Vermont Long-Term Forecast Model Drivers

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Eric Fox, Mike Russo, Oleg Moskatov, Parlad Dhungana

Agenda

1. The COVID Recovery – Are We There Yet?
   - Review of AMI data trends

2. Calibrating End-Use Intensities
   - EIA 2022 New England Outlook
   - State Residential Appliance Saturation Survey
   - National Energy Renewable Lab (NREL) ResStock and ComStock Integration with EE Program Savings

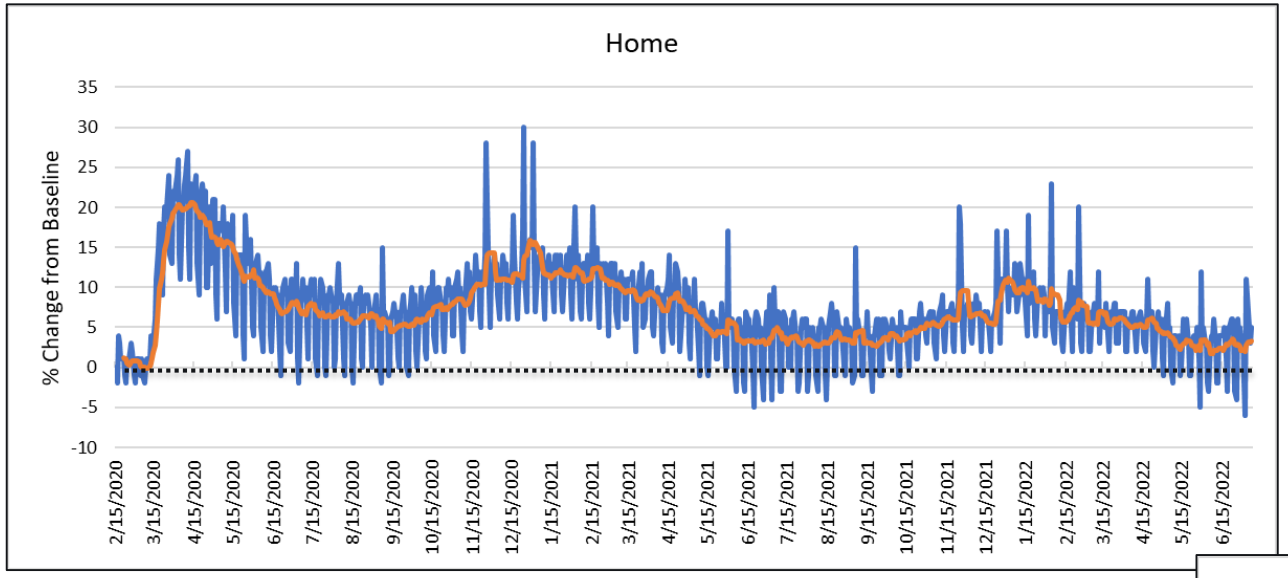
3. EV and Heat Pump Shapes and Impact on Loads

4. Impact of the Inflation Reduction Act (IRA)
   - Heat pumps, BTM solar, and EV adoption

5. Scenario Discussion
   - Business as usual
   - Meeting the CAP goals

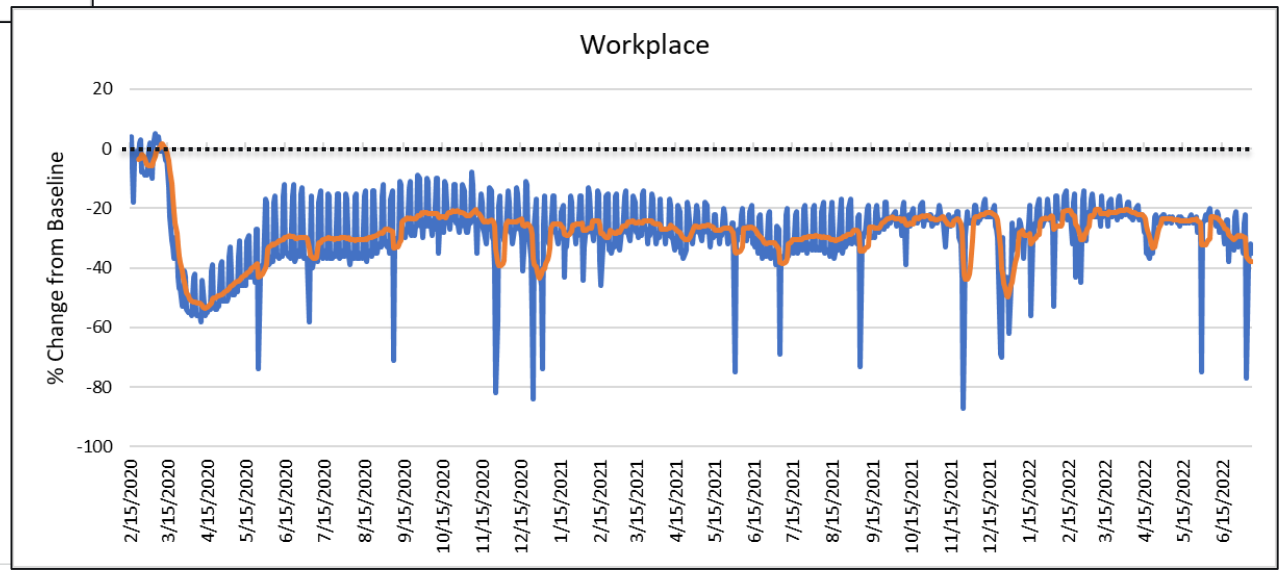
The COVID Recovery – Are We There Yet?

COVID Still Impacting People's Behavior



- Google Community Mobility Report
  - Reports people's location by place type in comparison to pre-COVID baseline
- No longer being updated as of October 2022

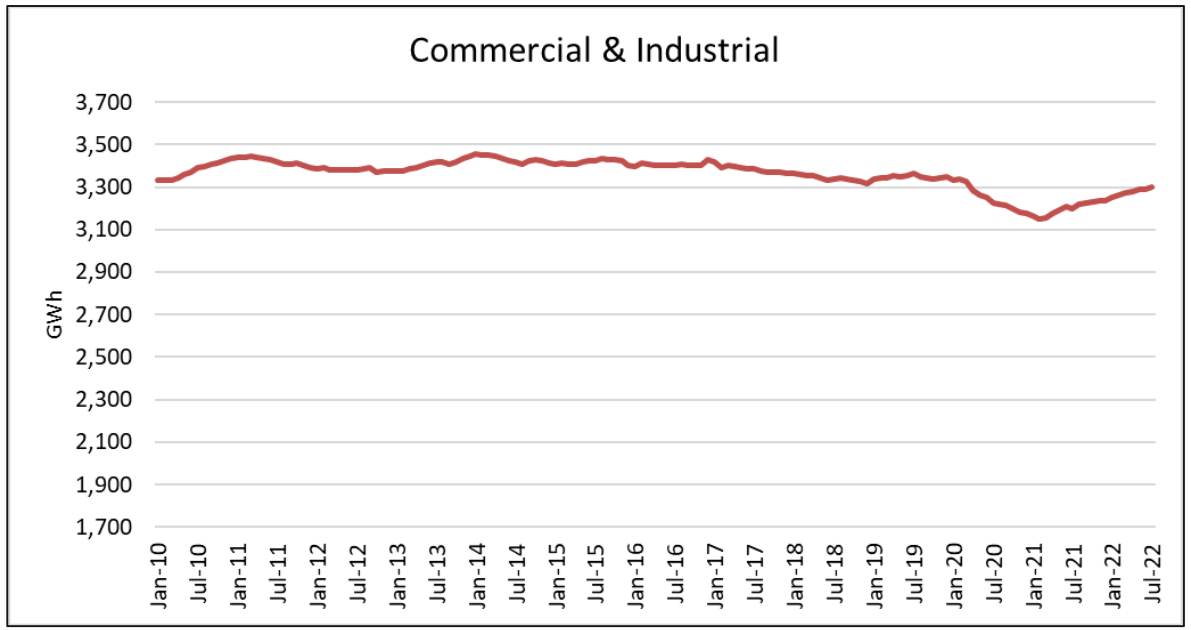
- People are still at home approximately 5% more compared to Pre-COVID
- Office related activity is still roughly 25% less compared to Pre-COVID

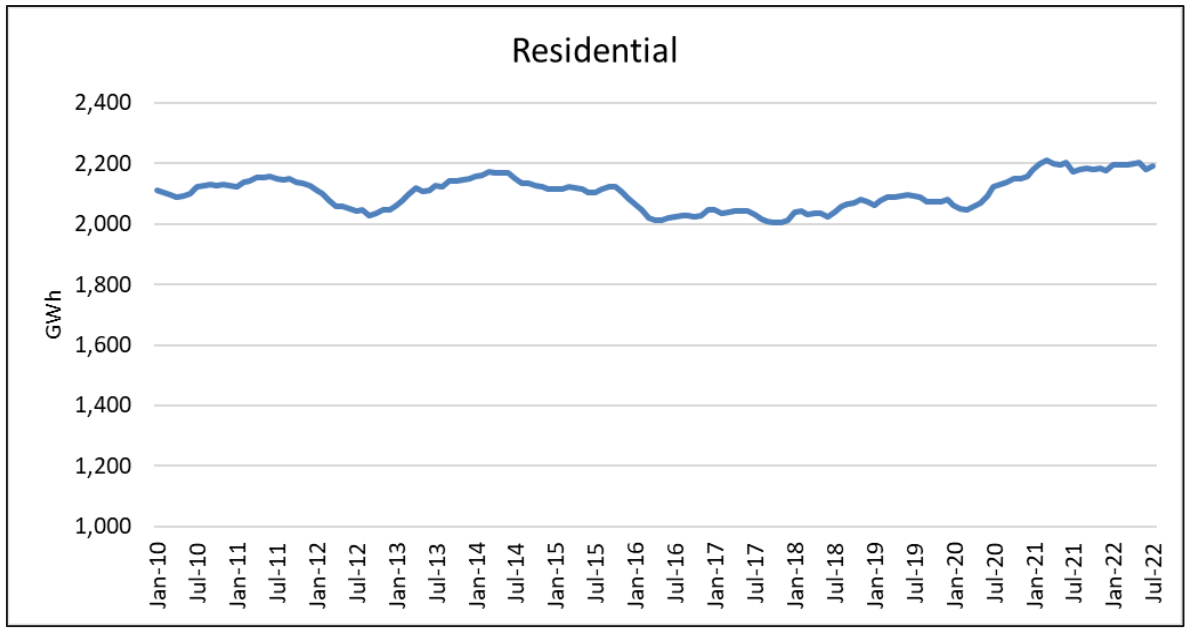


Class Sales

» Decline in commercial sales matched by increase in residential sales

» Net impact of COVID19 is neutral but beginning to think that we have seen a permanent structural change in how people work.





* 12-month rolling sum of reported class sales. EIA form 861m

Calibrating EIA End-Use Intensity Projections

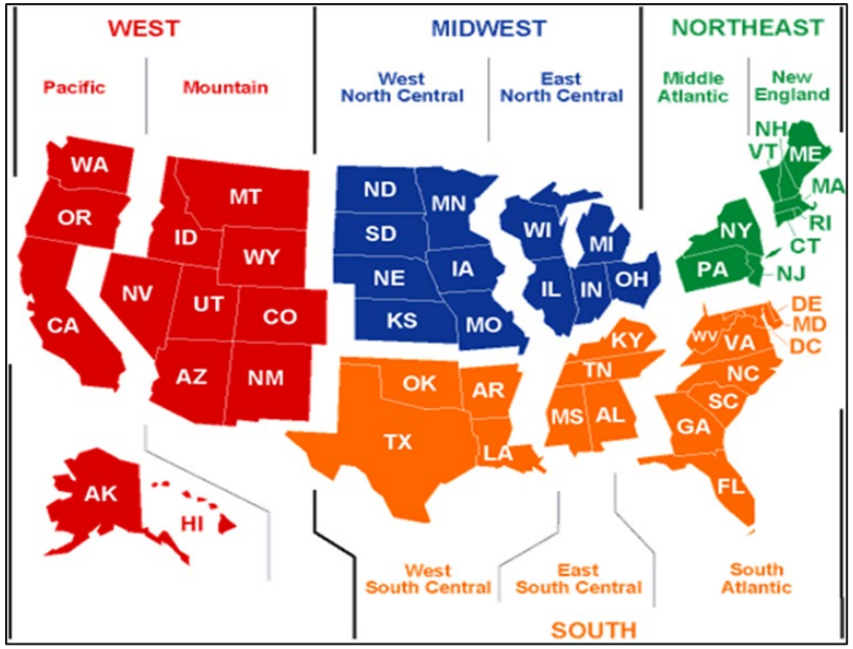
End-Use Intensities

» End-use intensities are a key drivers to long-term baseline residential and commercial sales forecast
- Residential – kWh per household
- Commercial – kWh per square foot

» End-use intensities incorporate
- Saturations (pct of homes or sqft) where the end-use is present
- Average stock efficiency (measure of kWh input per work output)
- kWh usage (residential – UECs, commercial – EUI)

» Projections based on the EIA 2022 Annual Energy Outlook
- Commercial: 11 building types, 9 end-uses
- Residential: 3 housing types, 20 end-uses

» Calibrate to Vermont with state-specific end-use data



The Residential Model Input

» Starts with base-year end-use consumption data in 2015

- Developed from the Residential Energy Consumption Survey (RECS)
- Incorporates sales, customer, appliance shipments data, BTM solar estimates, and regional EE savings estimates through 2021

  - ***End-use kWh sales = Saturation$_e$ * Households$_e$ * UEC$_e$***
    - All three inputs change over time
      - UEC driven by changes in stock efficiency and utilization (weather, price, income)
      - Saturations driven by technology options and costs, operating costs, and incentives
      - Households driven by housing demand – in and out migration, demographics, and second home market
    - End-Use Intensity = End-use sales /Households
      - Which is the same as Saturation * UEC
    - End-use intensities for heating, cooling, and non-weather sensitive end-uses are what are used in monthly residential average use models.

