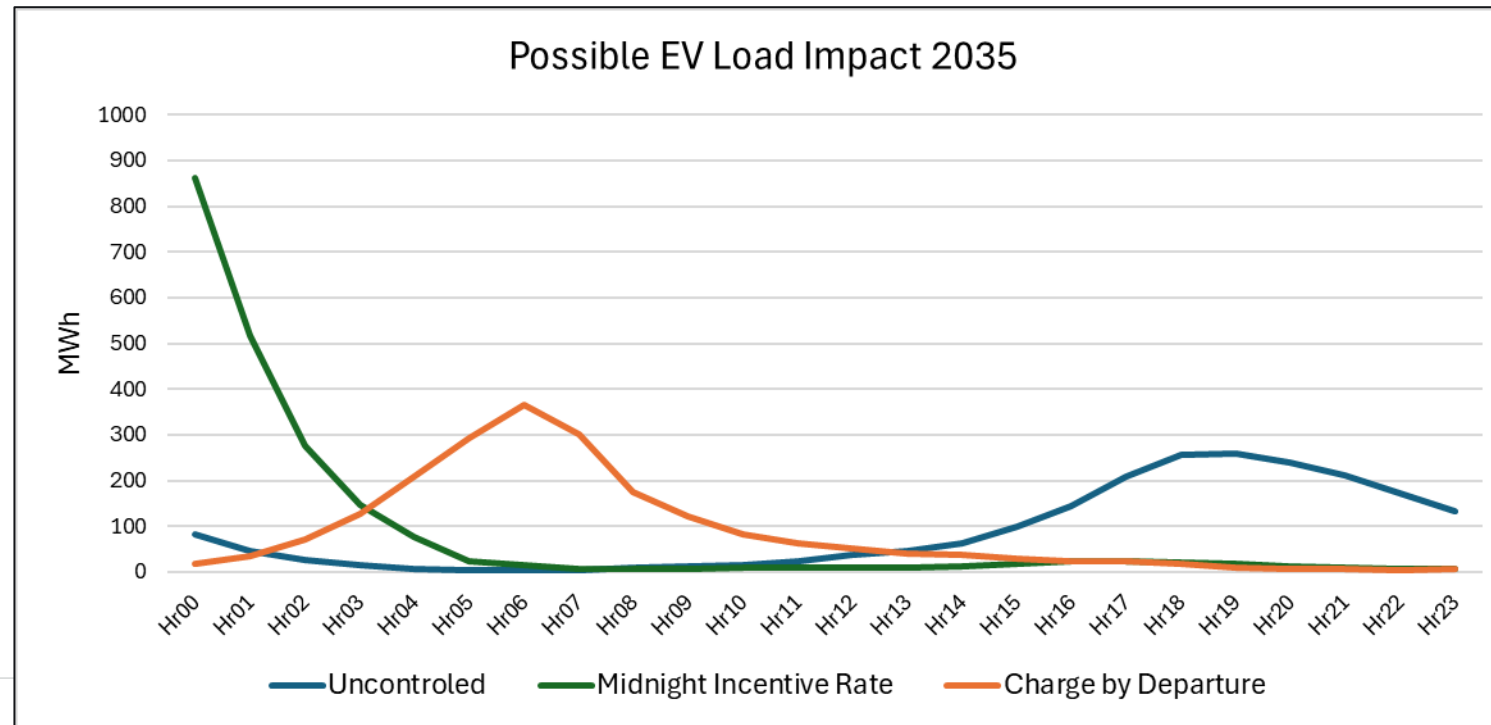


2026 Forecast if 2030 (68%) and 2035 (100%) mandates hold

- » Strong EV adoption over the prior two years
- » Governor rescinded the 2026 mandate (still holding to 2030 mandate)
  - But Trump just revoked California's EV mandate - ?
- » 2023 and 2024 EV adoption is more in line with the medium EV forecast scenario

