

# 2022 Final Transportation Electrification forecast

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*Load Forecast Committee*



Victoria Rojo

LOAD FORECASTING, SYSTEM PLANNING



# Updates from the Draft Forecast

- Updated peak hour bins to align with CELT 2021 final PV forecast
  - Applies to both personal light-duty and fleet vehicle forecasts
- Fleet vehicle forecast updates
  - Updated vehicle-miles-traveled (VMT) assumption for light-duty fleet vehicles
  - Rhode Island transit bus adoption forecast was updated to reflect increased deployment expectations
  - Hourly charging profiles for each vehicle class were refined
    - Smoothing and removal of outliers
  - New weather history 1991-2020
    - Aligns with new weather period utilized in the long-term load forecast
- Overall change in regional seasonal peak demand from the draft forecast is ~2% in 2031

# 2022 Transportation Electrification Forecast

## Overview

- Transportation electrification forecast framework
  - Forecast the adoption of electrified vehicles or “EVs”, for each state and the region over the next ten years
  - Utilize data-driven assumptions to convert the EV adoption forecast into estimated impacts on monthly energy and demand by state
- Starting with the CELT 2022 forecast, the ISO has expanded the scope of EVs considered to include select categories of fleet vehicles:
  - Light-duty fleet vehicles, medium-duty delivery trucks, school buses, and transit buses
- Light-duty EV adoption forecast figures used in the CELT 2021 forecast, and updated figures provided by the states for CELT 2022, implicitly reflect both personal and fleet light-duty EVs
  - To avoid double-counting, forecasts for light-duty EVs are discounted by the percentages below to remove fleet vehicles
  - These discount factors are based on state level vehicle stock data as of Q1 2021

	CT	MA	ME	NH	RI	VT
% Fleet	4.6%	6.0%	5.5%	7.2%	5.7%	5.3%

# ELECTRIC VEHICLE ADOPTION FORECAST

*Personal Light-Duty Vehicles and Select Classes of Fleet Vehicles*

# 2022 Light-Duty Personal EV Adoption Forecast

## States - Incremental Increases in Vehicle Stock

- Draft 2022 adoption figures shown reflect the removal of light-duty fleet EVs
- ME adoption forecast was developed to align with the state's [Climate Action Plan](#)
- VT adoption forecast reflects values submitted by state representatives
- CT adoption forecast values represent a blend of the CELT 2021 forecast and EV targets listed in the state's [Electric Vehicle Roadmap](#)
- RI adoption forecast was developed based on discussions with state and utility representatives
- MA and NH adoption forecasts result from carrying forward the CELT 2021 forecast

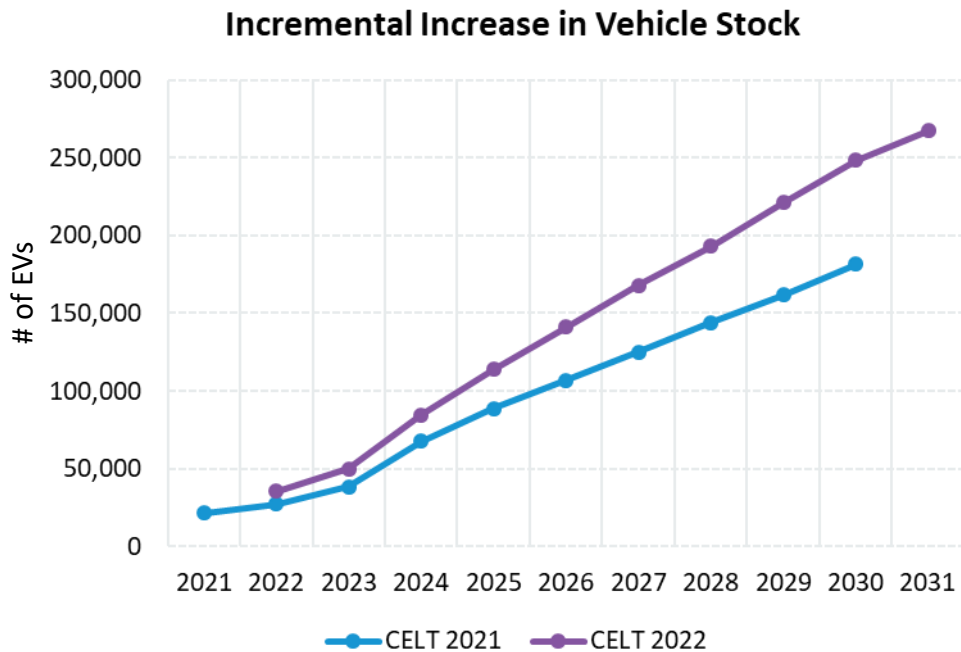
Light-Duty Personal EVs							
Year	CT	MA	ME	NH	RI	VT	NE
2022	17,001	6,201	3,262	3,269	2,332	3,370	35,435
2023	18,843	14,376	4,866	3,461	3,308	4,982	49,837
2024	20,961	38,430	8,259	3,685	4,331	8,776	84,442
2025	22,987	52,242	13,325	3,875	5,549	15,775	113,754
2026	29,365	59,101	18,299	5,165	7,559	21,465	140,954
2027	37,125	64,410	24,611	6,173	9,662	25,886	167,868
2028	44,636	69,735	32,571	7,115	11,895	27,189	193,140
2029	51,281	73,452	41,336	7,796	14,546	32,541	220,953
2030	62,014	75,403	51,368	8,964	17,246	33,285	248,280
2031	65,706	77,405	60,376	9,020	20,223	34,404	267,134
<b>Total</b>	<b>369,920</b>	<b>530,755</b>	<b>258,273</b>	<b>58,524</b>	<b>96,652</b>	<b>207,673</b>	<b>1,521,796</b>

Impact of Forecast on Light-Duty Personal Vehicle Stock							
	CT	MA	ME	NH	RI	VT	NE
<b>2021 Electrified Stock</b>	15,533	36,533	4,822	5,014	3,046	4,332	69,280
<b>Total Electrified (2022-2031)</b>	369,920	530,755	258,273	58,524	96,652	207,673	1,521,796
<b>Total Vehicle Stock</b>	2,856,427	5,082,420	1,247,151	1,222,363	782,764	518,562	11,709,687
<b>% of Stock Electrified by 2031</b>	13%	11%	21%	5%	13%	41%	14%

# New England Light-Duty Personal EV Adoption Forecast

*Comparison Between CELT 2021 and CELT 2022*

Year	CELT 2021*	CELT 2022
2021	21,708	
2022	27,249	35,435
2023	38,594	49,837
2024	67,948	84,442
2025	88,797	113,754
2026	107,095	140,954
2027	124,891	167,868
2028	144,168	193,140
2029	161,861	220,953
2030	181,580	248,280
2031		267,134
<b>10-year total</b>	<b>963,891</b>	<b>1,521,796</b>



\* CELT 2021 values shown reflect adjustment to remove light-duty fleet vehicles

# Fleet EV Adoption Forecast

- For the 2022 forecast the ISO has expanded the scope of vehicles considered to include 4 classes of fleet vehicles in each of the New England states
  - Light-duty fleet, medium-duty delivery, school buses, and transit buses
- Fleet EV adoption forecast development (for each fleet category, by state)
  - Develop a “sales forecast” of new fleet vehicles to be purchased each year
    - Combines vehicle replacement and fleet growth where possible
    - Assumes no early retirement of vehicles
  - Develop a consensus “EV sales share” forecast
    - Based on various policies, goals, reports, presentations, and/or announcements
  - Apply the “EV sales share” forecast to the “sales forecast” to get the number of additional fleet EVs on the road each year

# Current Fleet Vehicle Stock in New England

*As of March 31, 2021*

	Light-duty Fleet Vehicles		Medium-duty Delivery Vehicles		School Buses		Transit Buses	
	All	Electric	All	Electric	All	Electric	All	Electric
CT	142,921	623	4,581	0	5,265	2	771	2
MA	337,296	1,915	9,476	8	9,668	7	1,763	25
ME	66,180	210	1,869	0	3,777	1	194	0
NH	98,716	379	2,047	0	3,571	0	143	0
RI	48,552	199	1,389	0	2,404	0	252	3
VT	30,020	219	833	0	1,780	6	118	2
Total	723,685	3,545	20,195	8	26,465	16	3,241	32

