

Energy Innovation for a Net-Zero Future



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Efficient building heating and cooling, May 9, 2023

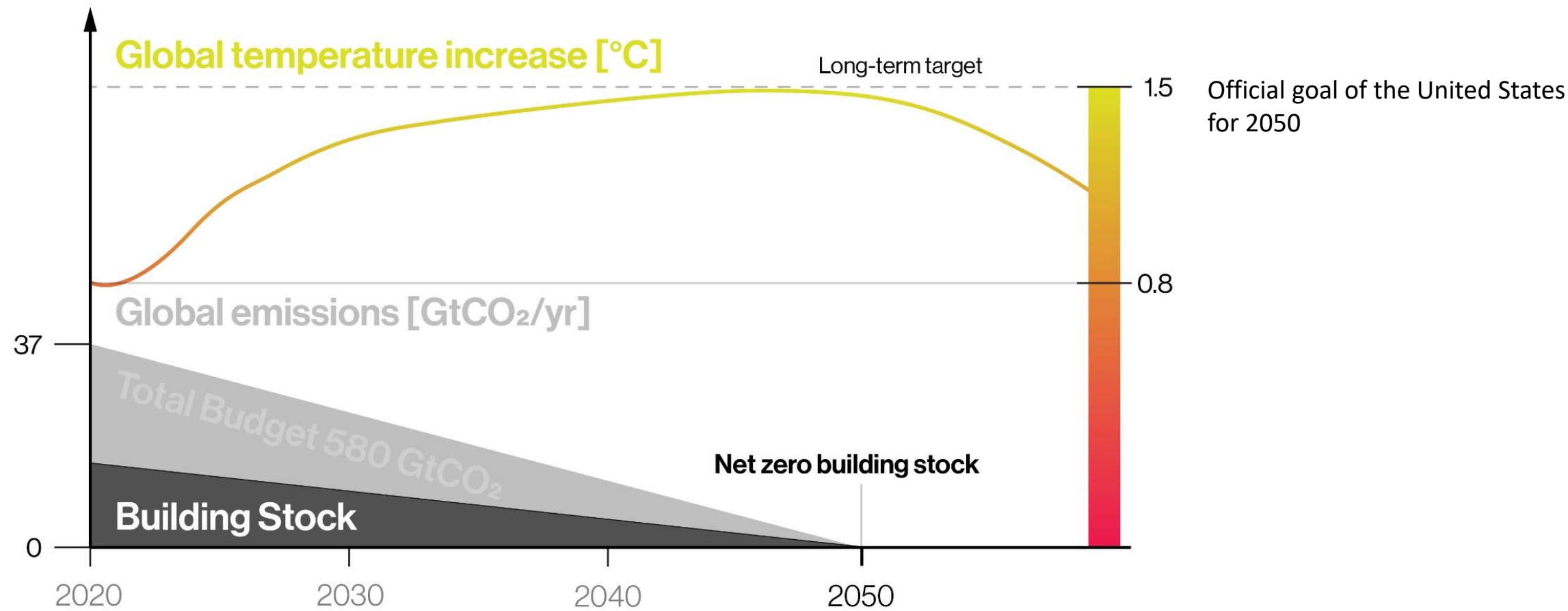
MIT SUSTAINABLE DESIGN LAB



Left: Snøhetta Powerhouse Telemark, Net Zero Office Building, Norway

Right: Utile Passivhaus in Brockton, MA

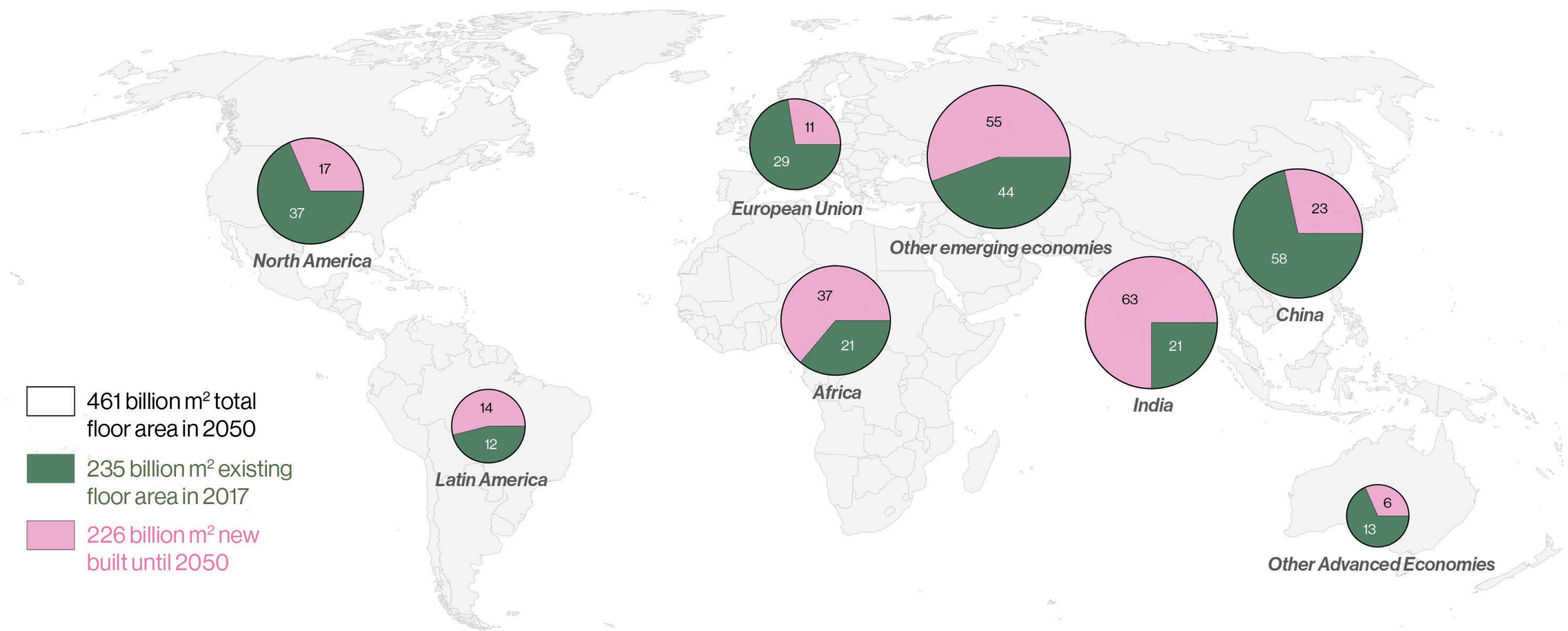
Climate Change and the Built Environment



