Technical Potential of Load Management in the Commonwealth

Public Engagement Session #1: Study Overview & Early Insights

MASSACHUSETTS
DEPARTMENT OF ENERGY RESOURCES

Energy+Environmental Economics

Applied Economics Clinic

July 30, 2025

Agenda

- Introductions | 5 min, all
- DOER Study Motivation, Tasks, & Goals | 5 min, State Team
- Technical Overview | 15 min, E3
- Modeling Approach & Selected Draft Results | 30 min, E3
- Next Steps | 5 min, AEC
- Q&A and Breakout Discussions | 30 min, all

Introductions - Project Team

DOER Core Team

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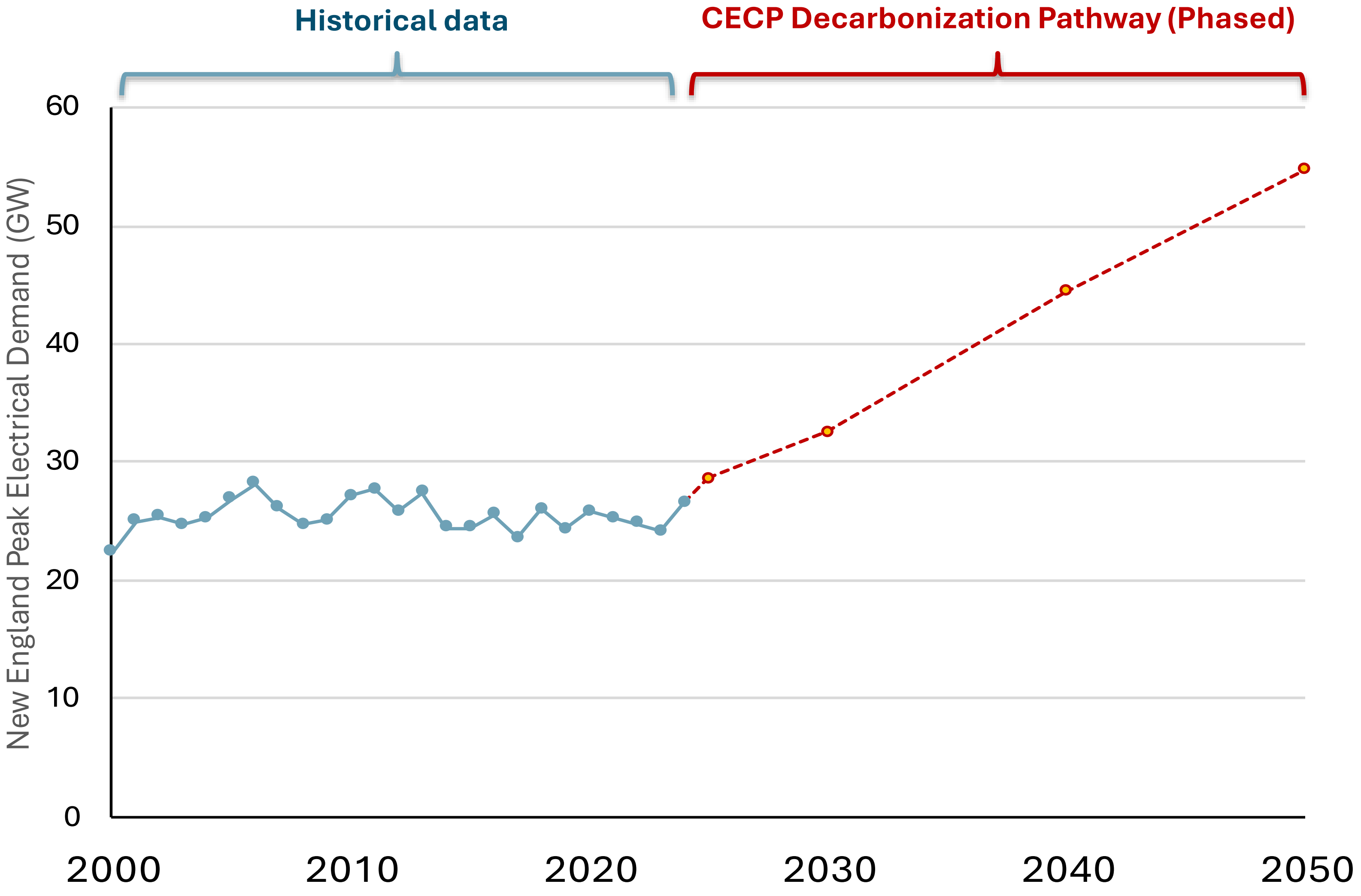
DOER's Mission

The Department of Energy Resources' (DOER) mission is to create a clean, affordable, resilient, and equitable energy future for all in the Commonwealth.

Who We Are: *As the State Energy Office, DOER is the primary energy policy agency for the Commonwealth. DOER supports the Commonwealth's clean energy goals as part of a comprehensive Administration-wide response to the threat of climate change. DOER focuses on transitioning our energy supply to lower emissions and costs, reducing and shaping energy demand, and improving our energy system infrastructure.*

What We Do: *To meet our objectives, DOER connects and collaborates with energy stakeholders to develop effective policy. DOER implements this policy through planning, regulation, and providing funding. DOER provides tools to individuals, organizations, and communities to support their clean energy goals. DOER is committed to transparency and education, supporting the accessible access to energy information and knowledge.*

Motivation


Historical data
CECP Decarbonization Pathway (Phased)
New England Peak Electrical Demand (GW)
60
50
40
30
20
10
0
2000
2010
2020
2030
2040
2050

Load Management Study

Goals

Quantify the potential for load management to reduce electric system costs

Provide technical assumptions and modeling to support DOER strategy, program design, & advocacy

Tasks	May	June	July	Aug	Sept
Task 1: Technical Potential					
Task 2. Cost-Benefit Analysis					
Task 3. Feasible Potential					
Task 4. Stakeholder Engagement		Public Meetings July 30th & Sept 10th + monthly advisory group meetings			
Task 5. Report				Expected release Fall 2025	

Technical Overview

Why is load management a key strategy for electric grid transition?

1

Electrification will dramatically increase load & peak load over the coming decades

2

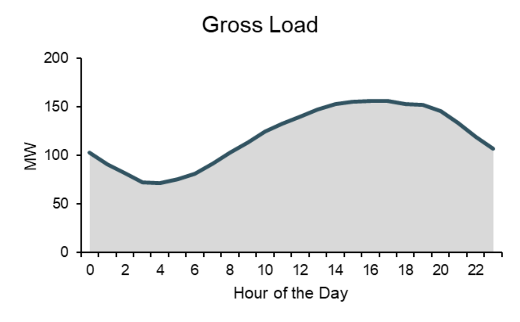
In parallel, renewable generation will shift periods of greatest resource need across hours, days & seasons

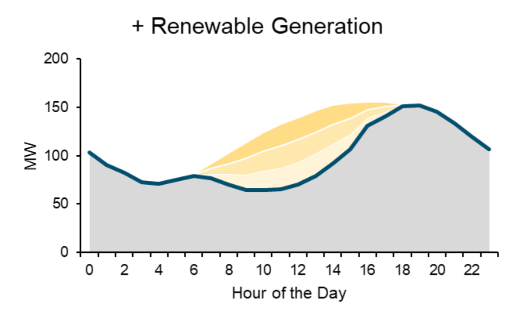
3

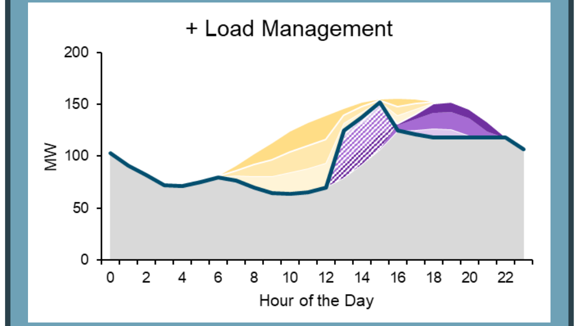
Load management can reduce and shift load, though without careful orchestration, can create rebound peaks

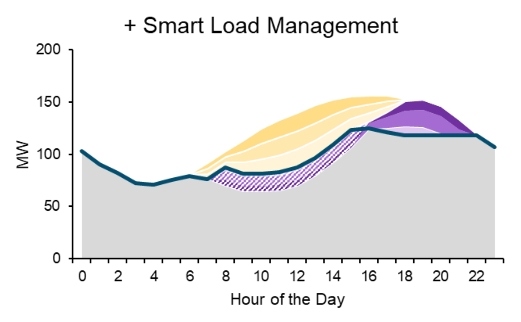
4

Well coordinated load management and storage can flatten net peak & reduce firm generation needs





