Draft 2023 Transportation Electrification Forecast

Load Forecast Committee

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Introduction

- The ISO's transportation electrification forecast seeks to forecast the energy and demand impacts associated with the uptake of electric vehicles (EVs) within selected categories of vehicles:
  - Light-duty personal vehicles
  - Light-duty fleet vehicles
  - Medium-duty delivery vehicles
  - School buses
  - Transit buses

Methodology Updates for CELT 2023

- Developed a more consistent approach to generate state-level EV adoption forecasts
  - This effort includes canvasing of all federal, state, and local goals regarding EV adoption
  - Details on state-level adoption forecasting were discussed in the December 9, 2022 transportation electrification adoption forecast presentation
- Enhanced weather sensitivity of the energy and demand impacts of the personal light-duty vehicle portion of the forecast
  - Aligns methodology across all vehicle types
  - Moves from static monthly profiles to dynamic modeling of daily energy consumption based on weather
  - For more information see slides 4-9 of the November 7, 2022 update on the transportation electrification forecast

EV ADOPTION FORECAST

EV Adoption Forecast Overview

- For the CELT 2023 forecast, ISO has developed a more consistent approach for generating state-level EV adoption forecasts
- ISO has developed two adoption scenarios that reflect different assumptions about the pace and extent of transportation electrification within each state
  - **<u>"Full Electrification" adoption scenario</u>**
    - Intended to represent an upper bound on the pace and extent of EV adoption
    - Reflects comprehensive EV adoption estimates reflective of state emissions goals and associated EV adoption targets will be developed
    - Assumes state ZEV (Zero Emissions Vehicle) goals are met entirely by electric vehicles
    - Assumes all vehicles in each vehicle class are electrified by 2050
    - ***This scenario is informational only (not directly used in the forecast)***
  - **<u>"Draft CELT 2023" adoption scenario</u>**
    - Intended to reflect the likely pace and level of EV adoption over the next 10 years given the current understanding of individual state goals, policies, and programs
    - Reflects uncertainty in the timing of goal achievement and extent to which electric vehicles will be utilized to accomplish goals
    - ***This scenario was used to generate the energy and demand impacts for the Draft CELT 2023 forecast***

Federal EV Adoption Considerations

- Inflation Reduction Act
  - Enacts a tiered incentive for the purchase of new personal light-duty EVs meeting increasingly strict vehicle assembly and material sourcing requirements through 2032
  - Includes incentives for the purchase of used EVs through 2032
  - Includes incentives for the purchase of commercial light, medium, and heavy-duty EVs though 2032
  - Impact on regional EV adoption remains uncertain
- Environmental Protection Agency's (EPA) Clean School Bus Program
  - Funding from the Bipartisan Infrastructure Law provides $5 billion over the next five years (FY 2022-2026) to replace existing school buses with zero-emission and low-emission models
  - A number of New England cities have already been awarded funding during the 2022 selection process and have made clear their intent to apply for future funding
- 2021 White House announcement regarding 2030 goal for light-duty vehicle sales which was applied to the adoption of both personal and fleet light-duty vehicles and aims for:

  "…electric vehicles to make up 50% of all vehicles sold in the United States by 2030."

State-Specific EV Adoption Considerations

- Multi-State Zero-Emission Vehicle MOUs
  - 2013 Multi-State Zero-Emission Vehicle MOU (MA, CT, RI, VT) - goal of 5 million light-duty ZEVs on road by 2025 across the 9 signatory states
  - 2020 Multi-State Medium- and Heavy-Duty Zero Emission Vehicle MOU (MA, CT, RI, VT, ME) - commitment to phase out fossil fuel-burning medium- to heavy-duty truck and bus sales by one hundred percent by 2050, with a target for 30 percent of new truck and bus sales to be zero-emission by 2030 in all 15 signatory states

- Various individual state and local considerations including
  - State transportation electrification "Road Maps"
  - Local (usually individual cities) announcements/goals/programs for transitioning public transit and school bus fleets to ZEV
  - State transportation electrification "Action Plans"

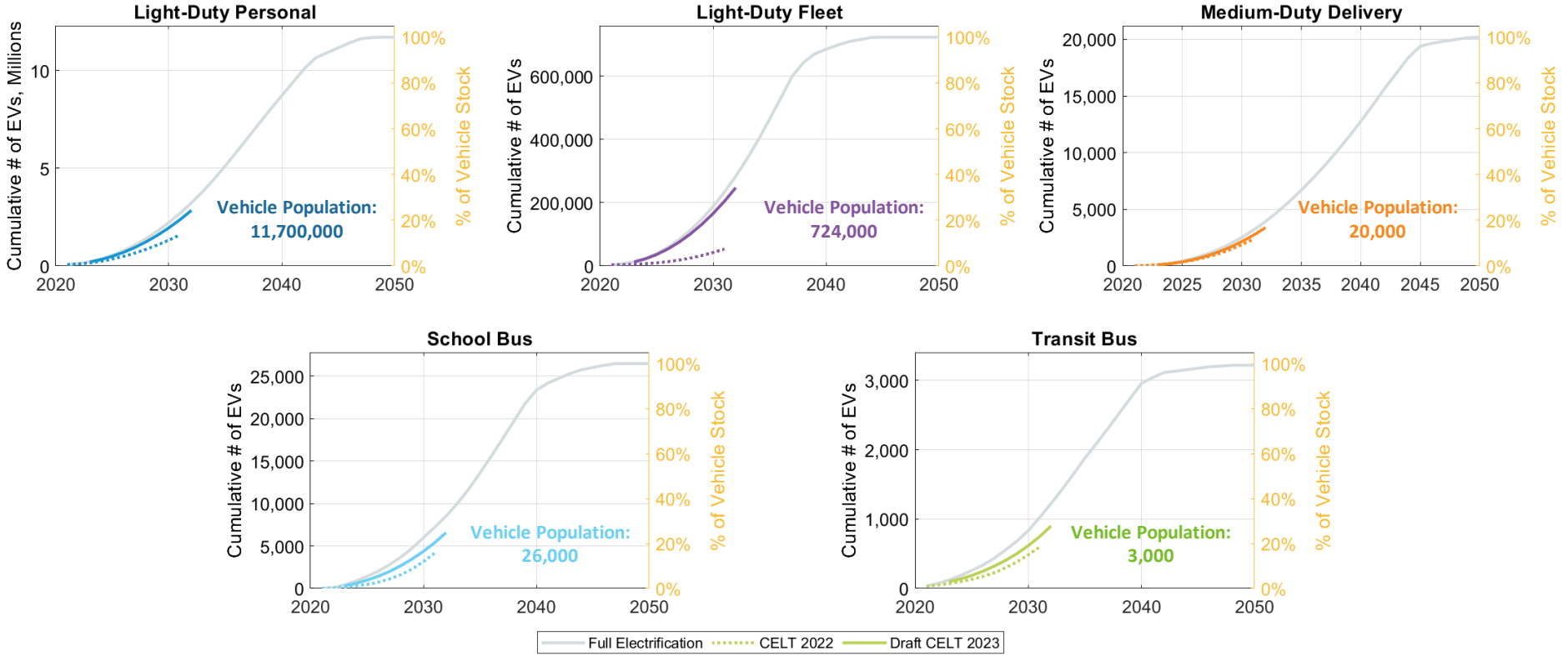
- Existing or anticipated adoption of California rules for ZEVs (MA and VT)
  - Advanced Clean Cars II (ACCII) requires by 2035 that 100% of light-duty vehicles sold will be ZEVs
  - Advanced Clean Trucks (ACT) requires by 2035 that:
    - 55% of Class 2b – 3 truck sales are zero emissions.
    - 75% of Class 4 – 8 straight truck sales are zero emissions.
    - 40% of truck tractor sales are zero-emissions