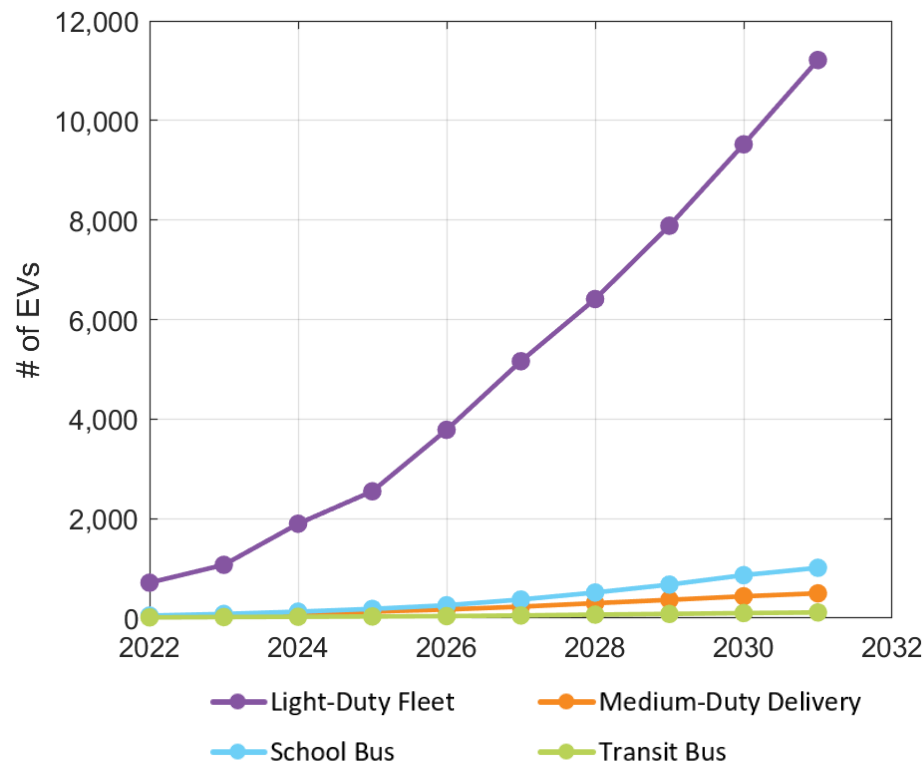
*Source: DNV Energy Insights USA Inc.*



# 2022 Fleet EV Adoption Forecast

*New England - Incremental Increases in Vehicle Stock*

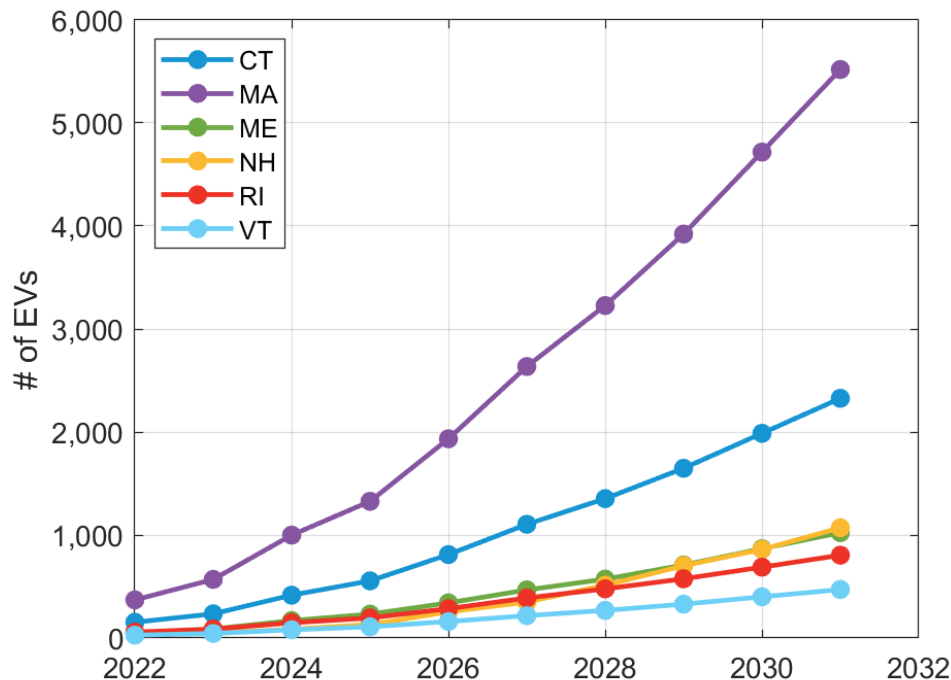
Fleet EV Adoption Forecast					
Year	LD Fleet	MD Delivery	School Buses	Transit Buses	Fleet Total
2022	713	48	51	15	827
2023	1,071	69	84	22	1,246
2024	1,897	94	130	28	2,149
2025	2,549	133	186	34	2,902
2026	3,784	174	259	41	4,258
2027	5,162	231	374	54	5,821
2028	6,411	301	515	71	7,298
2029	7,885	368	674	85	9,012
2030	9,520	439	864	102	10,925
2031	11,214	499	1,012	115	12,840
Total	50,206	2,356	4,149	567	57,278



# 2022 Fleet EV Adoption Forecast

*Light-Duty Fleet - Incremental Increases in Vehicle Stock*

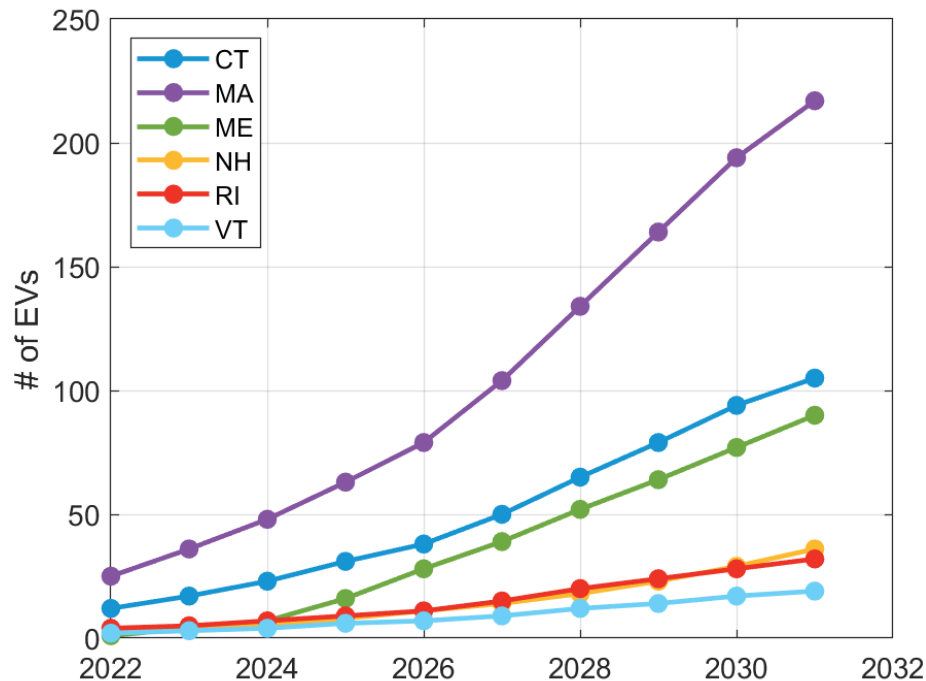
Light-Duty Fleet EVs							
Year	CT	MA	ME	NH	RI	VT	NE
2022	153	370	57	48	57	28	713
2023	235	569	88	48	87	44	1,071
2024	416	999	169	85	148	80	1,897
2025	555	1,327	232	131	195	109	2,549
2026	810	1,934	341	254	285	160	3,784
2027	1,104	2,636	467	349	389	217	5,162
2028	1,353	3,228	572	513	477	268	6,411
2029	1,648	3,922	709	702	575	329	7,885
2030	1,987	4,718	867	860	688	400	9,520
2031	2,327	5,519	1,023	1,070	804	471	11,214
Total	10,588	25,222	4,525	4,060	3,705	2,106	50,206



# 2022 Fleet EV Adoption Forecast

*Medium-Duty Delivery - Incremental Increases in Vehicle Stock*

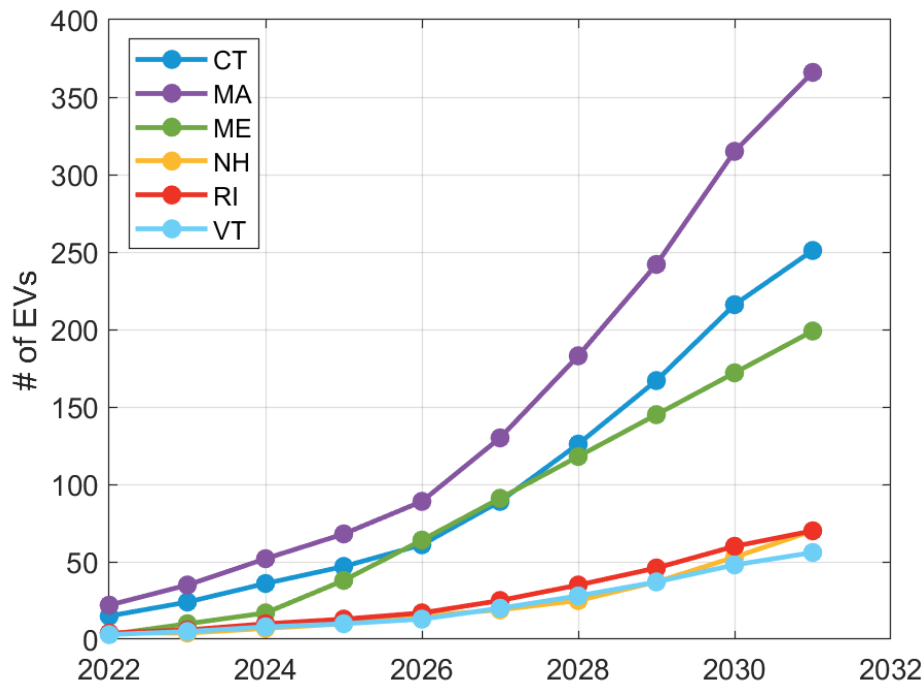
Medium-Duty Delivery EVs							
Year	CT	MA	ME	NH	RI	VT	NE
2022	12	25	1	4	4	2	48
2023	17	36	4	4	5	3	69
2024	23	48	7	5	7	4	94
2025	31	63	16	8	9	6	133
2026	38	79	28	11	11	7	174
2027	50	104	39	14	15	9	231
2028	65	134	52	18	20	12	301
2029	79	164	64	23	24	14	368
2030	94	194	77	29	28	17	439
2031	105	217	90	36	32	19	499
Total	514	1,064	378	152	155	93	2,356



# 2022 Fleet EV Adoption Forecast

*School Buses - Incremental Increases in Vehicle Stock*

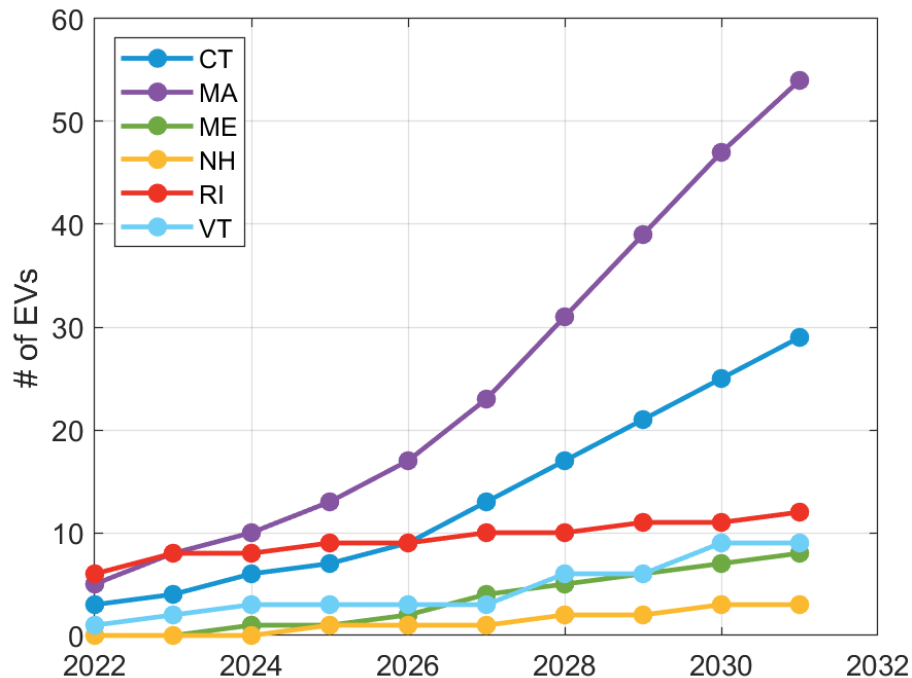
School Bus EVs							
Year	CT	MA	ME	NH	RI	VT	NE
2022	15	22	3	4	4	3	51
2023	24	35	10	4	6	5	84
2024	36	52	17	7	10	8	130
2025	47	68	38	10	13	10	186
2026	61	89	64	15	17	13	259
2027	89	130	91	19	25	20	374
2028	126	183	118	25	35	28	515
2029	167	242	145	37	46	37	674
2030	216	315	172	53	60	48	864
2031	251	366	199	70	70	56	1012
Total	1,032	1,502	857	244	286	228	4149