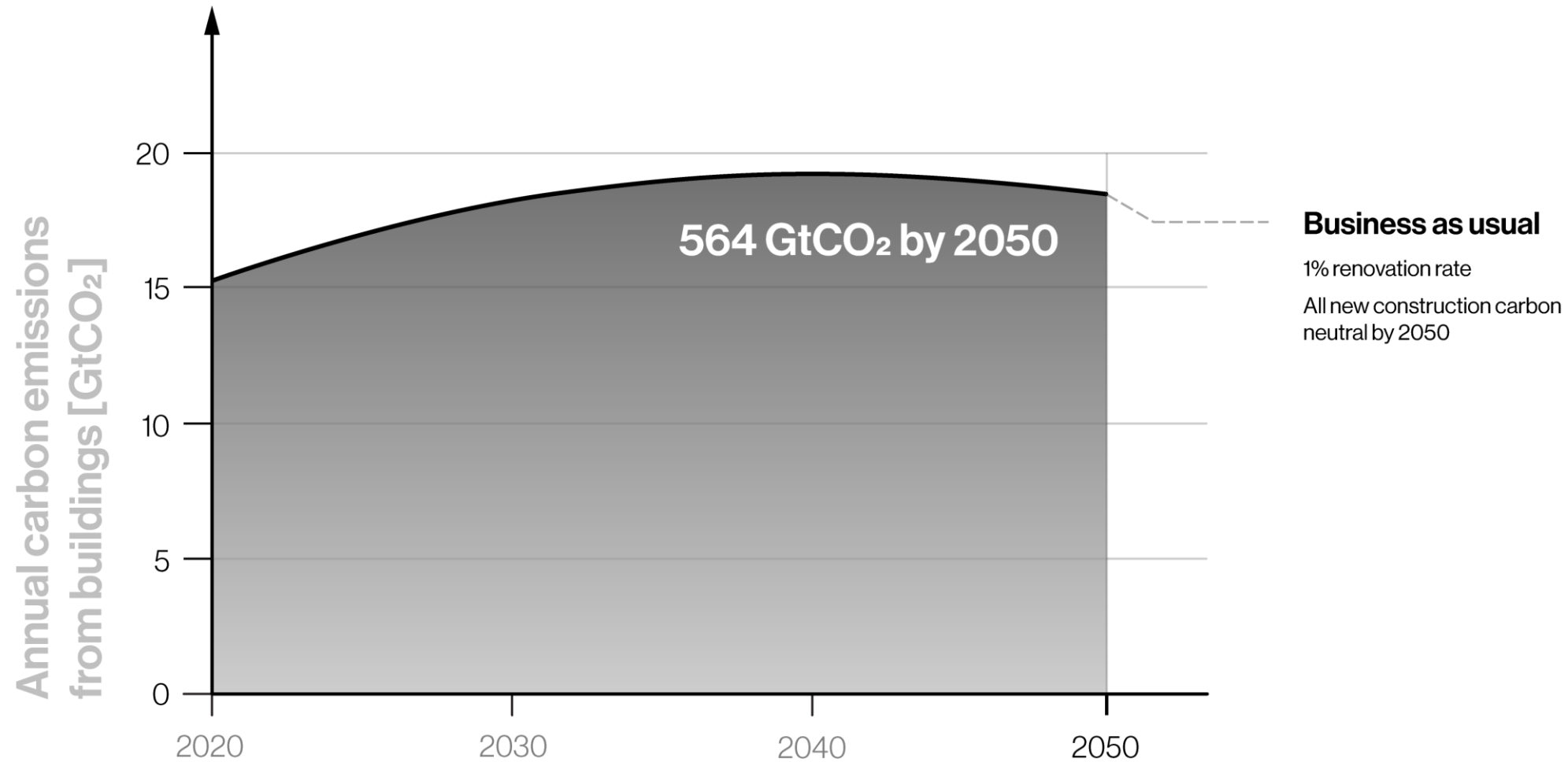
Our Challenge

We have 300 GtCO₂ and 30 years left to make the global building stock carbon neutral.

