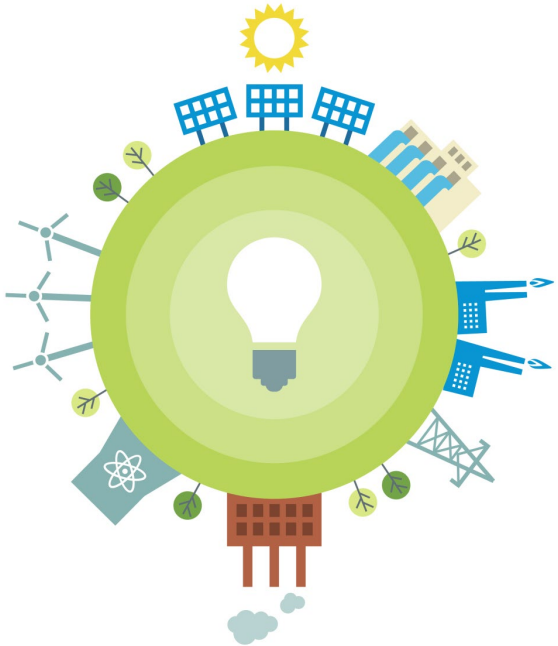
APRIL 30, 2021

2021 Final Transportation Electrification Forecast

Outline

- Introduction & Forecast Methodology
- Electric Vehicle Adoption
- Energy Forecast
- Demand Forecast



Acronyms

- **AEO** – Energy Information Agency's Annual Energy Outlook
- **BEV** – Battery Electric Vehicle
- **BTM PV** – Behind-the-meter Photovoltaic
- **CELT** – Capacity, Energy, Loads and Transmission
- **EIA** – Energy Information Agency
- **EV** – Electric Vehicle
- **FCM** – Forward Capacity Market
- **GHG** – Greenhouse Gas
- **HE** – Hour Ending
- **ICR** – Installed Capacity Requirement
- **LDV** – Light-Duty Vehicle
- **LFC-** Load Forecast Committee
- **P75** – 75th Percentile
- **PHEV** – Plug-in Hybrid Electric Vehicle
- **RSP** – Regional System Plan
- **TCI** – Transportation Climate Initiative

Introduction

- Transportation electrification is expected to play a pivotal role in the achievement of New England state greenhouse gas (GHG) reduction mandates and goals
- Forecasted impacts of transportation electrification on state and regional electric energy and demand are included as part of the 2021 Capacity, Energy, Loads, and Transmission (CELT) forecast
- ISO discussed methodology, assumptions, and related energy and demand impacts associated with the transportation electrification forecast at the NEPOOL Load Forecast Committee (LFC), including the following presentations:
  - Background, assumptions and methodology at the September 25, 2020 and November 13, 2020 LFC meetings
  - The draft 2021 forecast at the December 11, 2020 LFC meeting
  - The final draft 2020 forecast at the February 18, 2021 LFC meeting

Summary of Methodology

- The 2021 transportation electrification forecast focuses on light-duty vehicles (LDV), including cars and light-duty trucks
  - Electrification of other, non-LDV vehicle classes (e.g., freight vehicles, electric buses, rail, trolley) may be considered in future forecasts
- There are two general components to the transportation electrification forecast:
  1. Forecast the adoption of electrified LDVs for each state and the region over the next ten years
     - Adoption values to include battery-electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV)
  2. Data-driven assumptions to convert the EV adoption forecast into estimated impacts on monthly energy and demand by state
     - Include monthly demand and energy impacts per EV based on recent historical EV charging data licensed from ChargePoint, Inc.

ELECTRIC VEHICLE ADOPTION

Electric Vehicle Registrations

- For the 2020 transportation electrification forecast, the ISO had sourced historical registration data from the Alliance of Automobile Manufacturers
  - Data is currently available only through September of 2019 and appears to no longer be updating
  - For this reason, the ISO requested historical vehicle registration data from the states
- The ISO received historical LDV registration data from each of the six states
  - Some states were only able to provide incentive data. Data for MA and ME were adjusted to bring them into alignment with total registrations.
- Registrations from the last historical year will be used to allocate regional TCI projections to the states

2020 EV Forecast Registration Data (Alliance of Automobile Manufacturers)

	# of Registrations (2018)	% of Region (2018)
MA	21,258	51%
CT	9,799	24%
RI	1,738	4%
VT	2,926	7%
NH	3,099	7%
ME	2,529	6%
NE	41,349	100%