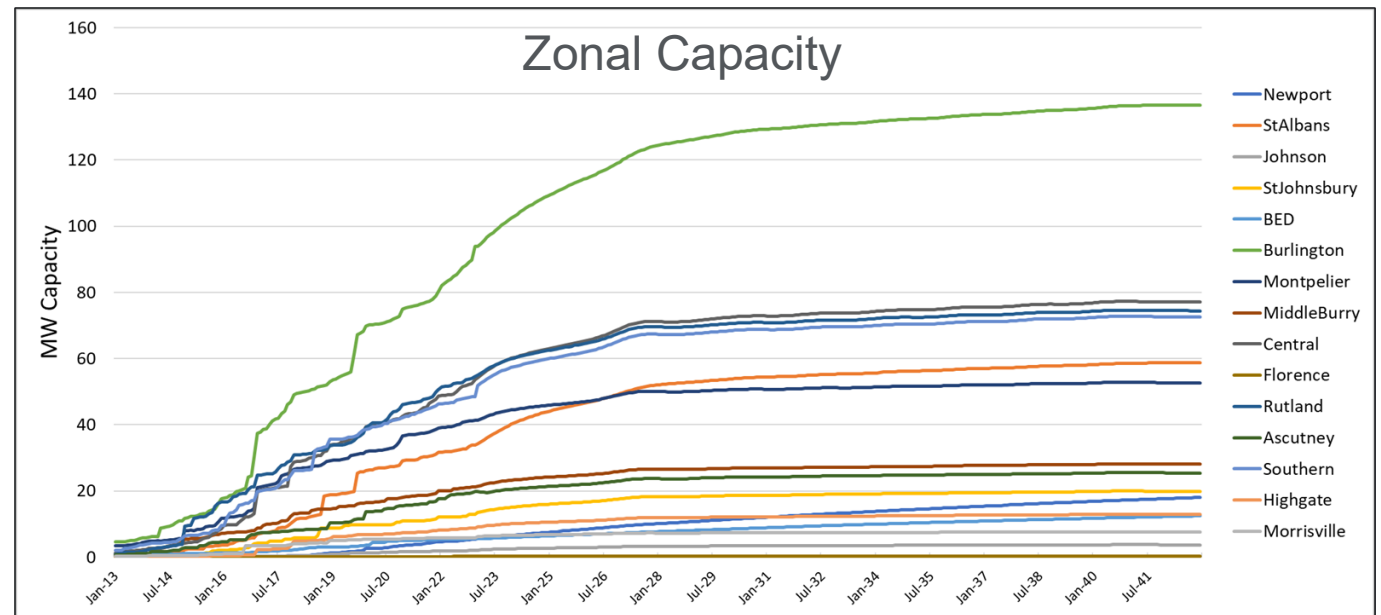
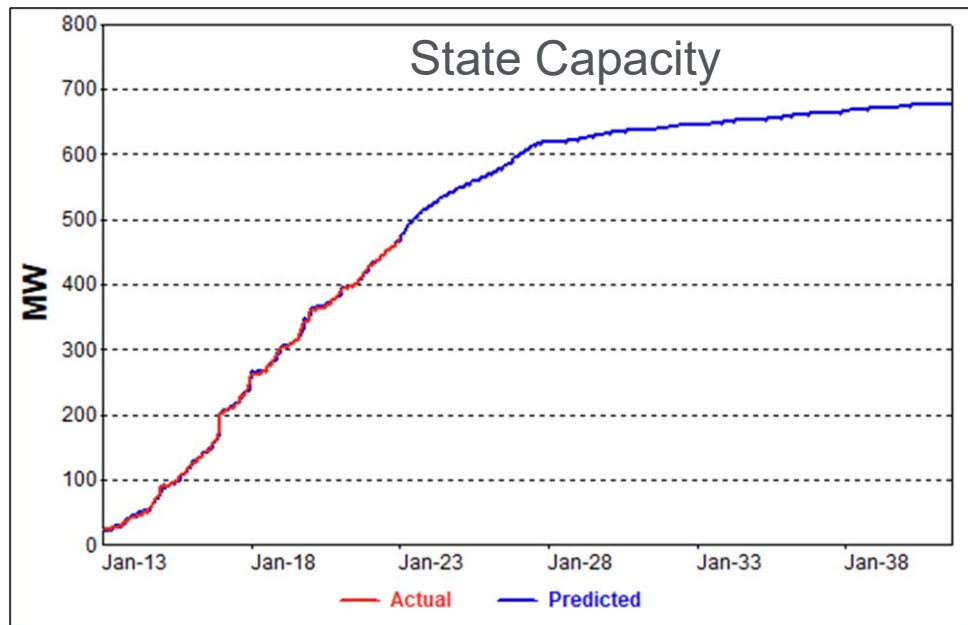
# Hypothetical EV Demand Impacts

