Priority R&D Needs to Decarbonize the Built Environment

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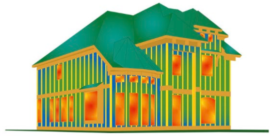
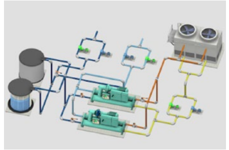
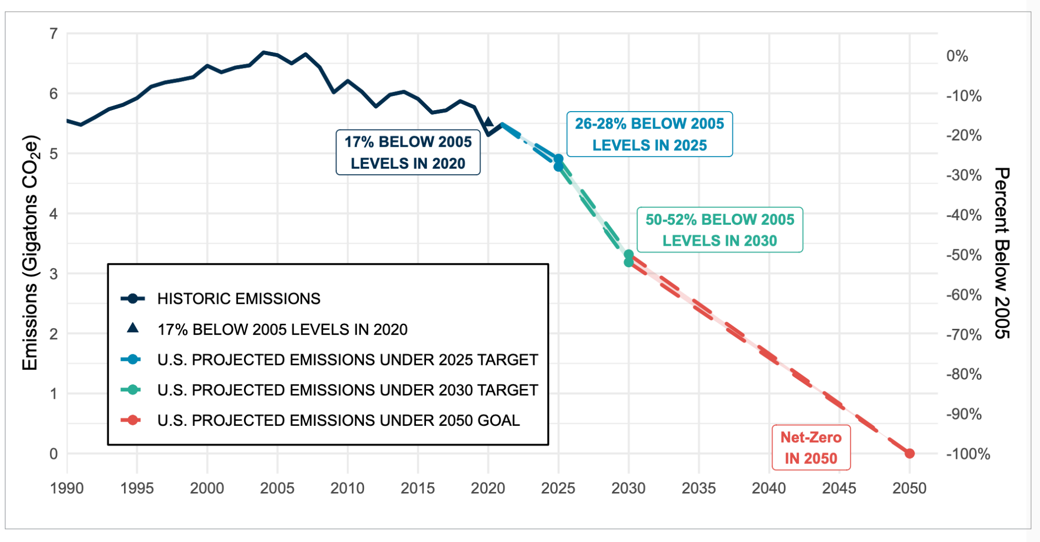
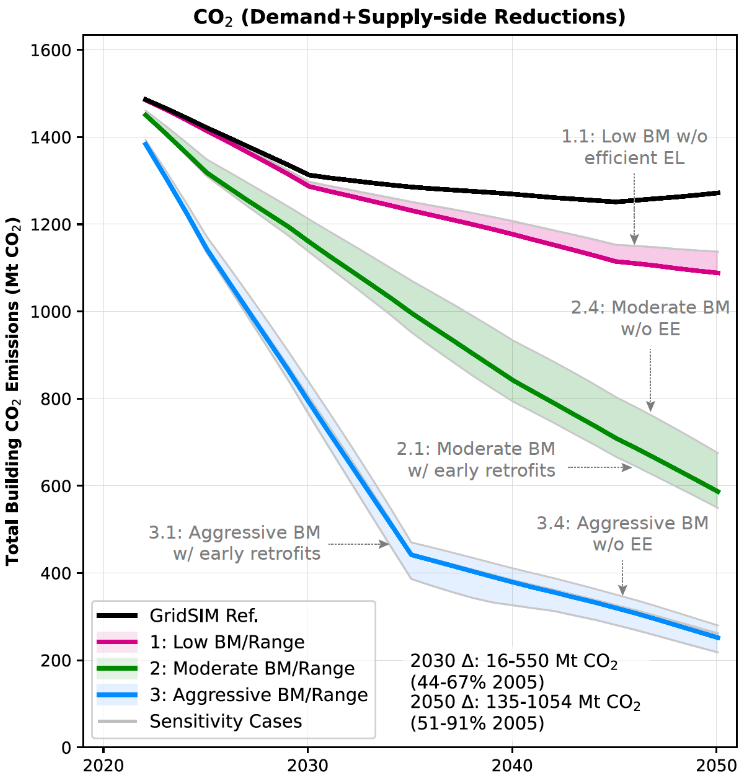
ENERGY TECHNOLOGIES AREA
BERKELEY LAB