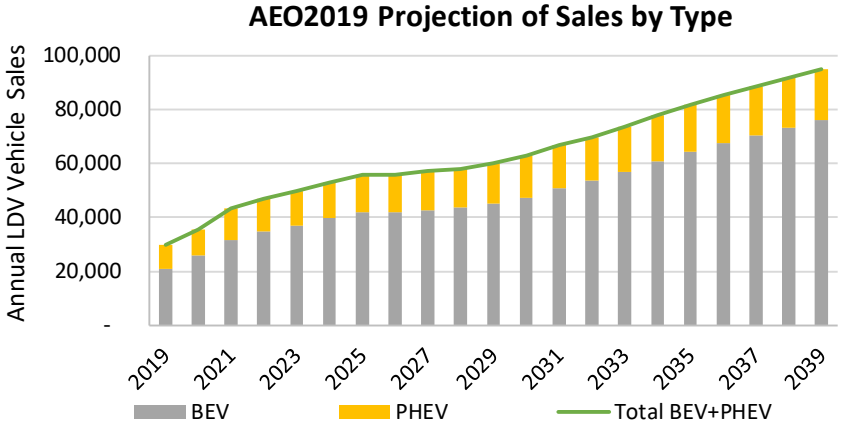
2021 EV Forecast Registration Data (State Provided)

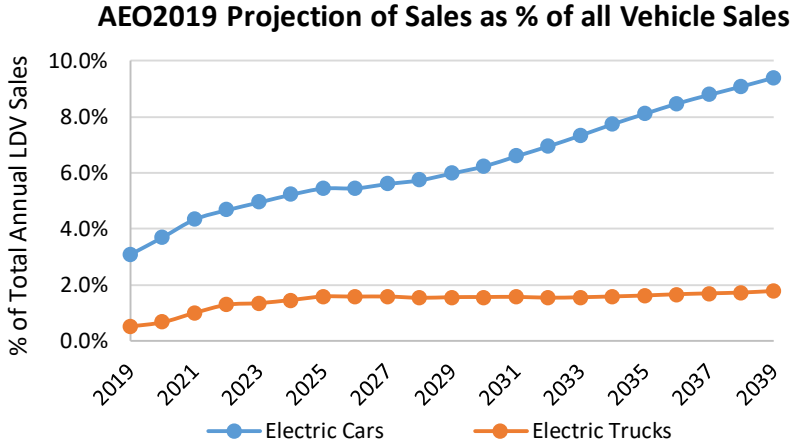
	# of Registrations (2019)	% of Region (2019)
MA	27,188	50%
CT	11,677	21%
RI	2,699	5%
VT	3,628	7%
NH	4,231	8%
ME	5,058	9%
NE	54,481	100%

2019 Annual Energy Outlook (AEO) Forecast

Energy Information Agency – Reference Case

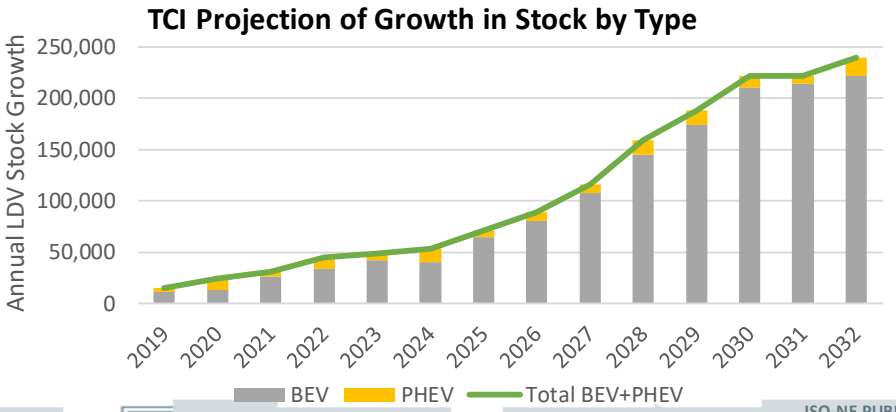
- EIA's 2019 AEO formed the basis for the adoption forecast utilized in the ISO's 2020 transportation electrification forecast
- The AEO reference case represents EIA's best assessment of how U.S. and world energy markets will operate through 2050
  - Assumes that current laws and regulations that affect the energy sector, including laws that have end dates, are unchanged throughout the projection period

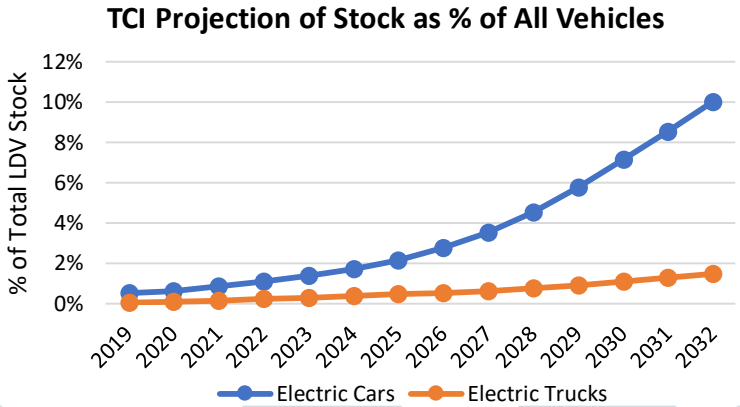




Transportation Climate Initiative (TCI)