Calibrating End-Use Intensities

» Start with the EIA's 2022 New England Residential Forecast

» Calibrate to prior year saturation estimates (based on past Vermont survey work)

» Calibrate to new saturation and UEC estimates

- NMR Group’s 2020 Residential Existing Single-Family Market Characterization Study
- National Renewable Energy Lab (NREL) Residential Stock (ResStock) building simulation results - 2018

End-use load profiles for the U.S. Building Stock

	ComStock	ResStock
Models Run (per weather year)	350,000 buildings	550,000 dwelling units
Representing	64% of U.S. commercial building stock per CBECS	137 million U.S. homes Excludes AK, HI, PR
Building Types	14	5
End Uses	19	49

Represents the building stock as it was in 2018, as nearly as possible
Results are available for both TMY3 (“typical”) and AMY 2018 (actual) weather

DOE National Laboratories

NREL Transforming ENERGY

Berkeley Lab Lawrence Berkeley National Laboratory

Argonne National Laboratory

Industry Partners

EPRI Electric Power Research Institute

neep Northeast Energy Efficiency Partnerships

neea Northwest Energy Efficiency Alliance

60 other organizations represented on technical advisory group

Residential End-Use Saturation Comparison

Saturation (%)					
End-Use	EqpType	EIA 2018	ResStock 2018	EIA 2020	VT 2020 (SF)
Heating	Primary	9%	5%	10%	11%
Cooling	Central	25%	40%	28%	28%
	RAC	36%	28%	36%	38%
WtHeat	EWHeat	36%	33%	36%	43%
Cooking	Cooking	70%	66%	69%	46%
Refrigeration	Ref1	100%	100%	100%	100%
	Ref2	33%	24%	34%	22%
	Frz	29%	25%	29%	
K&L	Dish	57%	42%	58%	
	CWash	74%	86%	74%	98%
	EDry	60%	74%	60%	81%
TV	TV	100%	100%	100%	100%
Lighting	Lighting	100%	100%	100%	100%
Misc	Misc	100%	100%	100%	100%

» Vermont 2022 SF saturations generally compare well to EIA and ResStock. Should have improved state estimates when we incorporate multi-family survey results

Commercial Model Inputs

- 2023 Forecast will be based on EIA 2022 New England Commercial AEO
  - 11 building types, 9 end-uses

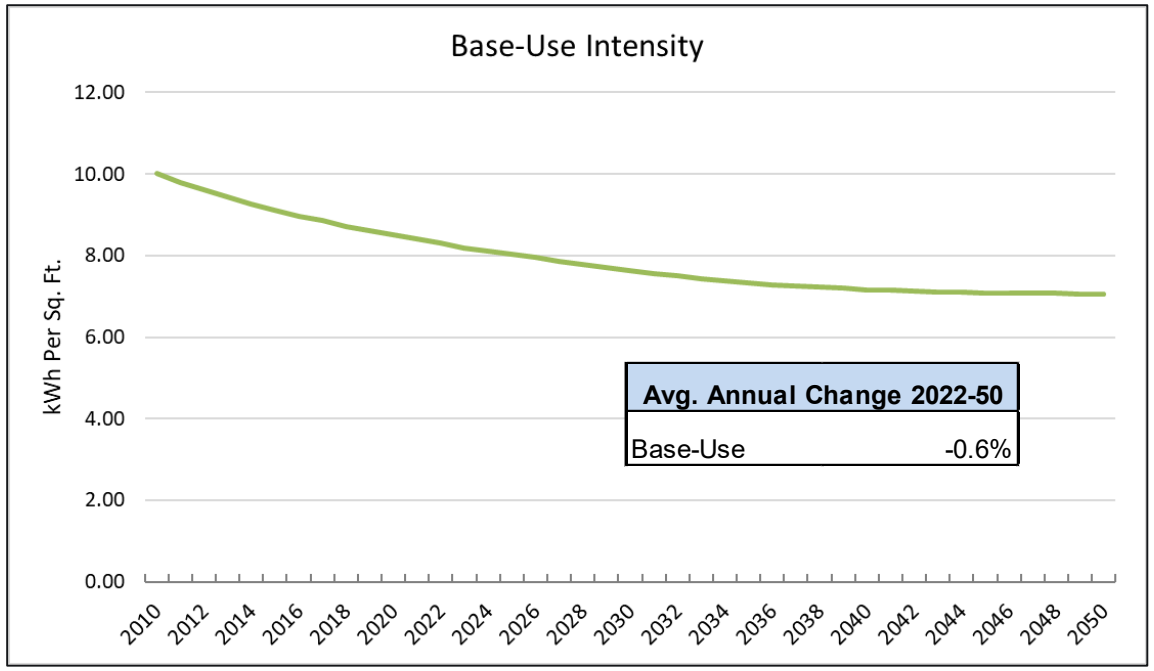
- Data collected includes:
  - End-use consumption by building type
  - Building-type square footage
  - End-use stock average efficiency
  - Back into saturation given calculated energy intensity and stock efficiency

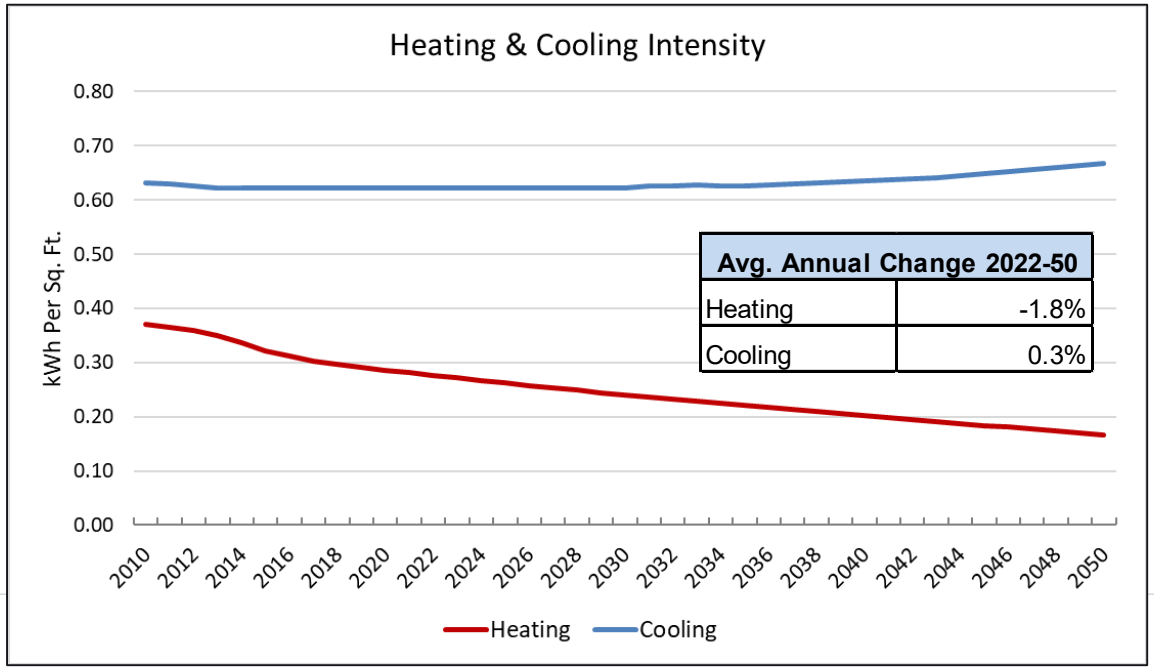
- **End-use sales forecast = square footage * end-use energy intensity (EI) * utilization**
  - Energy intensity driven by technology costs and efficiency
  - Utilization driven by weather, economic activity, and price

- The energy intensity estimate is what is incorporated into the commercial sales forecast model
  - Employment and GDP used as proxy for square footage and captures business related utilization

New England Commercial Energy Intensity Projections

Annual Energy Outlook 2022, New England





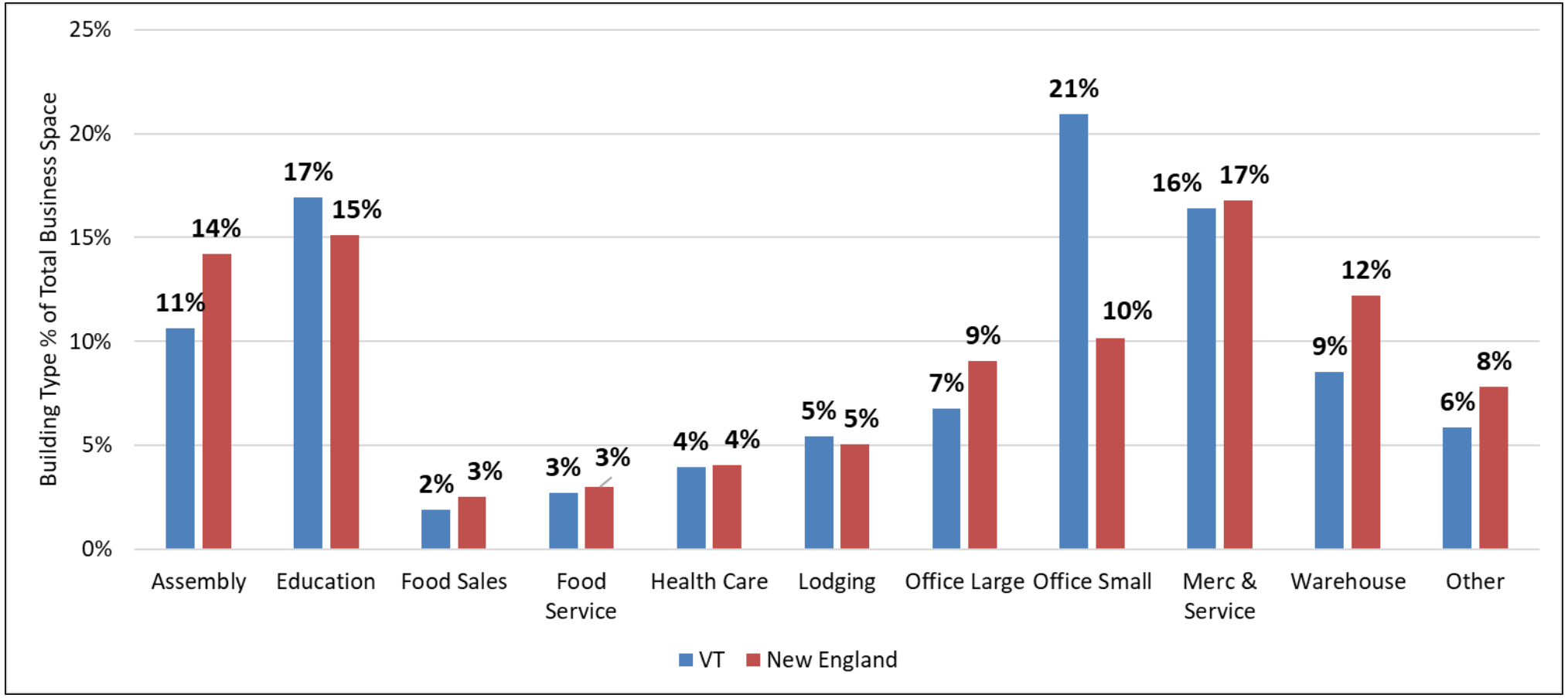
Vermont ComStock
(kWh per square foot)

End Use	Fullservice Restaurant	Hospital	Large Hotel	Medium Office	Primary School	Quick Service Restaurant	Retail Standalone	Retail Stripmall	Secondary School	Small Hotel	Small Office	Warehouse	Weighted Total
Cooling	2.73	2.36	2.38	0.78	0.92	1.77	1.01	1.38	0.96	1.78	0.70	0.02	1.07
Ext_Light	1.38	0.30	0.50	0.44	0.95	2.30	0.85	1.26	0.81	1.07	0.80	0.74	0.82
Fans	9.48	8.23	4.32	2.39	2.84	7.76	2.44	3.31	1.53	3.81	1.88	0.12	2.86
HeatRecovery	0.28	0.08	0.00	0.00	0.10	0.00	0.08	0.18	0.13	0.02	0.00	0.00	0.07
Heating	1.63	0.00	1.67	0.12	0.99	0.00	0.50	0.52	0.96	1.09	0.12	0.16	0.55
Interior_Equip	14.70	8.20	4.20	4.38	0.76	13.86	1.47	4.54	1.05	6.38	3.46	2.73	3.67
Interior_Lighting	3.93	2.98	1.65	0.99	1.89	4.78	5.74	6.03	1.61	4.11	1.03	1.33	2.62
Pumps	0.00	0.00	0.33	0.06	0.06	0.15	0.01	0.01	0.15	0.30	0.01	0.01	0.06
Refrigeration	2.16	0.11	0.43	0.00	0.63	4.19	0.00	0.00	0.49	0.00	0.00	0.00	0.24
Water	15.39	2.04	2.81	0.18	0.92	7.34	0.00	2.72	0.60	1.78	0.23	0.00	1.43
Total intensity	**51.69**	**24.29**	**18.29**	**9.35**	**10.07**	**42.16**	**12.10**	**19.95**	**8.29**	**20.32**	**8.24**	**5.11**	**13.40**
Floor Area (in SqFt.)	1,729,831	2,701,323	2,299,837	6,988,886	7,212,919	135,152	4,200,445	7,026,333	4,376,196	1,414,334	7,351,577	5,834,515	51,271,349
Floor Area in %	3.4%	5.3%	4.5%	13.6%	14.1%	0.3%	8.2%	13.7%	8.5%	2.8%	14.3%	11.4%	100%