From Efficient Components and Systems to Equitable, Sector-Wide Decarbonization









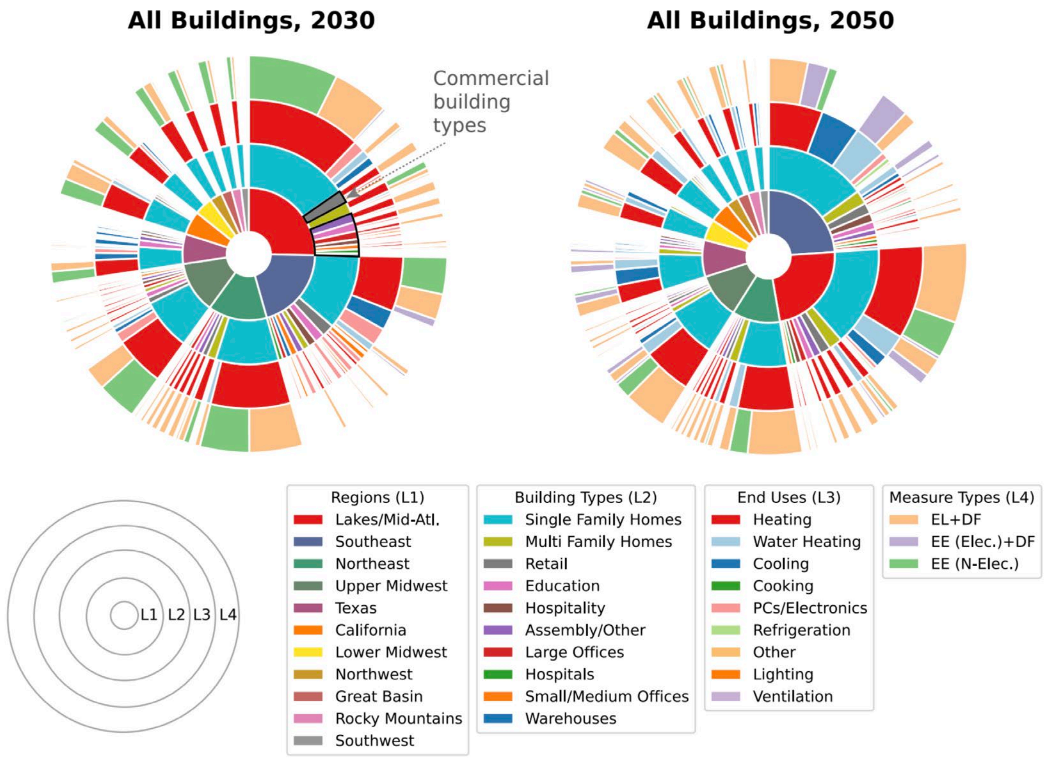
Business as usual reference

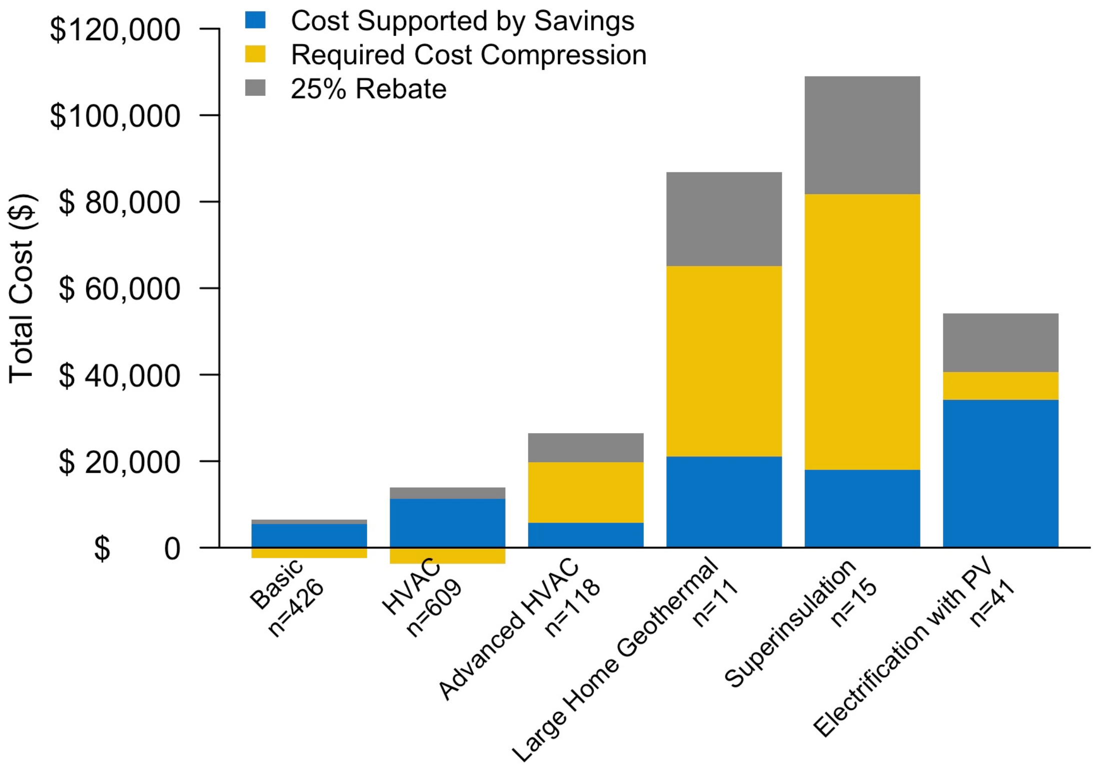
High rate of electrification

Moderate electrification, grid decarb, and efficiency, ~50% range by 2050

Most aggressive electrification, grid decarb, and efficiency, ~90% range by 2050

1. The largest emissions reduction potential lies within our homes





Emissions reduction potential from single- and multi-family homes is 65% of the total in 2030 and 72% in 2050.

Cost effectiveness constrains deeper decarbonization measures.

Health, usability and affordability are drivers of high-priority residential decarbonization R&D

Power-efficient Appliances (120V)

4.5 cu ft Condensing Washer/Dryer Combo	Heat Pump Water Heater	Through-Wall Heat Pump
10A, **1200W**	8.3A, **1000W**	6.3-15A, ~**1400W**
LG WM3998HBA	GE GeoSpring	Innova HPAC 2.0
		

RD&D Needs

Power management for electrification: smart panels, circuit splitters, and plugs

120V plug-in appliances

Field studies of improved health, and safety of decarbonized homes

Affordability analyses to target cost compression, financing solutions

2. The status quo in building controls is limiting success

- Commercial: 30% savings potential due to control and equipment faults, 19% un-accessed peak demand flex potential