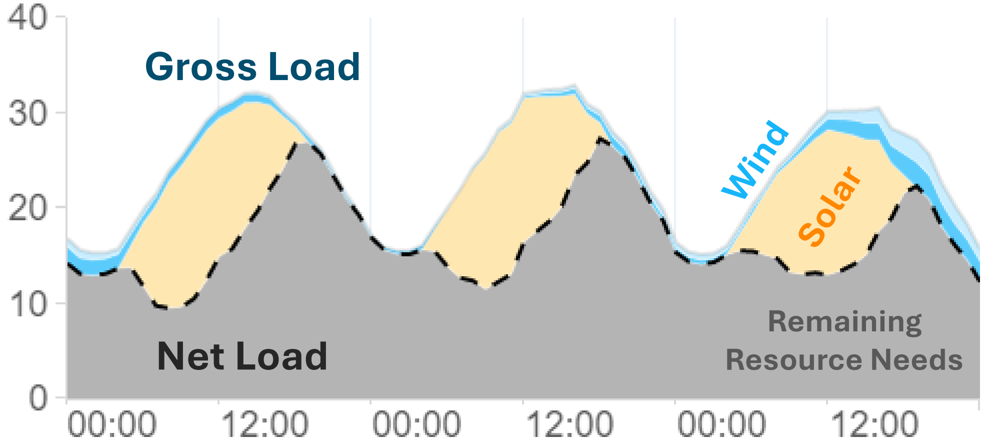




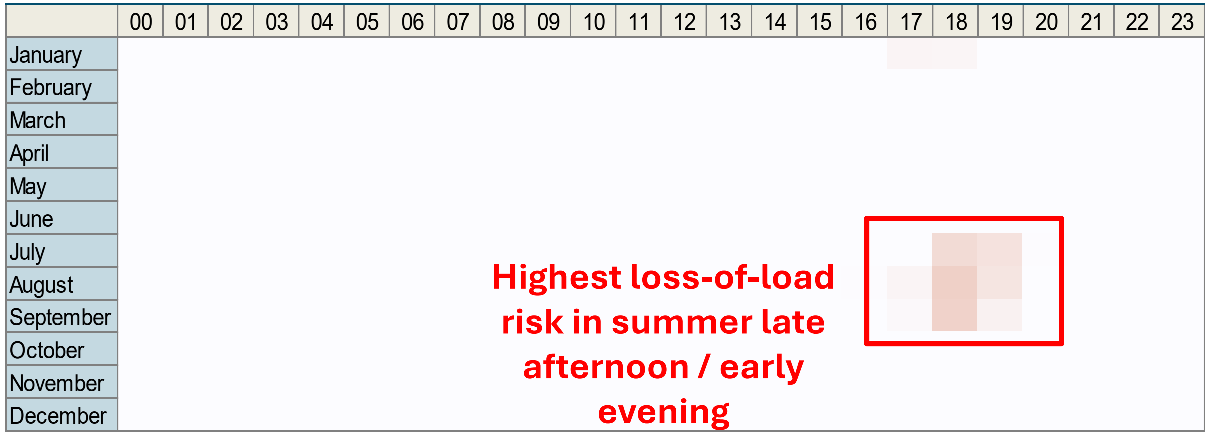
Net peak will shift from summer evenings in 2030 to winter evenings and mornings in 2050