- The TCI seeks to improve transportation, develop the clean energy economy and reduce carbon emissions from the transportation sector
  - 12 Northeast and Mid-Atlantic states and the District of Columbia
  - New England's share of TCI projections are based on 2017 US Department of Transportation data
- TCI Reference Case
  - Federal and state policies currently in effect are assumed to remain in place, but there is no emissions cap or associated investments
  - Reflects a variety of assumptions about how energy markets, technology costs, federal and state regulatory requirements, and other factors are likely to change under "business as usual"
  - Details are listed on the Modeling Methods and Results from TCI Regional Policy Design Process webpage





Final 2021 EV Adoption Forecast

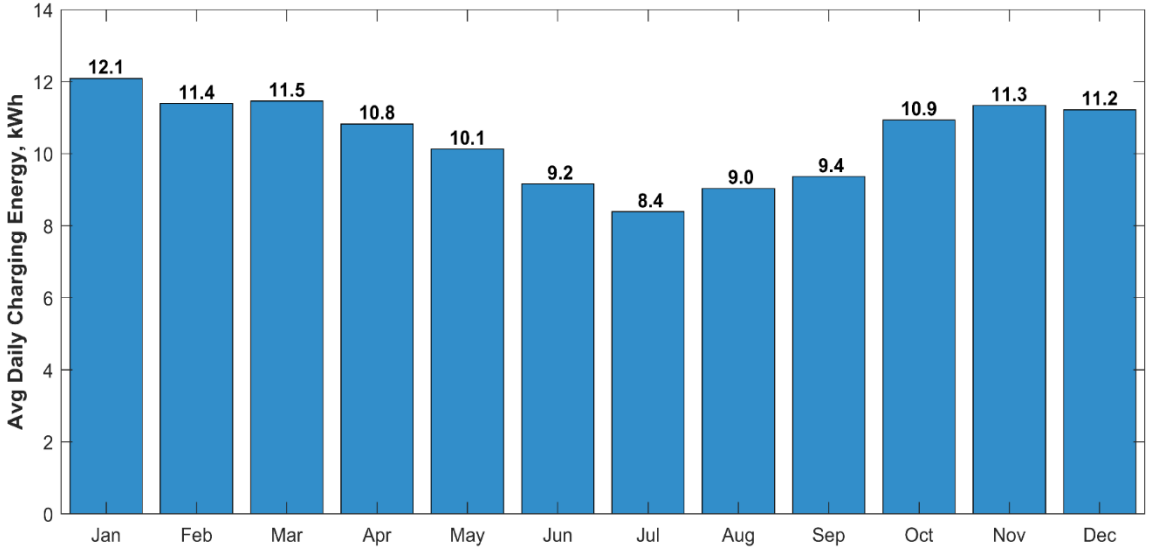
- ME adoption forecast was developed to align with the state's Climate Action Plan
- MA adoption forecast was developed based on discussions with state representatives
- VT adoption forecast reflects values submitted by state representatives
  - Unchanged from draft forecast
- State adoption forecasts for CT, NH, and RI are unchanged from the draft forecast and reflect the following:
  - Based on ISO's 2020 EV adoption forecast through 2025
  - For years 2026-2030 a 50/50 blend of the TCI reference case projections of electrified LDV stock growth and ISO's 2020 EV adoption forecast
    - New England's share of the TCI reference forecast is allocated to states based on state shares of 2019 EV registrations

Final EV Adoption Forecast							
Year	**CT**	**MA**	**ME**	**NH**	**RI**	**VT**	**NE**
2021	10,237	3,700	2,347	3,238	1,816	1,621	22,959
2022	11,143	6,600	3,452	3,524	1,976	2,140	28,835
2023	11,798	15,300	5,150	3,731	2,092	2,816	40,886
2024	12,561	40,900	8,741	3,973	2,228	3,688	72,091
2025	13,209	55,600	14,103	4,177	2,343	4,802	94,234
2026	16,208	62,900	19,367	5,567	3,390	6,203	113,635
2027	19,226	68,550	26,048	6,654	4,080	7,932	132,490
2028	21,771	74,218	34,472	7,669	4,776	10,008	152,913
2029	23,639	78,174	43,749	8,403	5,275	12,413	171,652
2030	27,097	80,250	54,365	9,663	6,081	15,062	192,518
Total	**166,890**	**486,192**	**211,793**	**56,599**	**34,057**	**66,684**	**1,022,214**