- State feedback
  - The ISO has shared all assumptions and references, along with preliminary adoption figures with each of the six New England states. Guidance was provided on:
    - Reasonableness of the "Full Electrification" scenario
    - Considerations for developing the "Draft CELT 2023" scenario

- The December 9, 2022 adoption forecast presentation lists considered drivers state by state
  - An updates version of state-level considerations will be included in the final 2023 transportation electrification forecast

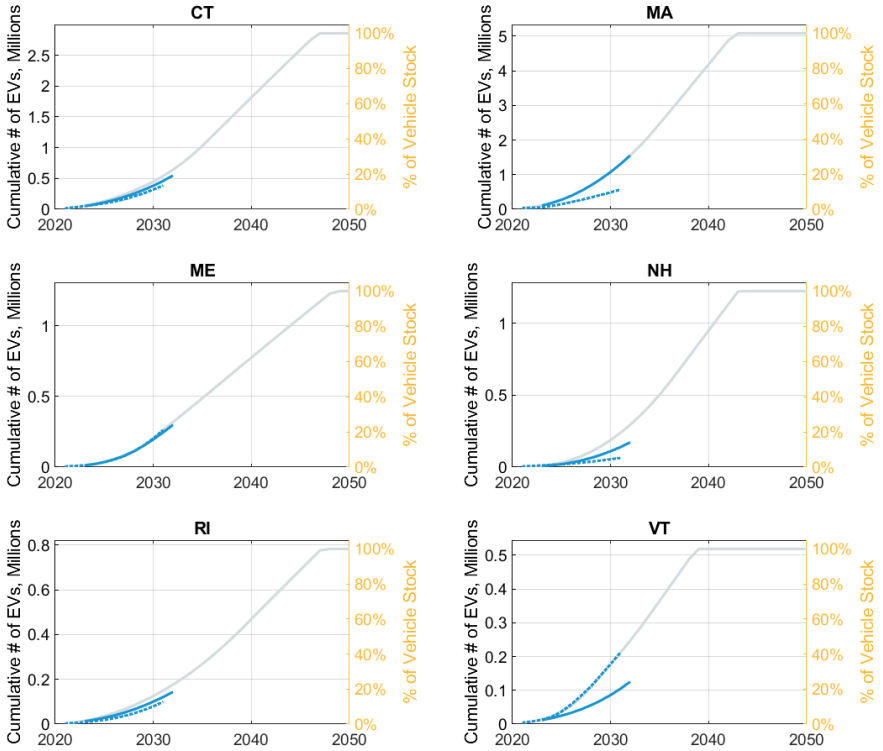
Draft 2023 EV Adoption Forecast

Cumulative EV Stock for New England



Personal Light-Duty EV Adoption

Cumulative EV Stock

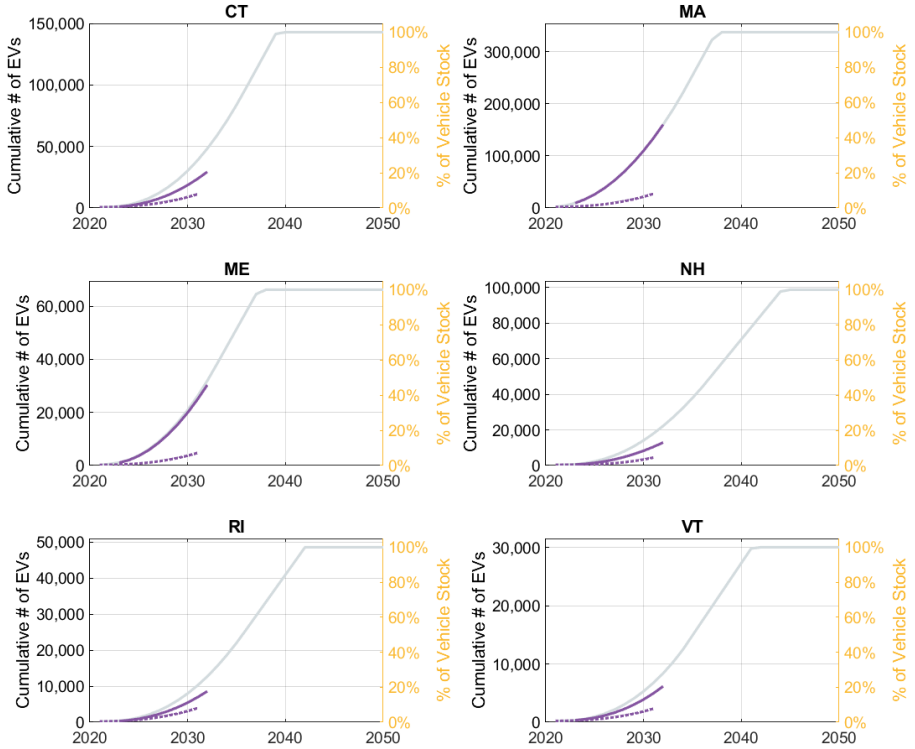


Annual Incremental Increase in EV Stock

Year	CT	MA	ME	NH	RI	VT	NE
2023	20,844	48,107	4,634	2,251	5,461	4,604	85,901
2024	27,146	72,081	9,218	4,801	7,165	5,748	126,159
2025	33,759	93,651	13,758	8,006	8,773	7,095	165,043
2026	40,468	116,072	19,036	11,115	10,414	8,601	205,706
2027	47,110	138,446	25,066	14,385	12,403	10,267	247,676
2028	53,768	160,595	32,035	17,830	14,418	12,097	290,742
2029	61,258	182,196	39,262	21,371	16,470	14,082	334,639
2030	68,898	203,904	45,314	24,946	18,577	16,089	377,727
2031	77,764	227,216	49,894	28,655	20,756	18,366	422,651
2032	87,919	251,736	52,854	32,593	22,643	20,935	468,679
10-year total (2023-2032)	518,934	1,494,004	291,071	165,953	137,080	117,884	2,724,923
Previous 10- year total (2022-2031)	369,920	530,755	258,273	58,524	96,652	207,673	1,521,796
Change	**+149,014**	**+963,249**	**+32,798**	**+107,429**	**+40,428**	**-89,789**	**+1,203,127**