Example Summer Week in July 2030

Renewable Output and Net Load (GW) – *Before Storage*

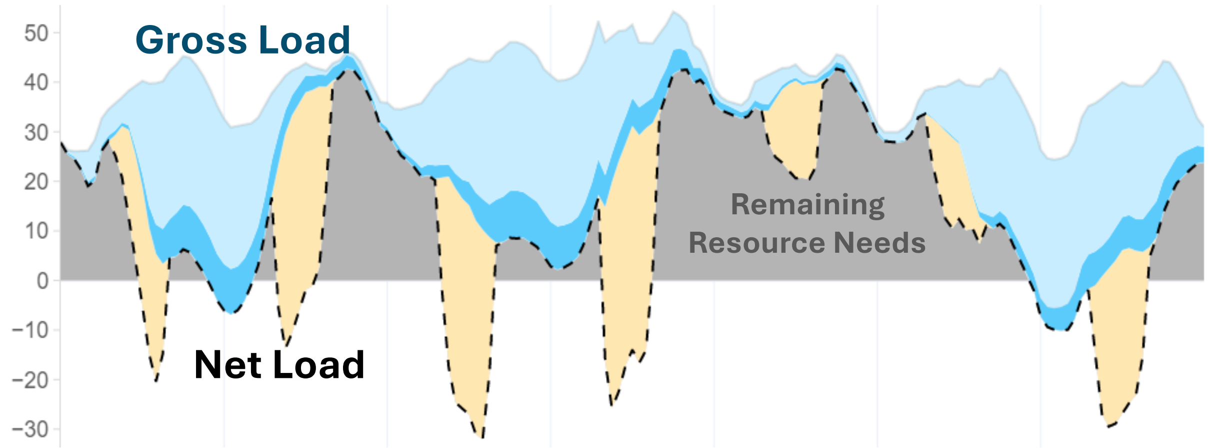


Month-hour System Firm Resource Needs

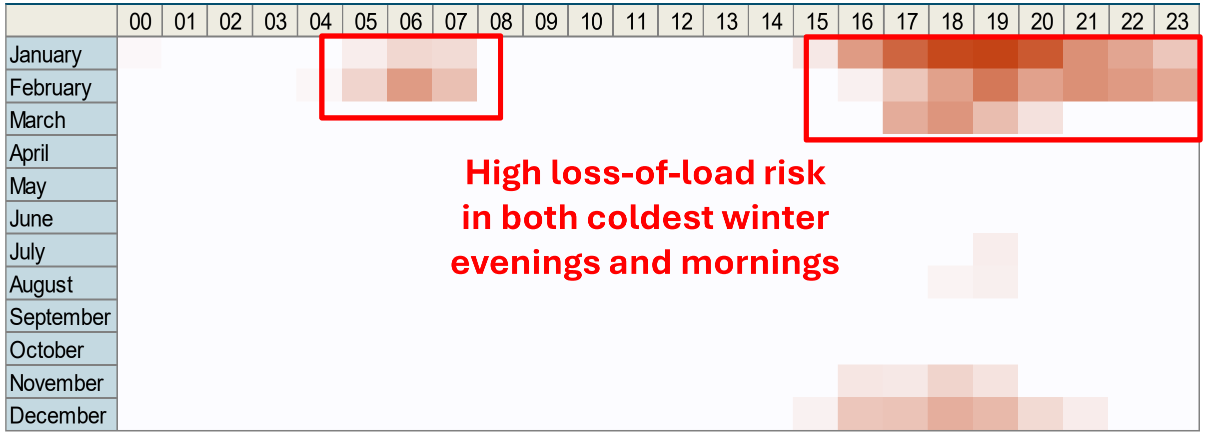


Example Winter Week in January 2050

Renewable Output and Net Load (GW) - *Before Storage*



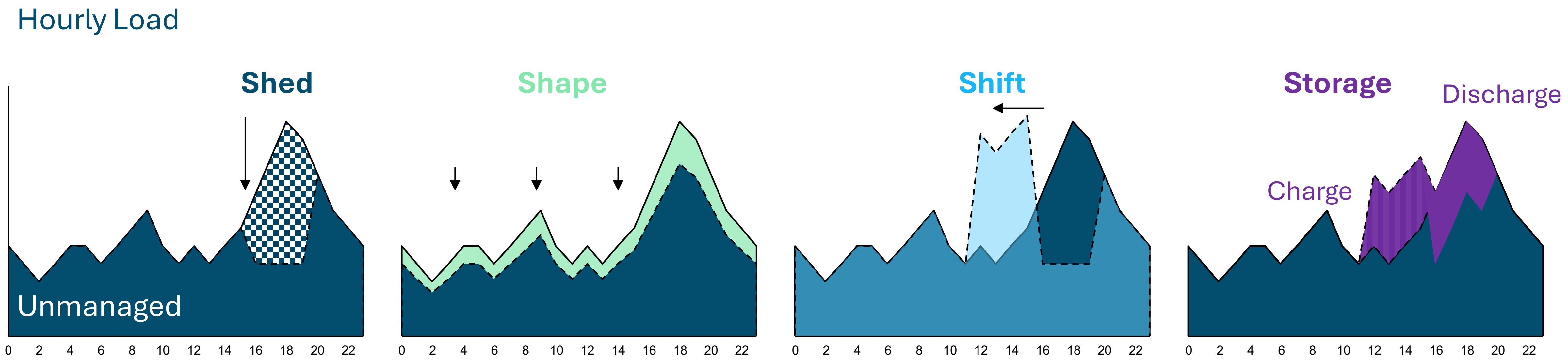
Month-hour System Firm Resource Needs



From DOER/E3 Charging Forward Study, December 2023

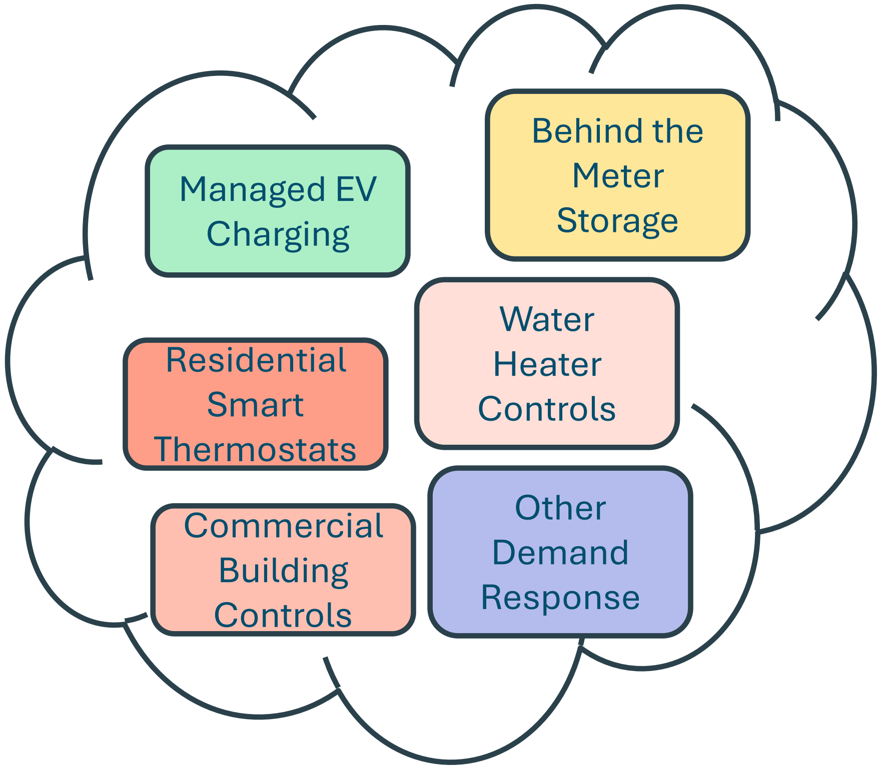
Load management strategies and storage help lower and align electricity demand with electricity supply

- **Diverse range of load management and flexibility technologies, organized here in three categories**
  - **Shed:** Loads that can be curtailed to provide capacity reductions, during peak hours (e.g., demand response)
  - **Shape:** Reshaping load for significant portions of the year (e.g., energy efficiency, price responsiveness, behavioral change)
  - **Shift:** Loads that can be shifted between hours, during peak hours (e.g., managed electric vehicle charging)
- **Storage provides similar service, shifting supply from hours with excess energy to discharge during challenging hours**
- **Key point: Most load management technologies and storage directly compete to flatten the same net peak – the order in which they are deployed directly influences how much is needed or available from remaining options**

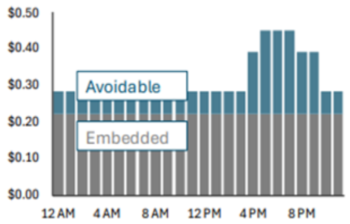


This study draws a distinction between load management <u>measures</u> and <u>programs/incentives</u> that unlock those measures

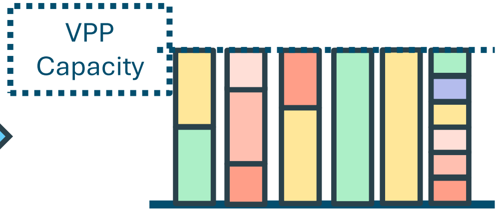
Measures = load management building blocks



Different measures will respond to different incentives



Time of use rates cause individual customers to shift use



Virtual Power Plants (VPPs) aggregate measures into a single dispatchable asset to participate in ISO-NE or grid services markets

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Modeling Approach

Load Management Strategies

Key data sources
- LBNL 2024, CA Demand Response, Potential Study, P4
- NREL ResStock and ComStock
- Ongoing EEA EVICC Managed Charging Study

Shape/Efficiency

- Cold-climate heat pumps
- Ground source heat pumps
- Stretch code for new construction
- Shell retrofits

Shift

- HVAC flexibility
- Water heating
- Appliances
- V1G and V2G
- BTM Storage

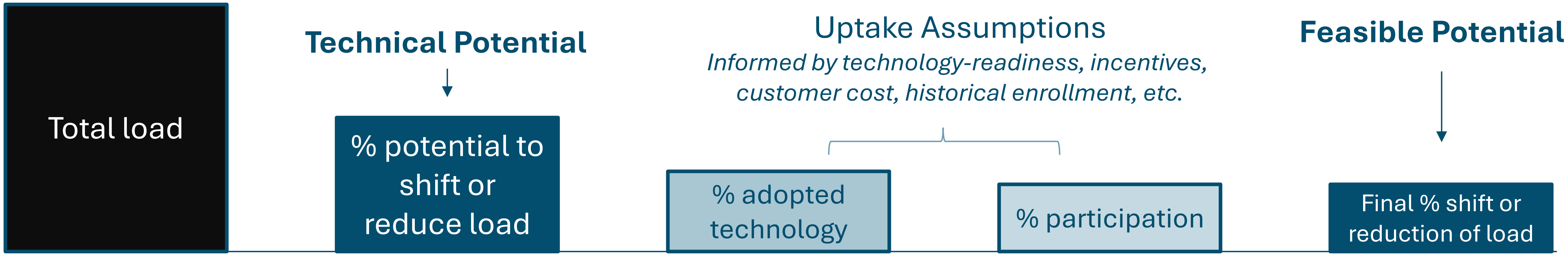
Shed

- Hybrid heat pumps*
- Industrial demand response

*Gas or fuel oil back-up heating system

Establishing Technical and Feasible Potential Scenarios

- **<u>Technical potential</u> reflects the maximum load shift and reduction potential of each measure in critical hours**
  - On a per-unit basis, this assumes estimated or observed reduction and shift behavior from prior programs and research efforts
  - For measure adoption, this assumes levels of technology adoption modeled in the Climate and Clean Energy Plan for 2050
- **Our <u>feasible potential</u> scenarios reflect range of futures in which load management strategies are prioritized, with:**
  - Lower: “more conservative uptake” portfolio where adoption and participation rates are extrapolated from existing program uptake, but assume increasing adoption of clean energy technologies like heat pumps and EVs
  - Higher: “ambitious policy” portfolio where adoption and participation rates are accelerated



High and low feasible potential scenarios help establish range of load management outcomes

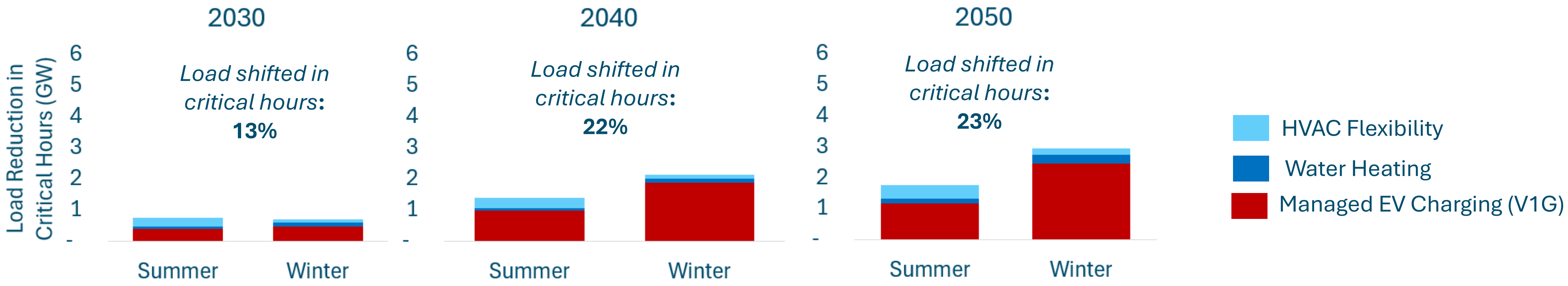
	EV Charging	Buildings	Industry	Storage
Low	Heavier emphasis on **V1G** (smart charging)	Lower participation in **HVAC, WH, & appliance load control** and **light shell retrofits;** lower **stretch code** adoption for new construction	Business-as-usual growth rate in Connected Solutions **demand response**	Lower **BTM storage** capacity deployment rate, informed by ESMP*
High	Heavier emphasis on **V2G** (Vehicle-to-Grid)	Increased participation in **HVAC, WH, & appliance load control** and **deep shell retrofits;** higher **stretch code** adoption for new construction	Higher enrollment in Connected Solutions **demand response**	Accelerated **BTM storage** capacity deployment rate, informed by ESMP