ENERGY

Estimating Energy Impacts of EV Adoption

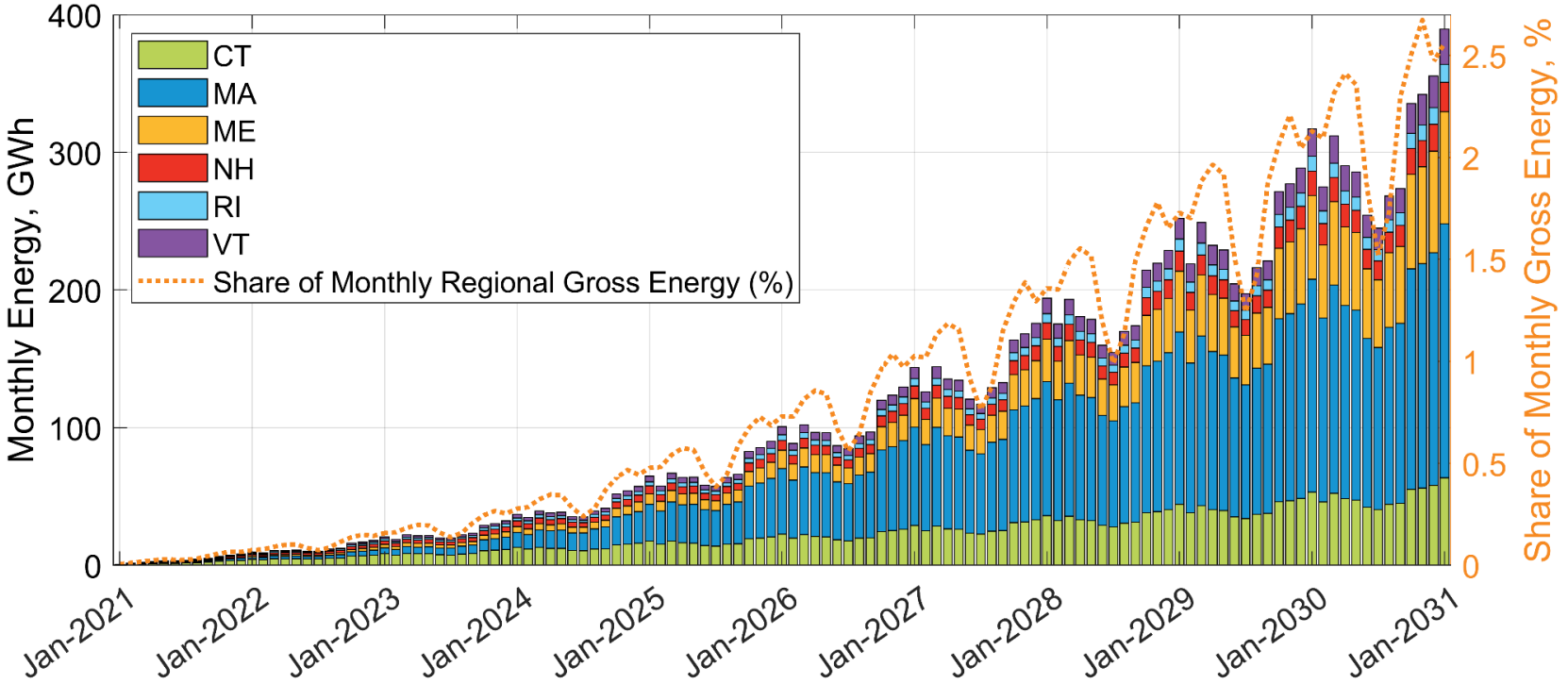
- Monthly energy is based on results of the ChargePoint data analysis discussed at the November 18, 2019 LFC (slides 10-25)
- The adjacent bar chart illustrates monthly kWh/day per EV used to estimate monthly energy
- Values reflect a 6% gross-up for assumed transmission and distribution losses



Data source: ChargePoint, Inc.

Final 2021 Transportation Electrification Forecast

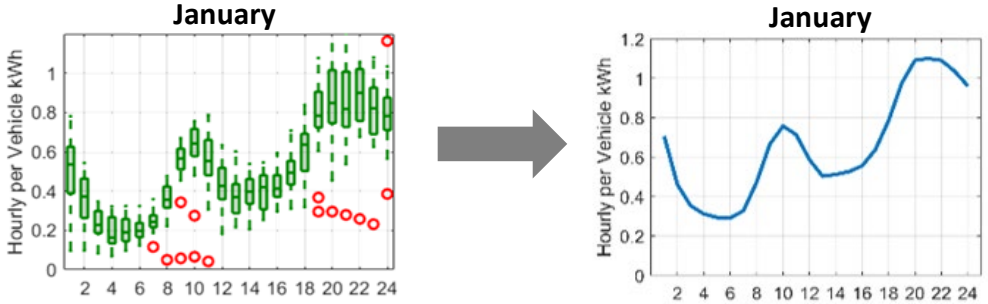
Monthly Energy



DEMAND

Estimating Demand Impacts of EV Adoption

- Hourly weekday EV demand profiles are used to estimate demand impacts
  - These values reflect the 75th 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