- » Uncontrolled or unincentivized EV charging will result in significant demand impact with peak EV charging coinciding with system peak times, 4-7pm. Utilities offer uncontrolled or TOU incentive rates to reduce load during peak events or move charging to off peak hours.
- » With potentially 300,000 EV on the road by 2030 the depend impacts could range from a few hundred to nearly 900MW.
- » 900 MW impact under the midnight TOU rate could be mitigated with a staggered start time

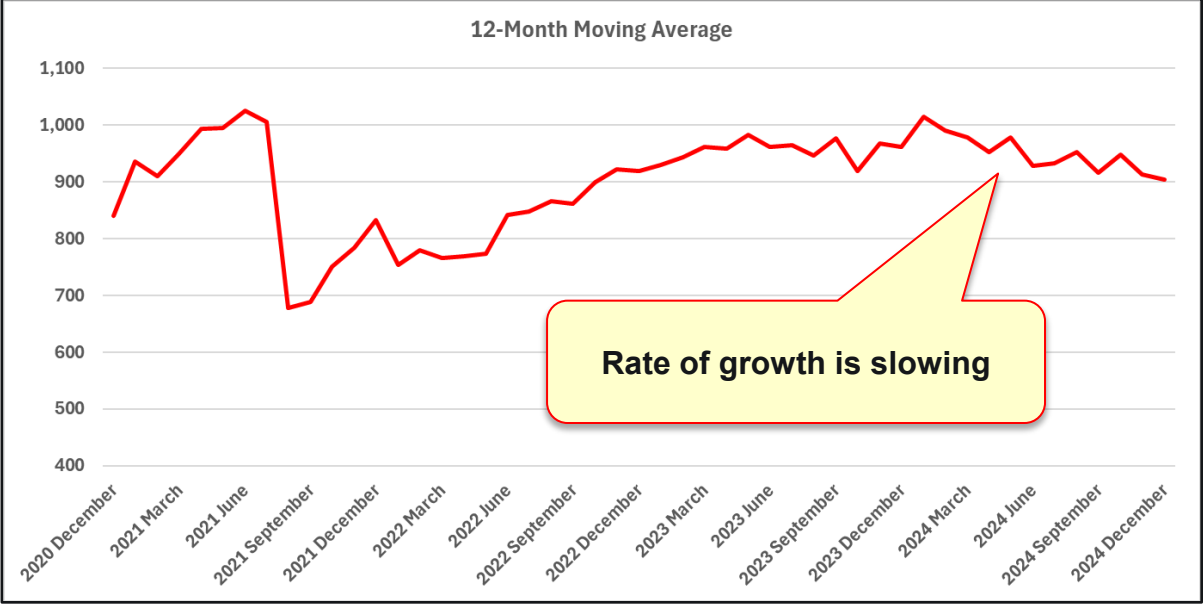
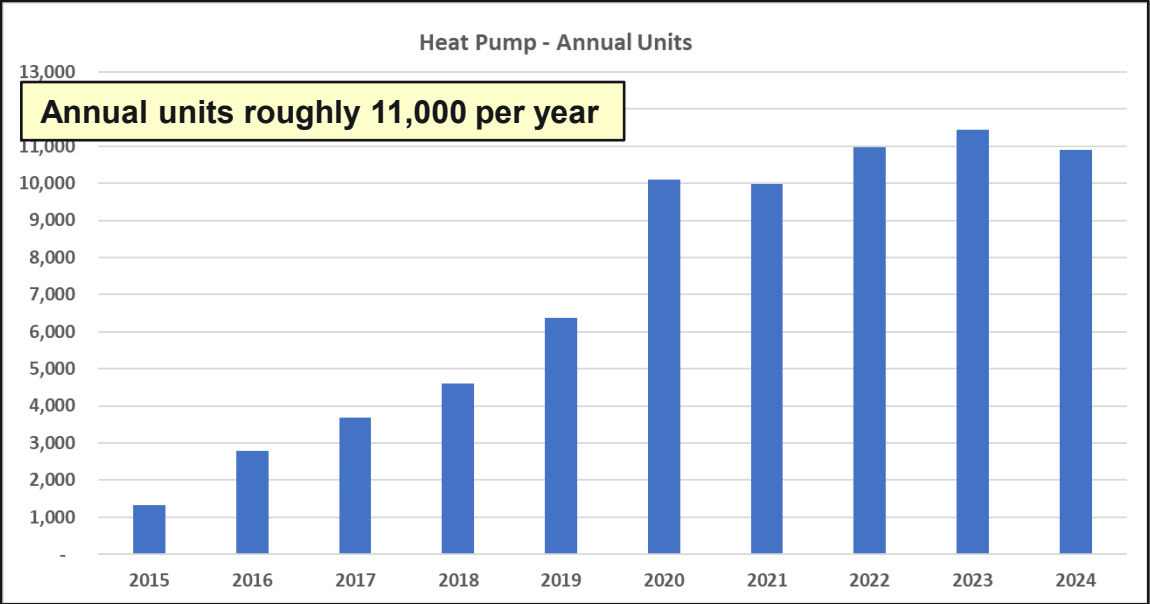