*Electric System Modernization Plan

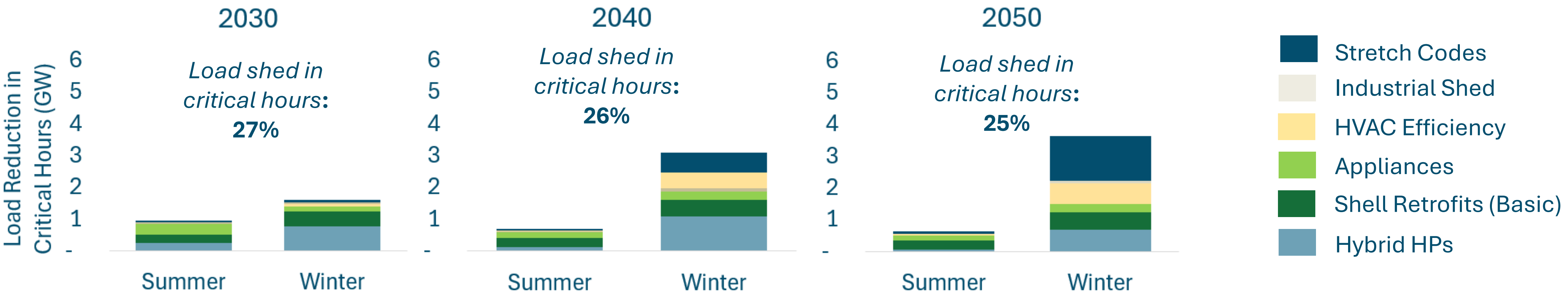
Selected Draft Results

Draft Technical Potential results point to EV load management and efficiency emerging as highest potential measures

Shift Aggregate Technical Potential

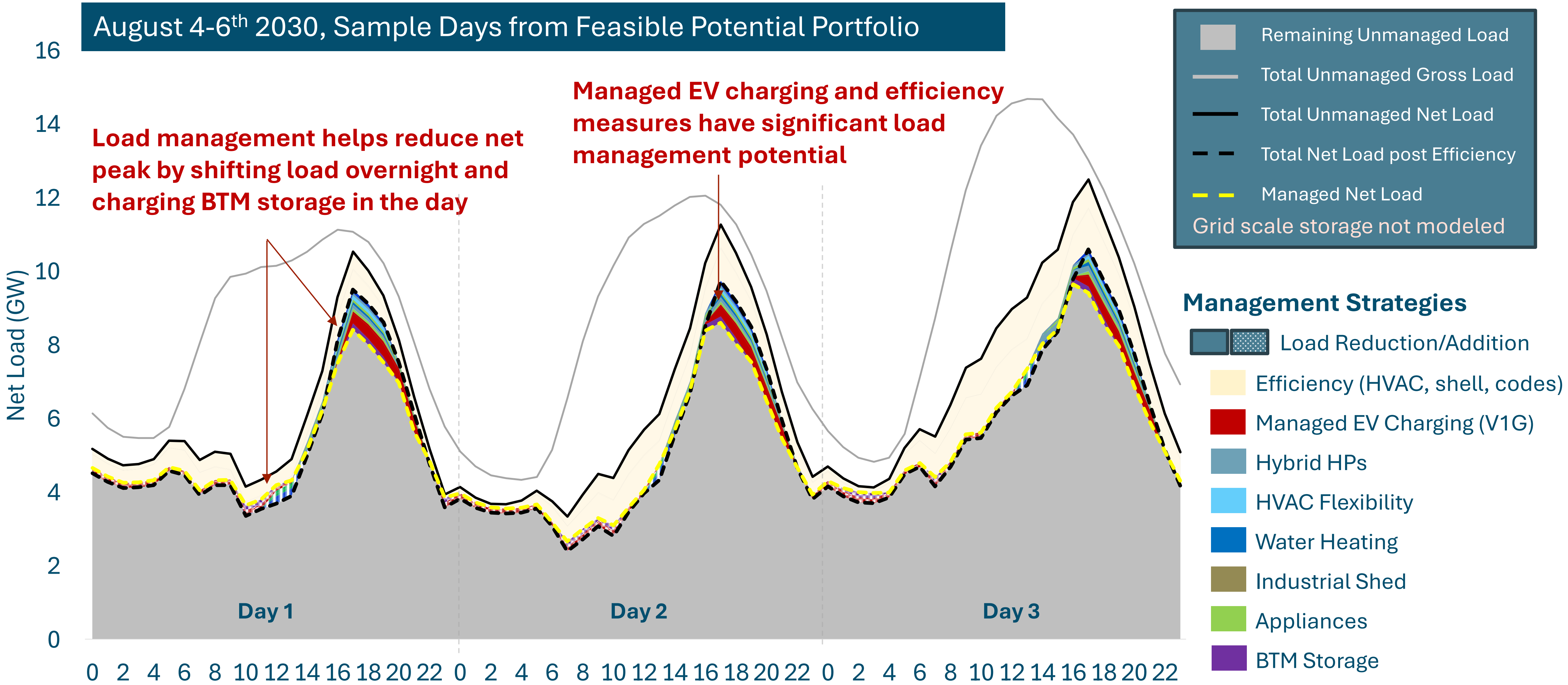


Shed and Shape Aggregate Technical Potential

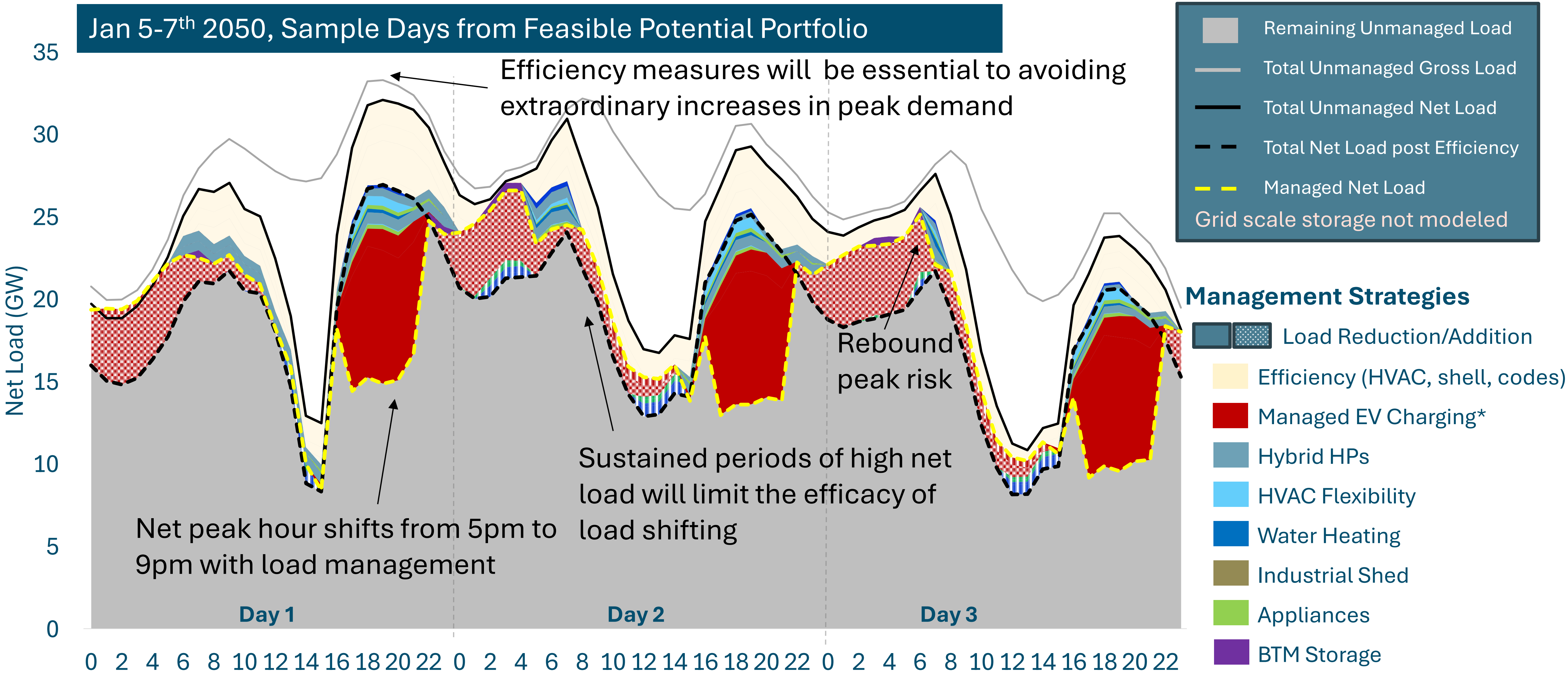


*Weighted average of load reduction across top 20% critical hours.
% values shown reflect % of gross load.