Fleet Light-Duty EV Adoption

Cumulative EV Stock

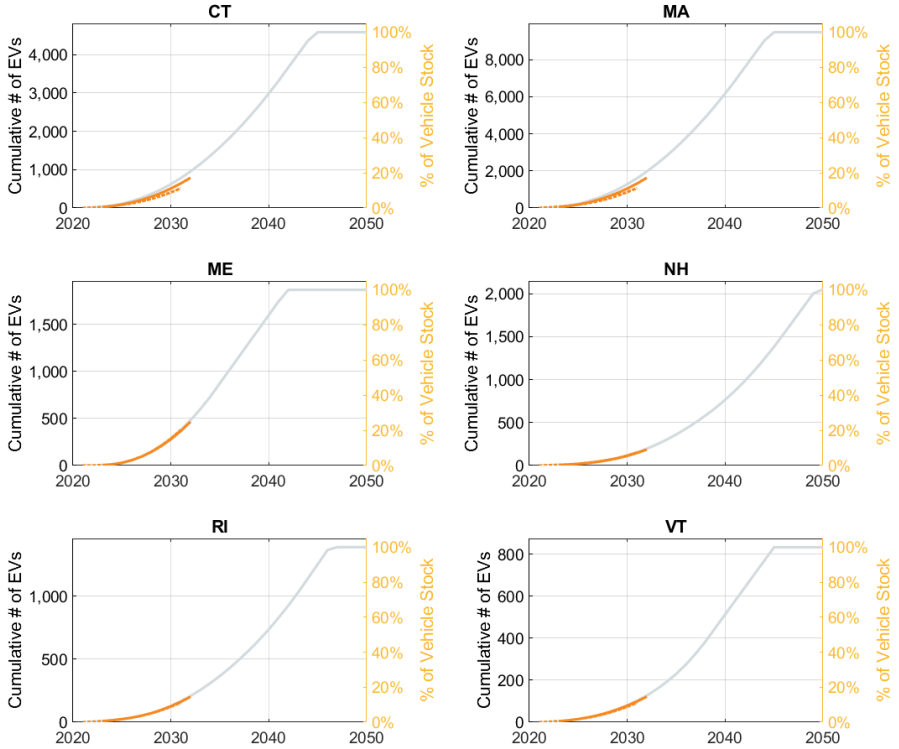


Annual Incremental Increase in EV Stock

Year	CT	MA	ME	NH	RI	VT	NE
2023	348	4,784	494	153	101	95	5,975
2024	782	7,175	1,002	345	228	166	9,698
2025	1,338	9,567	1,577	590	390	265	13,728
2026	1,877	11,959	2,130	828	547	369	17,710
2027	2,450	14,351	2,693	1,081	714	487	21,777
2028	3,059	16,743	3,257	1,349	891	620	25,919
2029	3,702	19,135	3,821	1,625	1,079	757	30,117
2030	4,362	21,526	4,385	1,900	1,271	899	34,344
2031	5,040	23,918	4,948	2,181	1,469	1,050	38,607
2032	5,735	26,310	5,437	2,473	1,671	1,211	42,838
10-year total (2023-2032)	28,693	155,468	29,744	12,525	8,361	5,919	240,713
Previous 10- year total (2022-2031)	10,588	25,222	4,525	4,060	3,705	2,106	50,206
Change	**+18,105**	**+130,246**	**+25,219**	**+8,465**	**+4,656**	**+3,813**	**+190,507**

Medium-Duty Delivery EV Adoption

Cumulative EV Stock

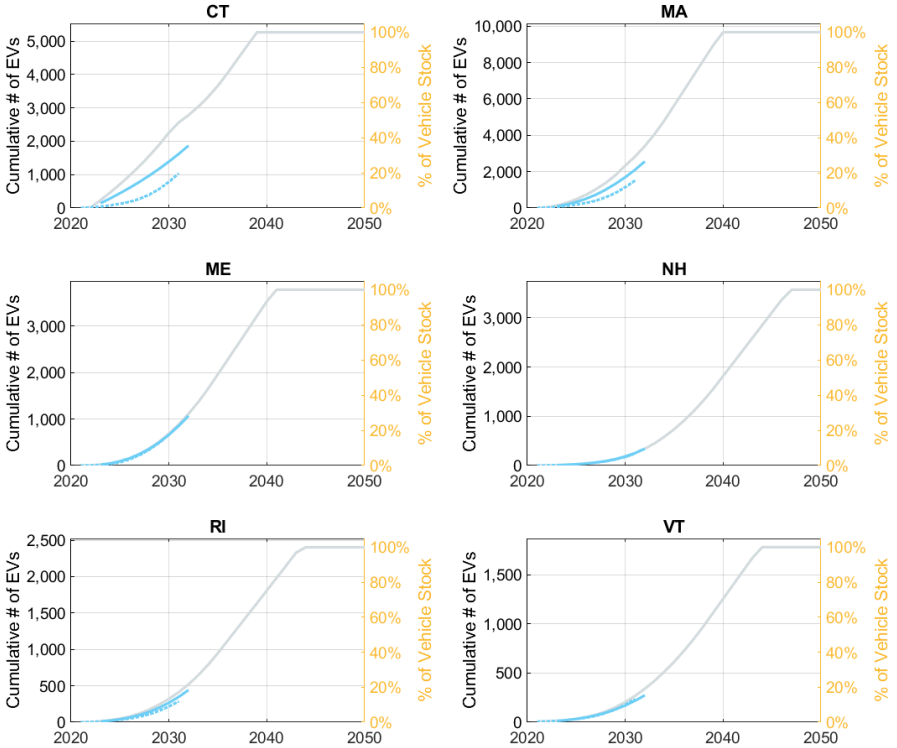


Annual Incremental Increase in EV Stock

Year	CT	MA	ME	NH	RI	VT	NE
2023	13	27	4	3	5	3	55
2024	26	52	7	5	7	4	101
2025	40	83	18	8	9	6	164
2026	54	112	27	10	12	8	223
2027	68	141	38	14	16	10	287
2028	83	171	50	18	20	13	354
2029	99	204	61	23	25	15	426
2030	115	238	74	28	30	18	502
2031	132	272	86	34	35	20	579
2032	148	311	99	41	40	23	661
10-year total (2023-2032)	778	1,611	464	184	199	120	3,352
Previous 10- year total (2022-2031)	514	1,064	378	152	155	93	2,356
Change	**+264**	**+547**	**+86**	**+32**	**+44**	**+27**	**+996**

School Bus EV Adoption

Cumulative EV Stock

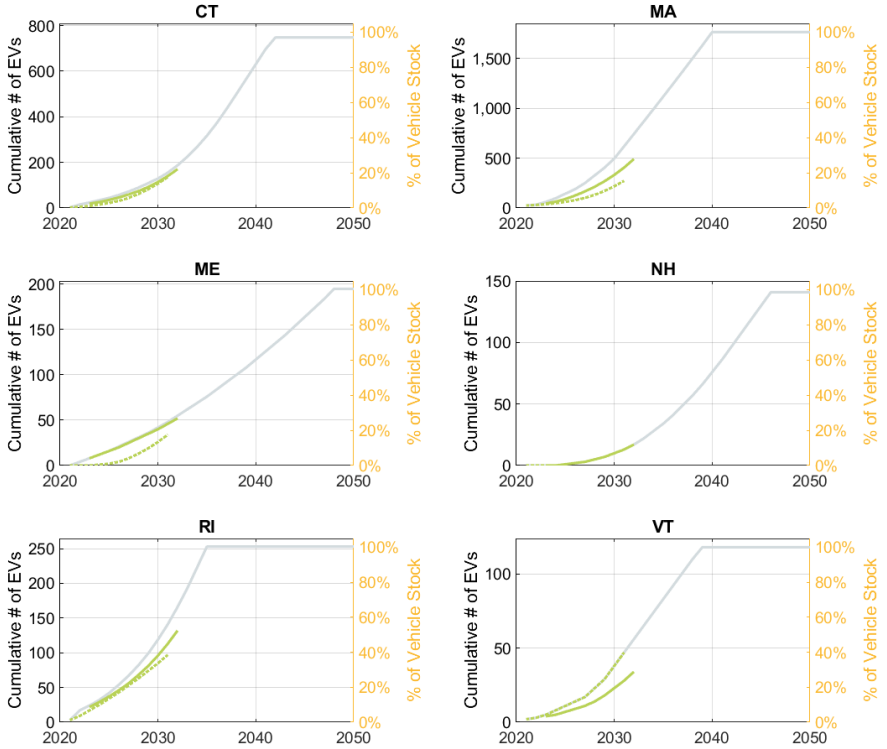


Annual Incremental Increase in EV Stock

Year	CT	MA	ME	NH	RI	VT	NE
2023	133	68	14	4	8	5	232
2024	144	103	27	7	11	8	300
2025	154	140	47	11	18	12	381
2026	165	179	66	15	25	16	467
2027	176	224	89	21	34	21	564
2028	188	277	112	29	44	27	678
2029	202	320	138	40	56	33	789
2030	217	362	164	53	68	40	904
2031	230	410	190	70	81	48	1029
2032	248	459	217	88	94	56	1161
10-year total (2023-2032)	1,857	2,542	1,064	338	439	266	6,505
Previous 10- year total (2022-2031)	1,032	1,502	857	244	286	228	4149
Change	**+825**	**+1,040**	**+207**	**+94**	**+153**	**+38**	**+2,356**