» Represents 2018 using actual 2018 Vermont weather

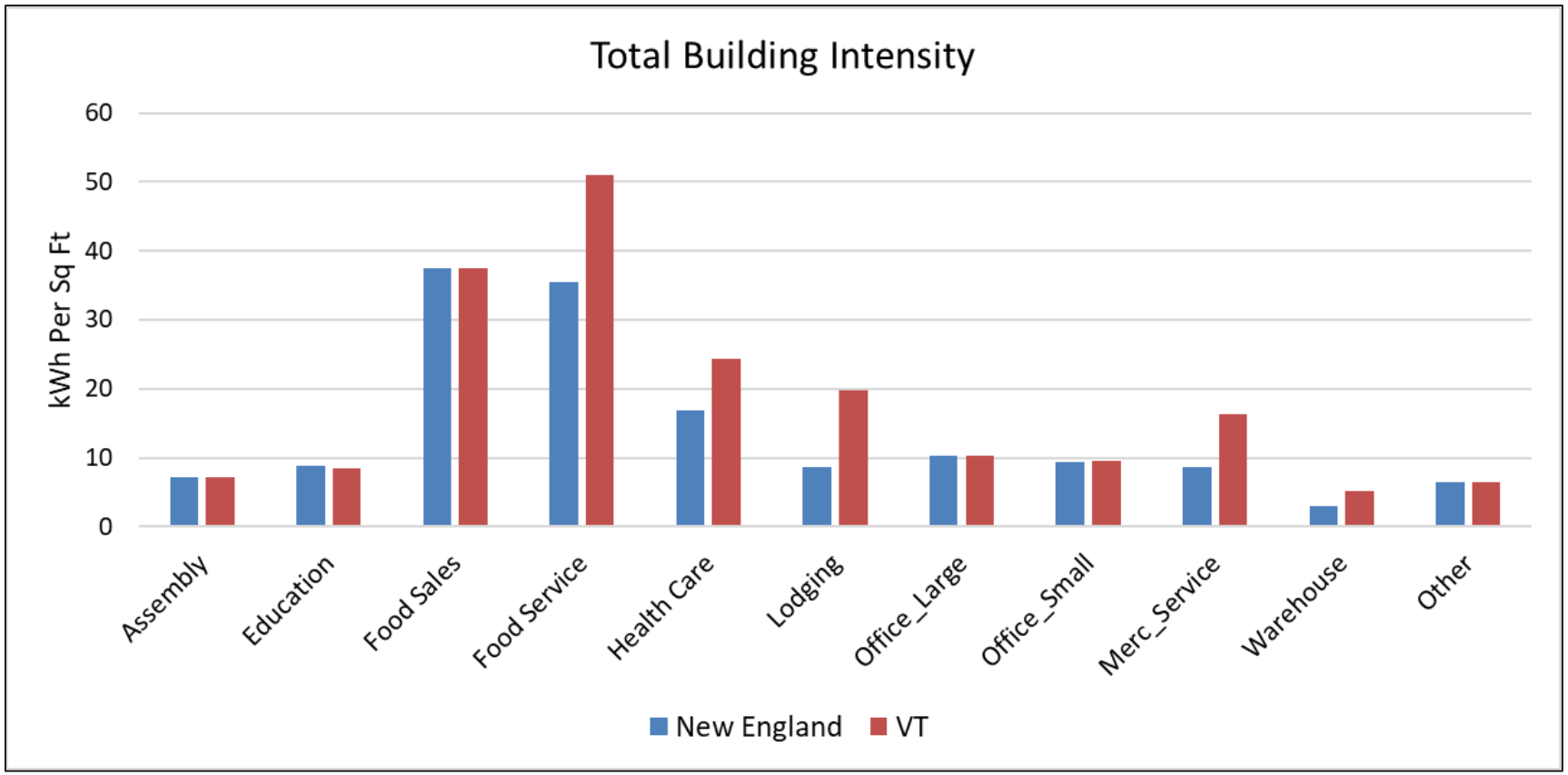
Building Mix Comparison with EIA

2018

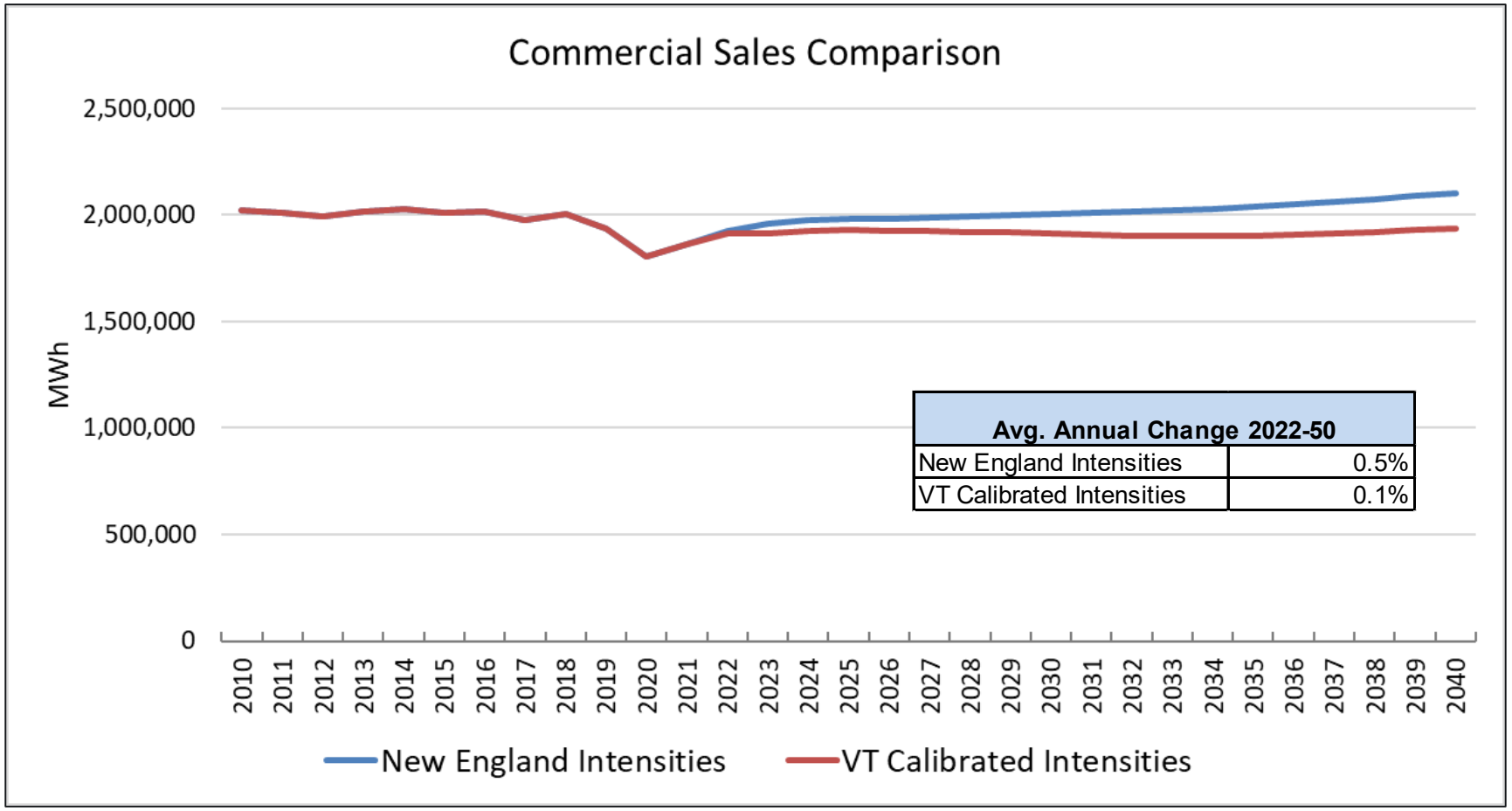


Comstock Energy Intensity Comparison with EIA

2018



Impact on Commercial Sales Forecast



Avg. Annual Change 2022-50	
New England Intensities	0.5%
VT Calibrated Intensities	0.1%

EV and Heat Pump Load Impacts

Current Electric Vehicle Market Information: Vermont

- As of January 2022, there were 6,585 registered electric vehicles in the state, with a nearly 50/50 split between all-electric(BEV) and plug-in hybrid electric(PHEV)
  - In 2020 projected 6,562 EVs by 2021 and 8,702 by 2022 (on track with what we are actual sales)
- Top 5 registered BEV & PHEV models

BEV Model	Count	PHEV Model	Count
Nissan Leaf	887	Prius Prime	756
Chevy Bolt	609	Toyota RAV4 Prime	417
Tesla Model 3	525	Chevrolet Volt	315
Tesla Model Y	324	Toyota Prius Plug-in	278
Tesla Model X	175	Ford CMax Energi	213

- State incentive of up to $8,000 for the purchase of electric vehicles
  - Maximum vehicle cost of $40k/$45k for PHEV and BEV
  - Maximum amount applicable for adjusted gross income of less than $50k, no incentives for income greater than $125k
- Utility incentives of $750-$2,900 for the purchase of electric vehicles
  - Free or discounted level 2 chargers
  - Incentivized charging rates

Current Electric Vehicle Market Information: U.S.

- A total of 77,687 EVs(63,243 BEVs and 14,444 PHEVs) were sold during September 2022 in the U.S., up 42.4% from the sales in September 2021. EVs captured 7% of total light-duty sales.

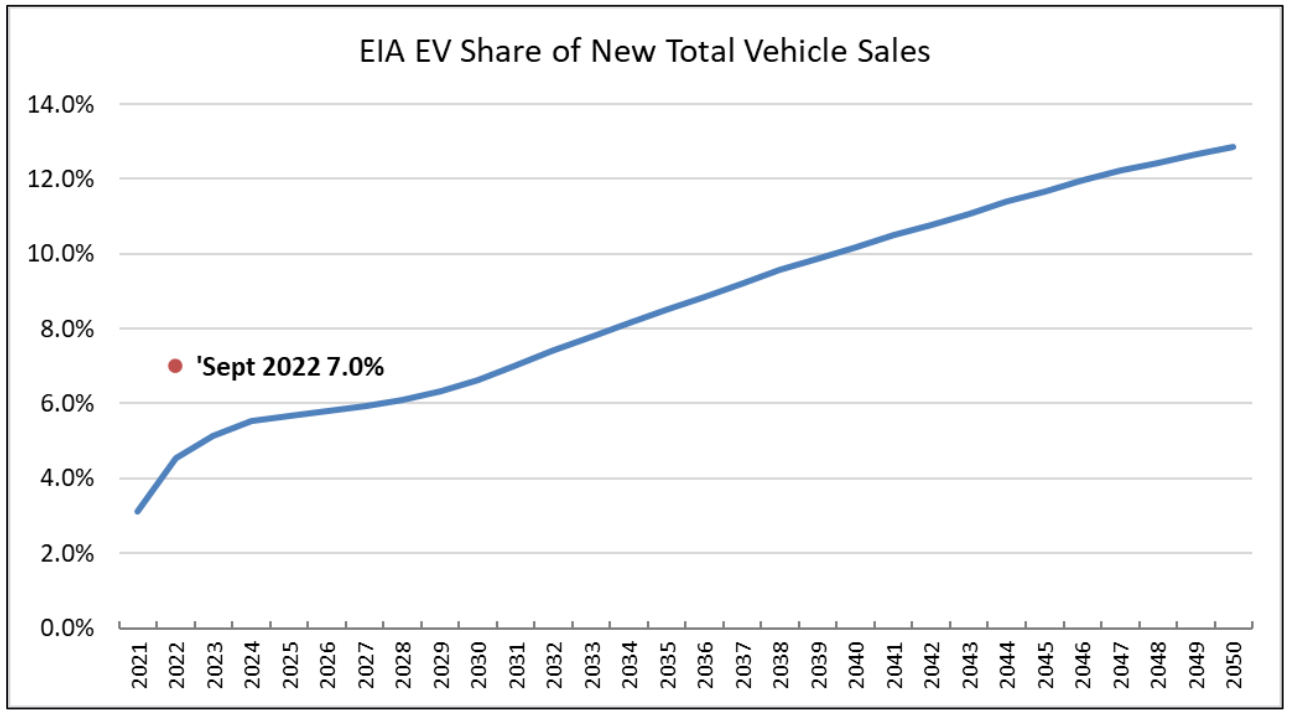
- Over 200,000 EVs sold in the 3rd quarter (June-Sept), highest quarter sales to date