EV charging and efficiency measures play greatest role in clipping summer evening net peak demand in 2030



By 2050, load management strategies could play a major role in net peak management, and will need to be coordinated



*mix of V1G and V2G

Next Steps, Q&A, and Breakout Discussions

Timeline

Tasks	May	June	July	Aug	Sept
Task 1: Technical Potential					
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Task 5. Report					Expected release Fall 2025

Analysis Results

- Technical potential: July
- Feasible potential: August

Public Engagement Sessions

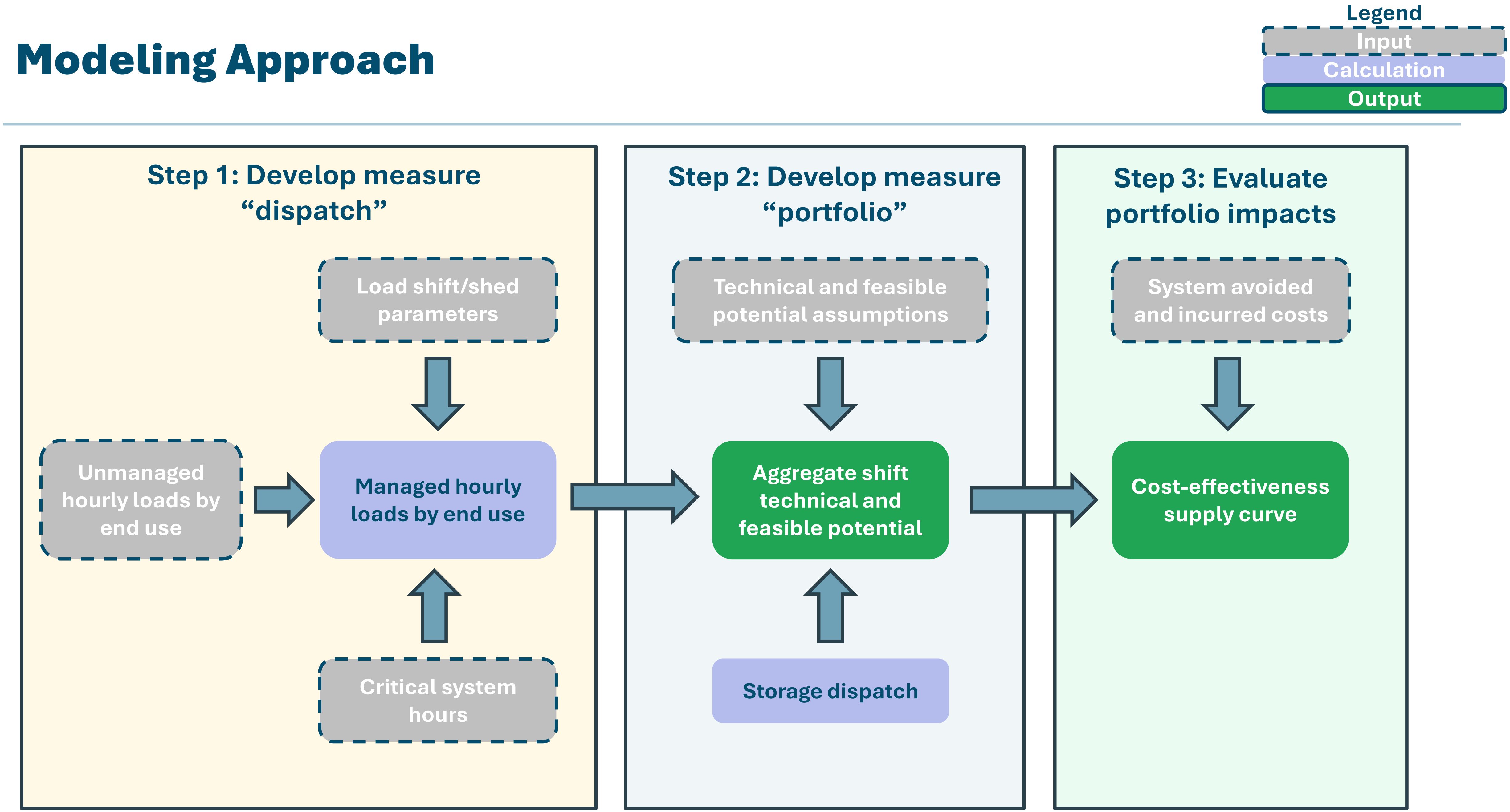
- July 30
- September 10

Discussion and Q&A

- **What are the key strategies or approaches you think its important for this study to consider?**
- **What are key enablers to load management that the state should be considering?**
- **What are key barriers to load management that the feasible potential research task should consider, and that the state should address?**
- **Other general feedback or questions**
  - Reactions to draft results?
  - Questions for study technical team or state team?

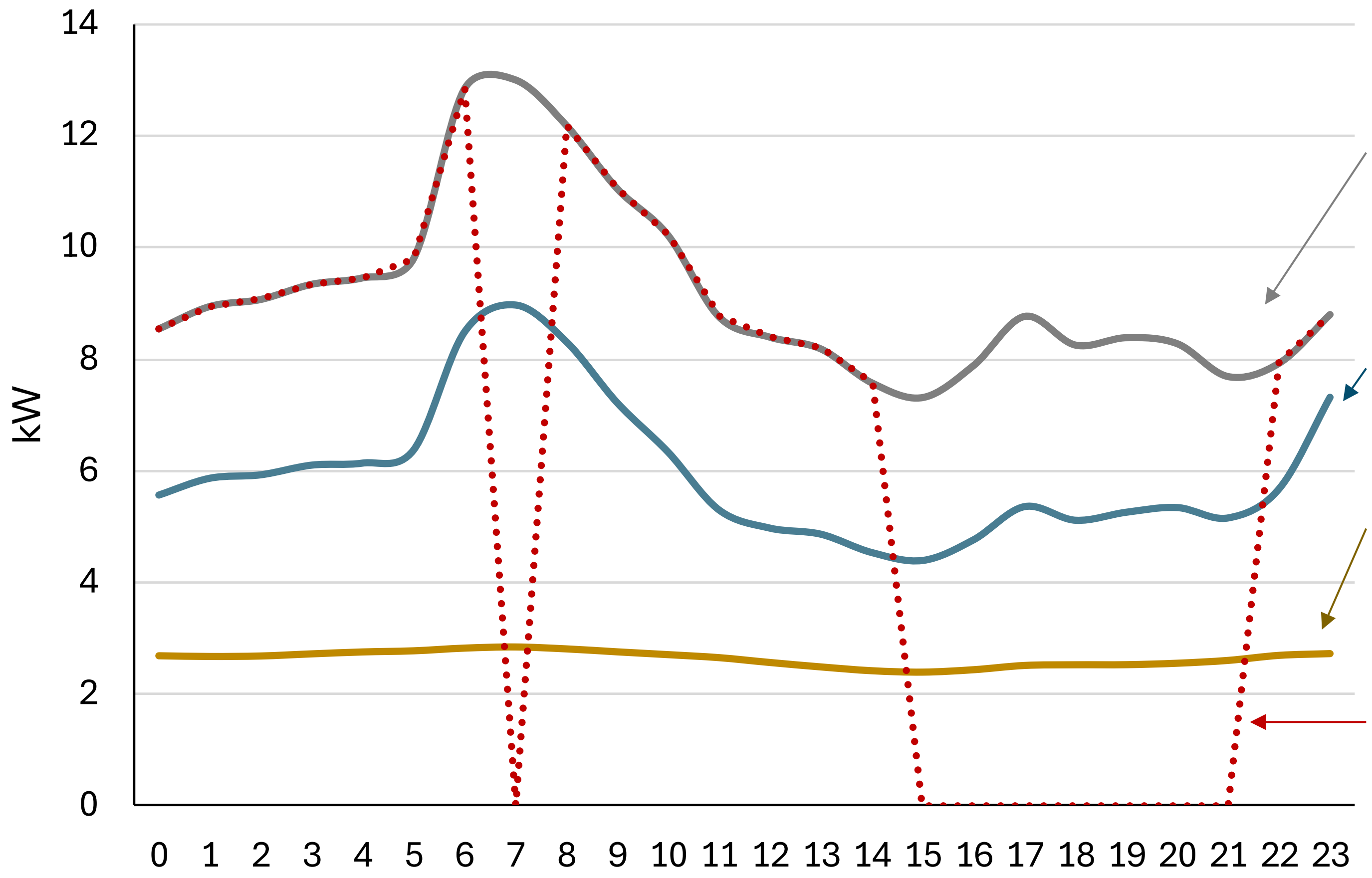
Appendix

Modeling Approach



Efficient heat pumps can serve as passive or active measures to reduce building electrification peak demand