# 2022 Fleet EV Adoption Forecast

*Transit Buses - Incremental Increases in Vehicle Stock*

Transit Bus EVs							
Year	CT	MA	ME	NH	RI	VT	NE
2022	3	5	0	0	6	1	15
2023	4	8	0	0	8	2	22
2024	6	10	1	0	8	3	28
2025	7	13	1	1	9	3	34
2026	9	17	2	1	9	3	41
2027	13	23	4	1	10	3	54
2028	17	31	5	2	10	6	71
2029	21	39	6	2	11	6	85
2030	25	47	7	3	11	9	102
2031	29	54	8	3	12	9	115
Total	134	247	34	13	94	45	567



# ESTIMATING ENERGY AND DEMAND IMPACTS OF ELECTRIFIED FLEET VEHICLES

# Methodology

- Energy and demand impacts are based on analysis of fleet vehicle driving patterns and a sample of fleet vehicle charging data
- For each fleet vehicle class the following inputs were developed
  - Annual vehicle miles traveled (VMT)
  - Monthly allocation of VMT
    - Reflects seasonal driving patterns
    - Allocations for monthly VMT to weekdays/weekends
  - Hourly allocation of daily charging, by month
    - Shapes for Weekdays and weekends
  - Relationship between weather (daily average dry-bulb) and EV efficiency (kWh/mile)
- Monthly energy and demand impacts were developed for each fleet vehicle class
  - Develop VMT assumptions for all days within a month
  - Apply temperature sensitive efficiency relationships to get daily energy
  - Apply daily charging shapes to allocate charging to hours
  - Monthly energy impacts stem from the same 30 year normal period used in the load forecast
  - Monthly demand impacts result from applying the weather distribution used in the load forecast and extracting the 95<sup>th</sup> percentile
  - Scale to adoption forecast

# Update to Input Assumptions from Draft Forecast

- Vehicle-miles-traveled (VMT) assumptions for light-duty fleet vehicles were updated to better reflect fleet activity
- Hourly charging shapes for each fleet vehicle type were smoothed and refined to remove outliers

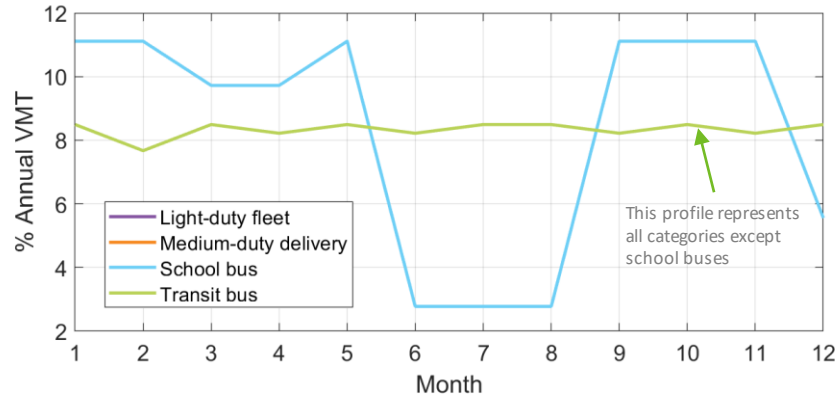


# Vehicle Miles Traveled (VMT)

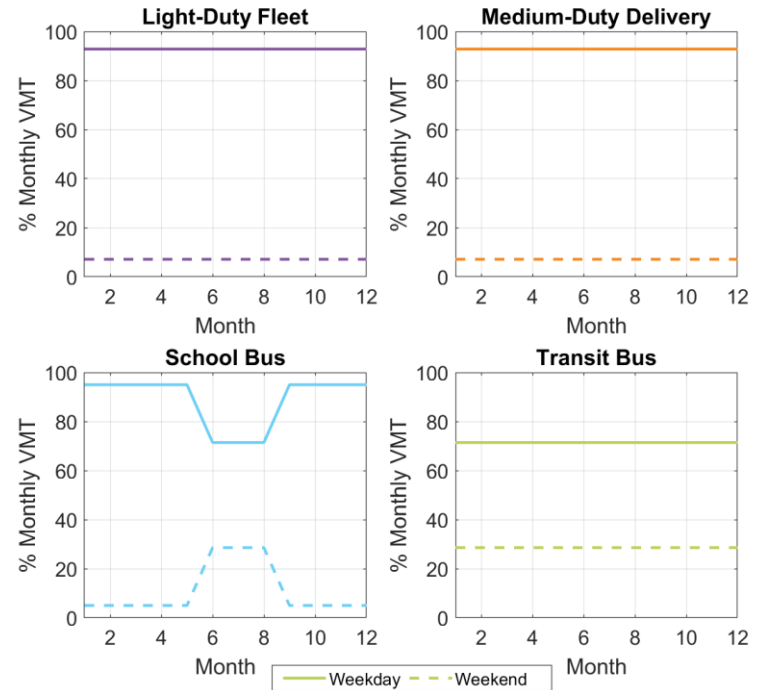
## Annual VMT

Vehicle Category	Average Annual VMT
School bus	11,483
Transit bus	38,488
Medium-duty delivery	13,655
Light-duty fleet	21,258

## Monthly VMT Allocation

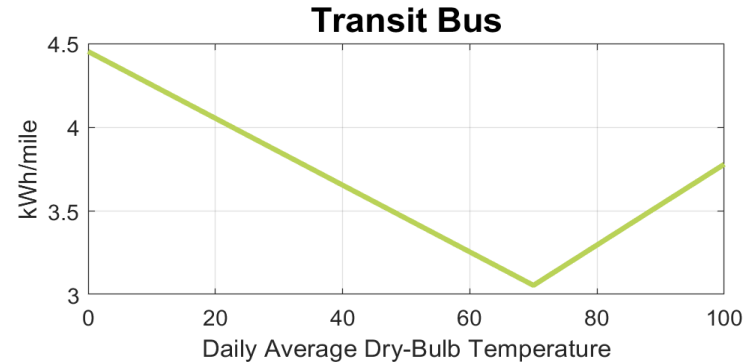
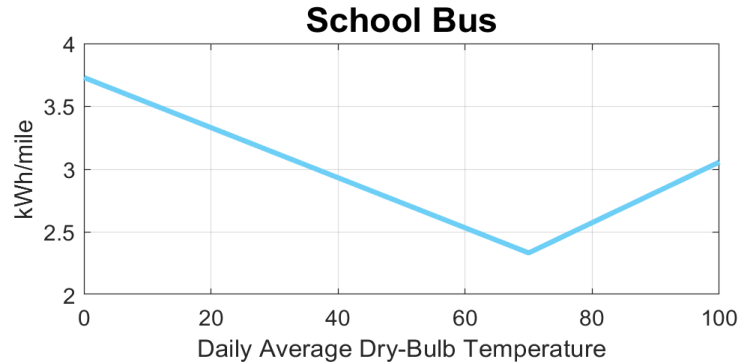
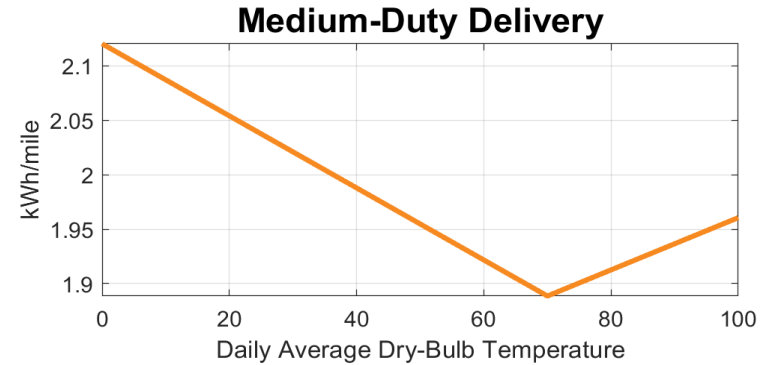
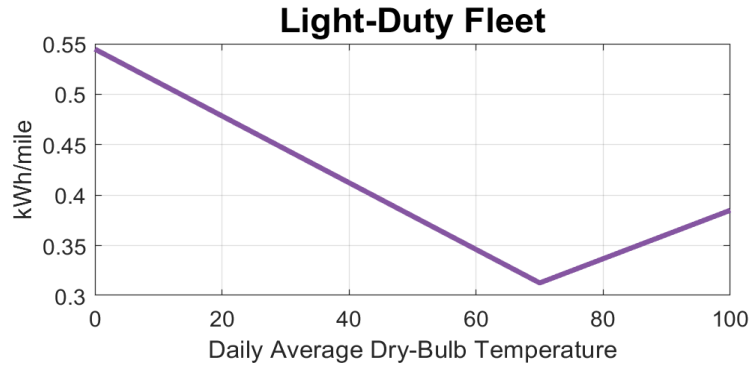