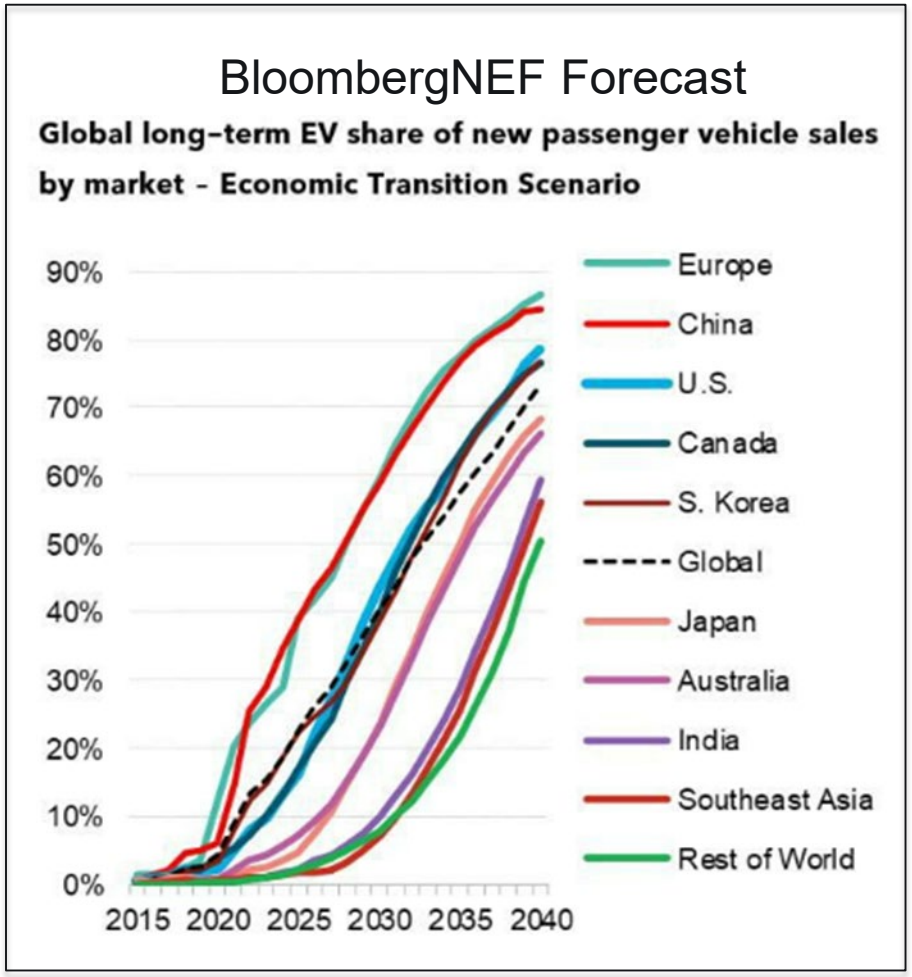
- Tesla accounted for 64% of sales in Q3, down from 74% in Q1

- Average sales price of an EV was $66,000, compared to $48,000 for internal combustion engine vehicles

- IRA(Inflation Reduction Act) removes the 200,000 per manufacturer unit cap on the federal EV tax credit.
  - Maximum vehicle cost of $55k for cars and $85k for SUV/trucks
  - Maximum adjusted gross income of $150k for single filers and $300k joint filers

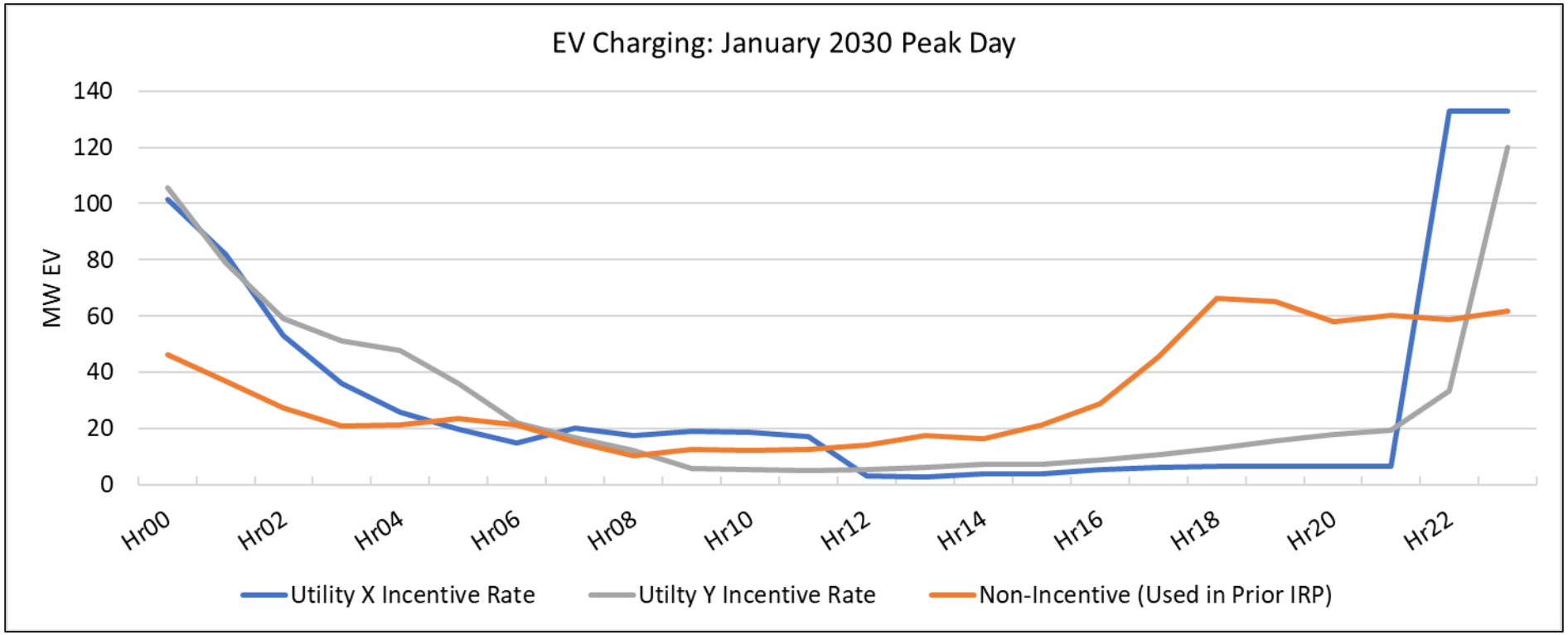
Current EV Sales Forecasts





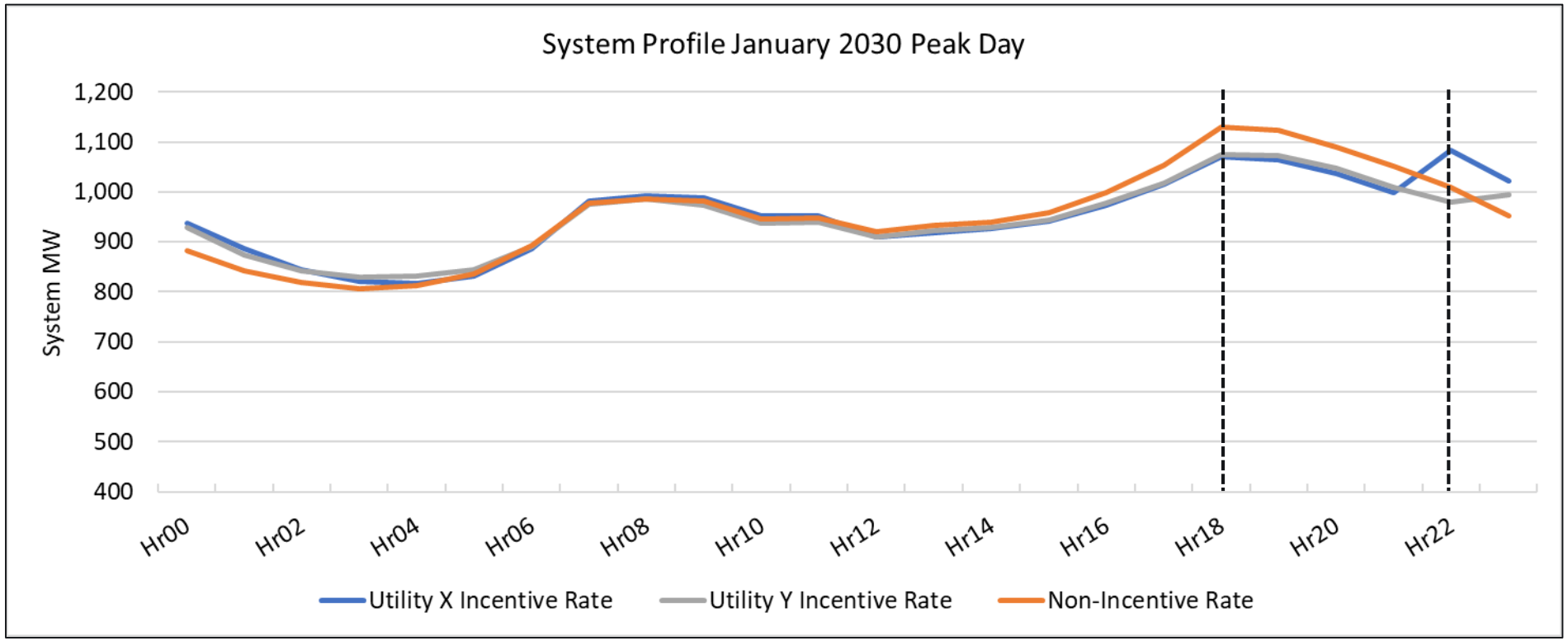
- The EIA continues to forecast low EV adoption compared to all other industry experts
- Bloomberg forecasting 80% of new cars sales will be electric by 2040, compared to 10% forecasted by EIA

Charging Profiles Matter: Residential Charging



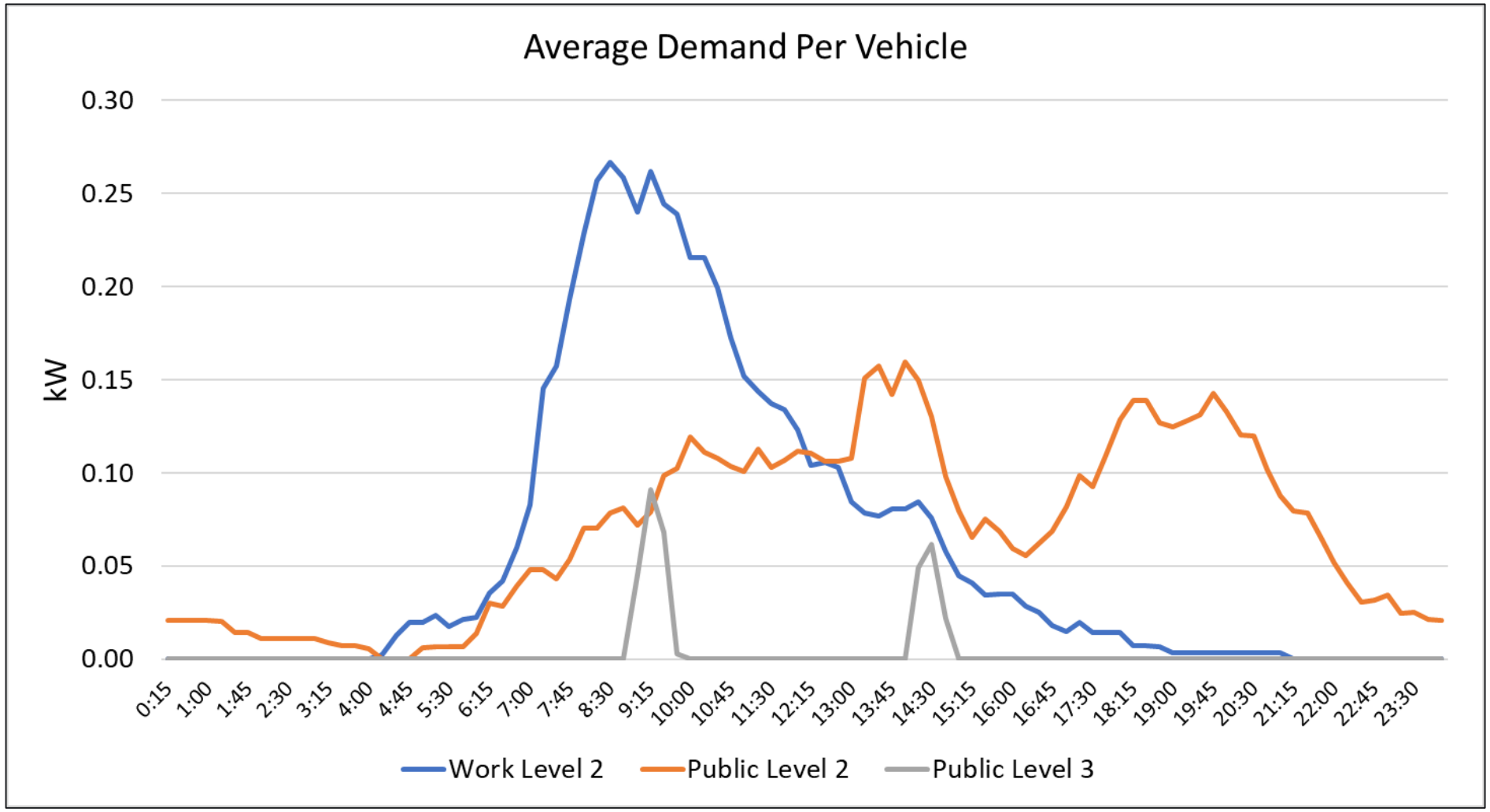
- Approximately 72,000 EVs by 2030
- With incentivized rates total EV demand could be twice as large but maximum demand would occur 4-5 hours later in the evening