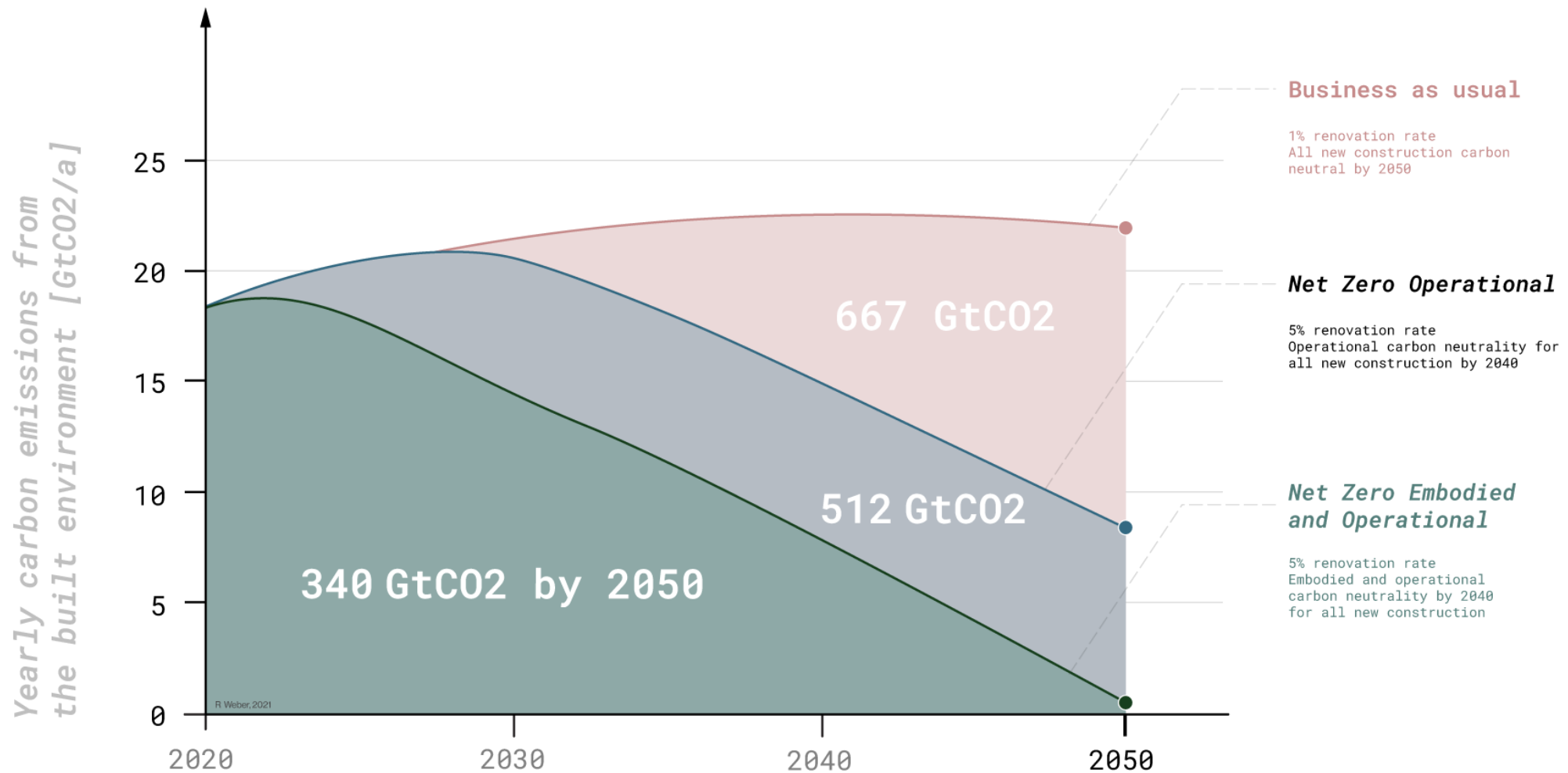
The building stock is going to double until 2050



Total annual carbon emissions from buildings



Total annual carbon emissions from buildings

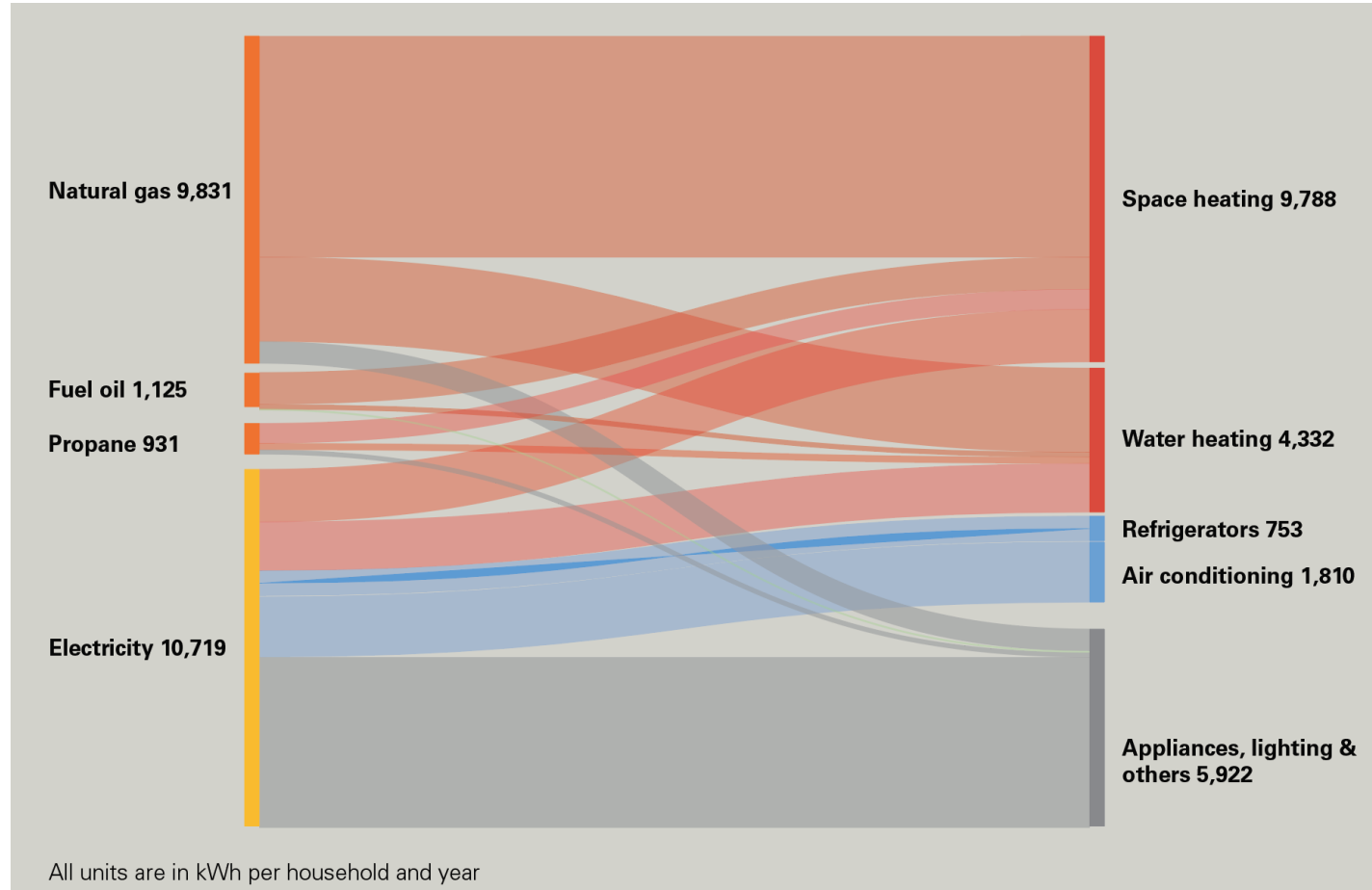


Our building goals for 2030

Increase annual retrofitting rate to 5%

All new construction is carbon neutral.