## Day-type VMT Allocation



# Electric Vehicle Efficiency

## *Energy Consumption as a Function of Daily Temperature*

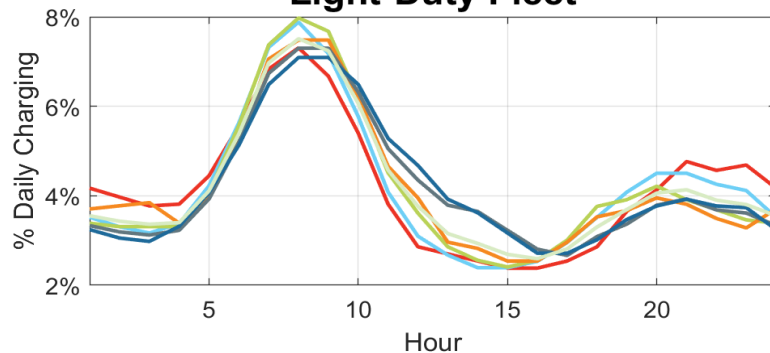


*\* School bus and transit bus efficiencies reflect an adjustment for the partial use of auxiliary cabin heating systems*

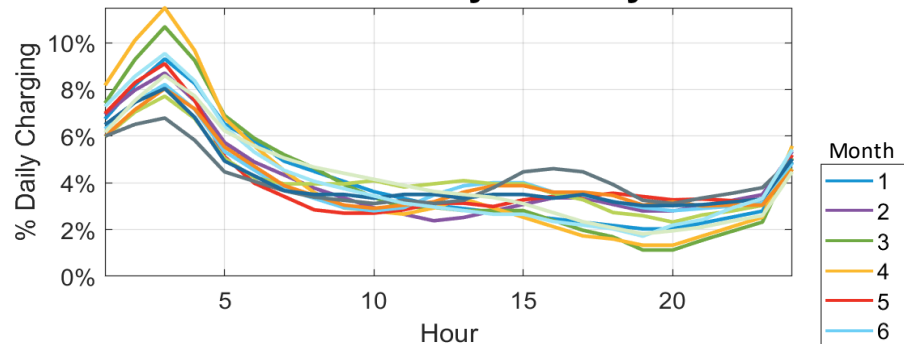
# Allocation of Hourly Charging by Month

*Non-Holidays & Weekdays*

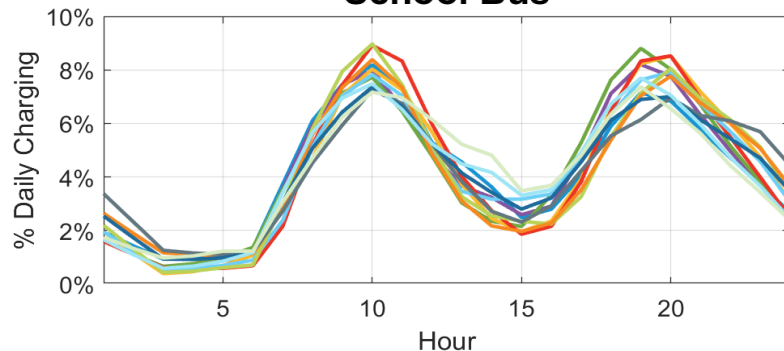
## Light-Duty Fleet



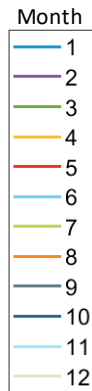
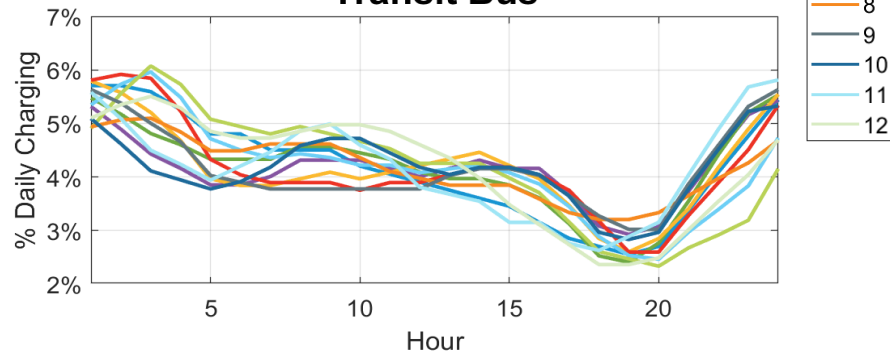
## Medium-Duty Delivery



## School Bus



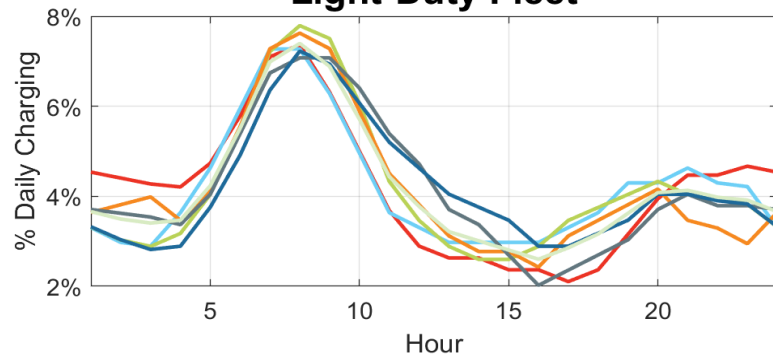
## Transit Bus



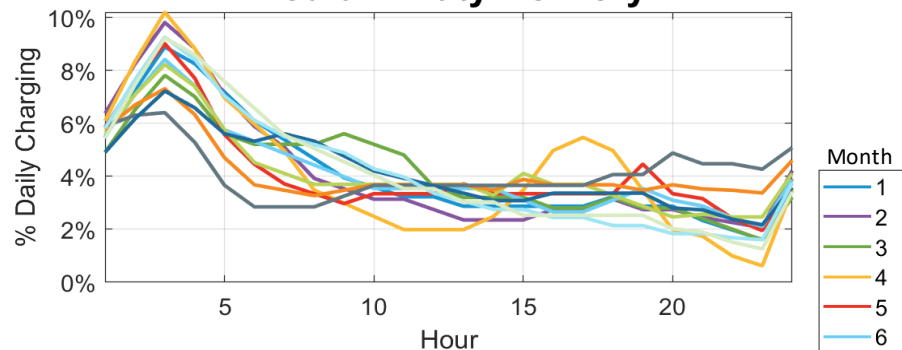
# Allocation of Hourly Charging by Month

*Holidays & Weekends*

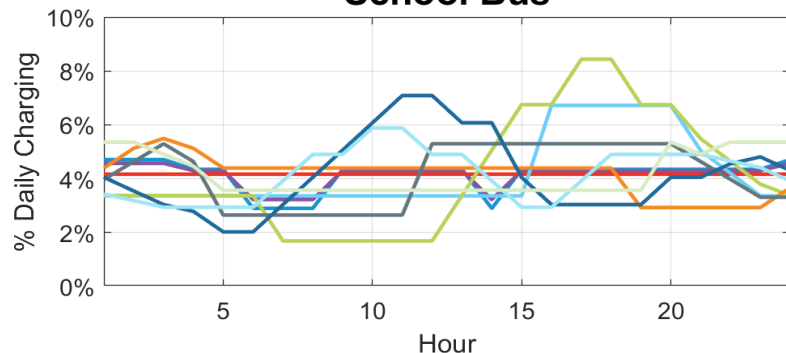
## Light-Duty Fleet



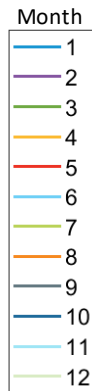
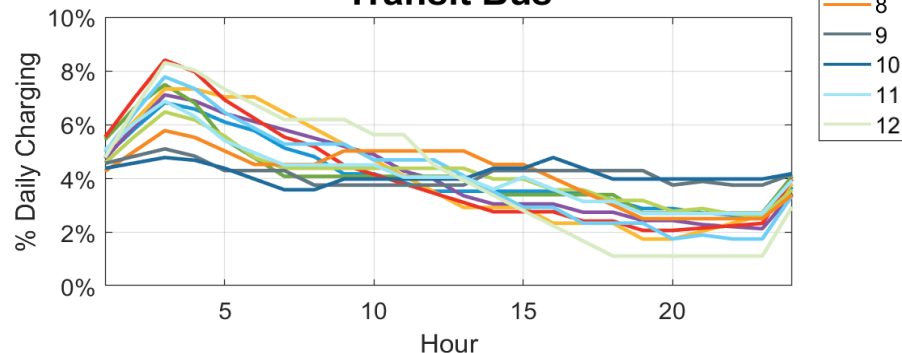
## Medium-Duty Delivery



## School Bus



## Transit Bus

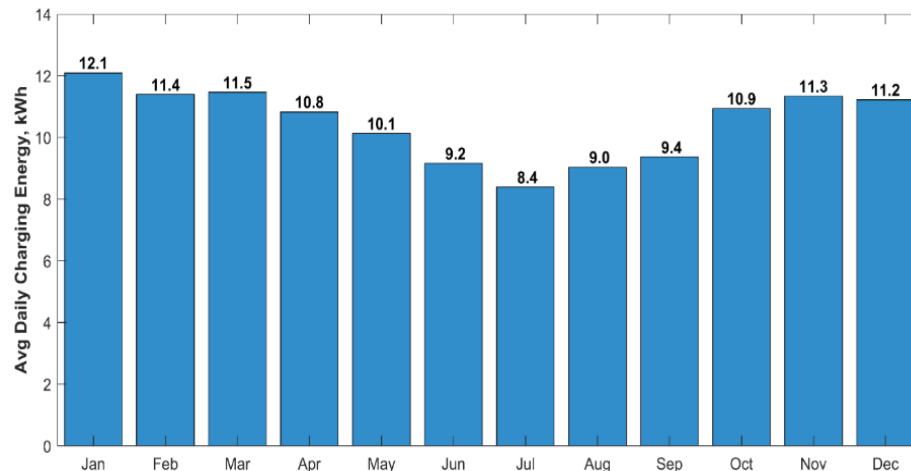


# ENERGY FORECAST

# Estimating Energy Impacts of EV Adoption

- Personal light-duty vehicles

- Monthly energy is based on results of the ChargePoint data analysis
- The adjacent bar chart illustrates monthly kWh/day per EV used to estimate monthly energy