# Solar Forecasting Approach

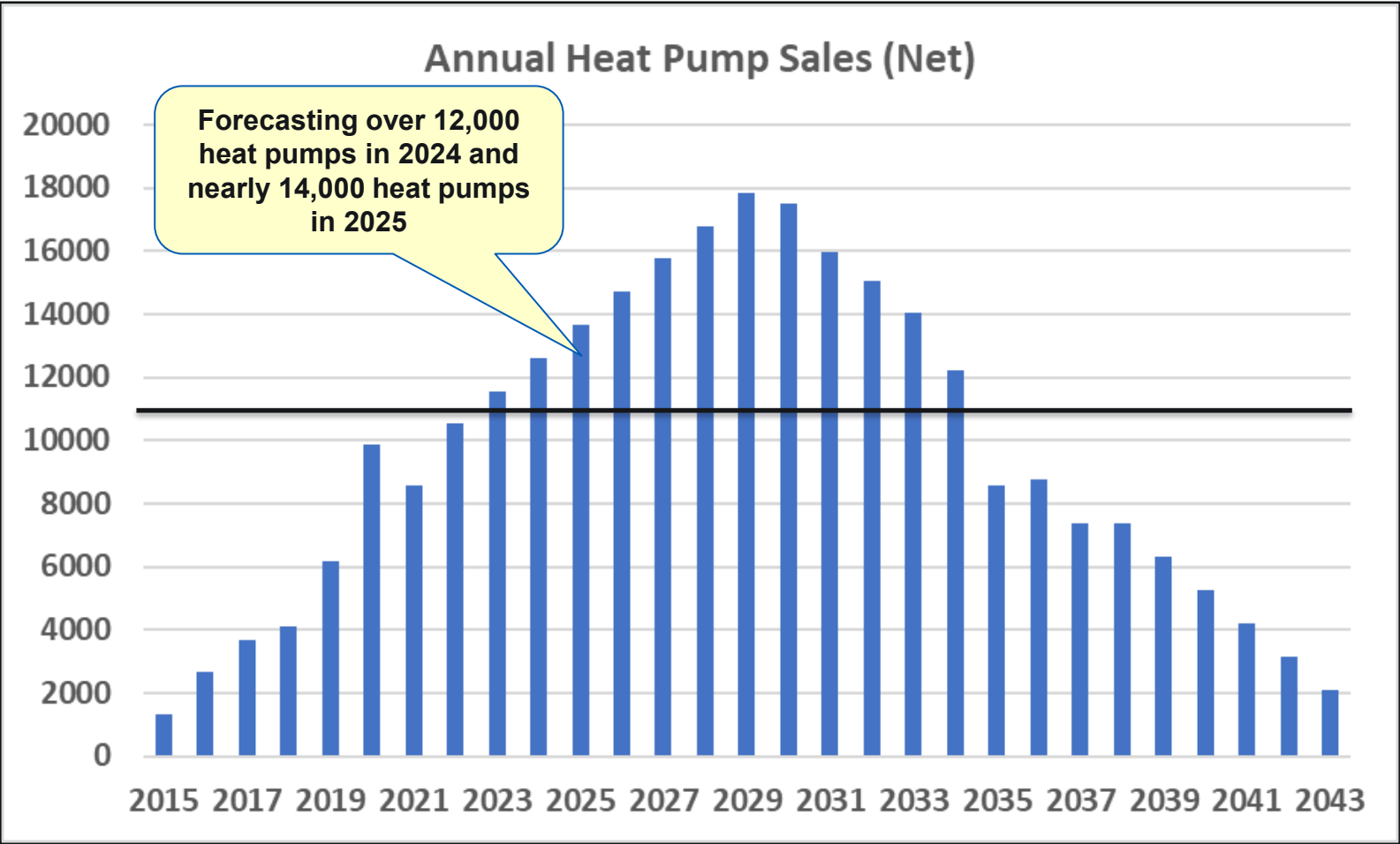
- » Capacity (excluding utility scale and standard offer) modeled as a function of simple payback.
  - Payback incorporates:
    - system costs, incentives, electric rates, and payments for excess generation.
  - Cubic model specification used to impose S-shaped curve.