Example Daily Household Heat Pump Load during Winter Day, 2030



Standard air source heat pump has high peak demand due to decreased efficiency at very low temperatures

Cold-climate heat pumps retain higher efficiency at low temperatures

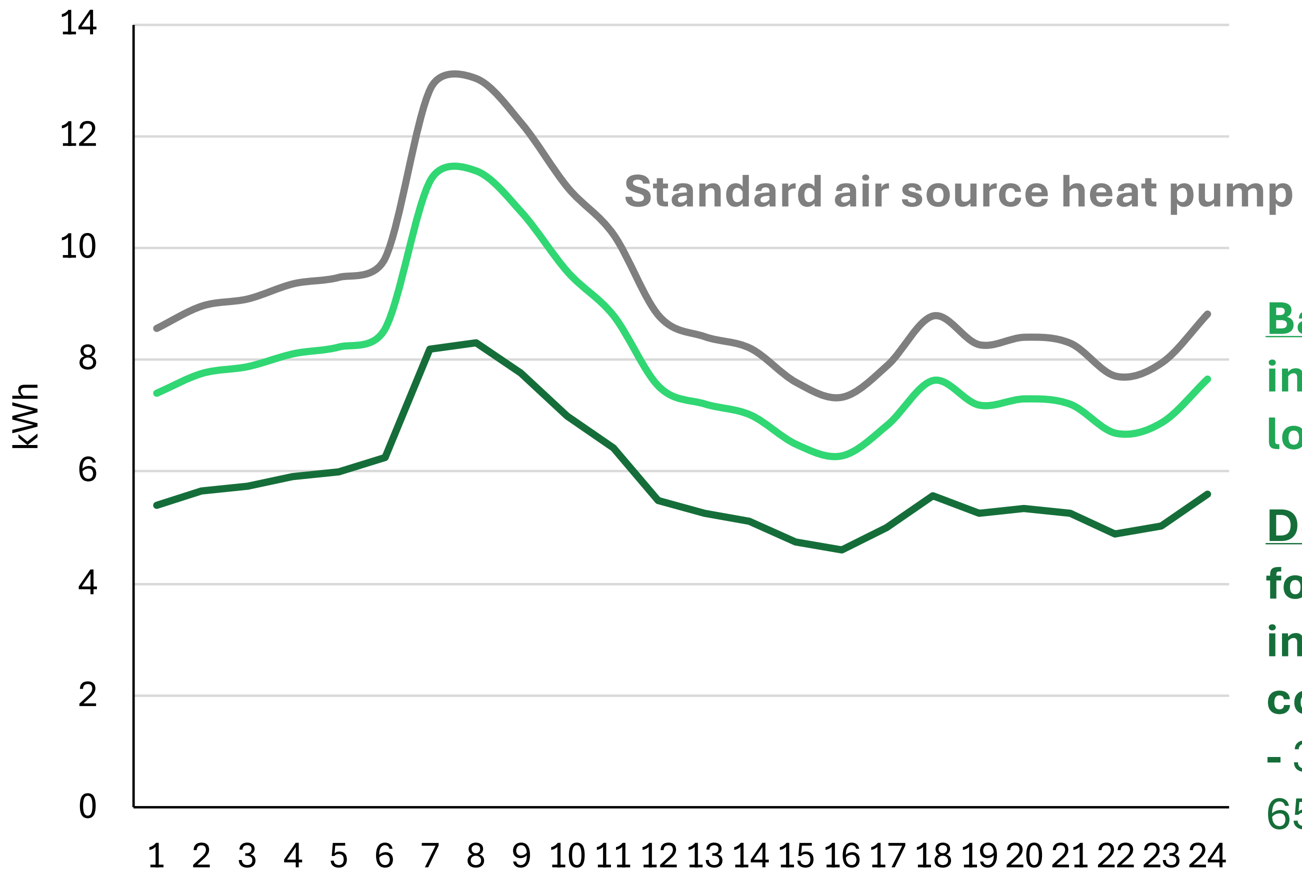
Ground-source heat pumps* offer significantly higher heating efficiency, but at significantly higher cost

Hybrid heat pumps with gas backup offer the greatest peak demand reduction due to switchover at critical hours

*assuming individual household GSHP; networked GSHP would see even higher efficiency gains

Building shell measures serve as passive measures reducing space conditioning energy demand

Example Daily Household Heat Pump Load during Winter Day, 2030



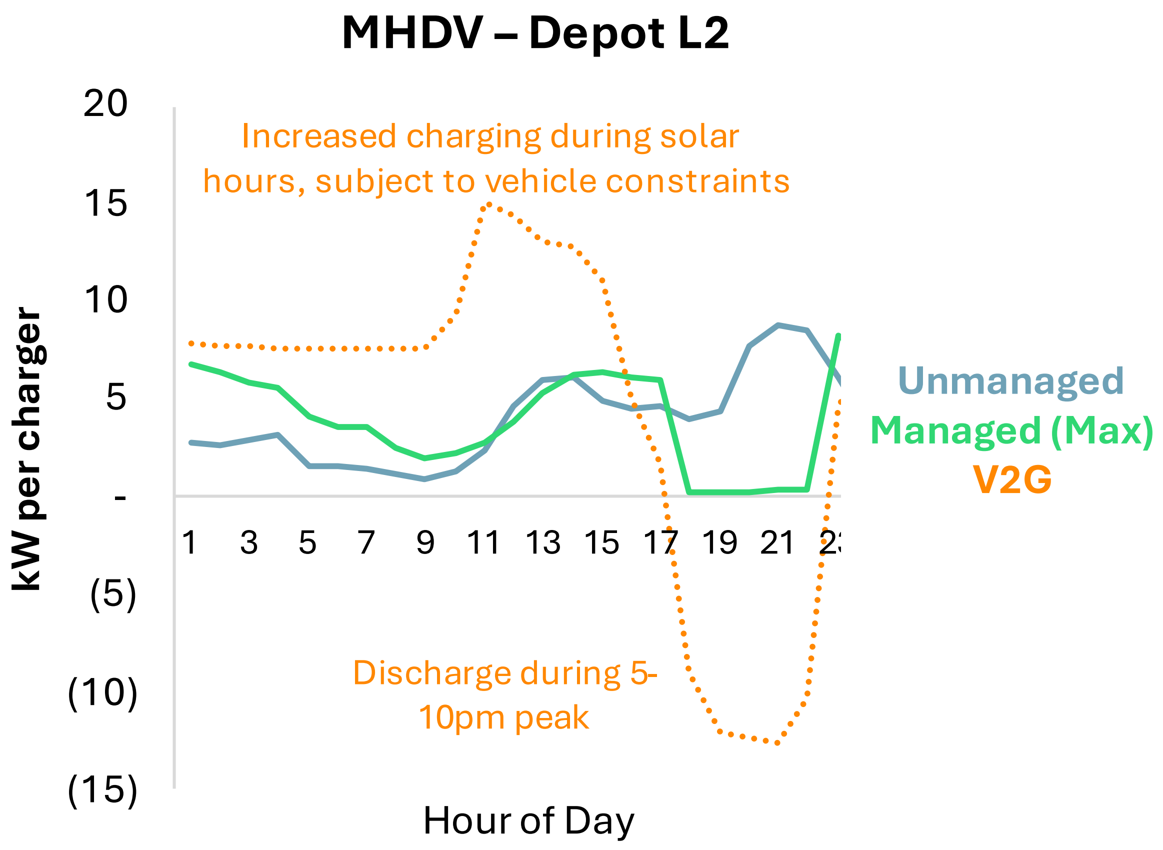
Basic shell improvements including attic insulation and air sealing can reduce heating loads by up to 20%