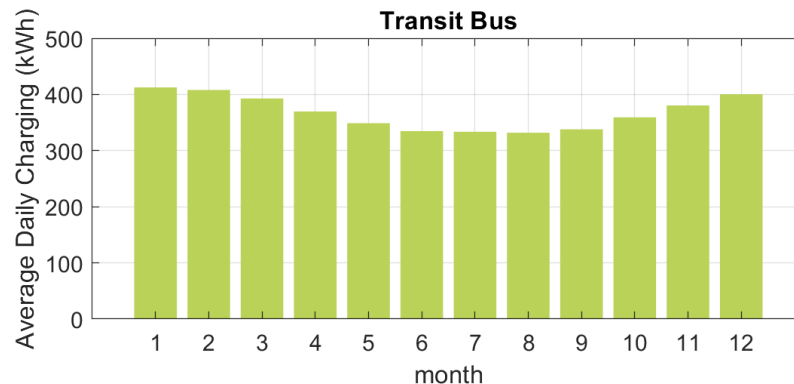
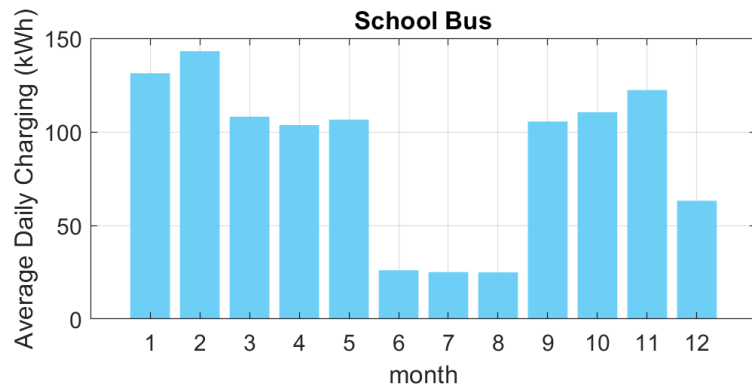
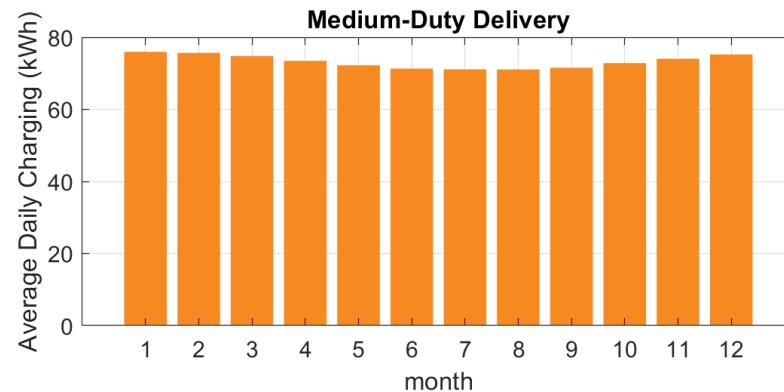
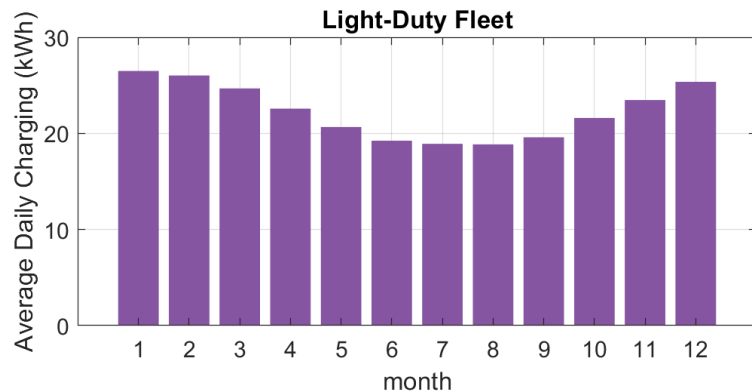


- Fleet vehicles

- Monthly energy is calculated for each class of fleet vehicles based on state weather and VMT
- Average monthly kWh/day for New England are shown on the following slide

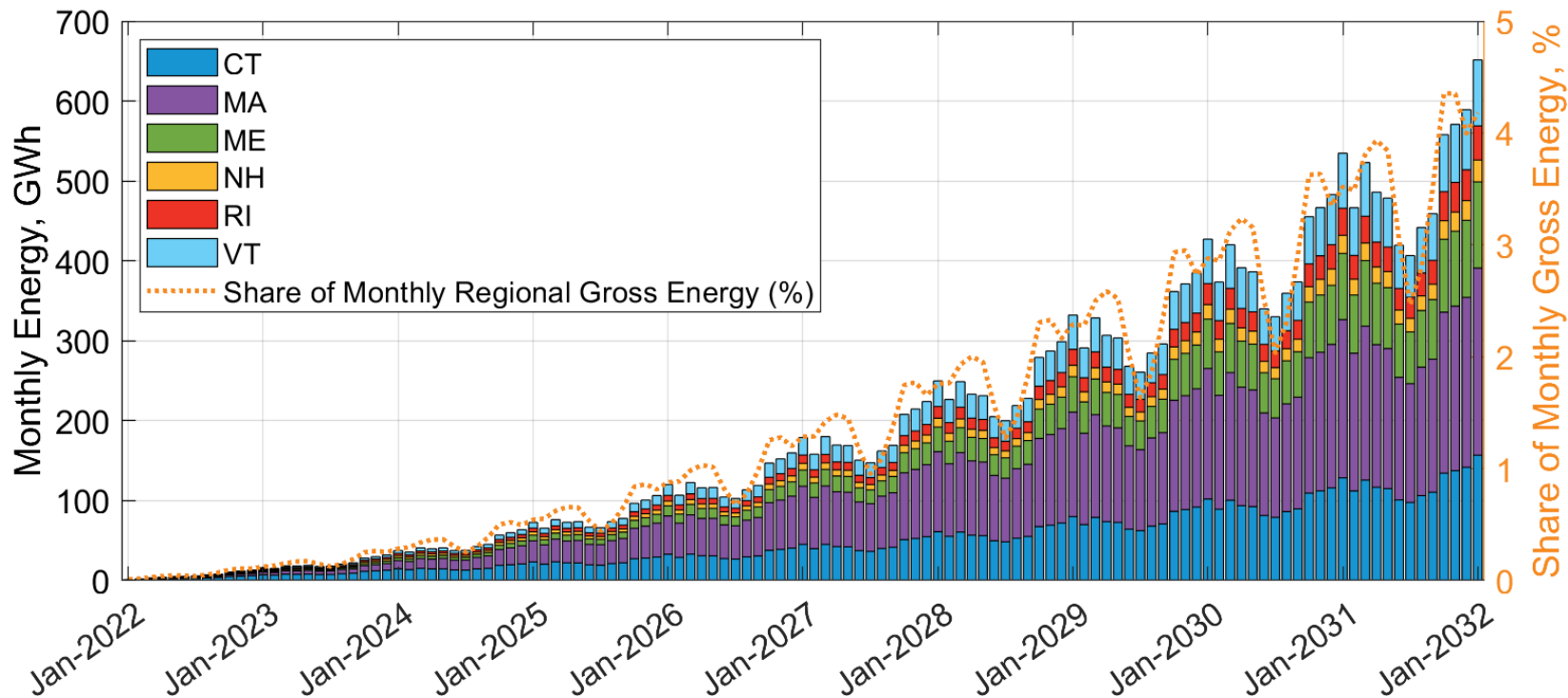
# Estimating Energy Impacts of EV Adoption