- Smaller, but analogous and growing challenges in residential sector

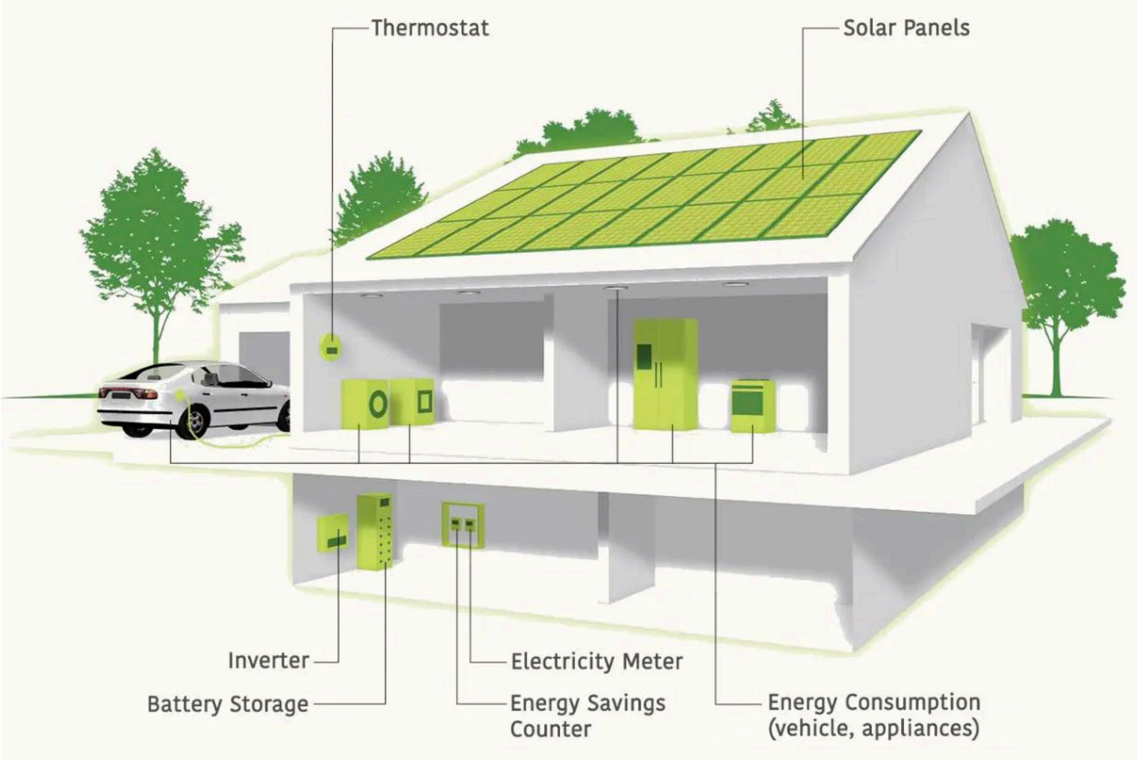


Image: Yale Environment 360

Performance-assured low-carbon operation will lock-in benefits

Application Needs

Scale across extreme heterogeneity

Preserve design intent throughout lifecycle

Integrate traditional end-uses and DERs

Minimize cost, emissions, maximize health, comfort and productivity

→

RD&D Needs

Sematic system interoperability

Digitization of controls delivery process

Self-correcting and fault-tolerant algorithms

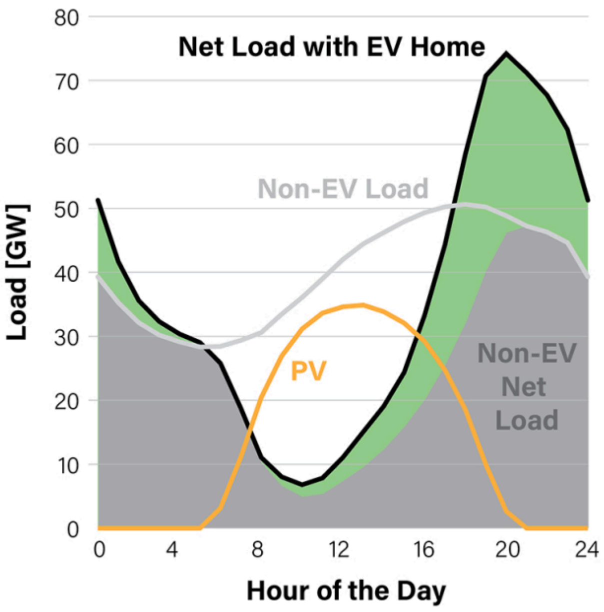
Classical and ML-based diagnostics and control optimization