Transit Bus EV Adoption

Cumulative EV Stock



Annual Incremental Increase in EV Stock

Year	CT	MA	ME	NH	RI	VT	NE
2023	7	14	4	0	6	1	32
2024	7	19	4	0	7	1	38
2025	9	27	4	1	8	2	51
2026	11	35	4	1	9	2	62
2027	13	41	5	1	10	2	73
2028	15	47	5	2	12	3	83
2029	18	55	5	2	13	4	98
2030	22	64	5	3	15	5	114
2031	26	73	6	3	17	5	131
2032	30	86	6	4	19	6	151
10-year total (2023-2032)	158	461	48	17	116	31	833
Previous 10- year total (2022-2031)	134	247	34	13	94	45	567
Change	**+24**	**+214**	**+14**	**+4**	**+22**	**-14**	**+266**

METHODOLOGY

Methodology Overview

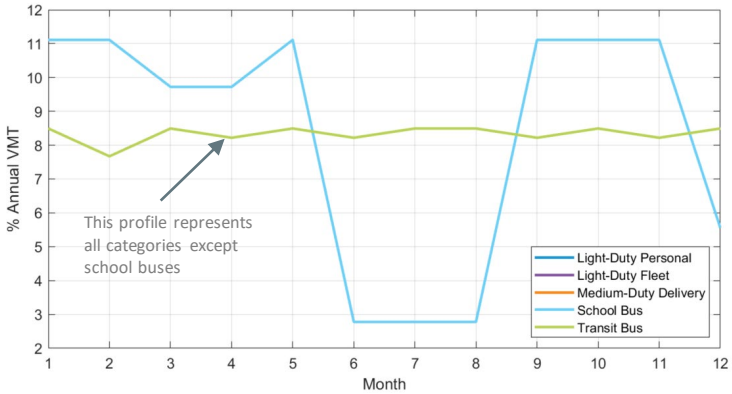
- Energy and demand impacts are based on analysis vehicle driving patterns and a samples of vehicle charging data
- Inputs developed specific to each vehicle category
  - Annual vehicle miles traveled (VMT)
  - Monthly allocation of VMT
    - Reflects seasonal driving patterns
    - Allocations for monthly 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 are developed for each vehicle category
  - 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
  - Scale to adoption forecast

Vehicle Miles Traveled (VMT)

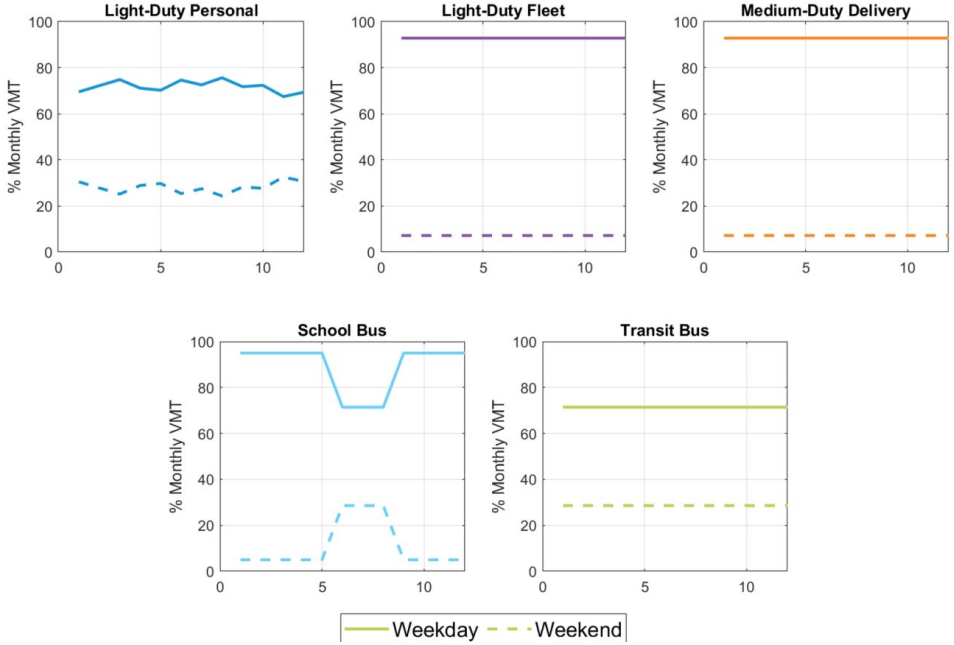
Annual VMT

Vehicle Category	Average Annual VMT
School bus	11,483
Transit bus	38,488
Medium-duty delivery	13,655
Light-duty fleet	21,258
Light-duty personal	11,505