## *Fleet EV Average Daily Energy – New England*



# 2022 Transportation Electrification Forecast

## Monthly Energy

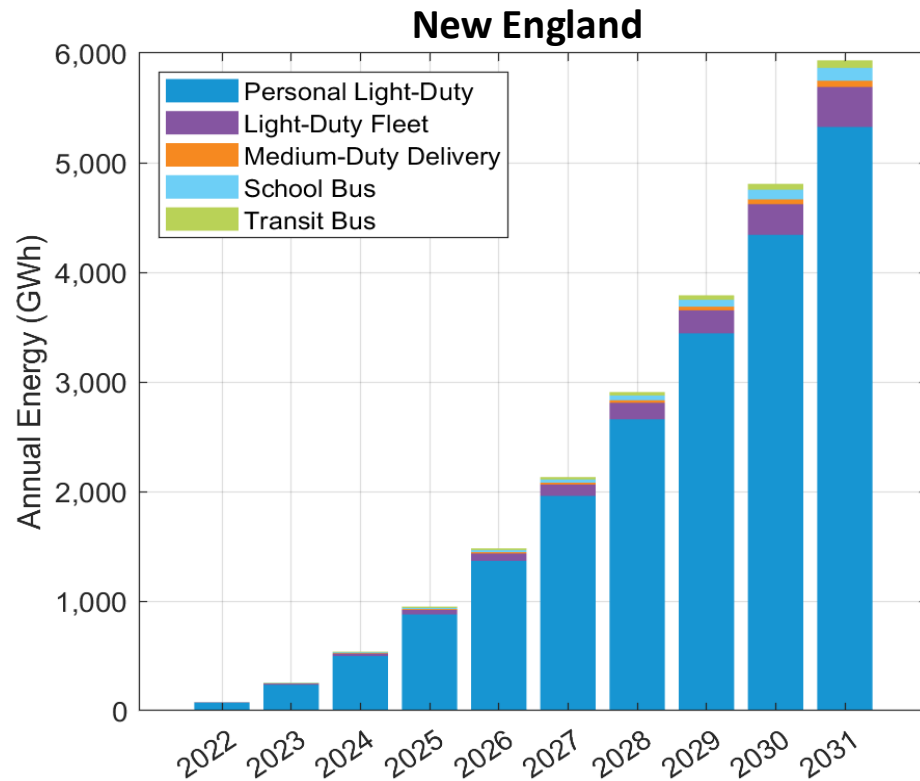




# 2022 Transportation Electrification Forecast

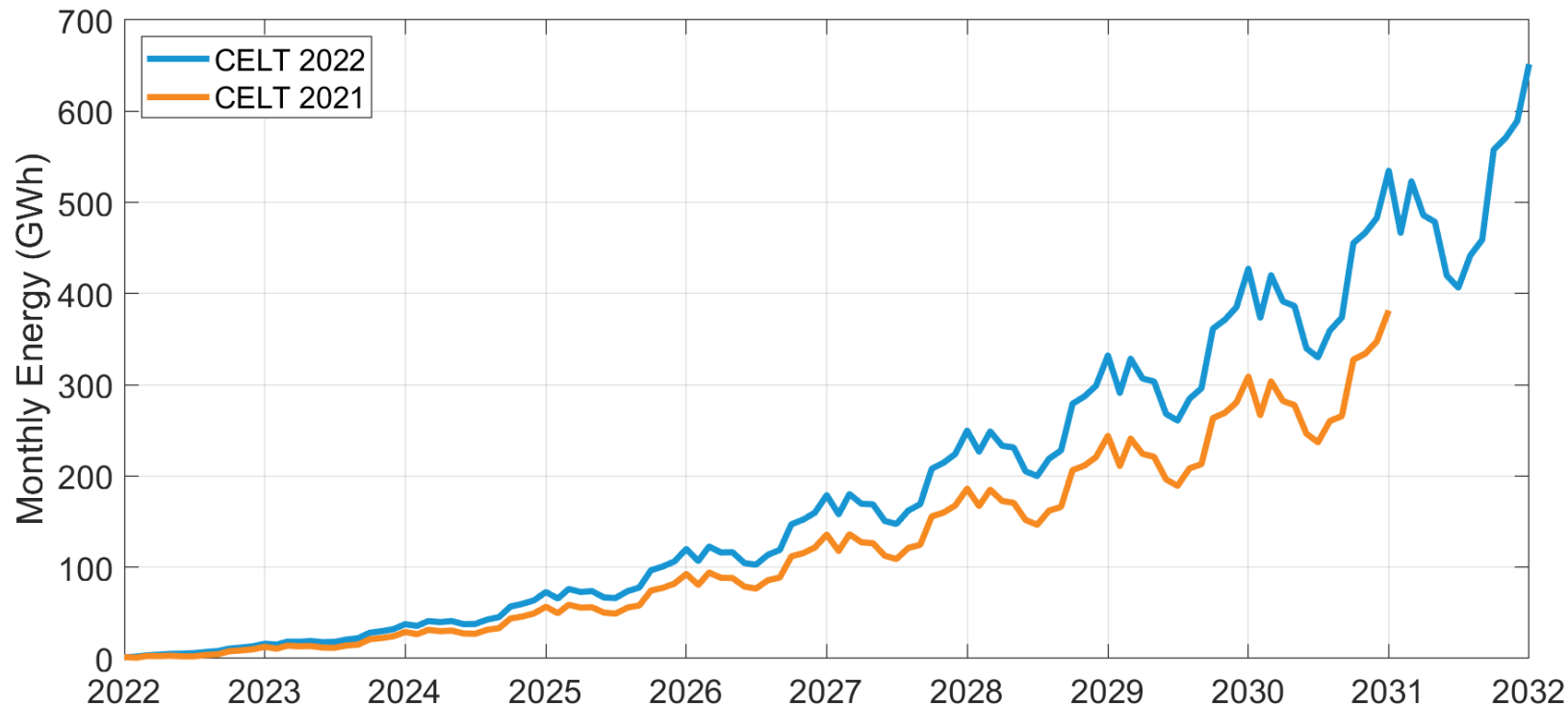
## *Annual Energy*

Annual Energy (GWh)							
Year	CT	MA	ME	NH	RI	VT	NE
2022	36	15	7	7	6	7	78
2023	108	62	24	20	18	24	256
2024	189	176	51	35	35	52	539
2025	279	365	96	51	57	101	950
2026	389	598	161	71	87	175	1,481
2027	530	861	251	96	125	269	2,132
2028	706	1,156	372	127	173	375	2,908
2029	909	1,471	525	162	231	493	3,790
2030	1,152	1,810	718	203	300	624	4,807
2031	1,428	2,166	949	249	383	761	5,934



# Transportation Electrification Energy Forecast

*Comparison Between CELT 2021 and CELT 2022 for New England*

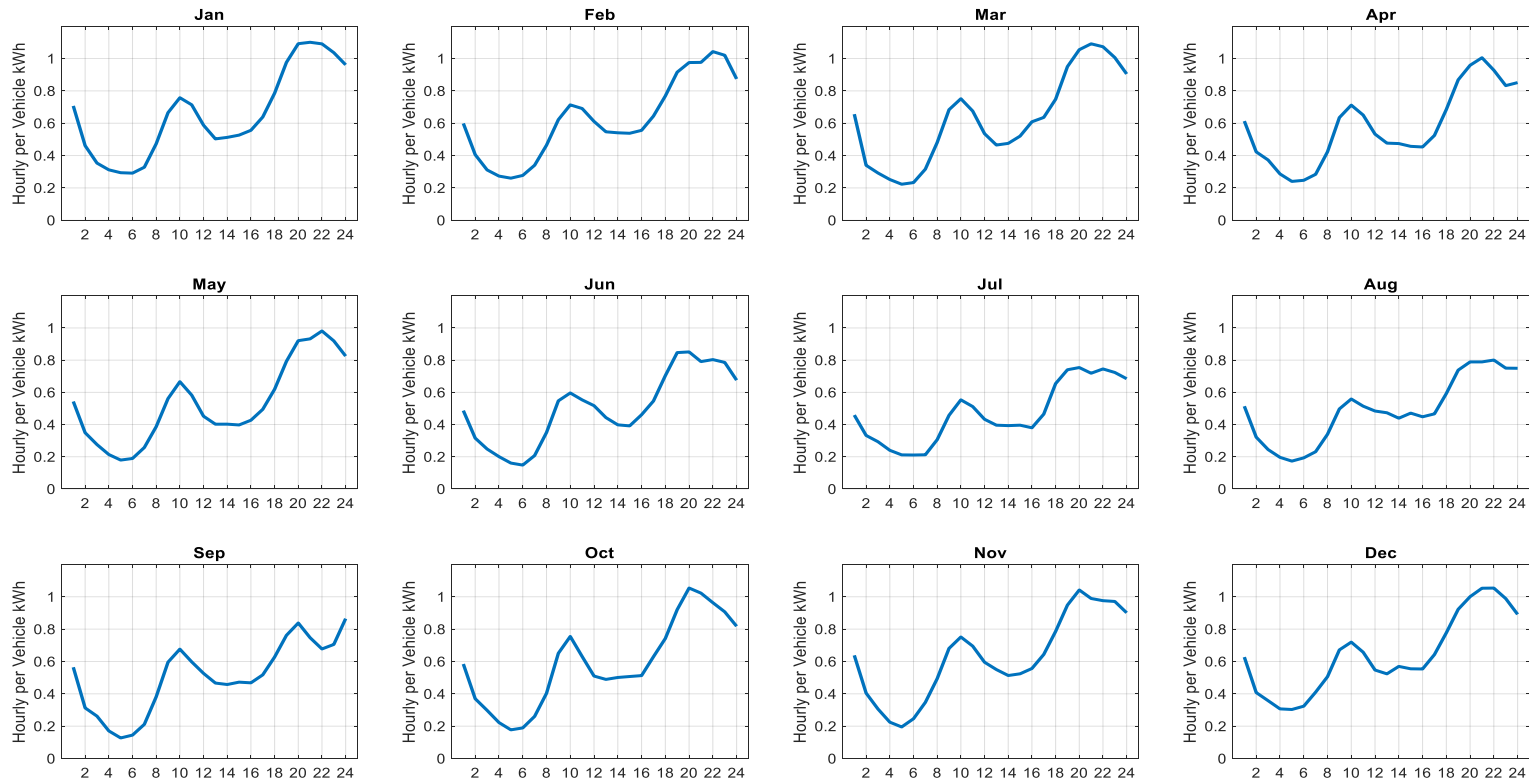


# DEMAND FORECAST

# Estimating Demand Impacts of EV Adoption

- For applications that include hourly analysis, EV demand will be modeled hourly
  - E.g., probabilistic ICR analysis
- Other forecast applications and reporting require a deterministic peak value (e.g., CELT report), and for which:
  - Winter peak demand:
    - Use the monthly average EV demand from HE 18-19
    - January-April, October-December
  - Summer demand impacts should reflect expectations of peak shifting due to increasing BTM PV penetrations (slides 30 and 31)
- Personal Light-Duty Vehicles
  - Hourly weekday EV demand profiles are used to estimate demand impacts
  - These values reflect the 75<sup>th</sup> percentile (“P75”) of the aggregated hourly EV data discussed as part of the [November 18, 2019 LFC](#) (slides 10-25)
    - P75 values serve to capture more extreme values than averages (e.g., due to weather effects), but are not the most extreme data points, which could be more of an artifact of a relatively small EV sample size
- Fleet Vehicles
  - Hourly weekday allocation of daily energy is used to estimate demand impacts
  - Daily energy is derived using VMT and temperature responsiveness of electric vehicle efficiency as outlined on slide 15