‘Flight simulator’ environments to test and vet solutions

3. Demand-side flexibility is critical to a reliable affordable energy transition

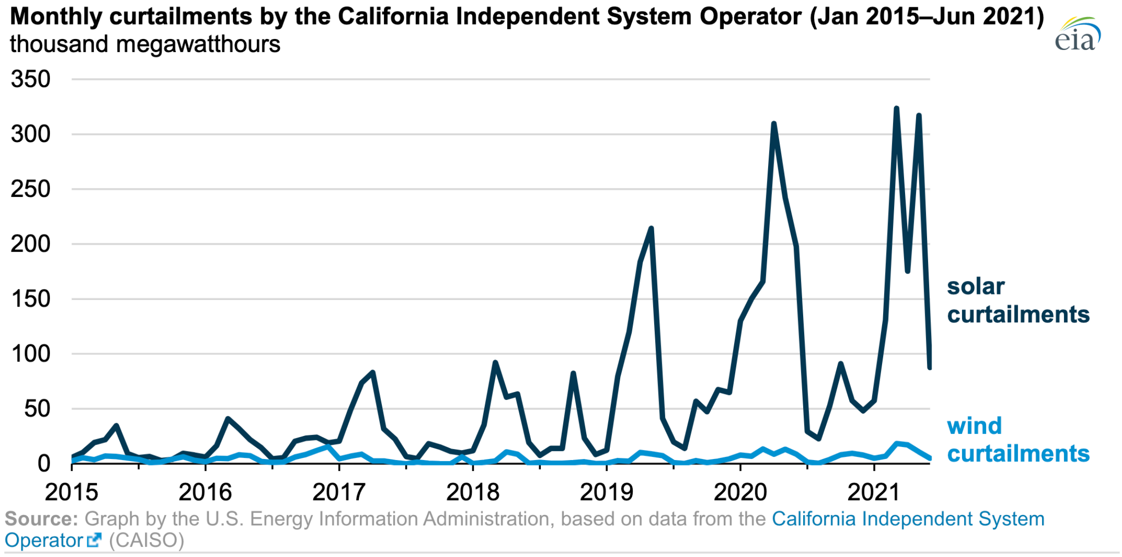
Electrification of buildings and transportation increases the magnitude and changes the time of the peak

c) INTEGRATION: EV charging can impact power system planning and operations, particularly with high shares of variable renewable energy.

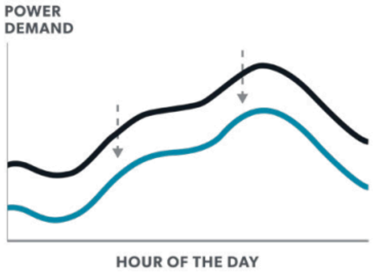
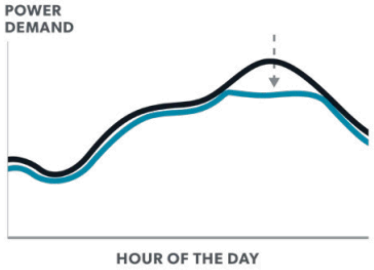
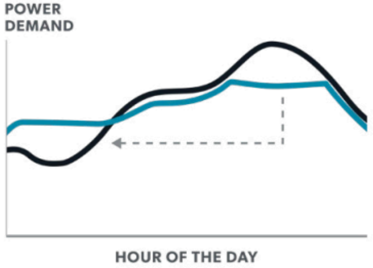


Muratori and Mai 2021, The shape of electrified transportation

With increased renewables, we see a mismatch of generation and demand



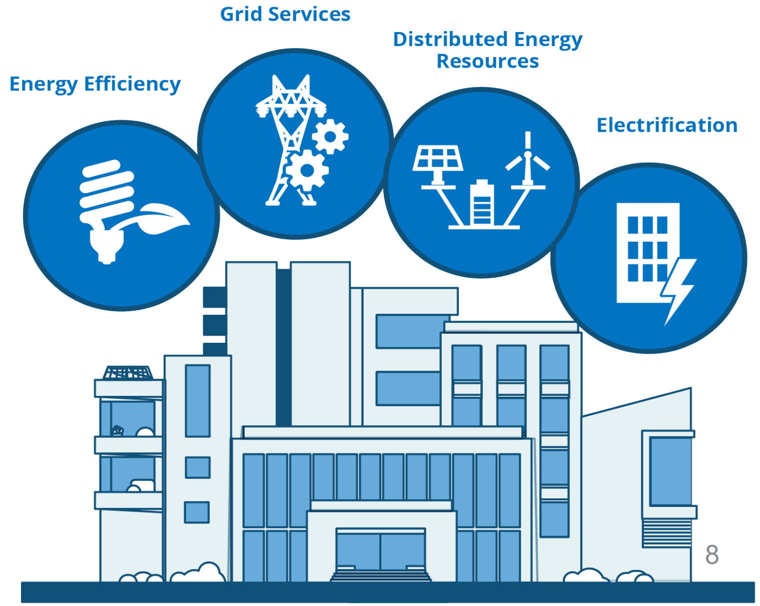
Buildings can provide critical grid services in support of the energy transition