US Residential Energy Carriers and Uses for 2015 normalized by Household



Focus on efficient building heating and cooling

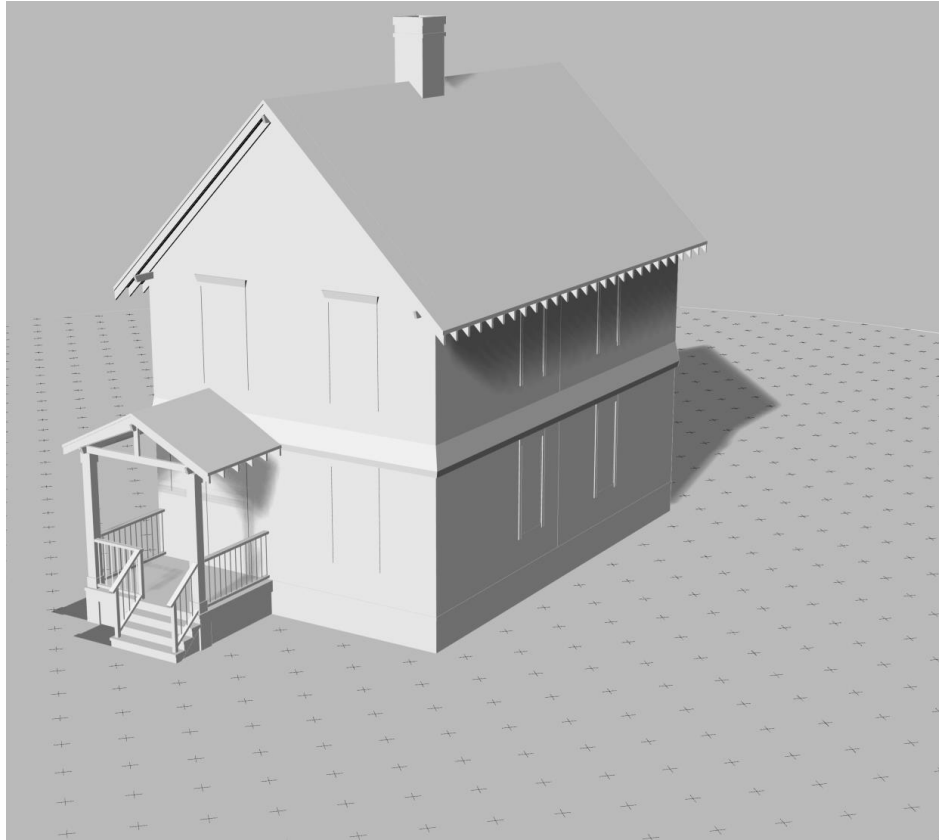
62% Space heating and domestic hot water
11% Cooling and refrigeration
27% Appliances and lighting

What **technology pathways** lead
to net zero retrofits?