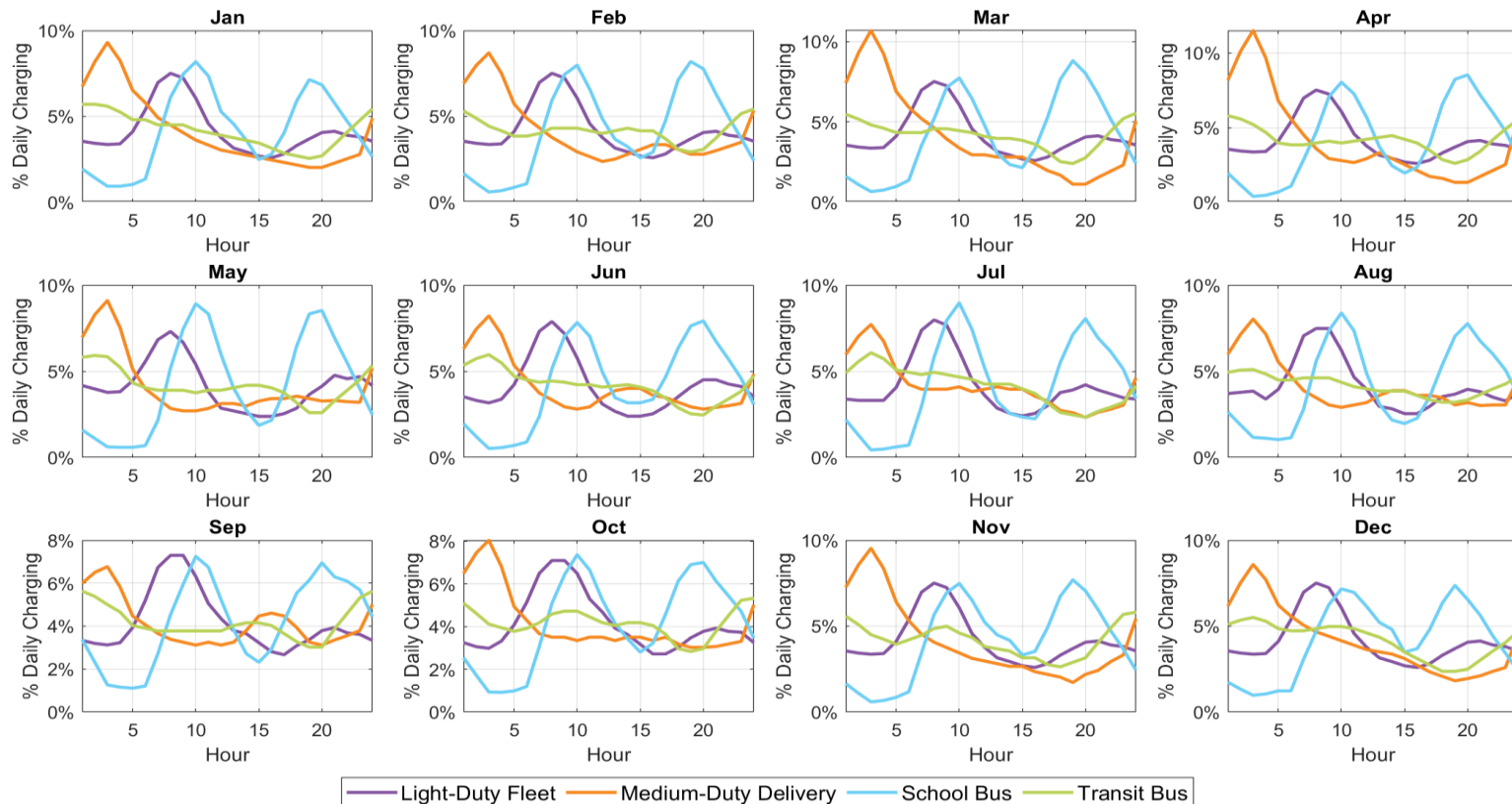
# Personal Light-Duty EV Hourly Demand



Data source: ChargePoint, Inc.

ISO-NE PUBLIC

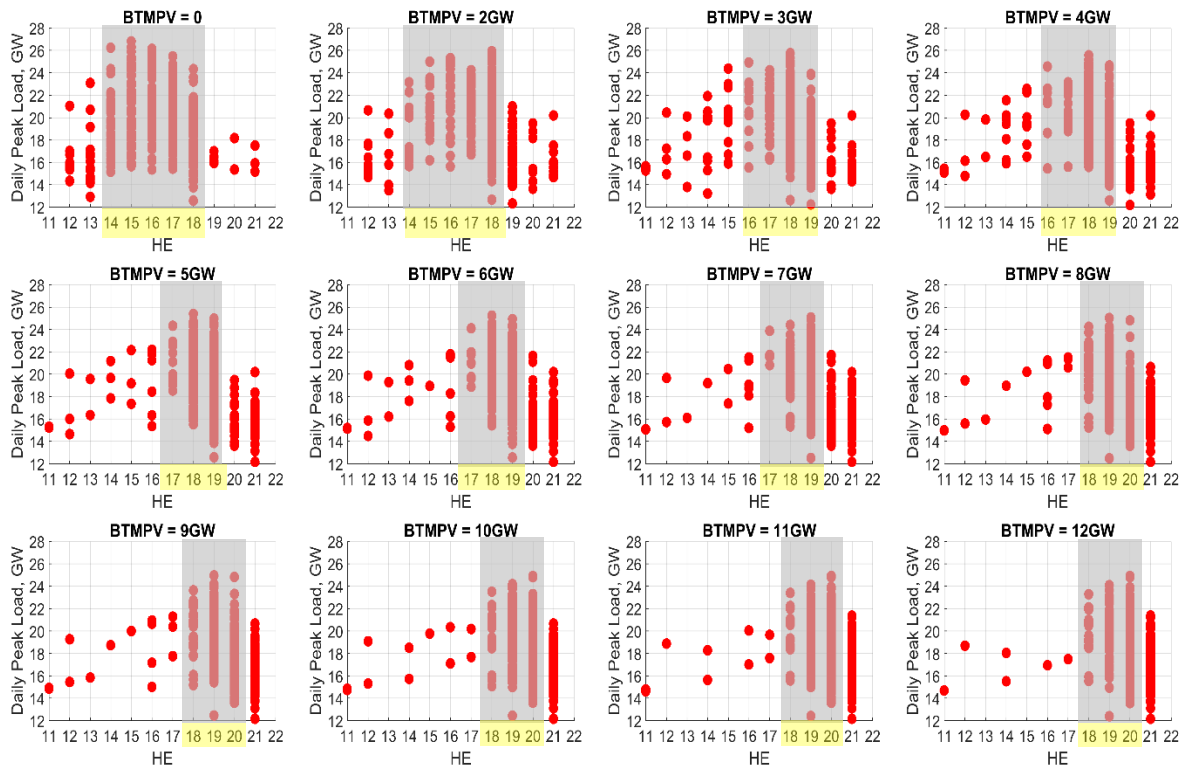
# Fleet EV Hourly Demand



— Light-Duty Fleet — Medium-Duty Delivery — School Bus — Transit Bus

# Summer Peak Net Load as BTM PV Increases

- Hourly net load and BTM PV data from the summers (July/August) of 2014-2019 were analyzed to simulate net loads with increasing penetrations of BTM PV
- Scatter plot shows the hour ending (HE) and magnitude (in GW) of net peak load as BTM PV increases
- Gray areas reflect estimated window of hours peak load may occur
  - Yellow areas highlight peak hours



# Interaction of EV Summer Demand and BTM PV

- For forecast applications and reporting that require a deterministic peak value, EV demand during the summer months is estimated as the average monthly EV demand during the summer peak hours tabulated to the right
  - May through September
  - Hours reflect effect of shifting peak demand due to BTM PV
- Used for forecasts of fleet vehicles and personal light-duty personal vehicles

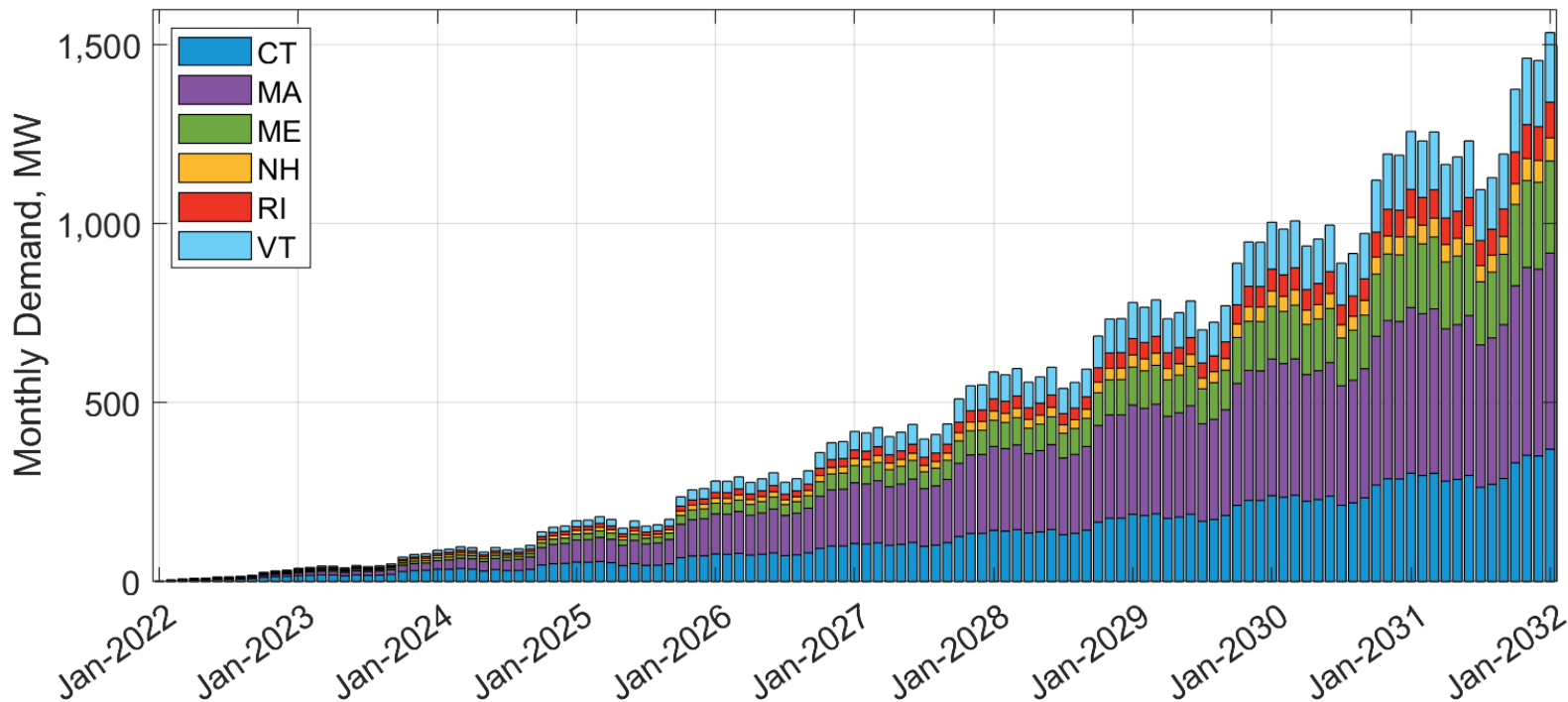
Year	PV Nameplate Bin (GW)*	Summer Peak Hours
2022	5	[17,18,19]
2023	6	[17,18,19]
2024	7	[17,18,19]
2025	7	[17,18,19]
2026	8	[18,19,20]
2027	8	[18,19,20]
2028	9	[18,19,20]
2029	9	[18,19,20]
2030	10	[18,19,20]
2031	10	[18,19,20]