	LOAD IMPACT	EXAMPLE MEASURE	EXAMPLE BENEFIT
Efficiency		Building has an insulated, tight envelope and an efficient HVAC system to reduce heating/cooling energy needs	Reduced costs of burning fuel to satisfy energy demand, and reduced emissions associated with lower fuel use
Shed Load		Building dims lighting system by a preset amount in response to grid signals while maintaining occupant visual comfort levels	Reduced investment in generation and transmission capacity due to lower peak demand
Shift Load		Connected water heaters pre-heat water during off-peak periods in response to grid signals	Reduced energy costs due to shifting consumption to cheaper hours of the day; avoided curtailment of renewables during off-peak periods

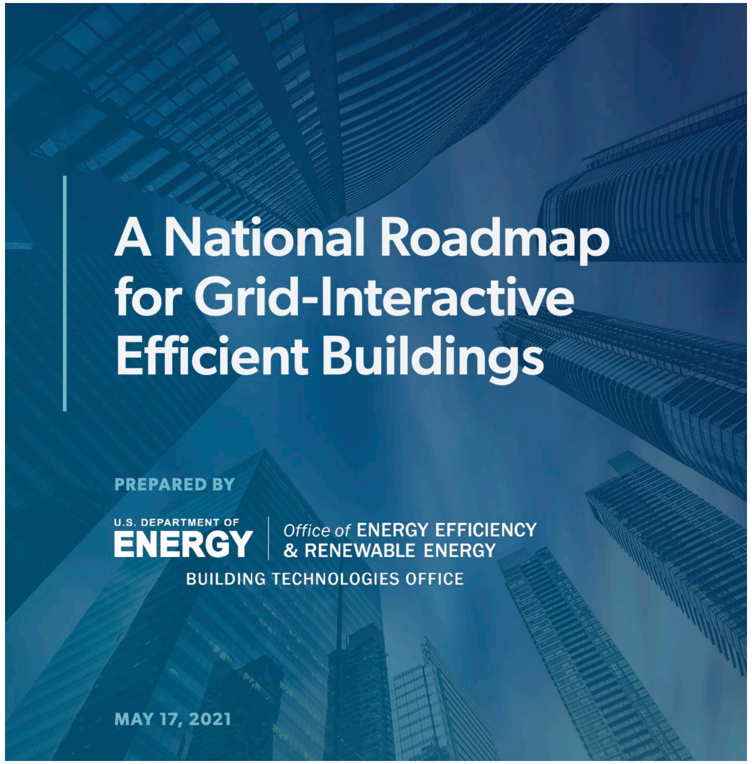
POWER DEMAND

U.S. power system benefits of $8-$18B/yr by 2030; 2–6% of total projected generation and transmission in 2030

Shift energy use to times of day when electrons are cleanest and most abundant; shed load to reduce the peak



DOE Roadmap details industry-wide barriers, recommendations



RD&D Needs

User friendly whole-building controls, thermal storage integration

Technology interoperability

Access and use of demand flexibility data, benchmarking

Understand user interactions with GEBs, role of technology and price models

GEB design, operation, decision making tools

** Cross-cutting needs to close the gap between technical potential and adoption potential

- Integrate behavior science, social science, and user-centered design into our work – towards the science of scaling deployment for building decarbonization

- Quantify and value co-benefits - health, productivity, and climate risk – overcome constraints of investment paradigms largely/exclusively built on avoided costs of energy

- Harness synergies between decarbonization and resilience, to meet market demand – this will drive additional R&D needs in technology, modeling, and measurement

THANK YOU