Case Study - New England Home

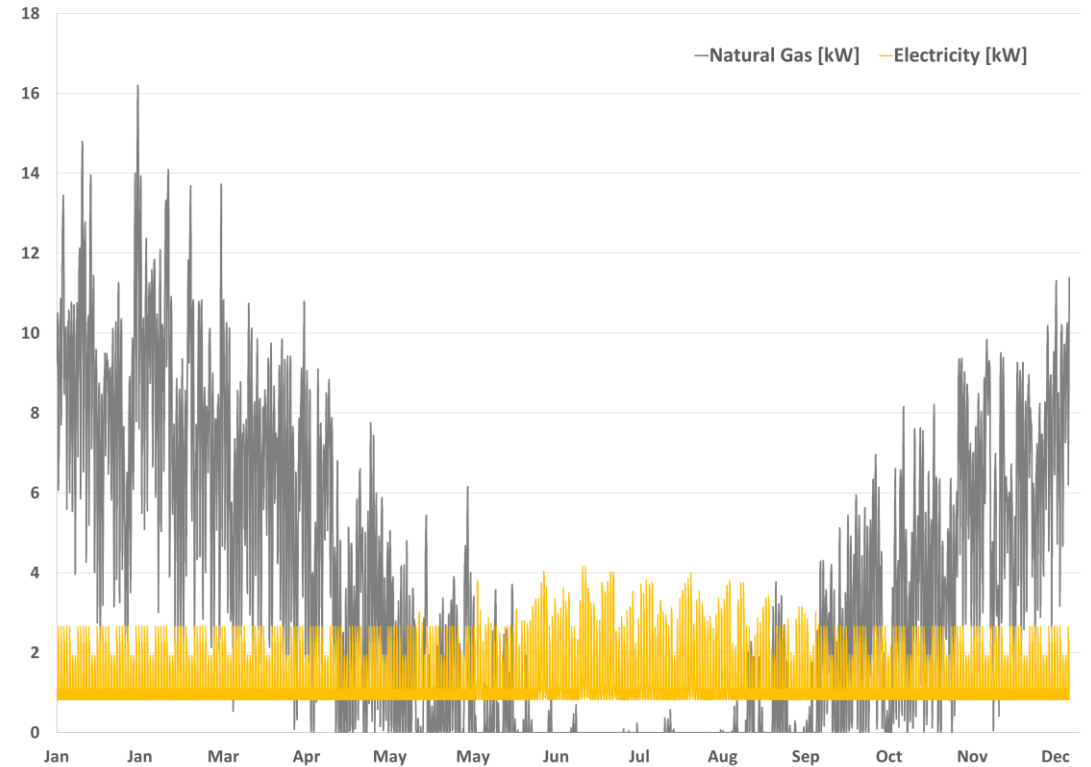
Owner perspective

Utilities \$3900 | Gasoline \$1700 | Emissions: 15.8tCO₂



Grid perspective

Peak_{Electric} = 4.2kW in July | Peak_{Natural gas} = 16.5kW in January

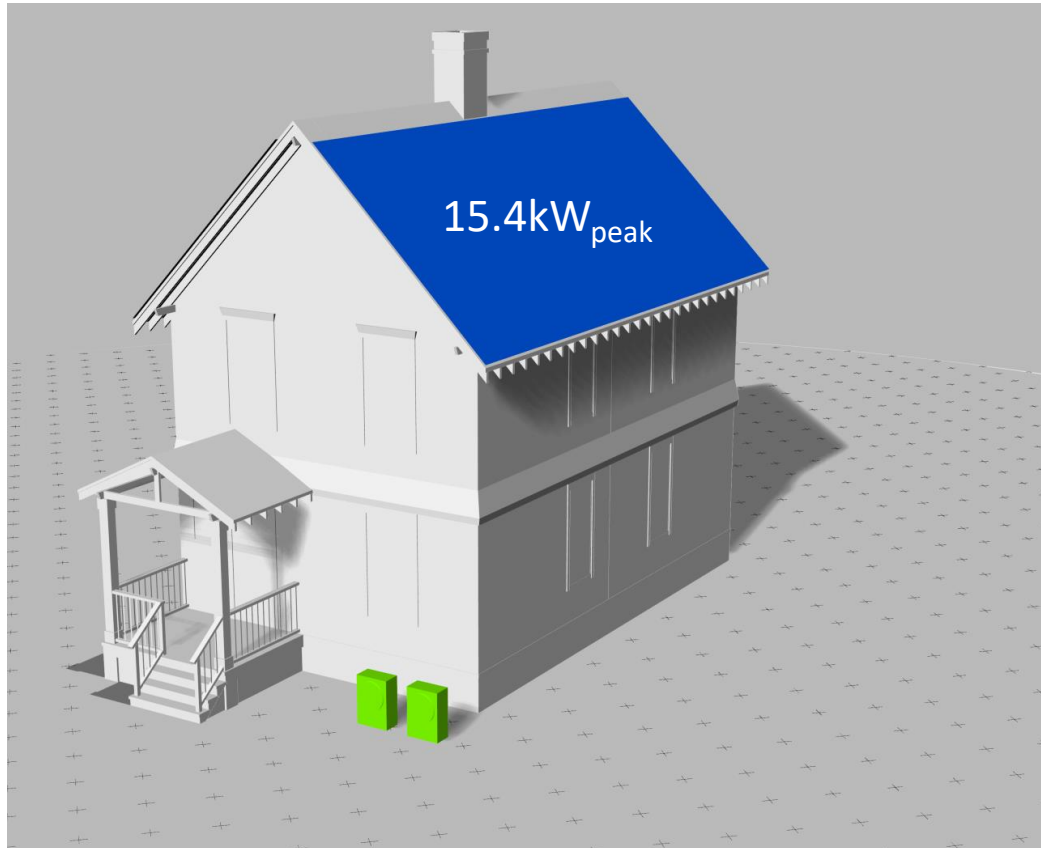


❑ How can our residents get to net zero while living in the house?