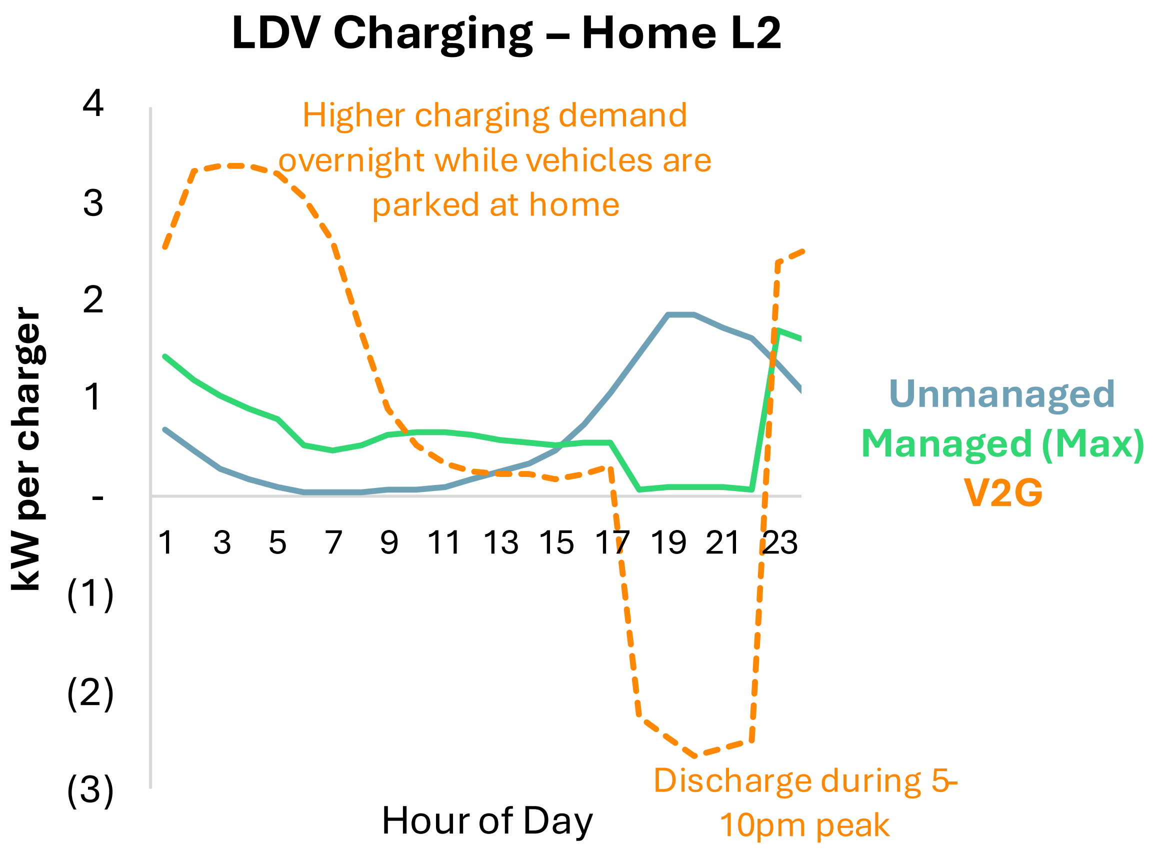
Deep shell retrofits including improved foundation and wall insulation can significantly increase energy savings, at higher cost compared to basic shell measures

- 35% savings shown here; load reduction of up to 65% achieved in pilot projects till date in MA.

V1G and V2G measures can shift load and contribute capacity during critical hours

Example 2030 Daily EV Charging Profiles

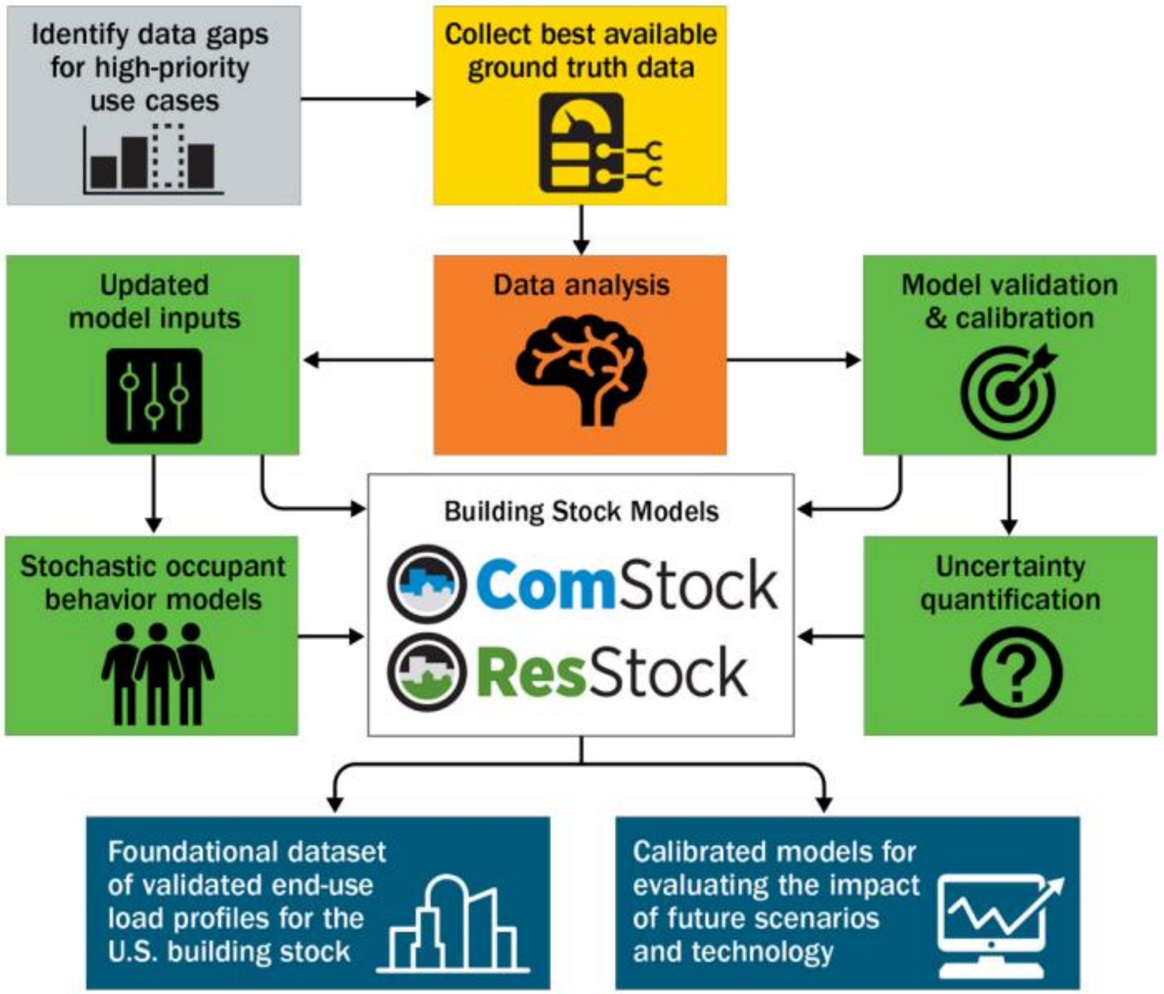




Shapes above developed in ongoing EEA study for Second EVICC Assessment

ResStock & ComStock may currently provide best known granular data source for Massachusetts' building stock

- **Collections of ~1 million energy simulations representing the entire US Building stock**
  - Based on a combination of calibrated and validated ground truth data and stochastic occupant behavior
- **Highly detailed, bottoms-up approach**
  - Geospatially down to the county level
  - Multitude of building characteristics available
  - Loads can be broken out at an end-use level and segmented by region, sector, building typology, technology, and more



Load Management Deployment Strategies

Current approach

Gross Load*

total load that the grid must meet on an hourly basis

Easy to track, communicate, & design programs around, but doesn't reflect when grid most needs to lower load given renewable output

Fix Peak Time Windows

specific windows based on historical or expected future net demand

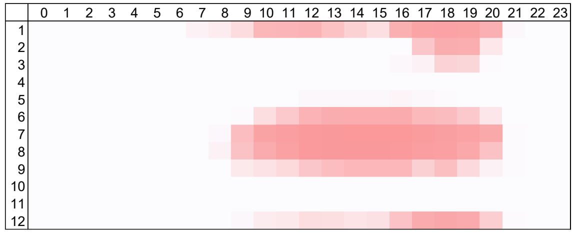
Easy to track, communicate & design programs for, but may overweight days without resource need and need updating over time to reflect evolving grid need