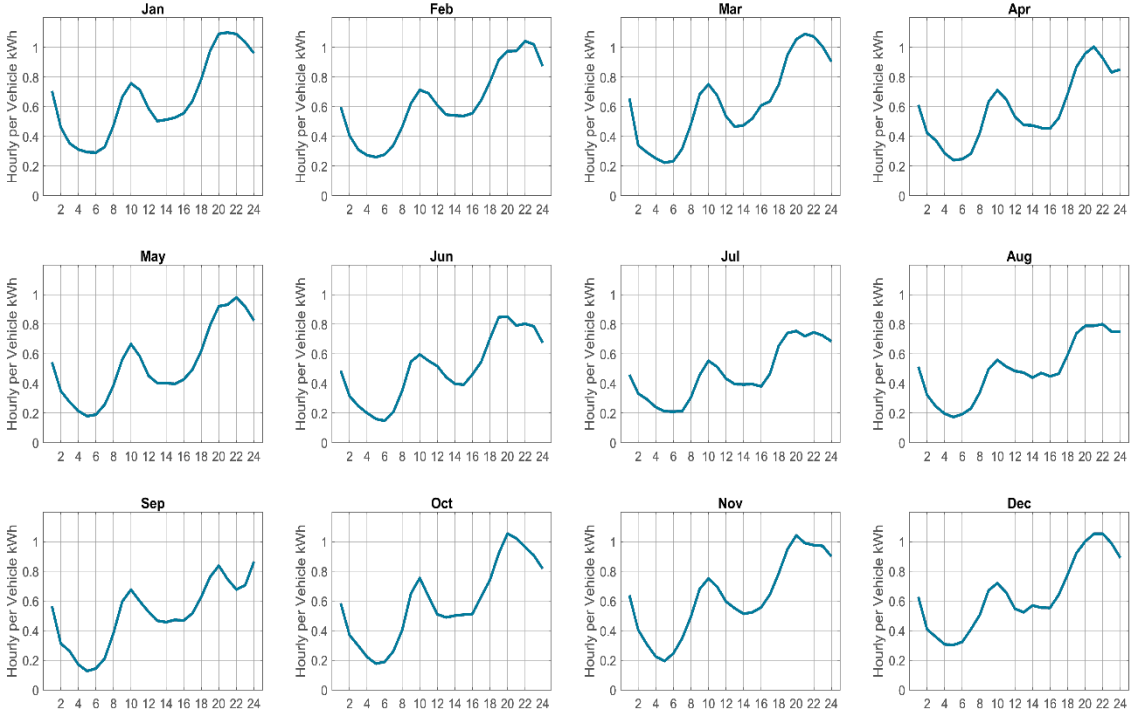


- Demand estimates are grossed up by 8% for assumed transmission and distribution losses, consistent with other forecast processes
- Resulting weekday demand profiles are shown on the following slide (all values reflect 8% gross-up)

EV Hourly Demand

- 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 (see next 2 slides)