PV(maximized) + Heat Pump

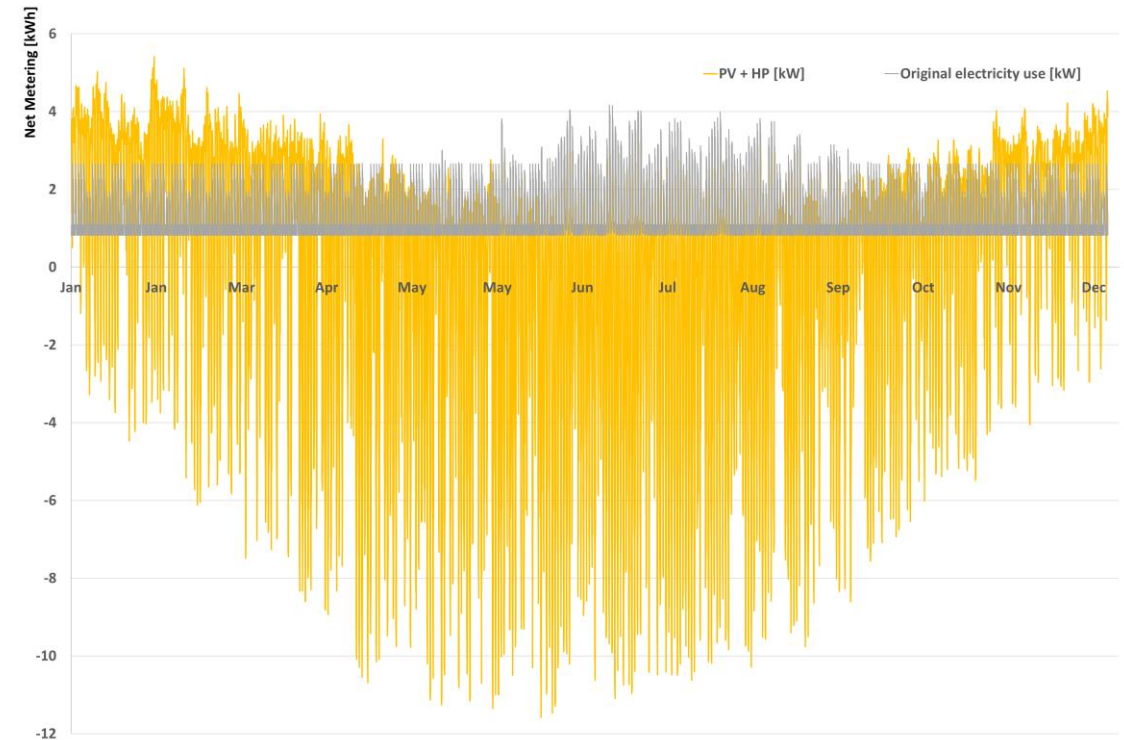
Owner perspective

Utilities **-\$113** | Gasoline **\$1700** | Emissions: **4.4tCO₂**



Grid perspective

Peak_{Electric} = **5.4kW** in July

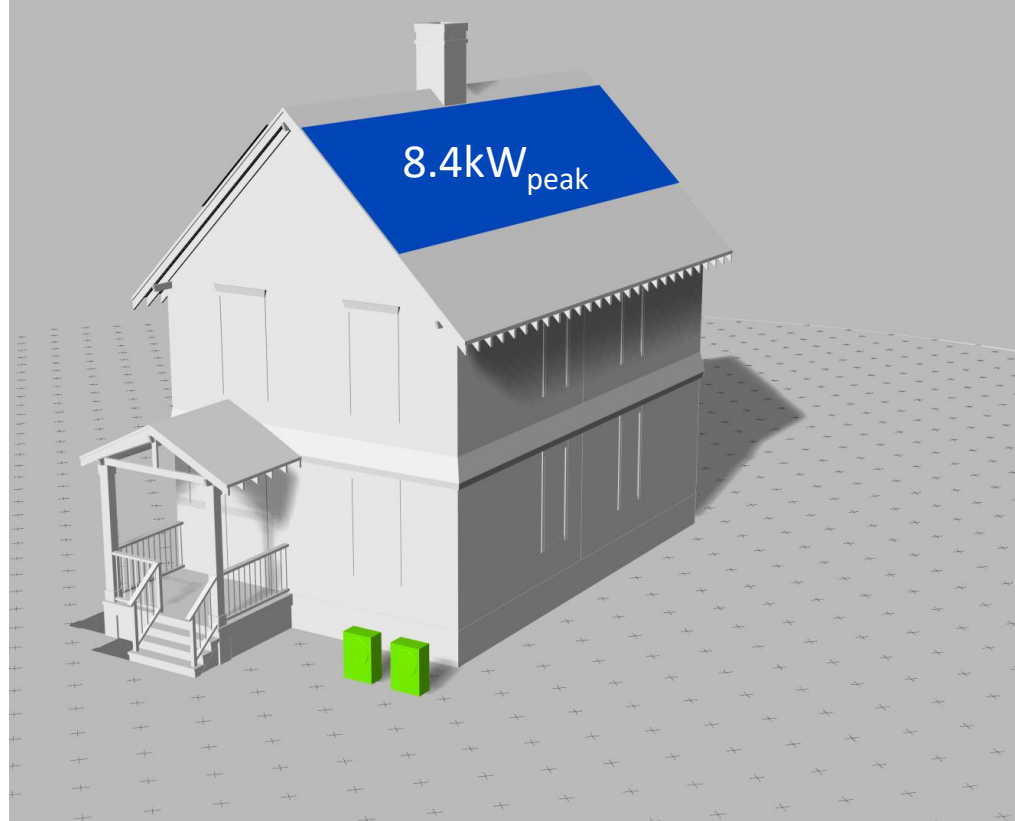


- ❑ Upfront cost: HP \$20,000 + maxed out PV \$33,000 = **\$53,000**
- ❑ Payback time: **13yrs**
- ❑ The building is “site net zero”. Electric peak moved to winter and increased by **70%**.