Monthly VMT Allocation

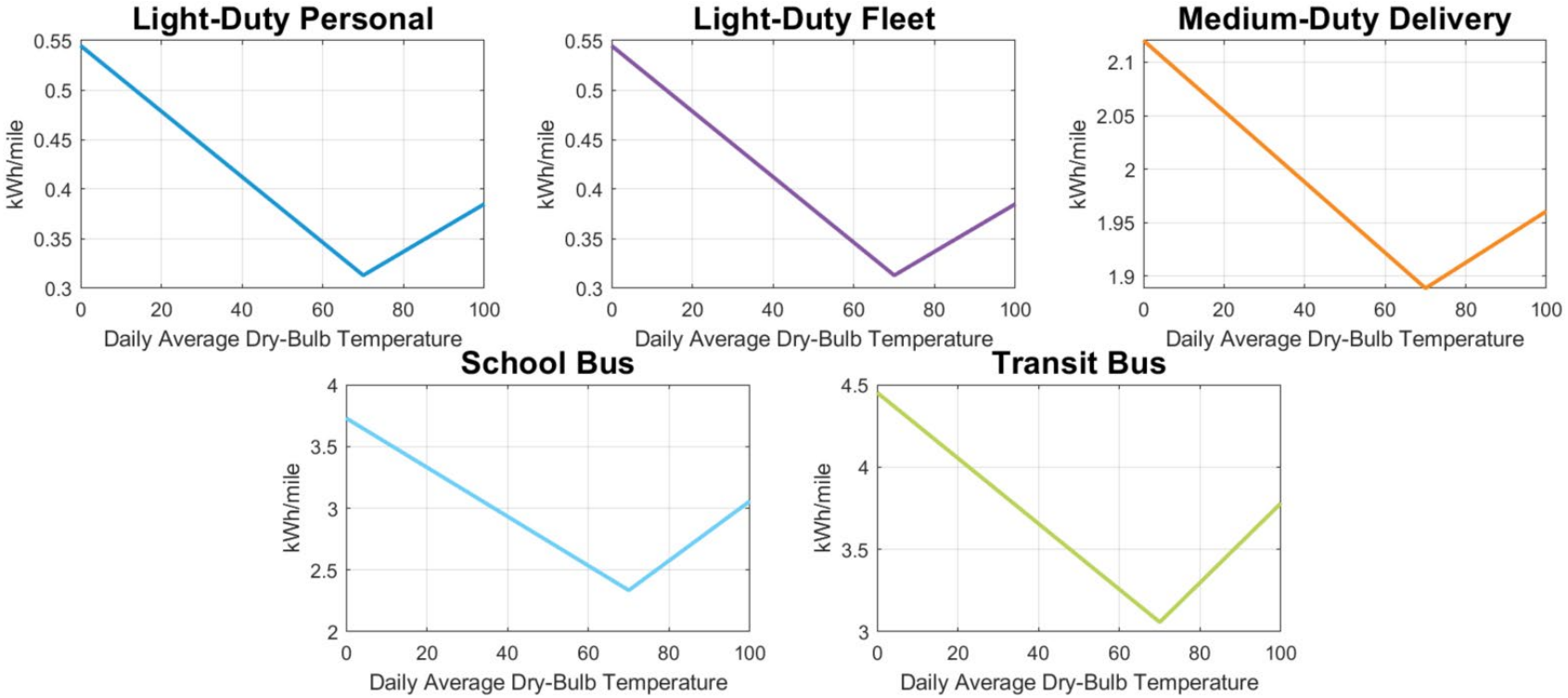


Day-type VMT Allocation



Electric Vehicle Efficiency

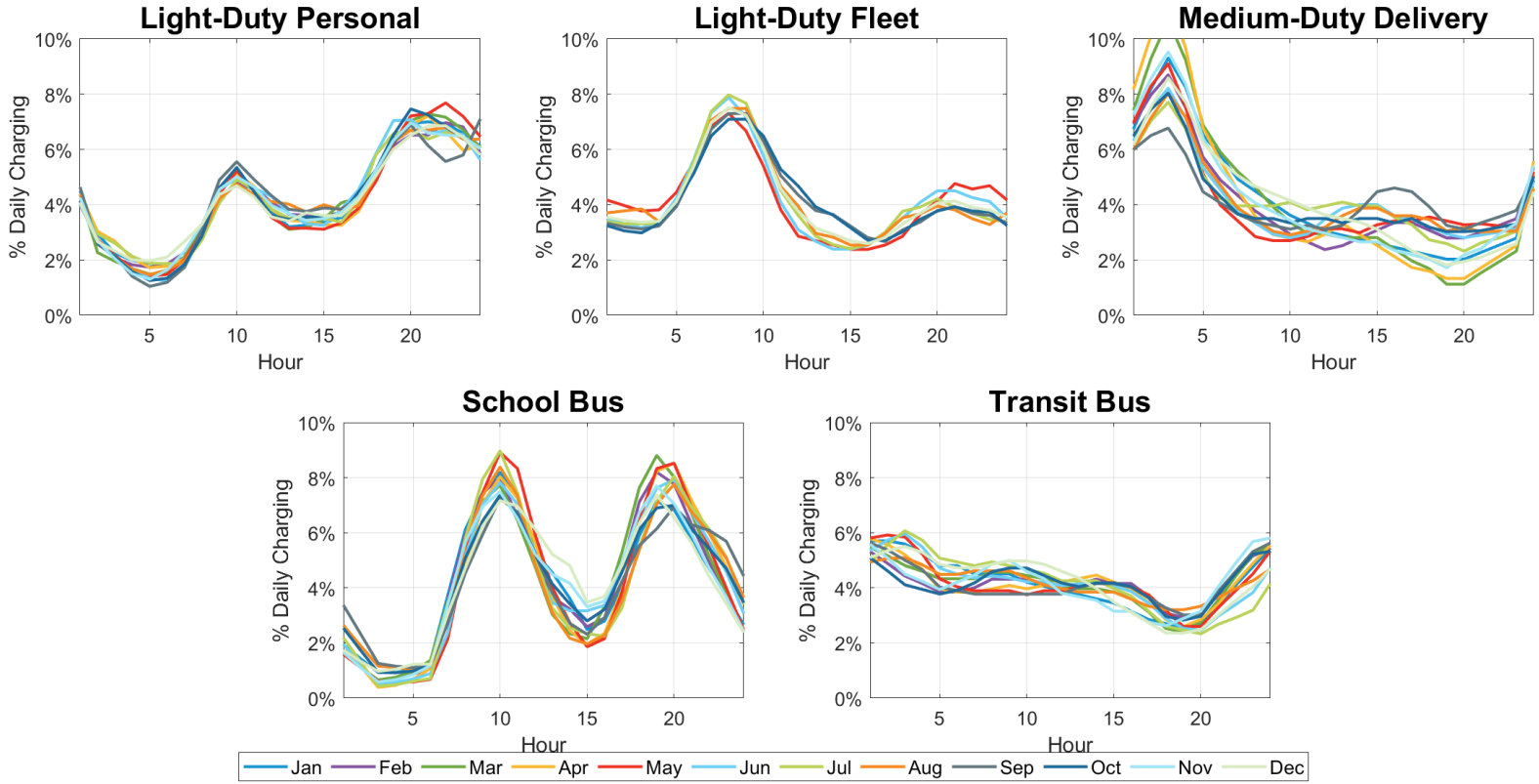
Energy Consumption as a Function of Daily Temperature