Charging Profiles Matter: Impact on System Demand



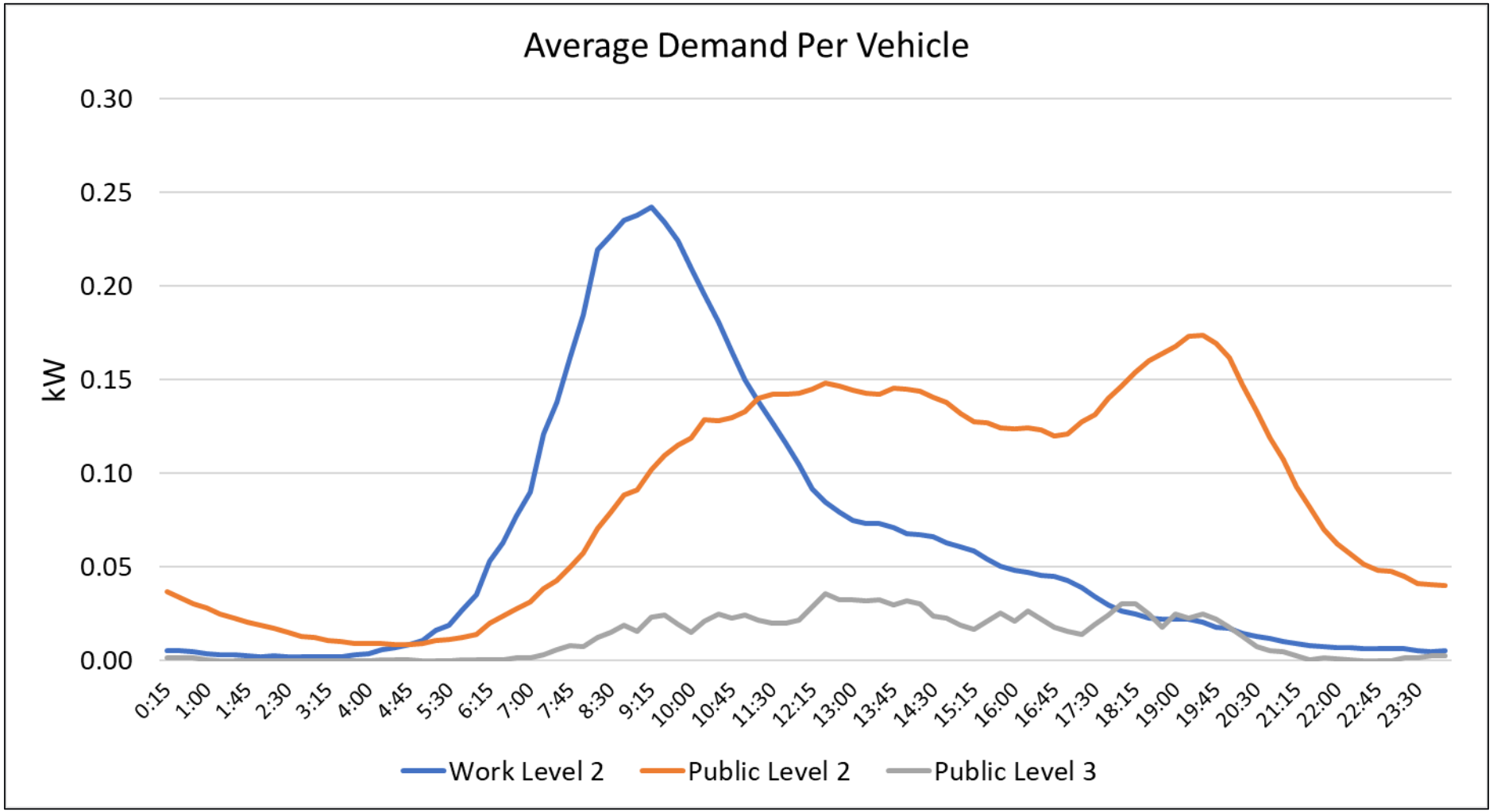
» Coincident demand impact is still lower with incentivized rates, timing of system peak may change

Work and Public Charging: 1,000 Vehicle Market



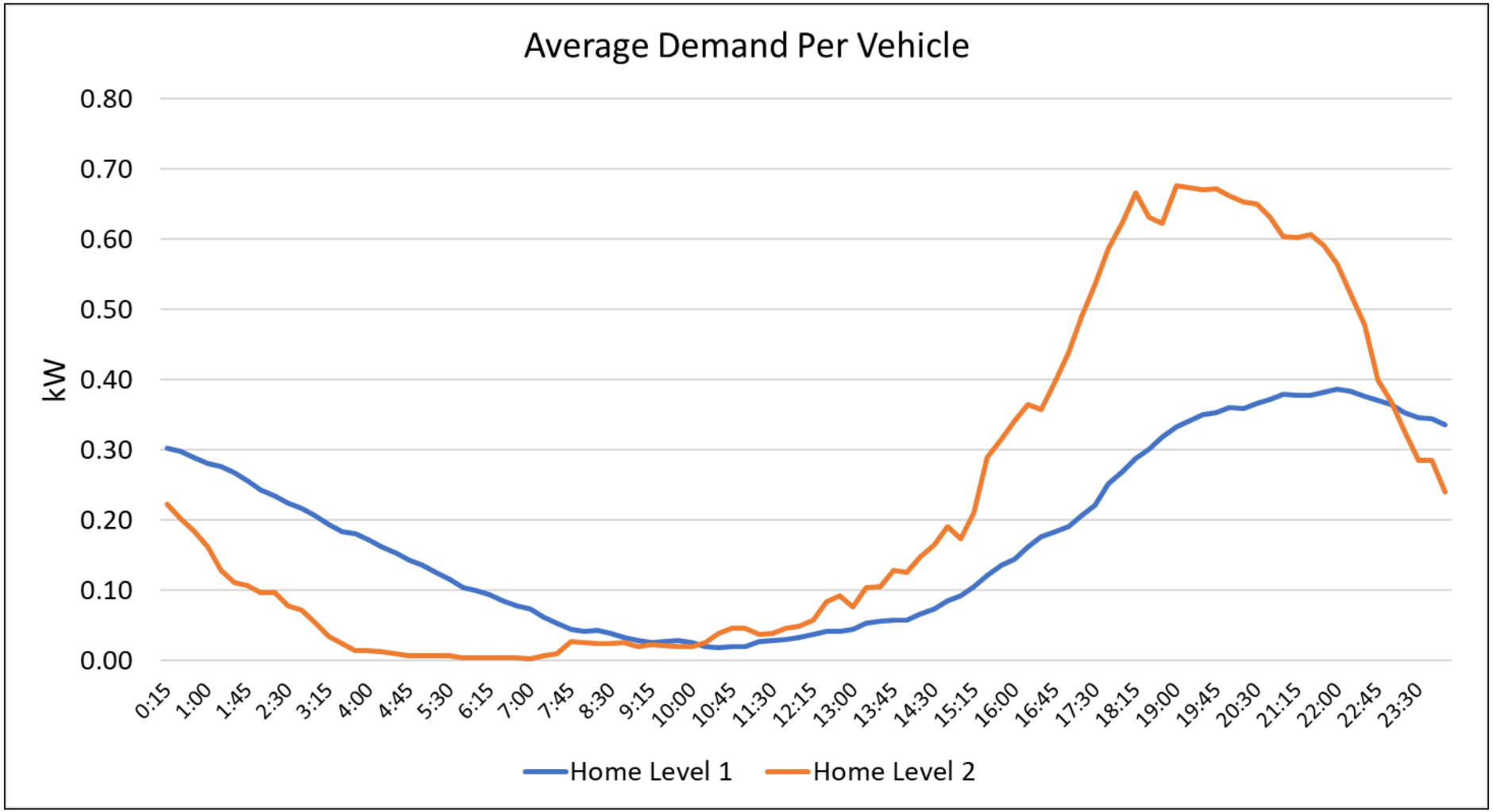
» Approximately 10%-20% of charging occurs away from home