Retrofit + PV + Heat Pump

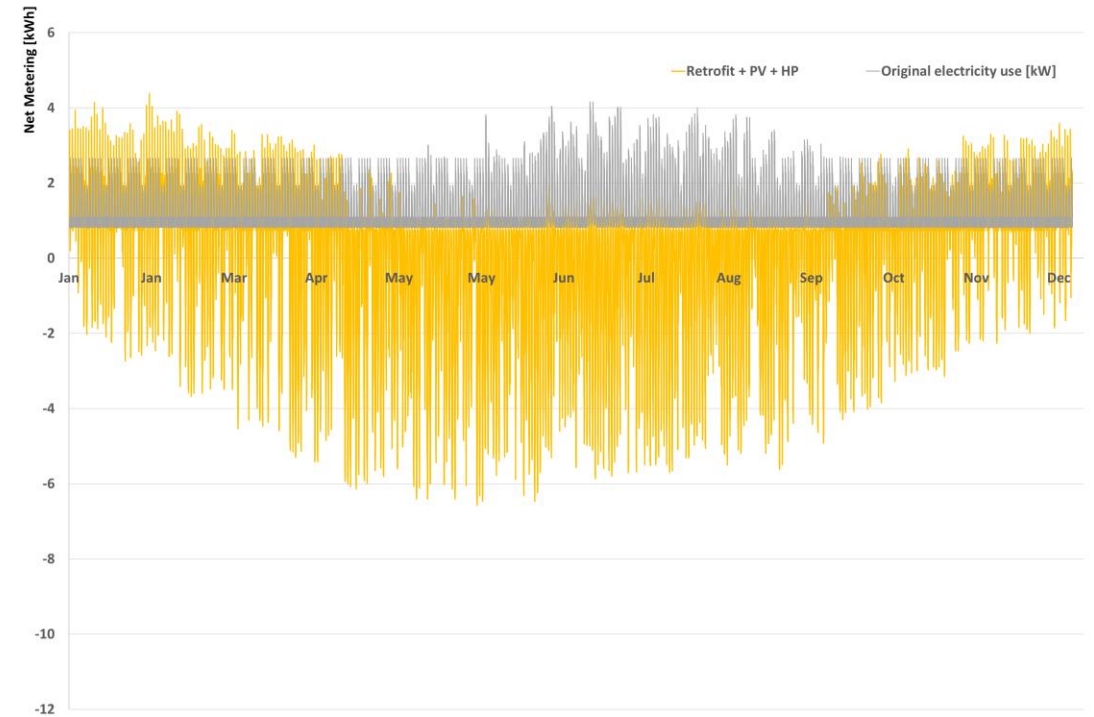
Owner perspective

Utilities **-\$73** | Gasoline **\$1700** | Emissions: **4.4tCO₂**



Grid perspective

Peak_{Electric} = **4.4kW in July**

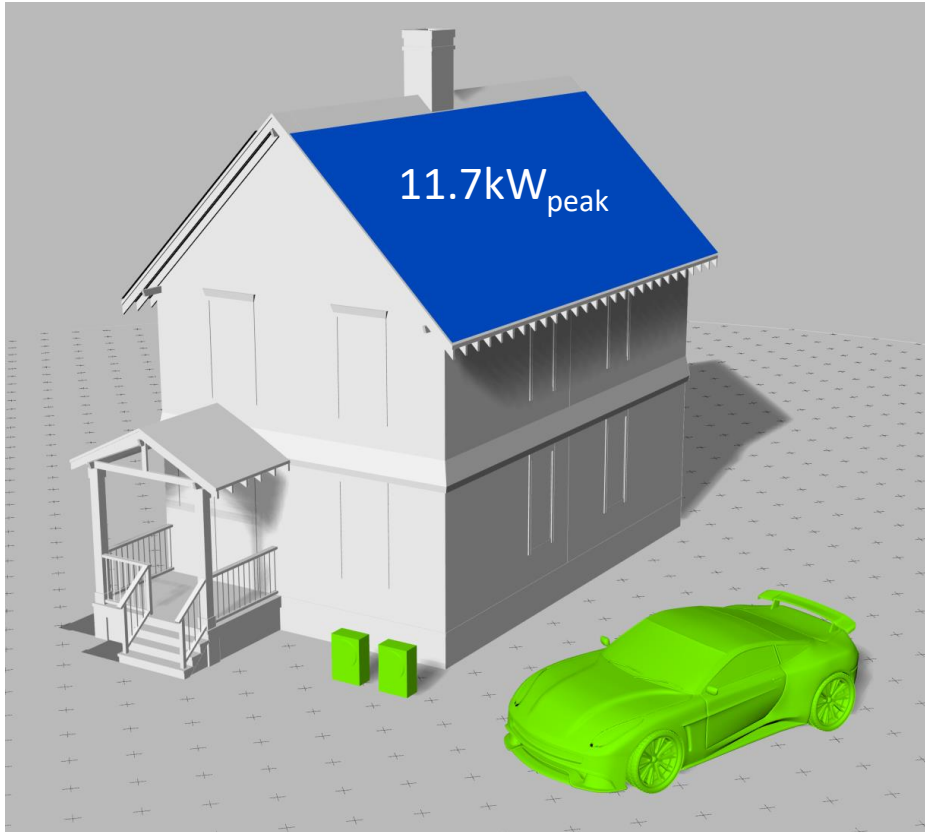


- ❑ Upfront cost: Eff. Appliances + LED + Smart thermostat + Insulate walls & attic + HP + right sized PV = **\$42,000**;
- ❑ Payback time: **10yrs**
- ❑ The building is still “site net zero”. Electric peak moved to winter and stabilized.