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

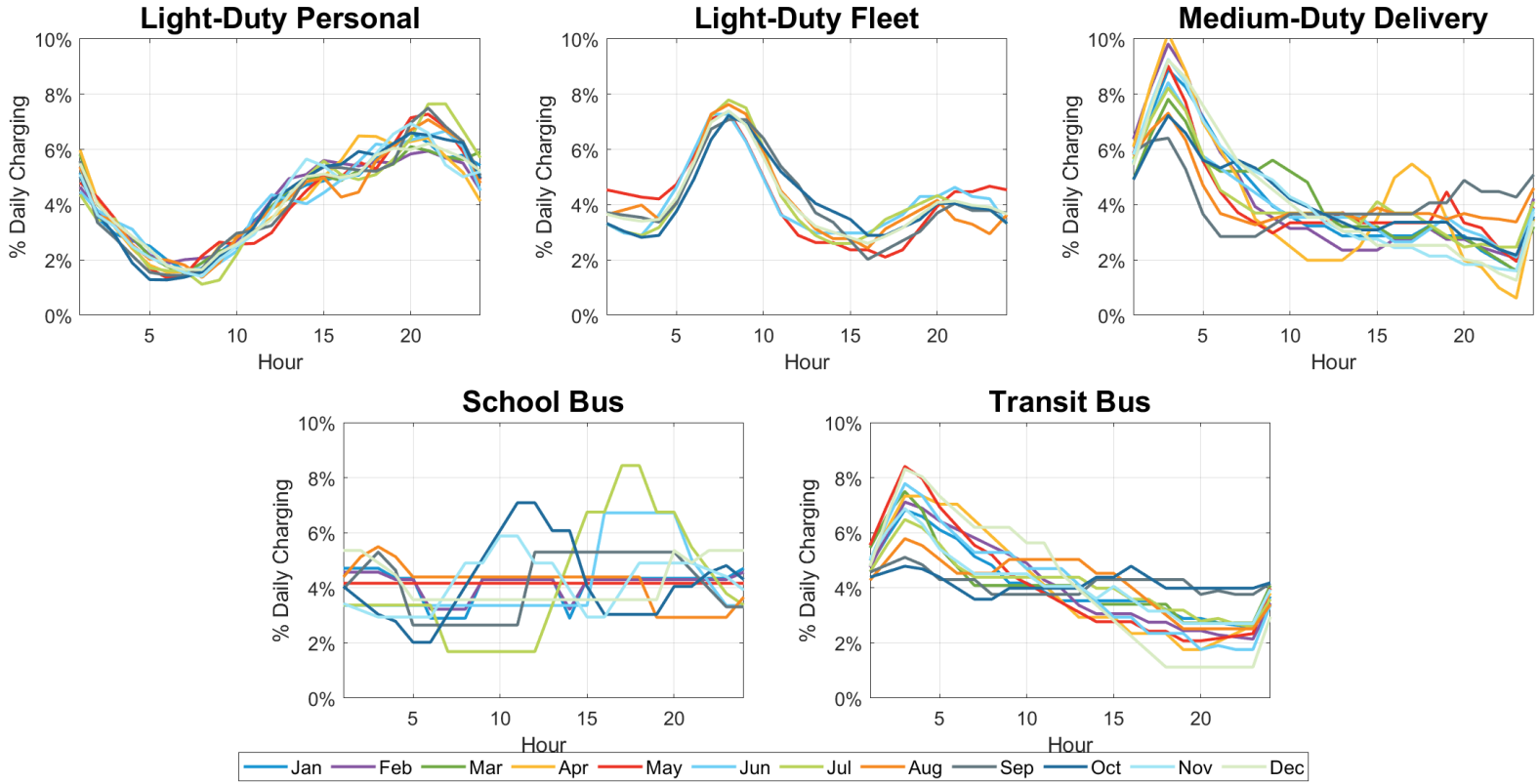
Allocation of Hourly Charging by Month

Non-Holidays & Weekdays



Allocation of Hourly Charging by Month

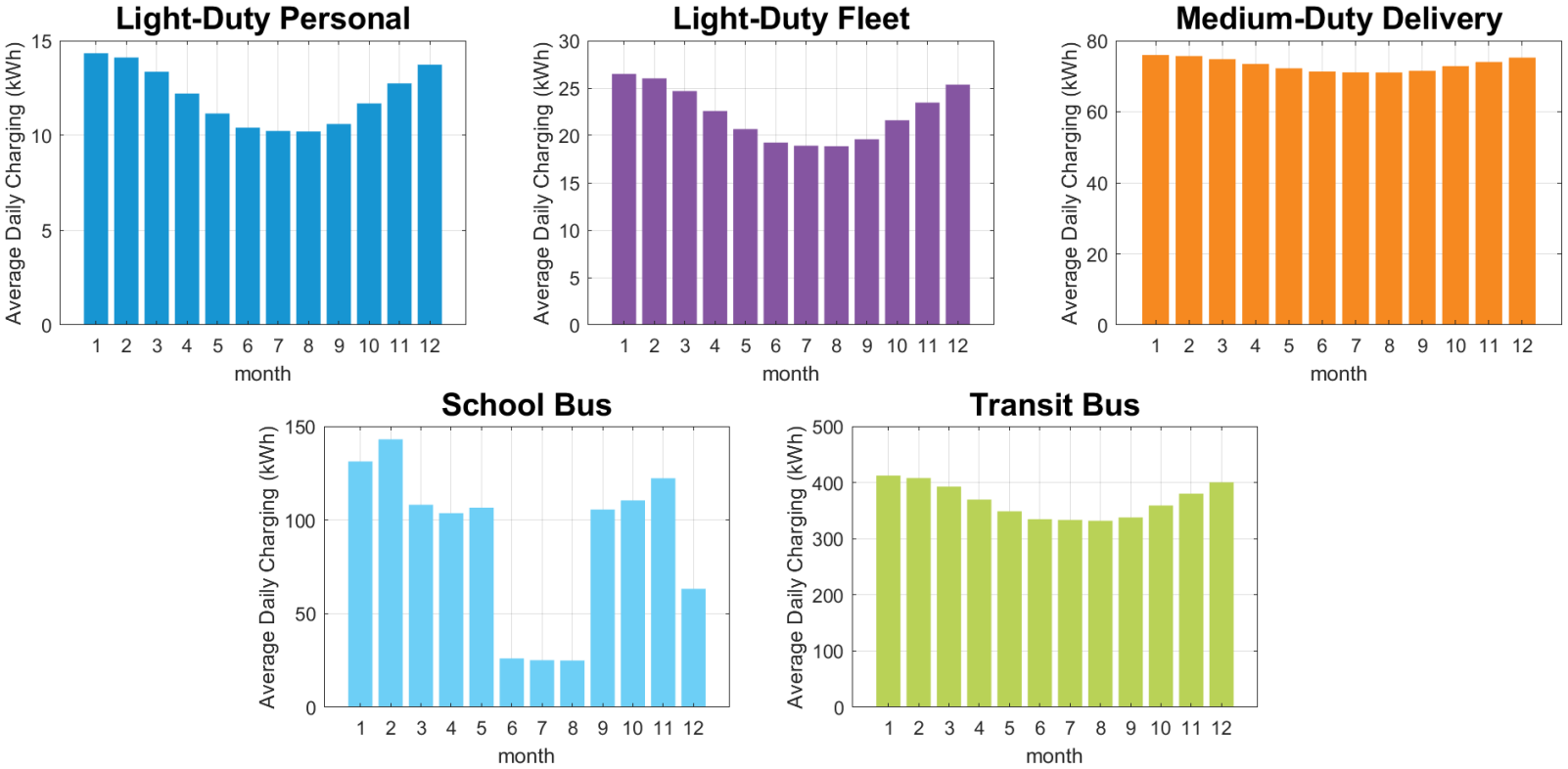
Holidays & Weekends



ENERGY FORECAST

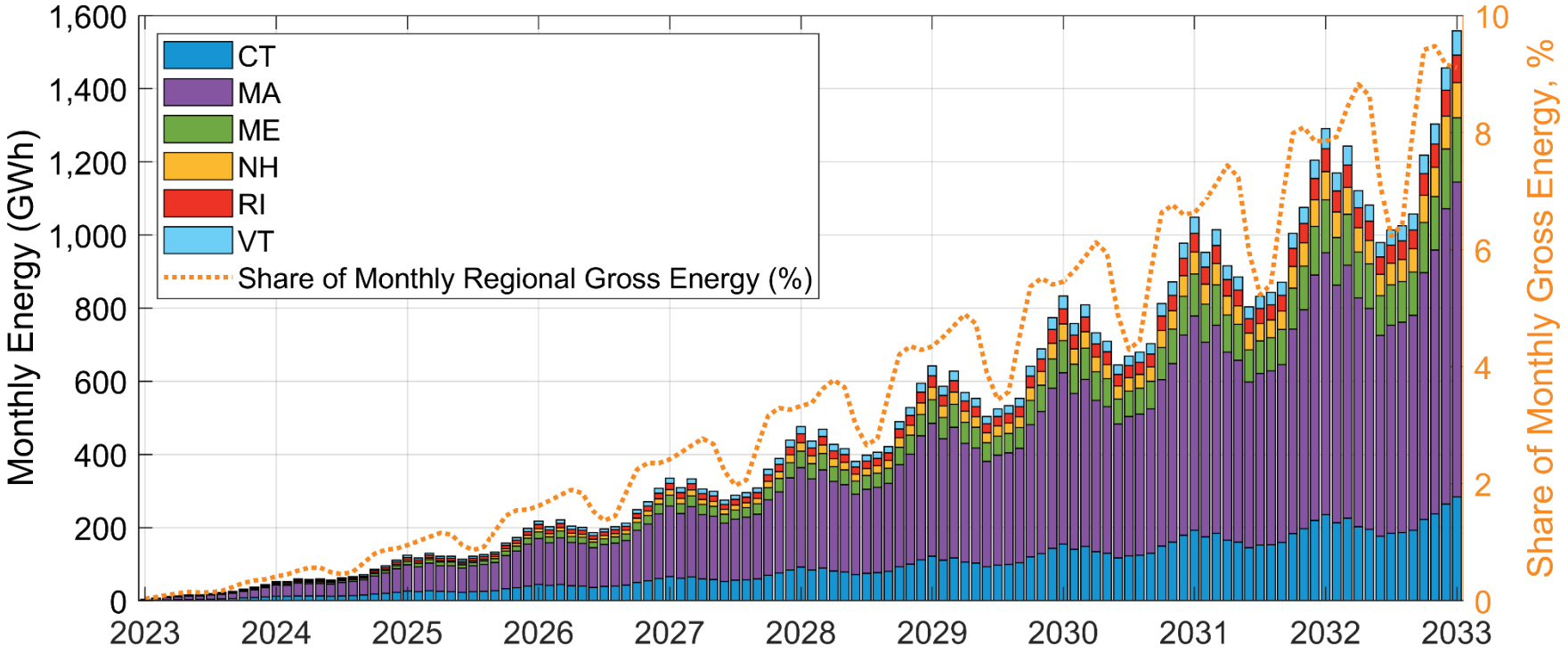
Estimating Energy Impacts of EV Adoption