Work and Public Charging: 70,000 Vehicle Market

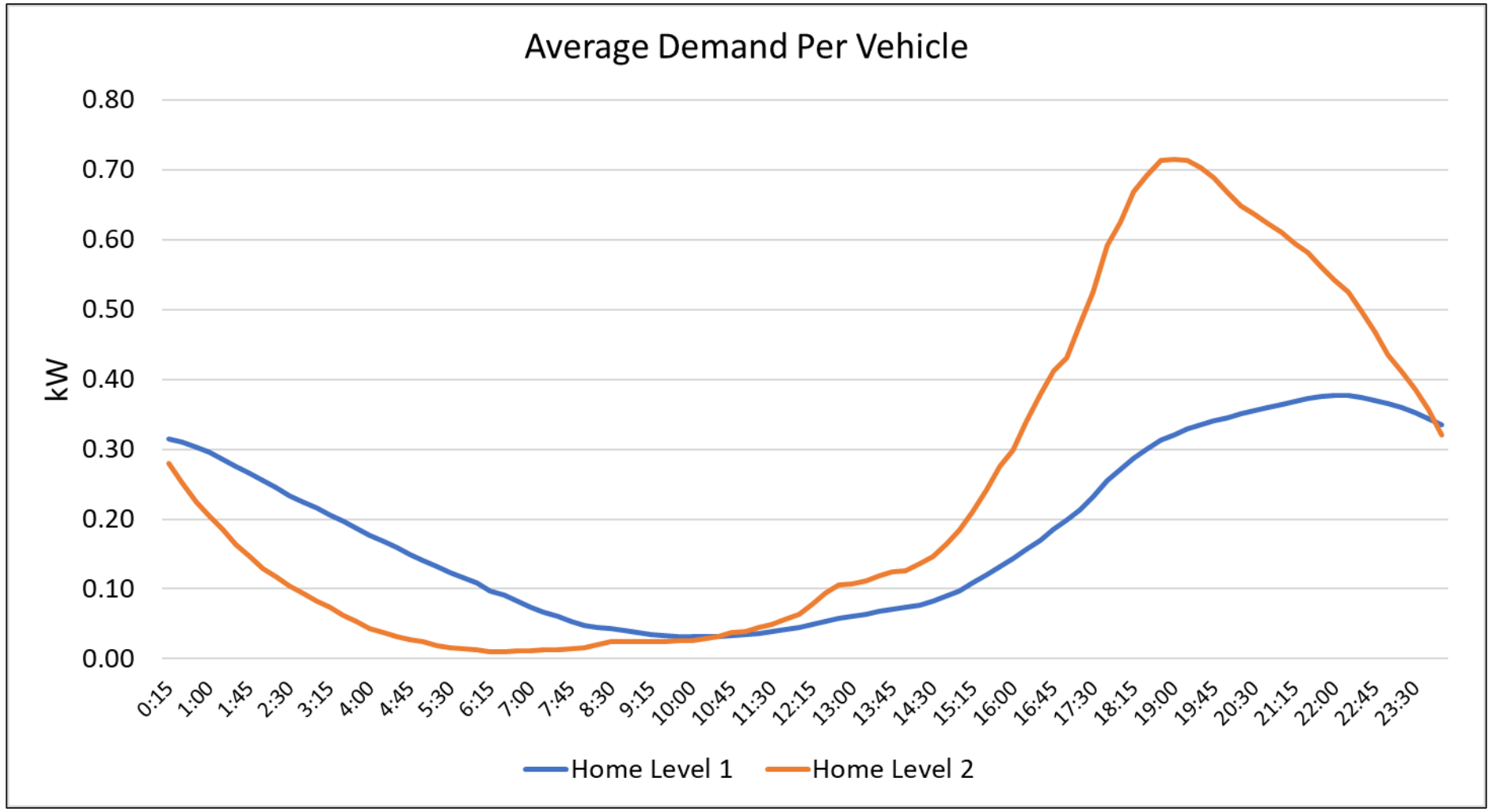


» Lower impact per vehicle with larger EV market, more diversified charging

Home Charging: 1,000 Vehicle Market



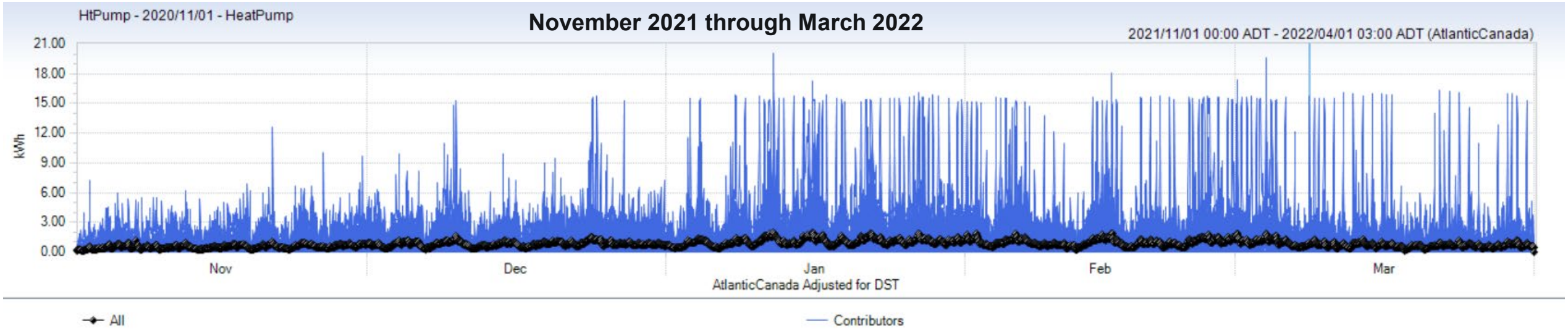
Home Charging: 70,000 Vehicle Market

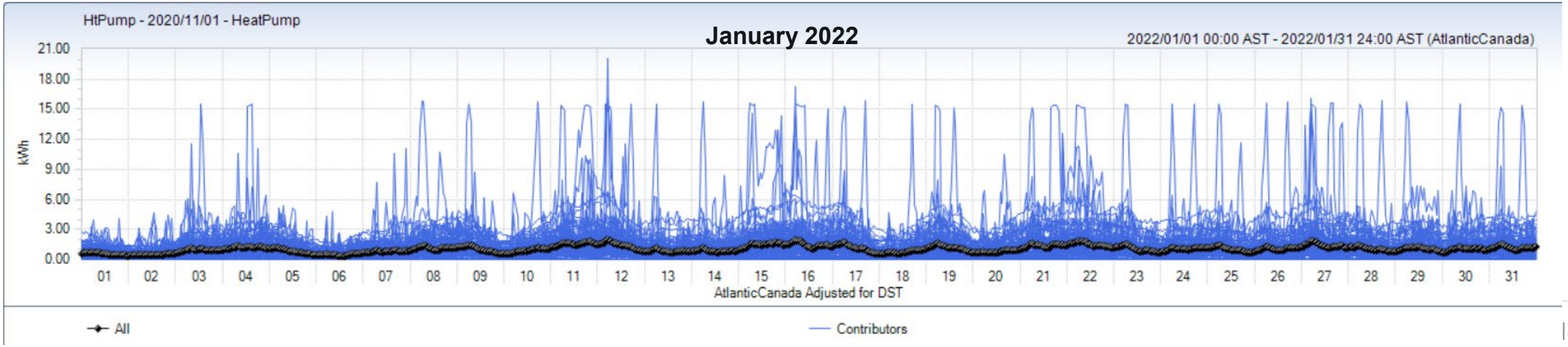


» Charge curve smooths out as more vehicles are added

NSP Heat Pump Study

Heat pump metered data for 125 sample households





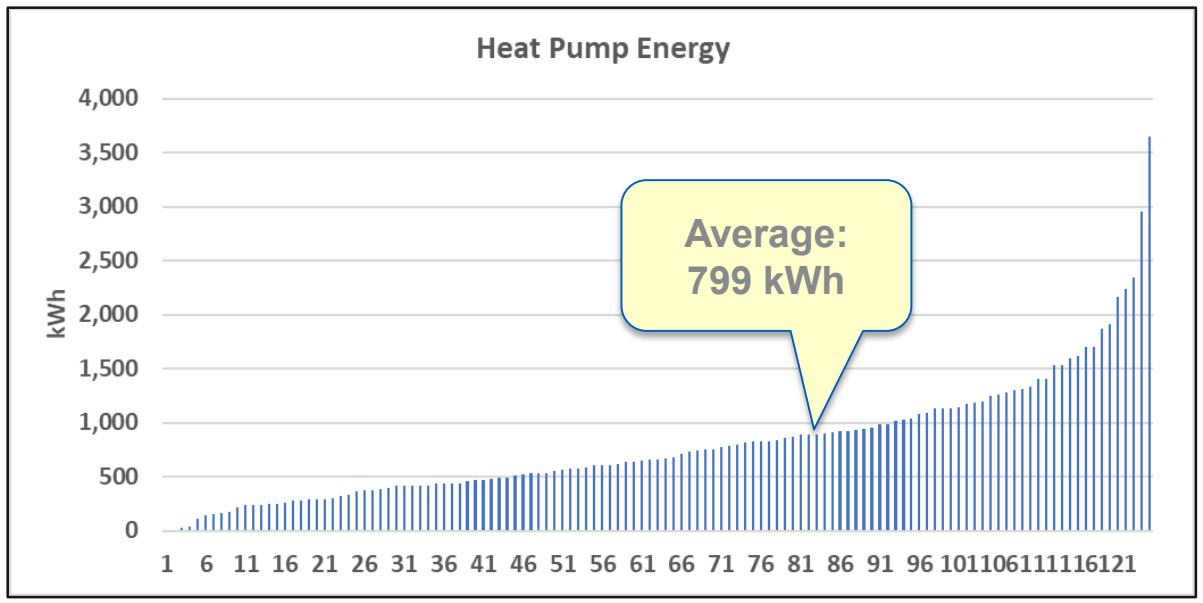
January 2022 Heat Pump Use Distribution

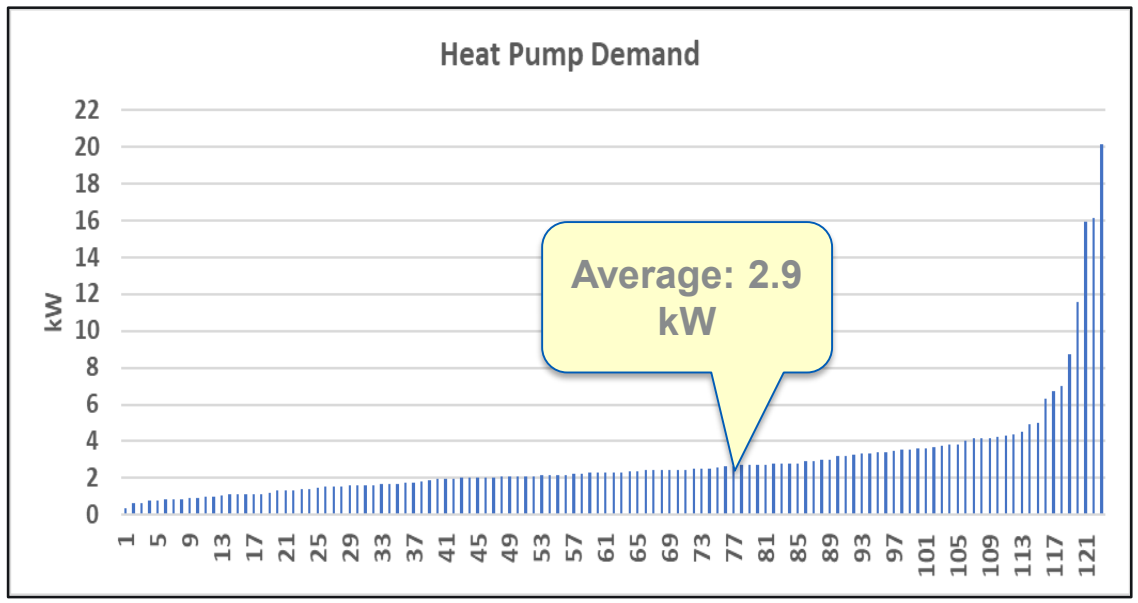
» 125 participants with metered data (slightly more than whole house load)
- Stratified sample selected from a recent participants in low-interest financing program (around 1,800 homes)

» Average use: 799 kWh, median: 665 kWh

» Standard deviation: 576 kWh
- minimum: 11 kWh
- maximum: 3,648 kWh

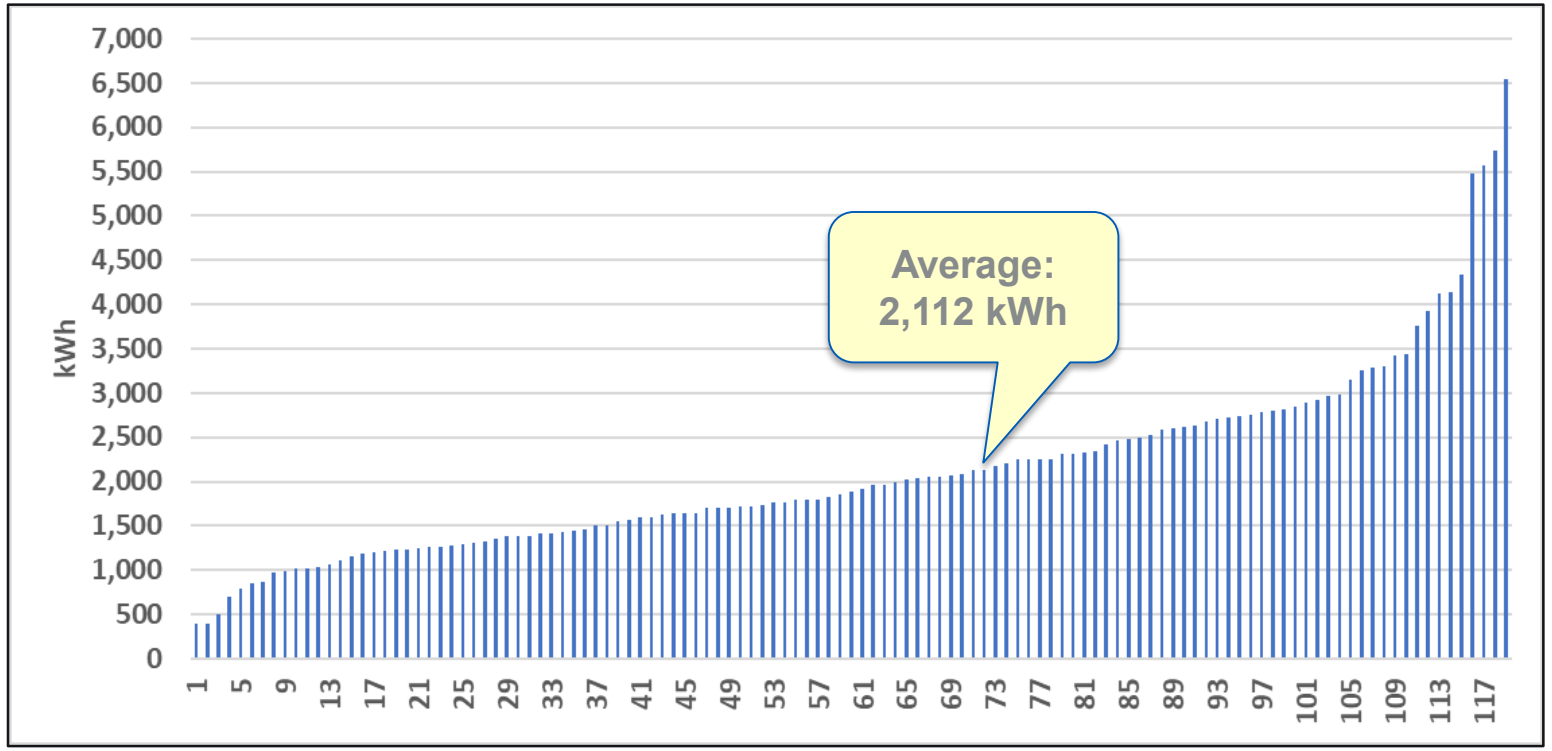
Heat pump demand from 0.3 kW to 20 kW



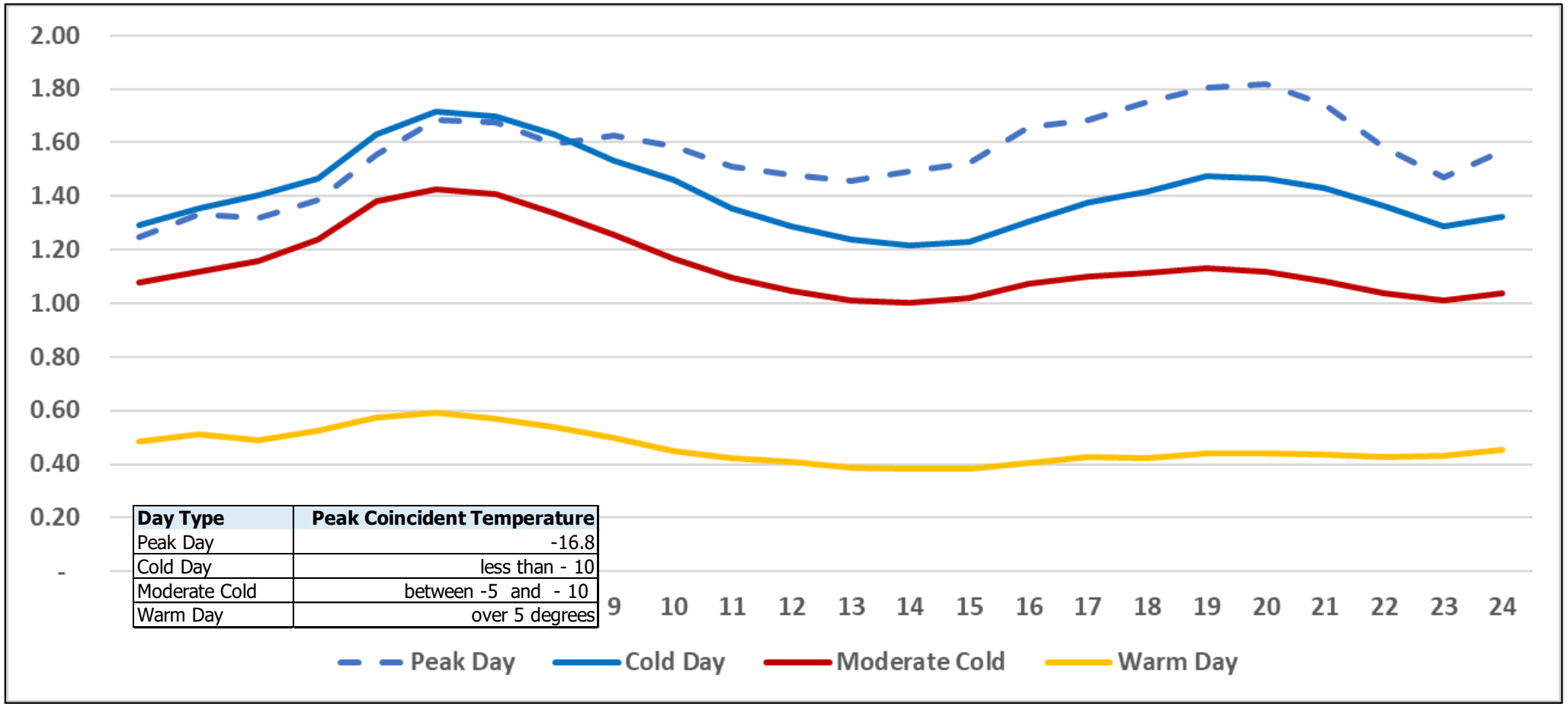


January 2022 Total House Average Use Distribution

» 119 participants with metered house data (compared with 82 last January)
» average use: 2,112 kWh, median: 1,891 kWh
» Wide distribution in participant usage, standard deviation: 1,064 kWh
  • minimum: 394 kWh
  • maximum: 6,548 kWh
» About equally split between
  • Electric primary heat
  • Non-Electric (oil and propane)