# Heat Pump Sales



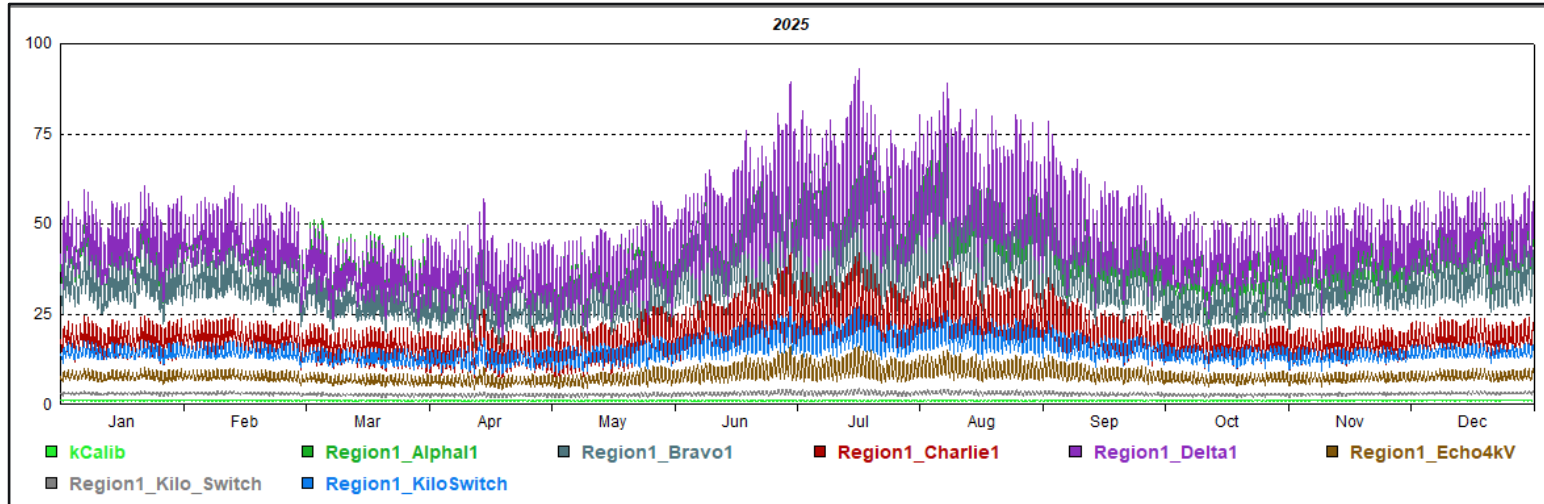
# State CCHP Projections



Below 2024 projections and a tough number to hit in 2025



# Substation Load Forecast



- » Like system to zone, start off allocating zone to substations
- » But then need to understand and forecast what's connected to the substation
  - Solar capacity
  - Customer mix (residential, commercial, large C&I)
  - Large C&I connected loads
  - New large C&I load additions
  - EVs
  - Battery storage
  - Zoning constraints
  - New substations and change in power flow
- » And application to generate hundreds of hourly load components, aggregate results, and present for analysis