Average Daily Charging Energy – New England



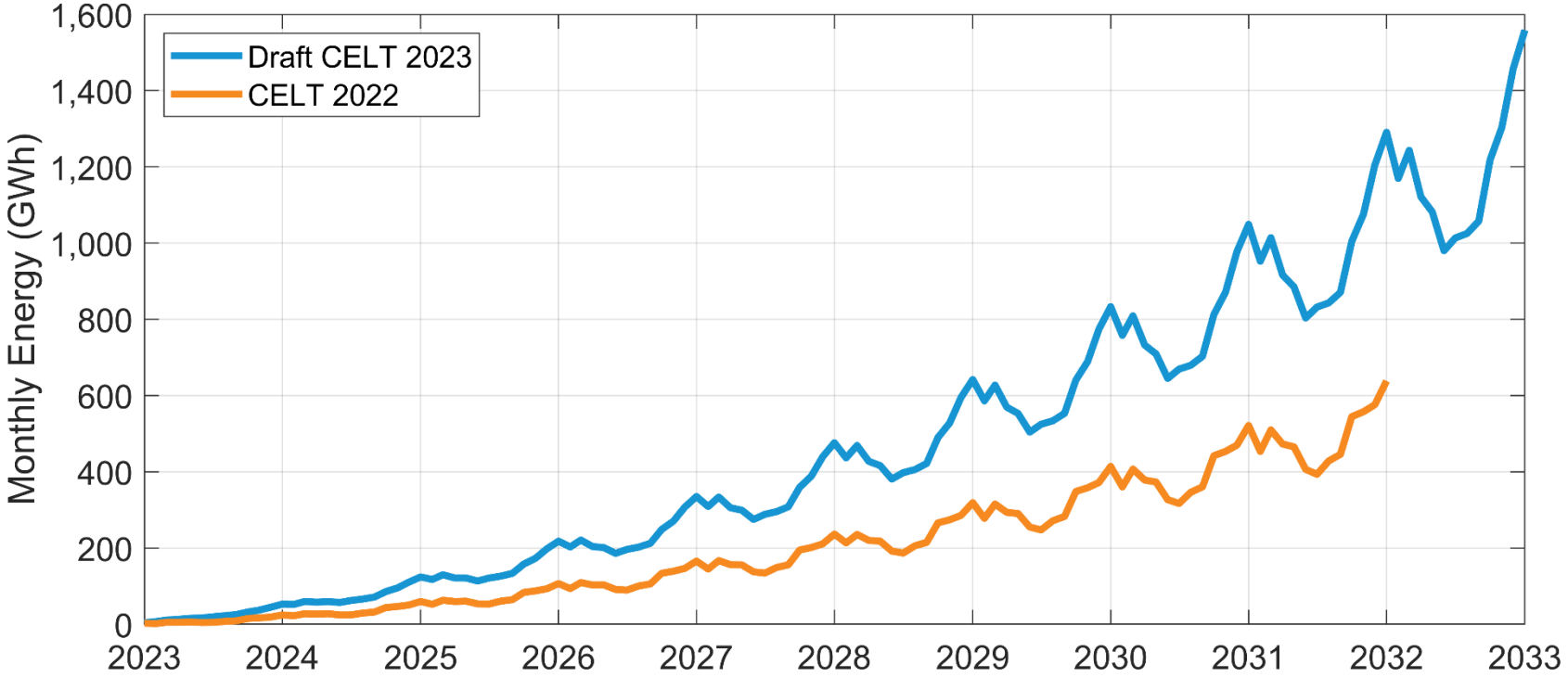
Draft 2022 Transportation Electrification Forecast

Monthly Energy



Transportation Electrification Energy Forecast

New England Comparison Between CELT 2022 and Draft CELT 2023



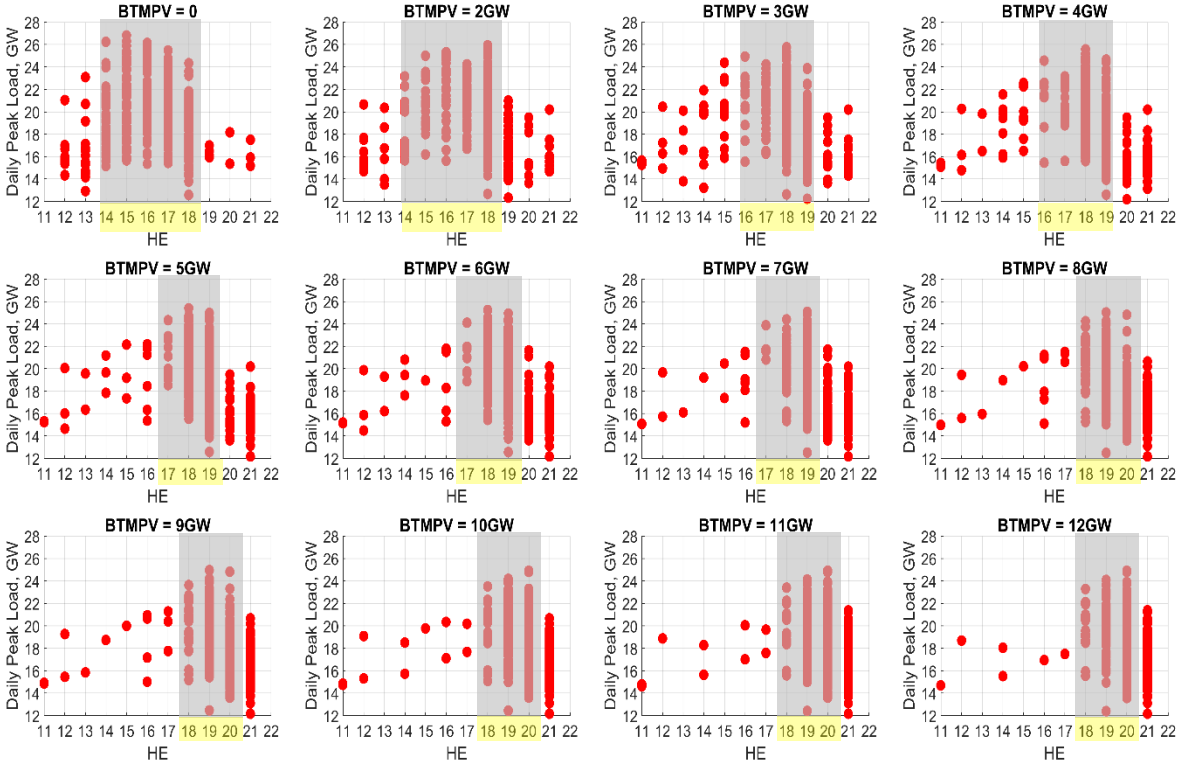
DEMAND FORECAST

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 26 and 27)
- Weather-sensitive demand impacts
  - 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 17

Summer Peak Net Load as BTM PV Increases

- Hourly net load and BTM PV data from the summers (July/August) of 2014-2021 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