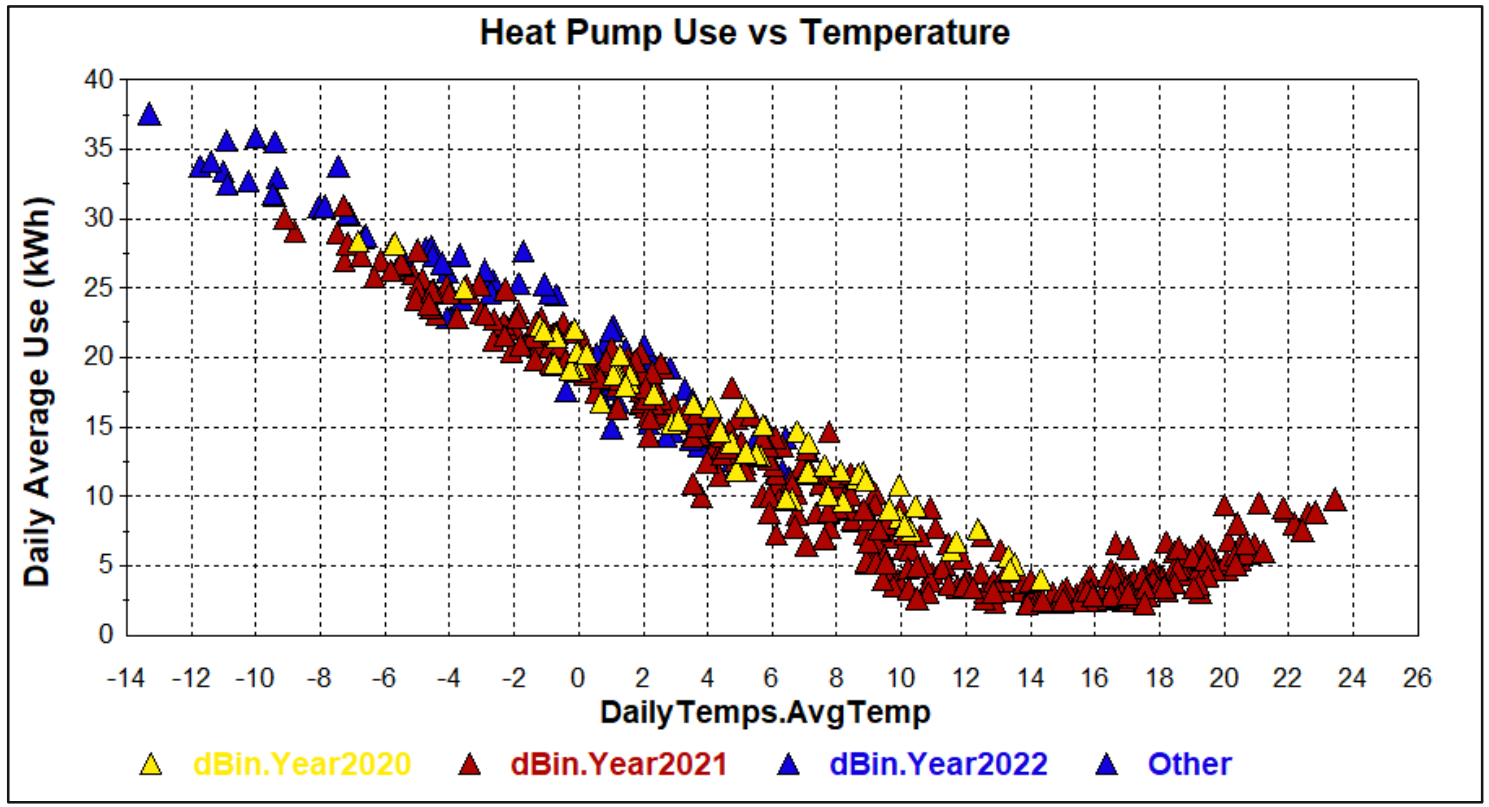
2022 HEAT PUMP PROFILE BY TEMPERATURE BIN



Day Type	Peak Coincident Temperature
Peak Day	-16.8
Cold Day	less than - 10
Moderate Cold	between -5 and - 10
Warm Day	over 5 degrees

Typically peaks in the morning
On the peak day – peaked at night

Heat Pump Load vs Temperature



» Strong linear relationship between heat pump load and winter temperatures

» Heating starting at 14 degrees, cooling around 18 degrees

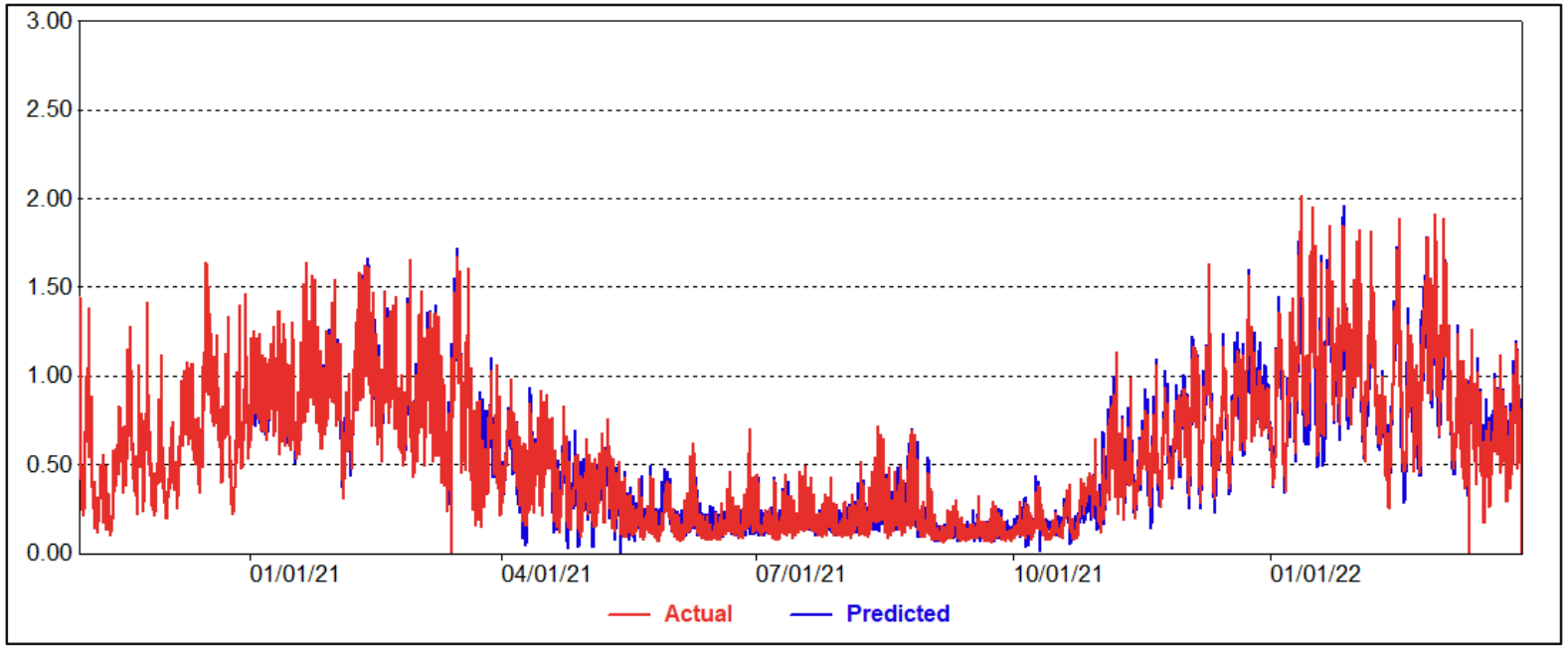
» Significantly colder in 2022. kWh input does not seem to be leveling out at coldest temperatures

Estimate heat pump hourly load model

» Estimation Period: Nov 20 – Mar 22

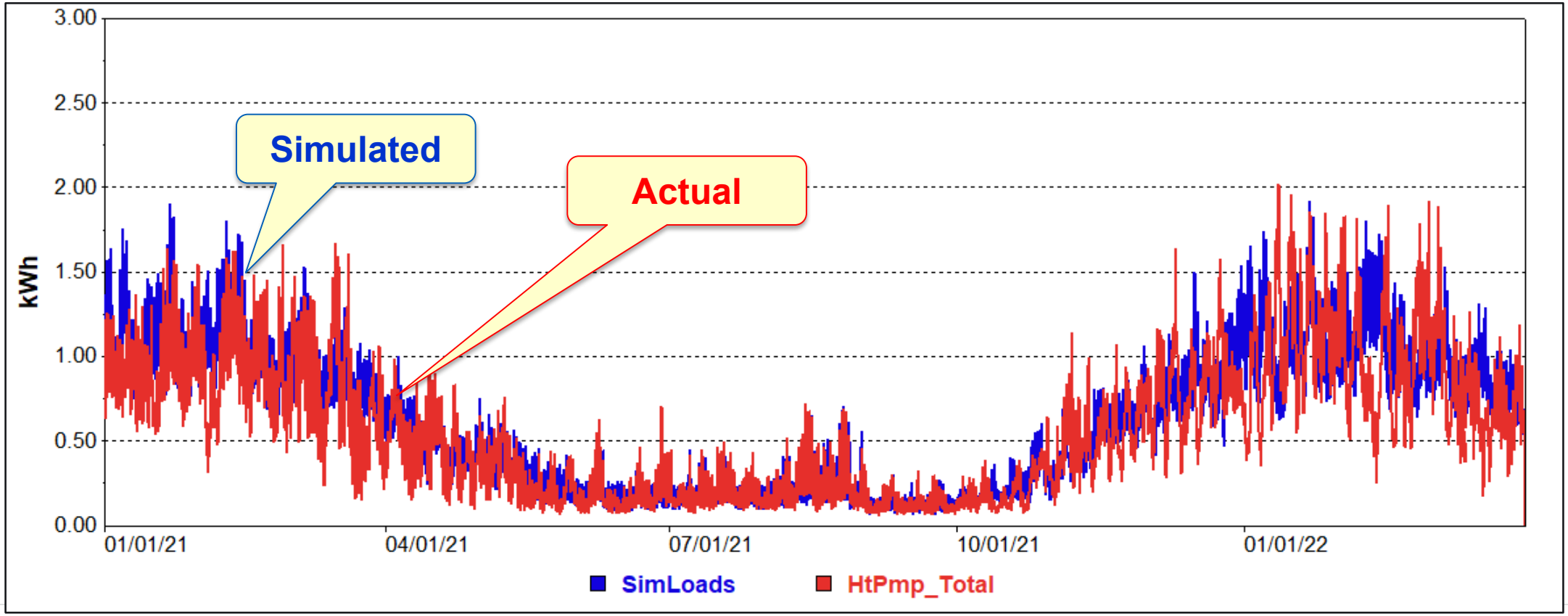
» Model variables

- HDD14
- HDD10
- HDD10Morning
- HDD10Evening
- CDD18
- Month Binaries
- Day of Week
- Holidays



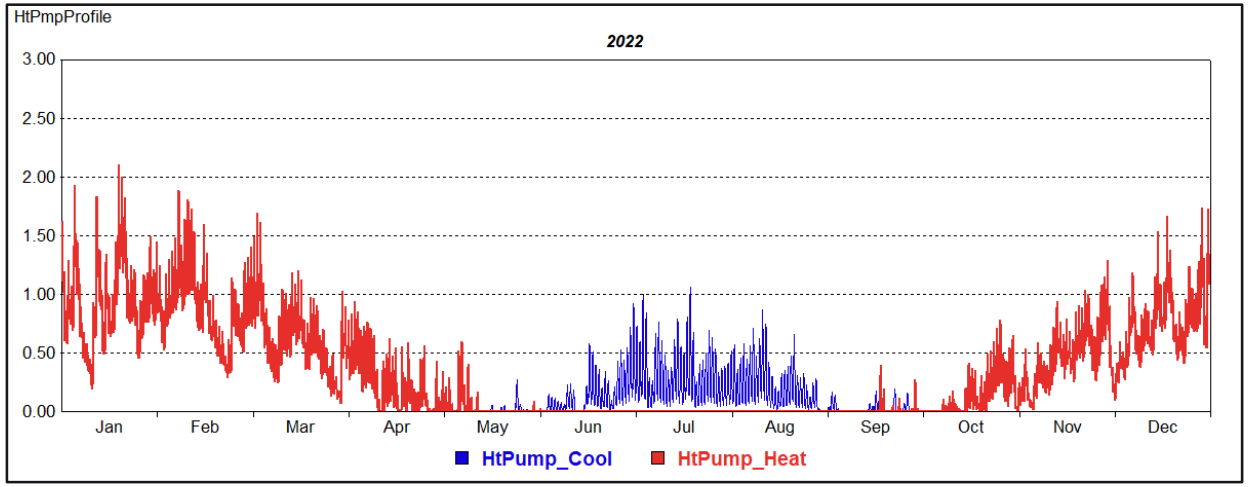
Actual and simulated (normal) heat pump loads
Winter 2021 through Winter 2022