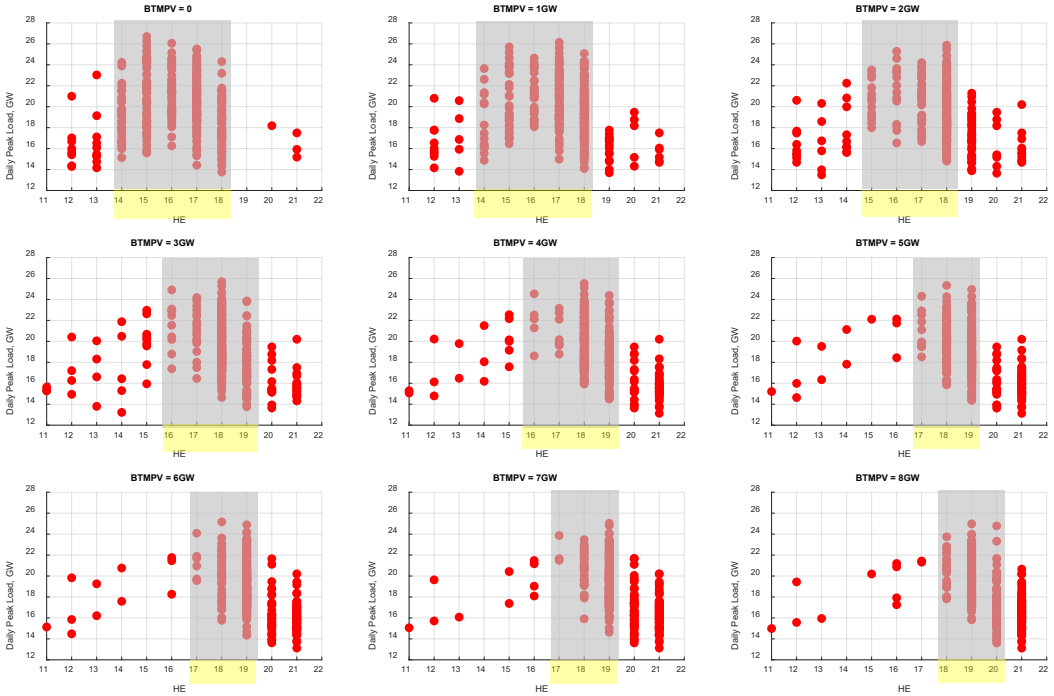
Weekday EV Profiles



Data source: ChargePoint, Inc.

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

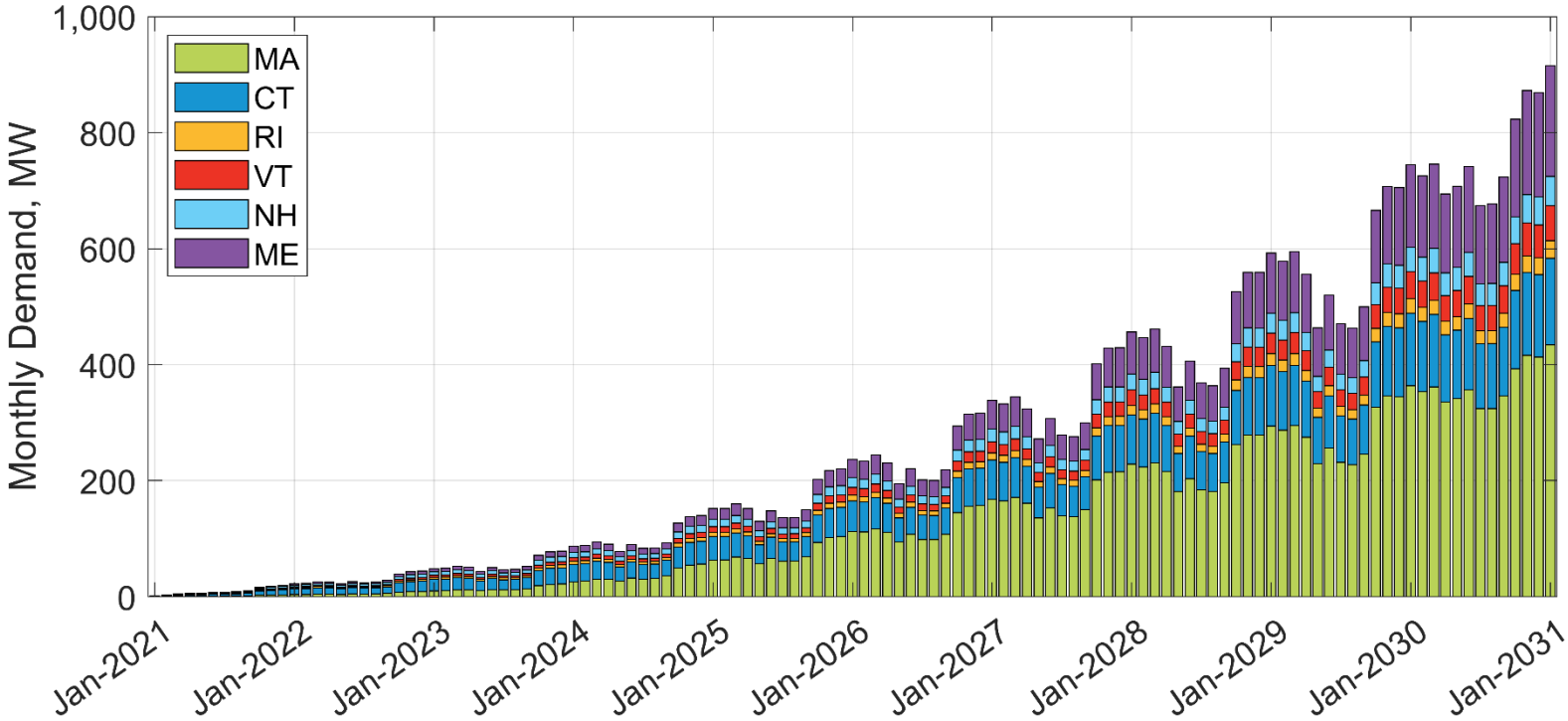
- For forecast applications and reporting that require a deterministic peak value, EV demand during the summer months is estimated as the average monthly EV demand during the summer peak hours tabulated to the right
  - May through September
  - Hours reflect effect of shifting peak demand due to BTM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