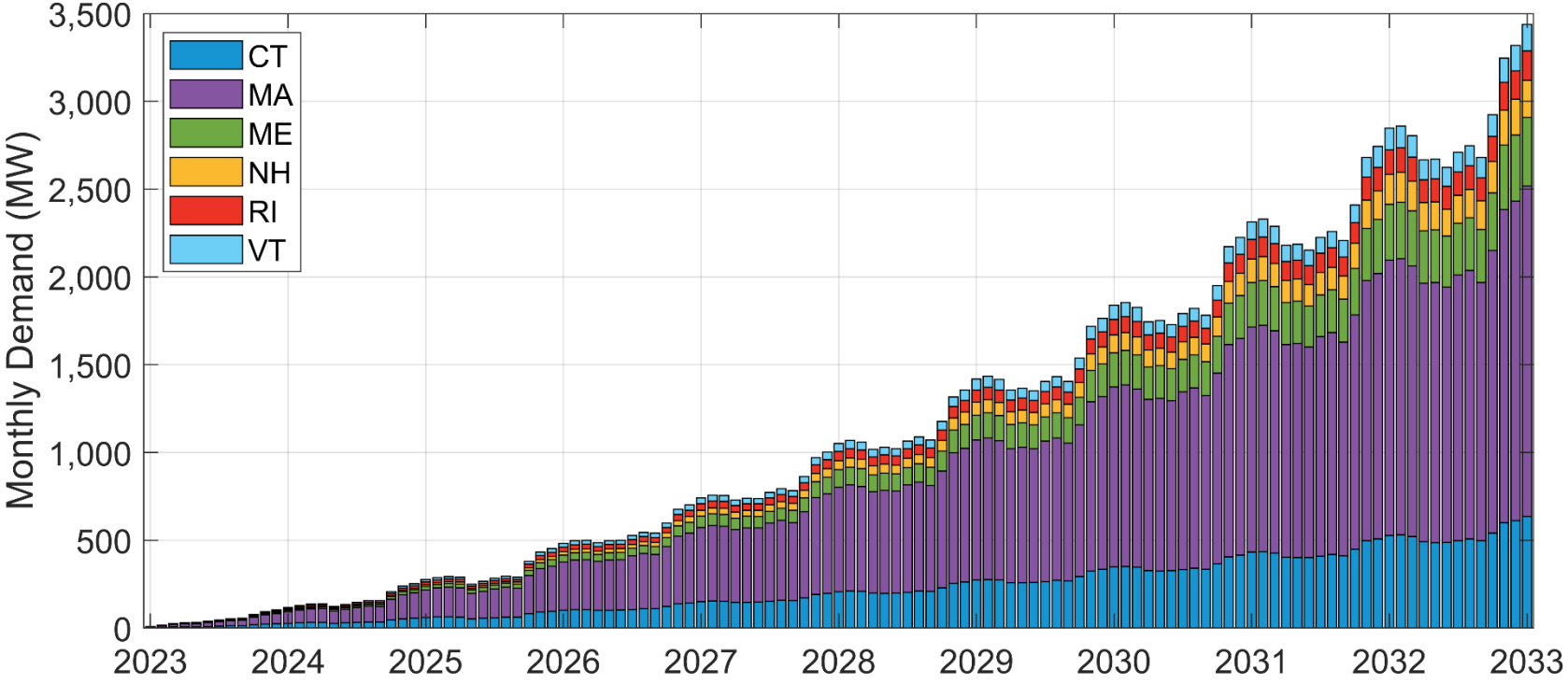
- For forecast applications and reporting that require a deterministic peak value, EV demand during the summer months is estimated as the average monthly EV demand during the summer peak hours tabulated to the right
  - May through September
  - Hours reflect effect of shifting peak demand due to BTM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

Year	PV Nameplate Bin (GW)*	Summer Peak Hours
2023	6	[17,18,19]
2024	7	[17,18,19]
2025	8	[18,19,20]
2026	8	[18,19,20]
2027	9	[18,19,20]
2028	10	[18,19,20]
2029	10	[18,19,20]
2030	11	[18,19,20]
2031	11	[18,19,20]
2032	11	[18,19,20]

**Based on 2022 PV forecast values*

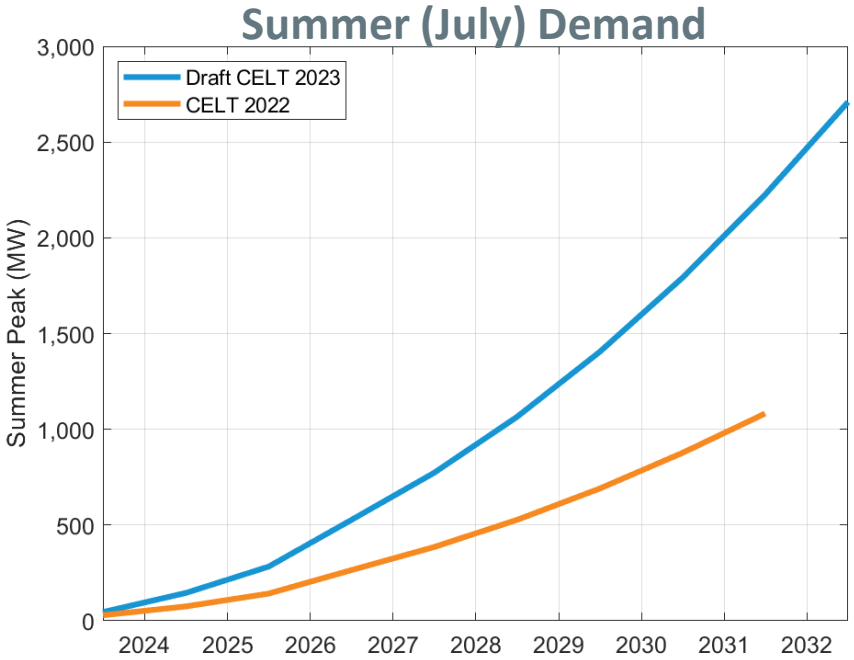
Draft 2022 Transportation Electrification Forecast

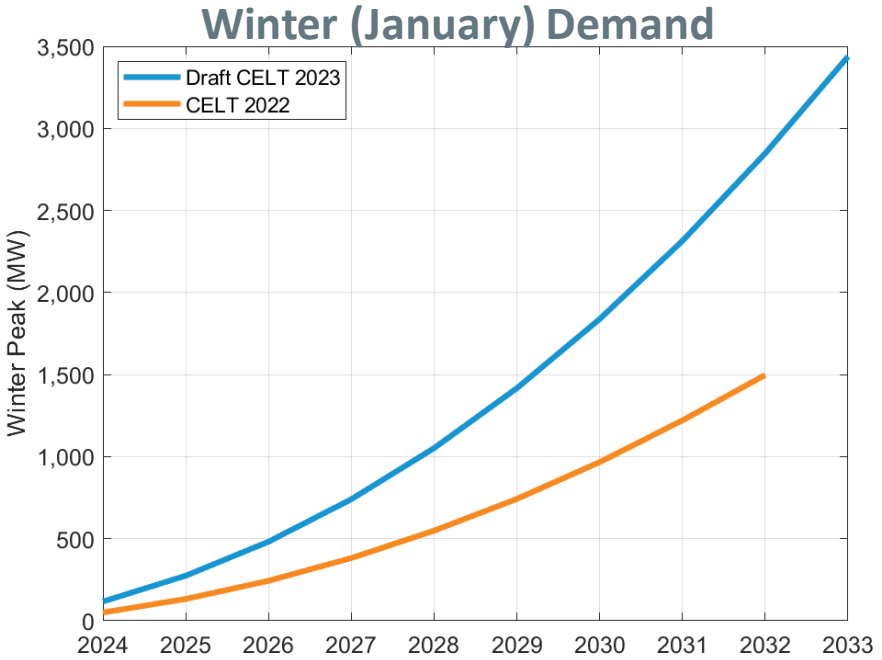
Monthly Demand by State



Transportation Electrification Demand Forecast

New England Comparison Between CELT 2022 and Draft CELT 2023*





* CELT 2022 values have been adjusted to begin accumulating 2023

NEXT STEPS

Next Steps

- ISO will continue to work with stakeholders to update adoption figures
- Final draft energy and demand impacts will be shared at the April 14, 2023 LFC meeting

Questions