*\*Based on 2021 PV forecast values*



# 2022 Transportation Electrification Forecast

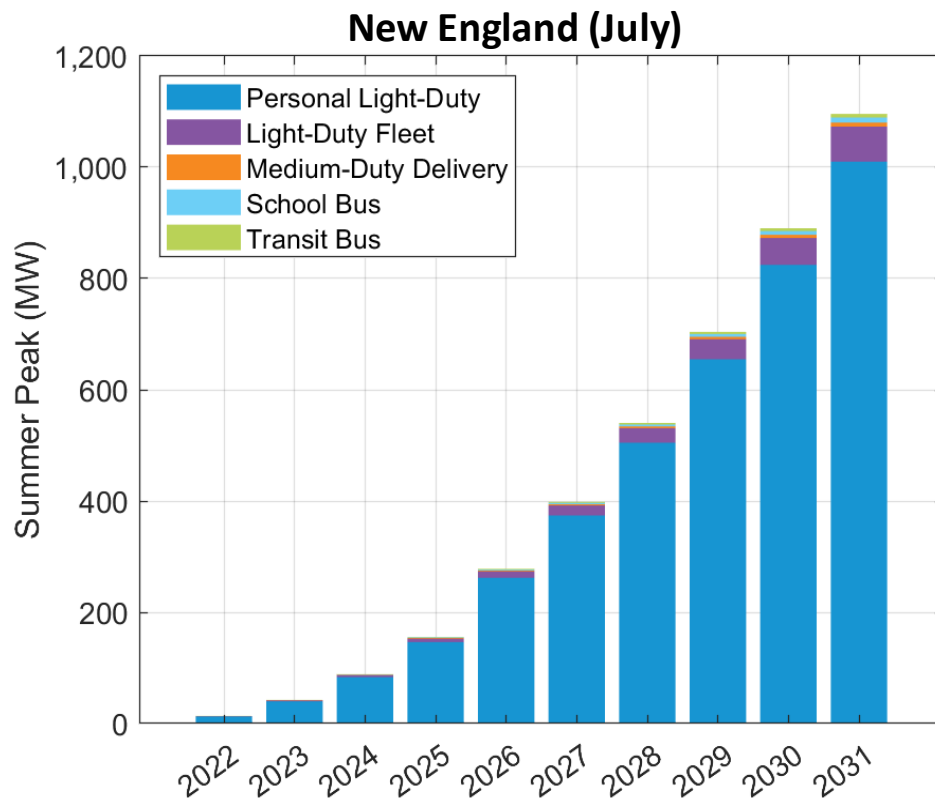
## *Monthly Demand by State*



# 2022 Transportation Electrification Forecast

## Summer Peak Demand

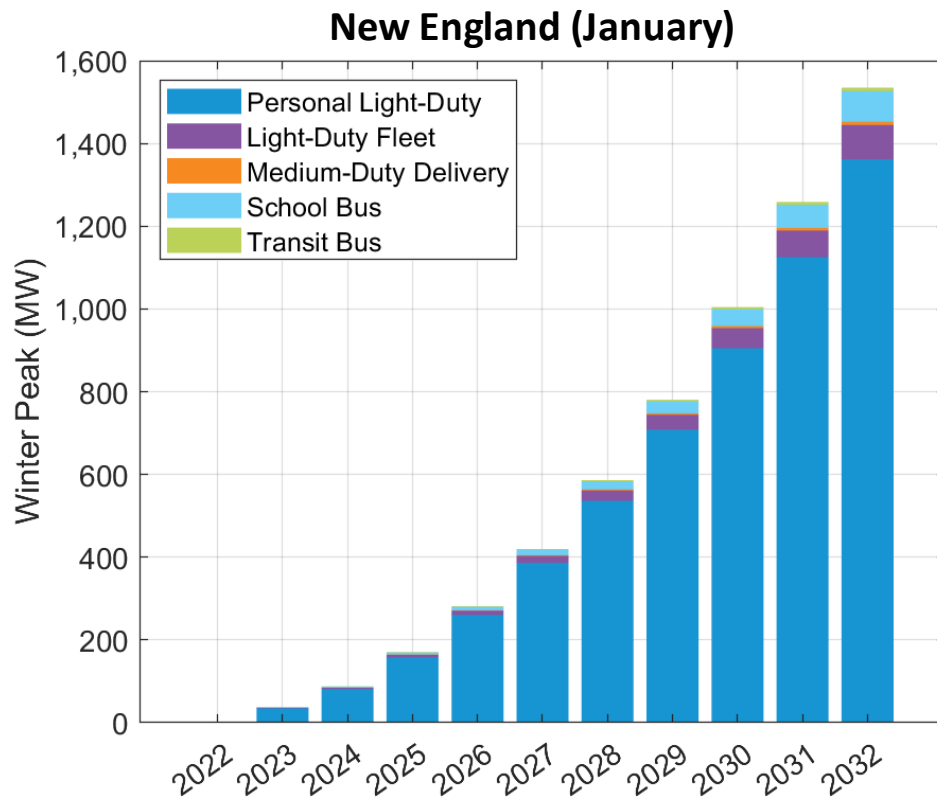
Summer Peak Demand (MW)							
Year	CT	MA	ME	NH	RI	VT	NE
2022	6	3	1	1	1	1	14
2023	18	10	4	3	3	4	43
2024	31	29	8	6	6	9	89
2025	46	60	16	8	9	17	156
2026	73	112	30	13	16	33	278
2027	99	161	47	18	23	51	399
2028	131	215	69	23	32	70	540
2029	169	273	98	30	42	93	704
2030	214	334	133	37	55	117	890
2031	264	398	176	45	70	142	1,096



# 2022 Transportation Electrification Forecast

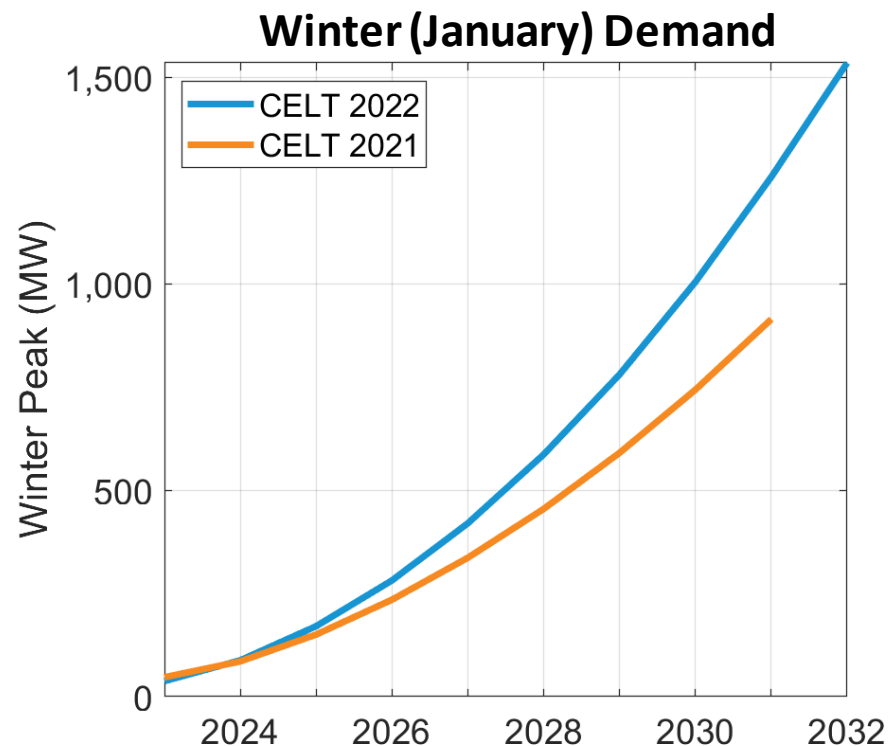
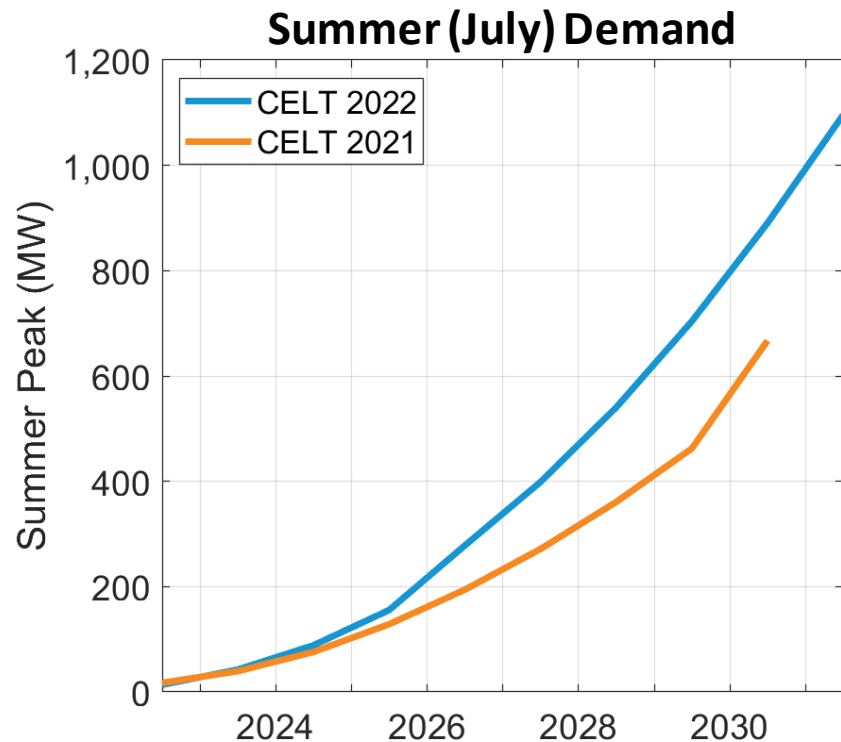
## Winter Peak Demand

Winter Peak (MW)							
Winter Of	CT	MA	ME	NH	RI	VT	NE
2022/23	17	8	3	3	3	3	38
2023/24	35	24	8	7	6	8	88
2024/25	55	62	17	10	10	17	171
2025/26	78	112	30	14	16	32	282
2026/27	107	170	48	19	24	52	420
2027/28	144	234	73	26	34	75	586
2028/29	188	305	106	34	46	101	780
2029/30	241	382	147	43	61	131	1,004
2030/32	303	463	198	53	79	162	1,258
2031/32	370	548	258	64	100	195	1,535



# Transportation Electrification Demand Forecast

*New England Comparison Between CELT 2021 and CELT 2022*



# Next Steps

- Finalized transportation electrification forecast will be included in the 2022 CELT gross and net load forecasts



# Questions