Year	PV Nameplate Bin (GW)*	Summer Peak Hours
2021	4	[16,17,18,19]
2022	5	[17,18,19]
2023	5	[17,18,19]
2024	6	[17,18,19]
2025	6	[17,18,19]
2026	6	[17,18,19]
2027	7	[17,18,19]
2028	7	[17,18,19]
2029	7	[17,18,19]
2030	8	[18,19,20]

**Based on 2020 PV forecast values*

Final 2021 Transportation Electrification Forecast

Monthly Demand



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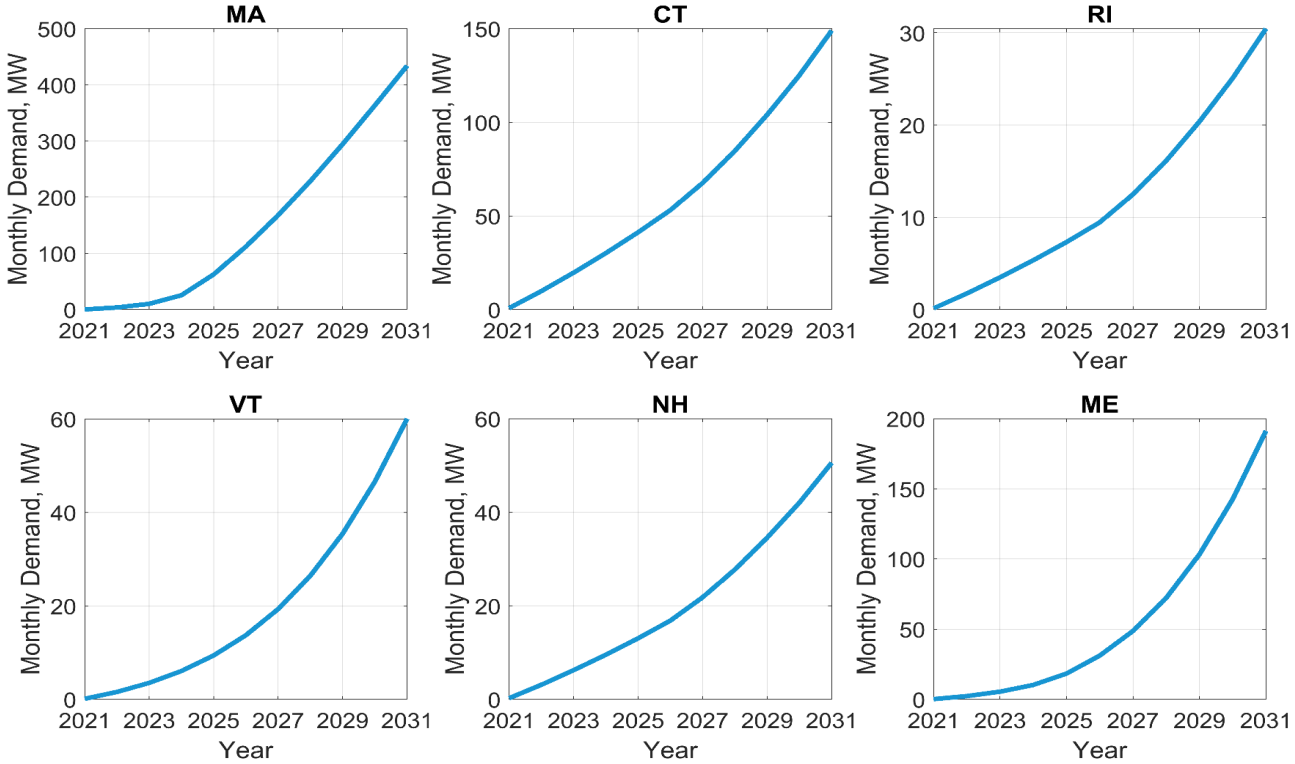
Winter Demand (January)