» Estimate heat pump loads with actual weather simulate with normal weather



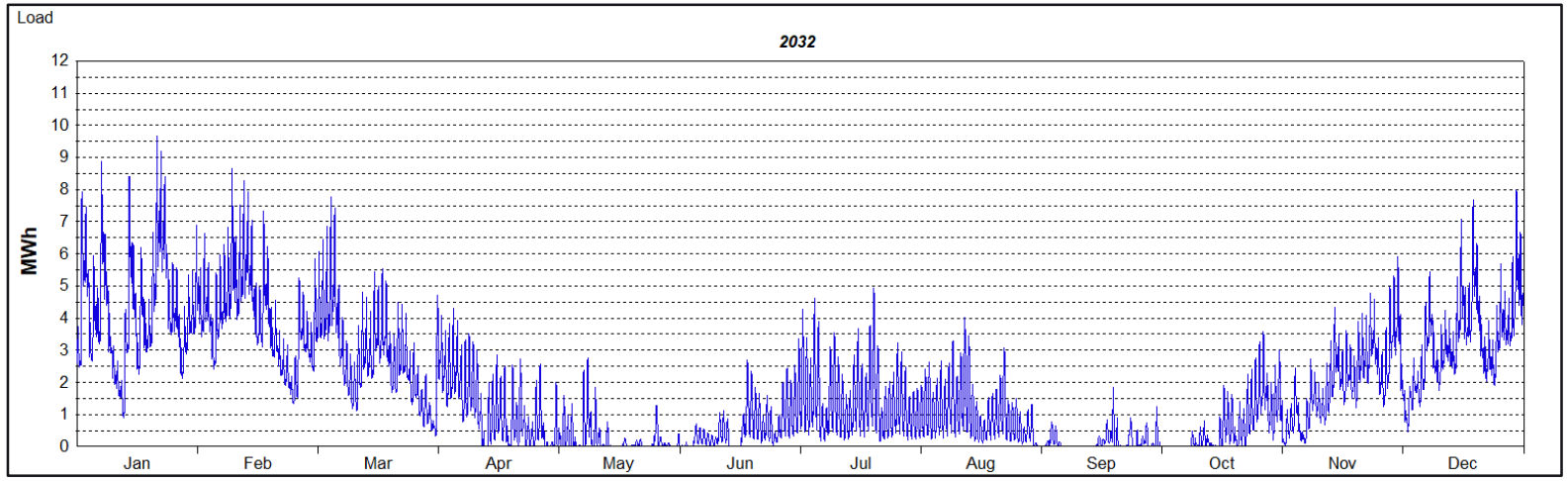
Vermont Heat Pump Load Profile

» Borrow the model and simulate with Vermont normal weather

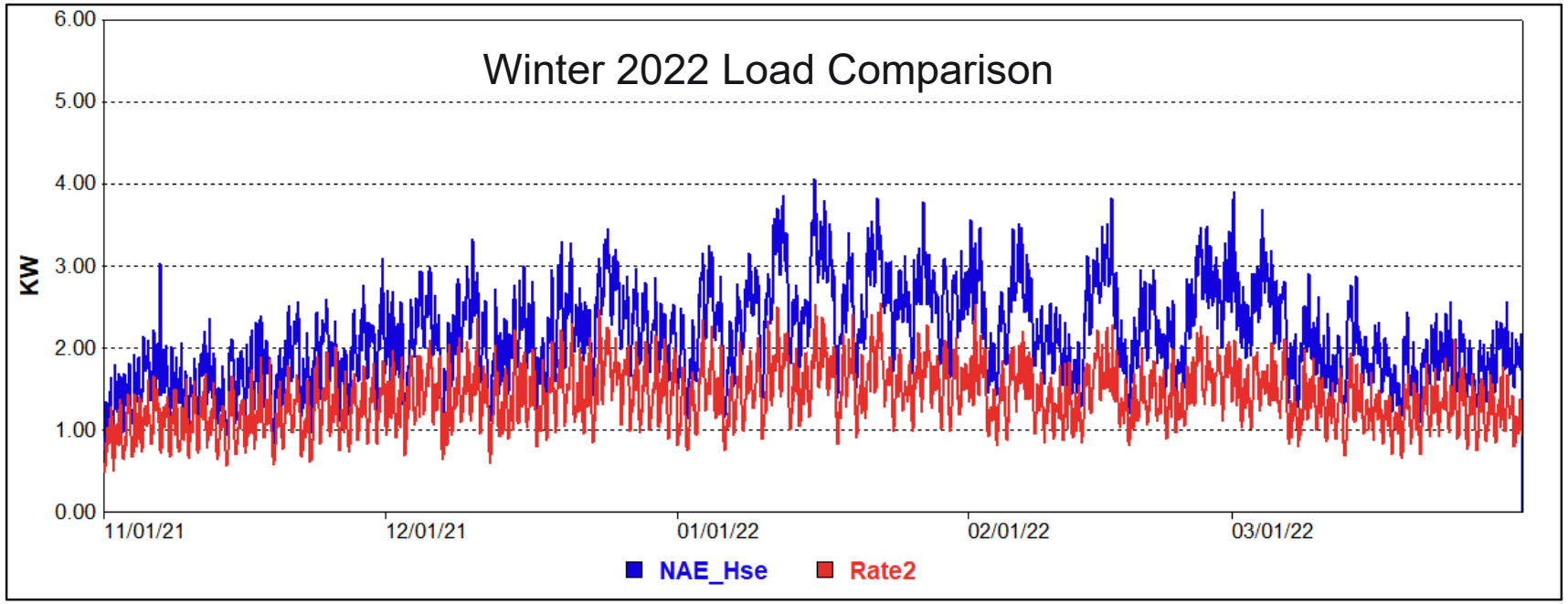


» Combine normal heat pump profile with heat pump sales forecast

- Additional cooling likely displacing RAC



Whole house load comparison with load research sample



» Oil and propane heated homes that added heat pumps have significantly higher loads
  - Higher cooling load as well as heating load

The Inflation Reduction Act Impact on Solar, EVs, and Heat Pumps

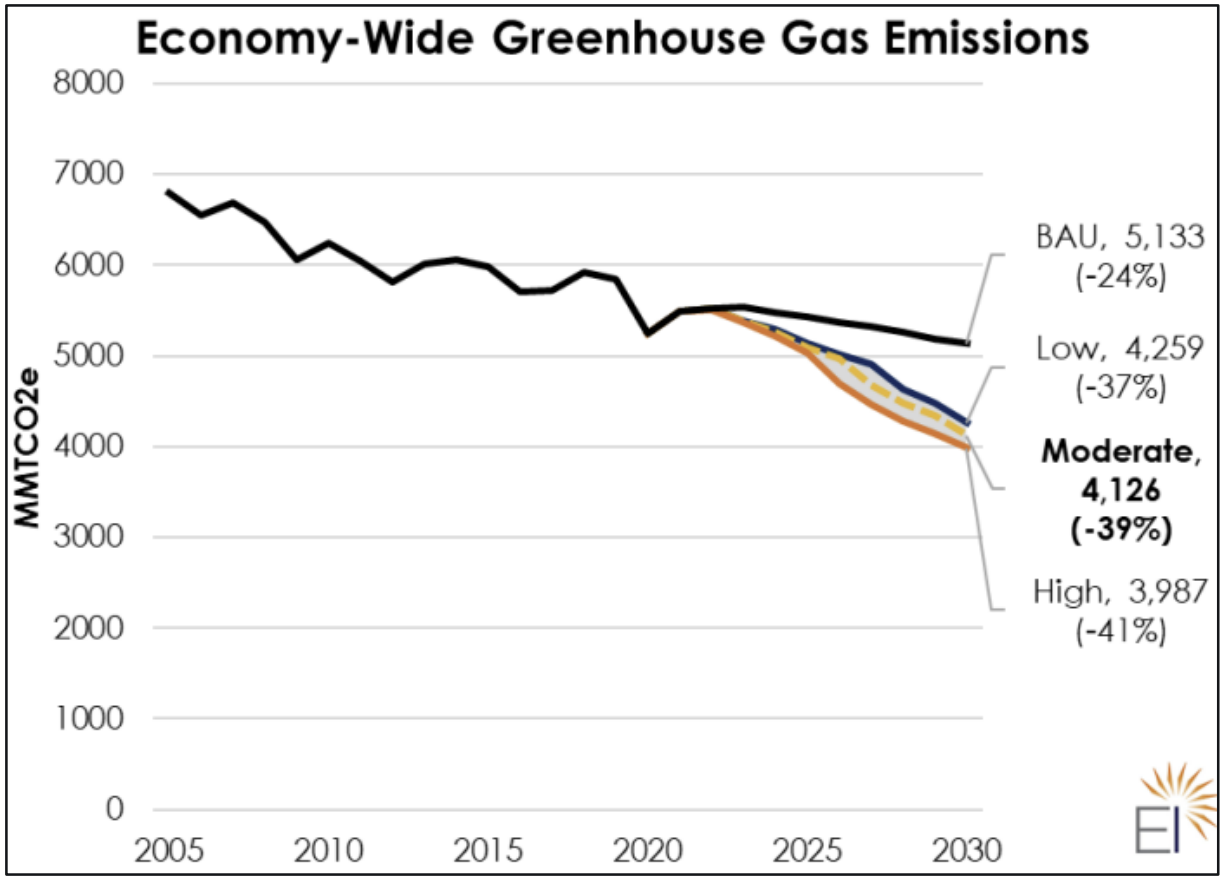
Inflation Recovery Act (IRA)

- $738 Billion Spending Bill Past Last August
  - $391 billion on energy and climate change
  - $238 billion in deficit reduction
  - Other money goes towards Affordable Care Act Subsidies, lower prescription drugs, and increase funding for IRS

- $369 billion into initiatives to promote clean energy and reduce green house gases.
  - Allocated over 10 years
  - Probably the most important climate bill since the Clean Energy Act passed in 2009
  - According to the nonprofit Energy Innovation the IRA could reduce U.S. emissions to 37% to 41% below 2005 levels by 2030 and create as many as 1.5 million new jobs

Historical and projected U.S. Greenhouse Gas Emissions

- CO2 emissions have been trending down since 2005
- Under Business as Usual by 2030 CO2 emissions will be 24% below 2005 levels
- Expected reduction from IRA is 39% below 2005 levels.



Modeling The Inflation Reduction Act Using The Energy Policy Simulator - Energy Innovation: Policy and Technology

Energy Efficiency and Electrification

» Tax Credits

- 25C Tax Credit: Supports a wide array of measures to encourage energy efficiency updates to commercial and residential buildings. Includes energy audits, air sealing and insulation, heat pumps, heat pump water heaters, electric panel upgrades, energy-efficient HVAC systems, energy efficient windows and doors.
- 45L Tax Credit: for new energy efficient homes. Includes multifamily buildings that achieve energy savings targets.

» Rebates

- The **HOMES** rebate program allocates $4.3 billion to state energy offices for consumer rebates for comprehensive home energy audits. Up to $4,000 for whole-house retrofits and doubled for households with 80% of median income. **Targets efficiency**.
- The **High-Efficiency Electric Home Rebate** allocates $4.5 billion to states for efficient electrification of low and moderate income (up to 150% of median income) households. **Targets electrification**.

- **Significant tax credits and rebates for weatherization, electrical panel and wiring upgrades, heat pumps, heat pump water heaters, electric stoves, and electric dryers**

Solar Incentives

» Extends current solar tax credits and increases tax credit from 26% to 30% of system cost
» For third-party suppliers and businesses, the tax credits are transferable
» Tax credit can increase up to 40% if the system is built in the U.S.
» Significant solar manufacturer tax credits for solar panels, inverters, and racking components

EV Incentives

» Removes manufacturing cap on vehicles eligible for tax credit
» Allows for the $7,500 tax credit to be used to reduce the vehicle cost directly (manufacturer gets the tax credit)
» Provides up to $4,000 tax credit on used cars (up to $25,000) but only on first resale.

The EV Catch

» Restricts incentives to cars under $50,000 and trucks and SUVs under $85,000
» Limits tax credits to households with less than $300,000 ($150,000 for an individual)
» Used car tax credits limited to households with less than $150,000.

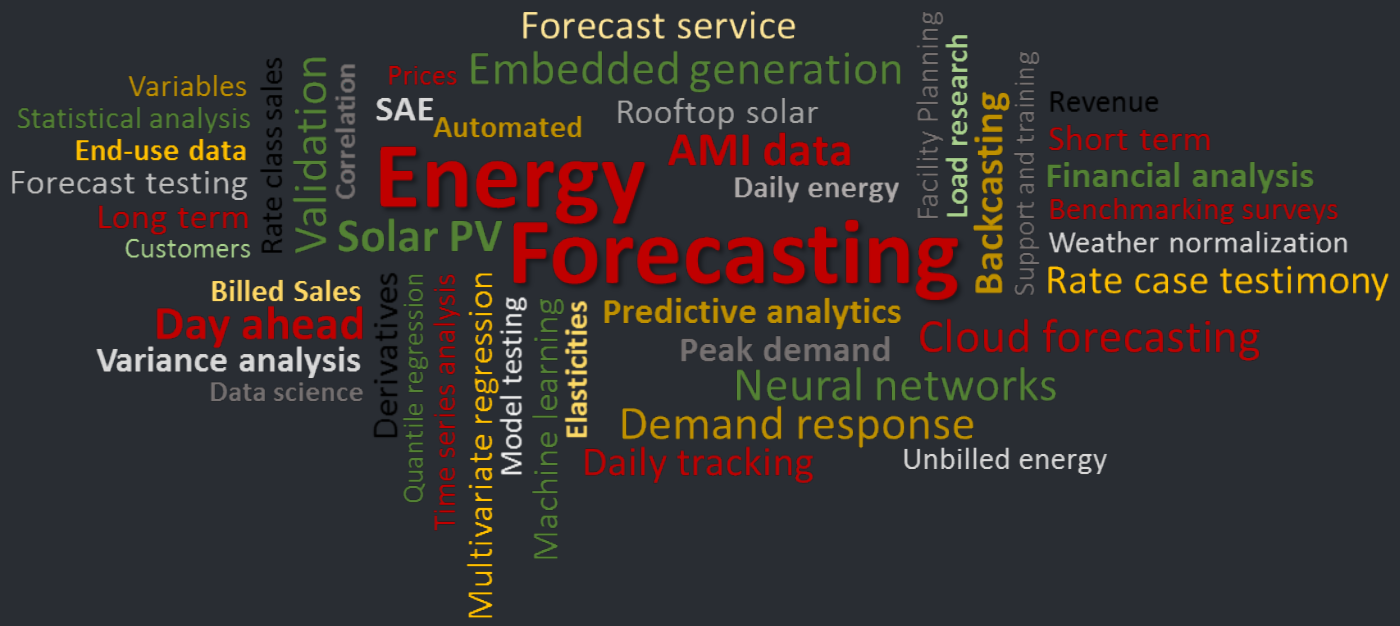
Discussion: Forecast Scenarios

Forecast Scenarios

» Business as usual
- Moderate economic growth
- Current level of energy efficiency funding
- Moderate penetration of EV and Heat Pumps
- Slower PV penetration

» Meeting CAP

» What must happen to meet CO2 reduction target
- How much fossil fuel heating and water heating must be displaced?
- What will the EV market share have to be to meet transportation emission reduction targets?
- What roll will mass transit (buses) and fleet electrification play?
- How much electrification can be offset with additional energy efficiency efforts
- How are the load impacts distributed across planning zones?



Thank You

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