# Roundtable Discussion

# Questions

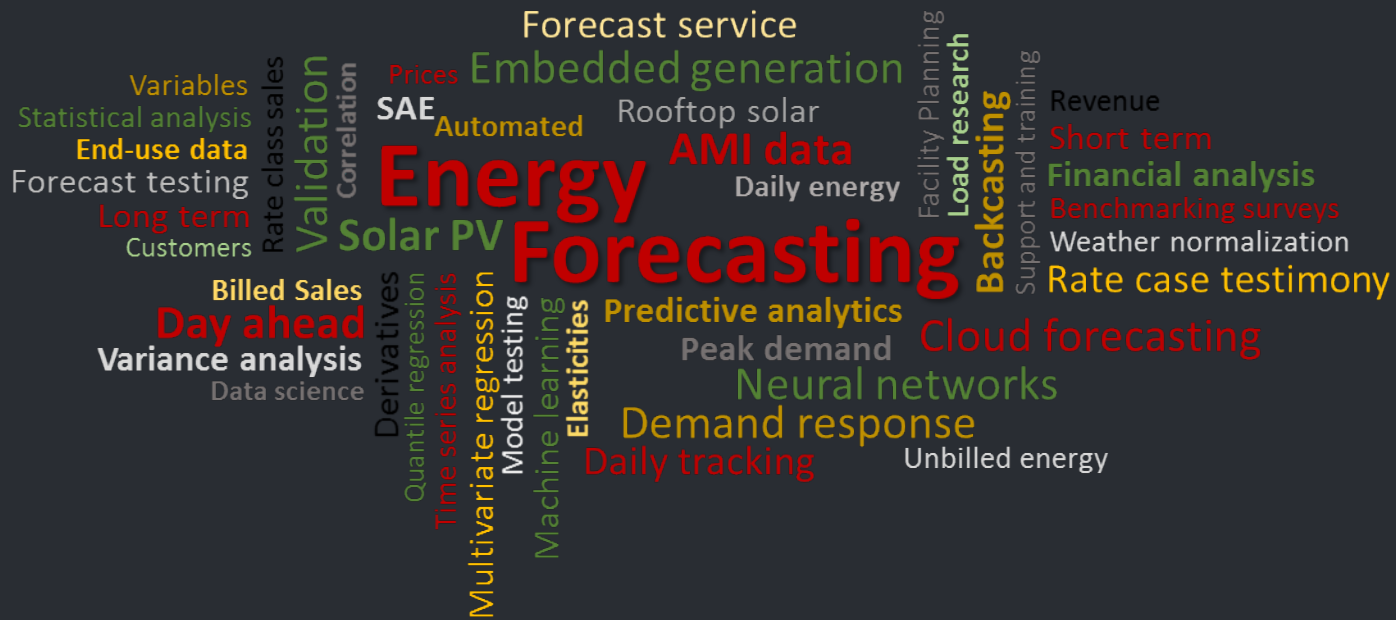
1. What changes would you like to see in the next forecast and overall forecast process?
2. What information would help you to do your own load analysis and forecast?
3. How do you see using the VELCO load forecast for leveraging your own IRP work

# Questions

4. What load data and information can you provide that would help improve the zone-level forecasts and in developing substation load forecasts? Data that could help improve the forecast include:
- Historical substation load data (ideally hourly data)
  - Aggregated rate class AMI data (mapped to substations)
  - Number of customers by type (residential, small commercial, large C&I customers) connected to the substation.
  - Connected EVs
  - DERs (hourly generation data)
  - Battery charging and discharging loads
  - EV charging load

# Questions

5. Do you have or are you planning load reduction programs and technologies that would impact substation and zone-level demand forecasts? This may include:
- EV charging rates
  - Interruptible load programs
  - Critical peak or TOU pricing
  - Utility-scale battery storage
  - Behind the meter (BTM) battery storage



# Thank You



<http://www.itron.com/forecasting>  
[www.itron.com](http://www.itron.com)