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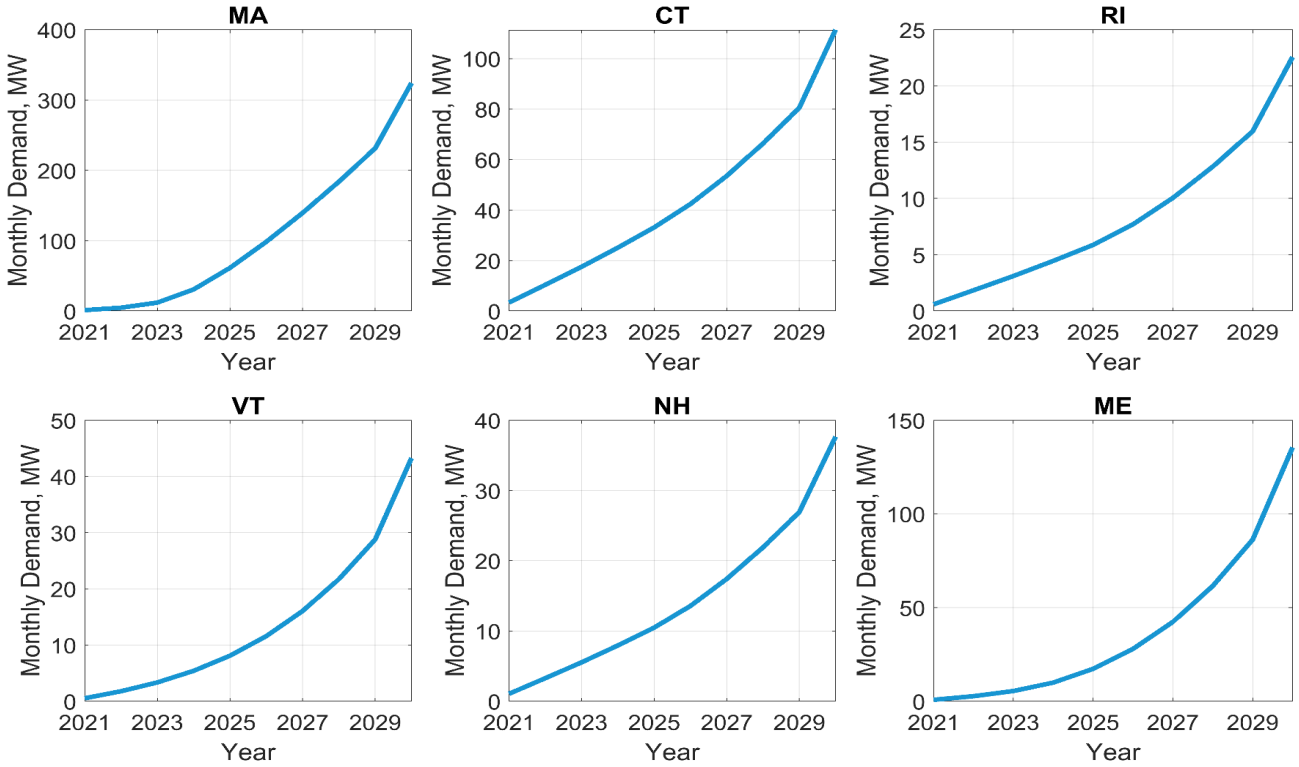
Summer Demand (July)



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Winter (January) and Summer (July) Peak Demand

Winter Peak (MW)							
Year (Winter Of)	CT	MA	ME	NH	RI	VT	NE
2021/2022	10	4	2	3	2	2	22
2022/2023	20	10	5	6	3	4	49
2023/2024	30	26	10	10	5	6	87
2024/2025	41	63	18	13	7	9	152
2025/2026	53	112	31	17	9	14	237
2026/2027	68	168	49	22	12	19	338
2027/2020	85	229	72	28	16	26	456
2028/2029	104	294	103	35	20	35	592
2029/2030	125	364	143	42	25	47	745
2030/2031	149	434	191	51	30	60	916

Summer Peak (MW)							
Year	CT	MA	ME	NH	RI	VT	NE
2021	3	1	1	1	1	1	7
2022	10	5	3	3	2	2	25
2023	18	12	5	6	3	3	47
2024	25	31	10	8	4	5	84
2025	33	61	17	10	6	8	136
2026	42	98	28	14	8	12	202
2027	54	139	42	17	10	16	279
2028	66	184	62	22	13	22	368
2029	81	231	86	27	16	29	470
2030	111	324	135	38	23	43	675

Final Transportation Electrification Forecast

Reporting and Publications

- The final 2021 transportation electrification forecast described herein is included in CELT 2021
  - All gross and net energy and demand forecasts reported in both 2021 CELT and in the 2021 Forecast Data workbook are inclusive of transportation electrification
  - Breakout of annual energy and seasonal demand are reported in 2021 CELT Section 1.7, and 2021 Forecast Data worksheet 16
- For probabilistic ICR studies, the transportation forecast is modeled hourly as a load addition
  - Hourly demand based on the demand plots illustrated on slide 19, scaled up by the monthly forecasted EV adoption in each state
- For the 2021 forecast, the state energy and demand transportation electrification forecasts are allocated to ISO Load Zones and Regional System Plan (RSP) Subareas based on information obtained during the ISO's annual Multiregional Modeling Working Group (MMWG) network model creation process
  - Load shares by substation are submitted by Transmission Owners, as described in Section 2.3 of the Transmission Planning Technical Guide Appendix J: Load Modeling Guide