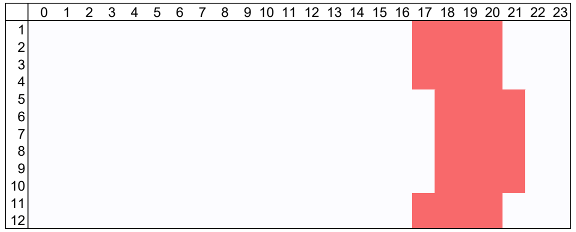
Critical Hours / Net Load*

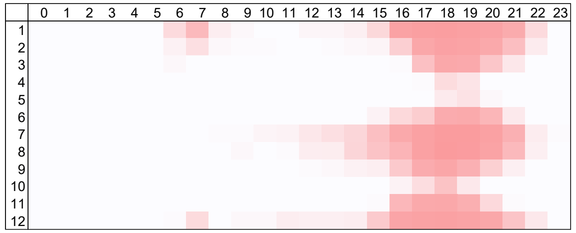
remaining resource need after renewable and thermal dispatch

Better representation of periods of greatest system need, but may be harder to design programs for

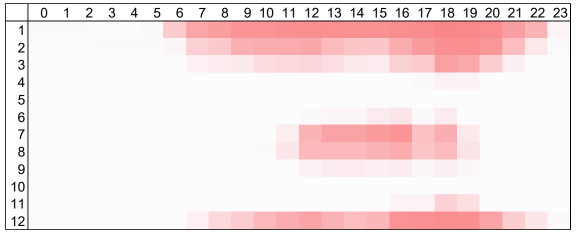
2030

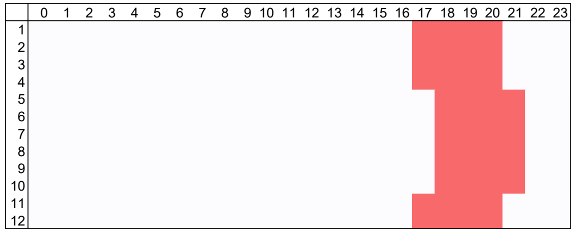


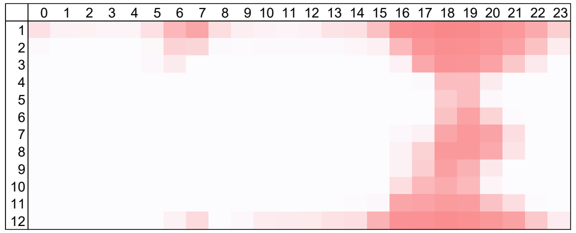




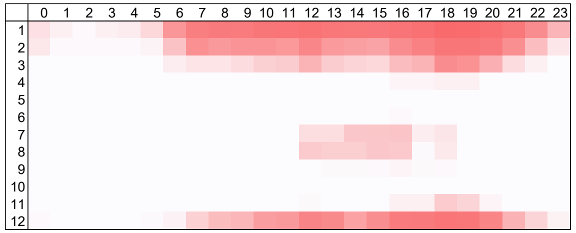
2040

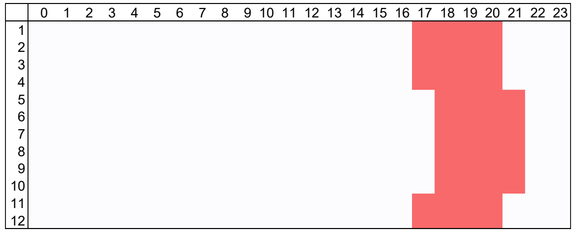


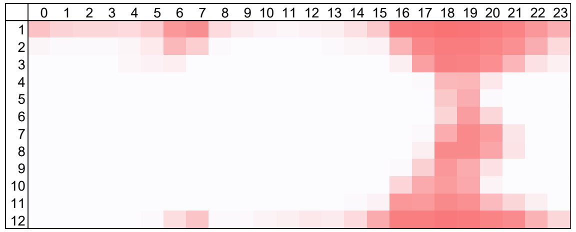




2050







*Currently using top 20% of hours, re-weighted to 100%. Net load shown is statistically estimated based on simulating many weather and load conditions.

Key Data Sources

Input	Source
Adoption of building shells, space/water heating, EVs	CECP
EV load shapes	EEA/Synapse EVICC Study *E3 weather-adjusted*
Industrial load shapes	NREL Dsgrid
Building load shapes	NREL ResStock and ComStock *Scaled to match CECP system peaks*
Building load shed and shift factors	LBNL *HVAC measures adjusted from CA to MA climate using design heating temperatures*
System gross load	Bottom-up estimate from loadshapes above and scenario adoption
System net load	CECP Phased Scenario renewable forecast *Calculated from gross load, subtracting CECP hourly generation of solar, wind, and hydro*
Installed BTM storage capacity	Annual utility storage report filings, Electric System Modernization Plan trajectories

Residential Load Management (LBNL)

Category	Technical Potential Modeling Assumption
HVAC *w. Programmable Communicating Thermostat*	*Load is shifted evenly into the preceding hours.* *In summer, 100% of load can be shifted for a 1-2 hr event, 82.5% for 3hrs, and 65% for 4 hrs.* *In winter, 20% of load can be shifted for a 1-2 hr event, 16.5% for 3hrs, and 13% for 4 hrs.* *CA->MA winter weather adjustments are based on heating design temperatures.* *Maximum shift duration of 4 hrs.*
Heat pumps with gas backup *w. Programmable Communicating Thermostat*	*Load is shed from every high demand hour.*
Dishwasher, washer, dryer, pool pump	*100% of load is shifted evenly to the preceding 8 hrs.*
Lighting, spa, plug load, pool heater, oven, well pump, fans	*Load is shed by 32.5% in each hour of a demand response event.**
Water heating	*Load is shifted evenly into the preceding hours. 100% of load can be shifted for a 1 hr event, 80% for 2hrs, 60% for 3hrs, and 40% for 4 hrs. Maximum shift duration of 4 hrs.*

*Spa: Manual shutoff capable of shedding 100% of load. 100% decreased to 30% to account for occupant availability to manually shut off the heater.
Plug Loads: provide shed capability when coupled with smart plugs or power strips. The shed fraction is assumed to be 50% based on the assumption that ~50% of electronics power draw is discretionary at any given time.
Lighting: Connected bulbs and manual shut-off. Can shut off 50% instantaneous, but drops to 35% (connected) or 15% (manual) for a window up to 4 hours duration

C&I Load Management (LBNL)

Category	Technical Potential Modeling Assumption
HVAC *w. Programmable Communicating Thermostat*	*Load is shifted evenly into the preceding hours.* *In summer, 90% of load can be shifted for a 1 hr event, 62% for 2 hrs, 56% for 2 hrs, and 50% for 4 hrs.* *In winter, 18% of load can be shifted for a 1 hr event, 12% for 2 hrs, 11% for 2 hrs, and 10% for 4 hrs.* *Winter weather adjustments are based on heating design temperatures.* *Maximum shift duration of 4 hrs.*
Heat pumps with gas backup	*Load is shed from every high demand hour.*
Lighting (Networked Control)	*Load is shed by 35% in each hour of a demand response event.*
Fans, heat recovery, pumps, refrigeration	*Load is shifted evenly into the preceding hours. 65% of load can be shifted for a 1 hr event, 65% for 2 hrs, 57.5% for 2 hrs, and 50% for 4 hrs.* Maximum shift duration of 4 hrs.*
C&I process load	*3-hour shed event measure 81% curtailment realization for length of DR call.*
Water Heating	*Load is shifted evenly into the preceding hours. 100% of load can be shifted for a 1 hr event, 80% for 2hrs, 60% for 3hrs, and 40% for 4 hrs. Maximum shift duration of 4 hrs.*
Storage	
Batteries	*Battery shifts load from the highest (net load)* ***4 hours*** *to the lowest* ***4 hours****. Batteries are assumed to have an 85% RTE.*

**Using refrigerated warehouse profile*

Transportation Load Management (EEA/Synapse)

Category	Charger Type	Technical Potential Modeling Assumption
Light Duty Vehicles (LDV)	Home L1 & L2 chargers	*95% participation, 100% off-peak charging.*
	Workplace chargers	*95% participation, 100% off-peak charging.*
	Public chargers	L2: *95% participation, 100% off-peak charging.* L3: *10% load reduction during on-peak periods for all chargers.*
Medium- and Heavy-Duty Vehicles (MHDV)	Private chargers	*95% participation, 100% off-peak charging.*
	Public chargers	*10% load reduction during on-peak periods for all chargers.*
V2G	Home L2 (LDV) and private chargers (MHDV)	Generalized dispatch profile adapted from other E3 V2G projects, discharging from 5-10pm peak period and charging subject to occupancy and minimum 25% EV battery charge constraints.