Retrofit + PV + Heat Pump + Electric Vehicle

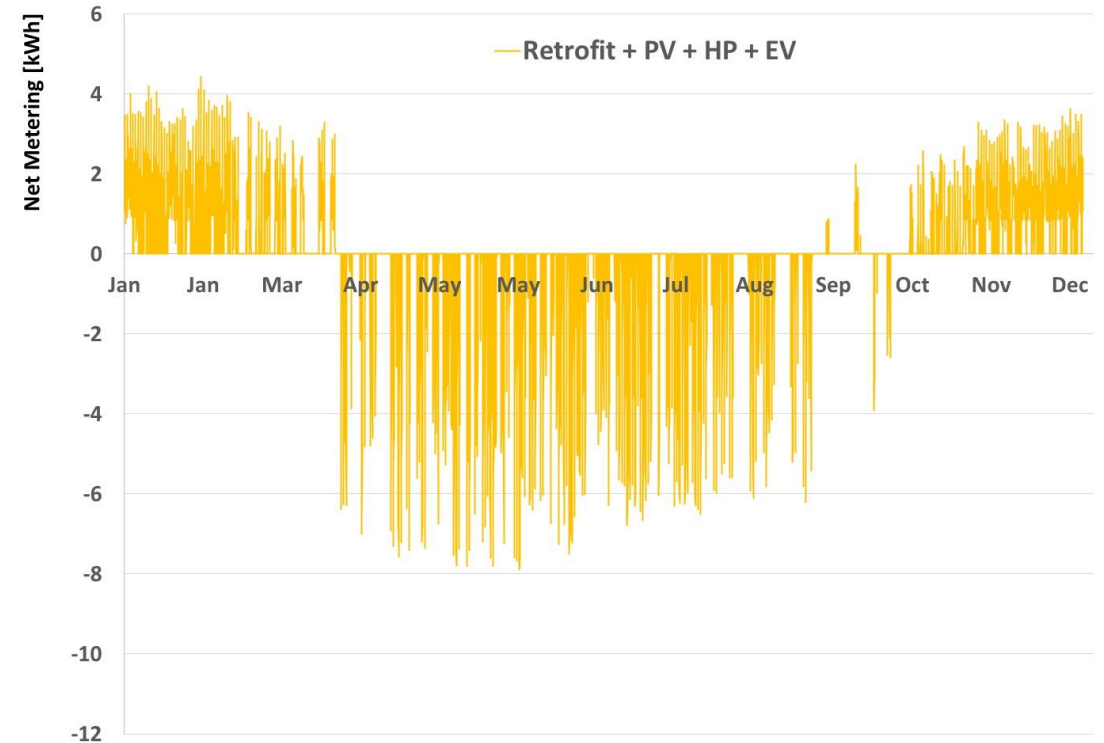
Owner perspective

Utilities **-\$60** | Gasoline **\$0** | Emissions: **0tCO₂**



Grid perspective

Peak_{Electric} = **4.4kW in July**

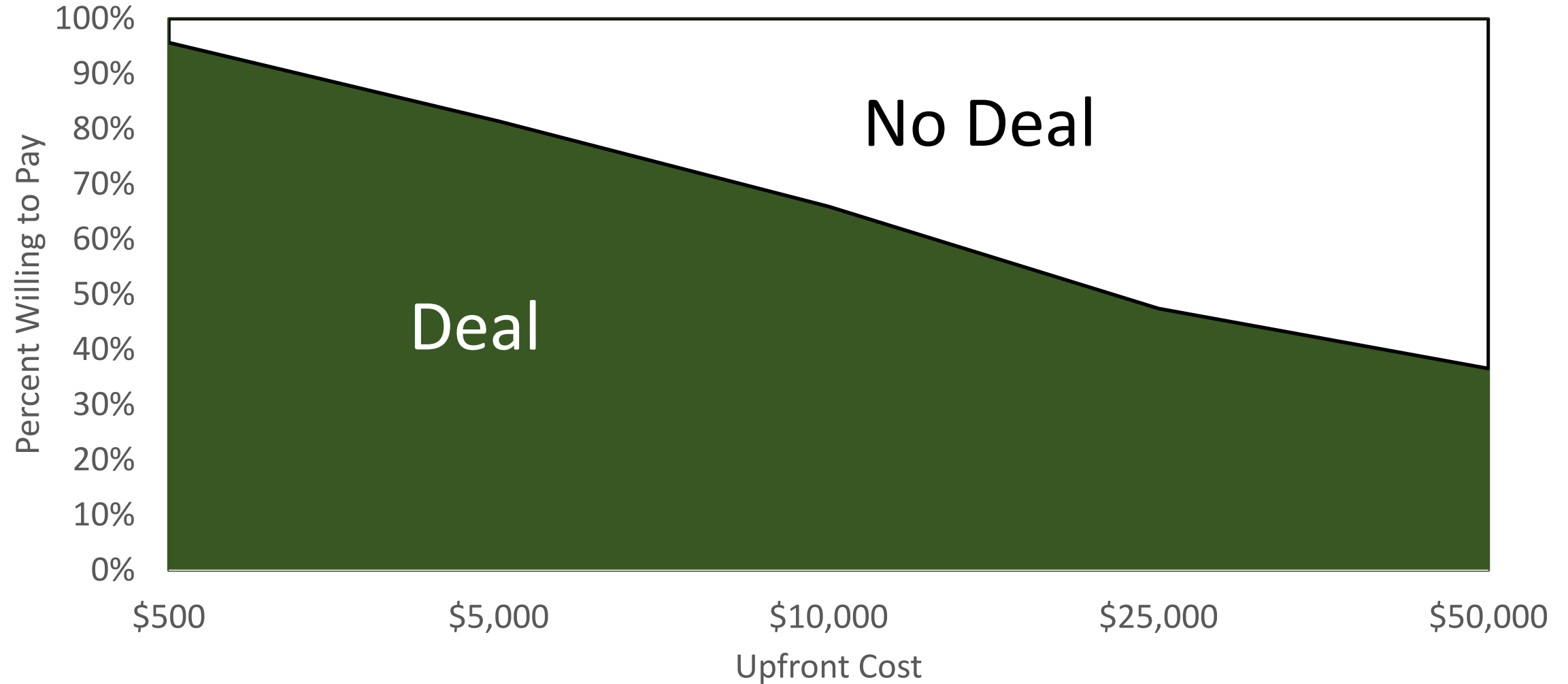


- ❑ Upfront cost: Eff. Appliances + LED + Smart thermostat + Insulate walls & attic + HP + right sized PV = **\$48,000**;
Payback time **8.5yrs**;
- ❑ Building off-grid from April to September. Battery control needs to be optimized.

Would owners pay for this?

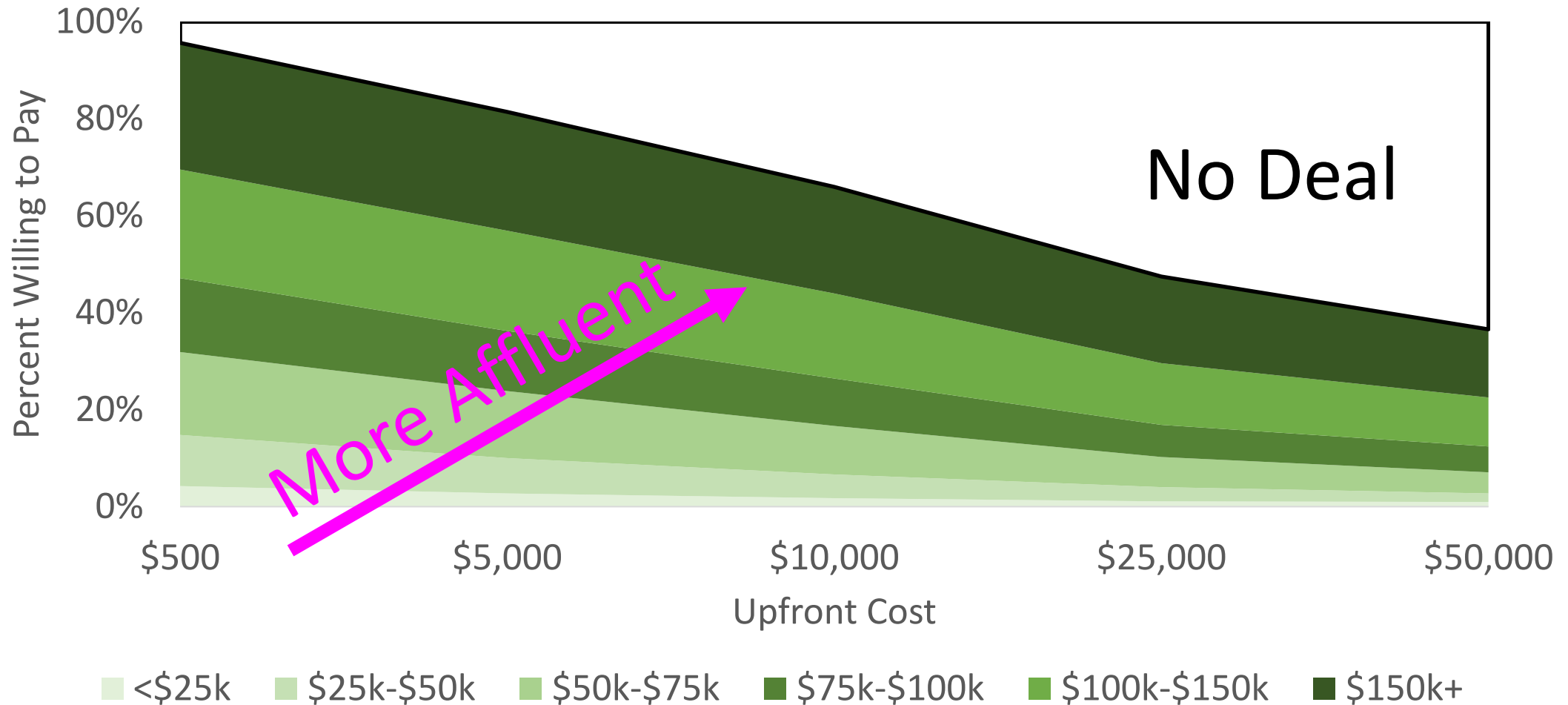
Percent Willing to Pay

Preliminary result



Percent Willing to Pay by Income

Preliminary result



- ❑ Technology adoption is biased towards home ownership and higher income levels.
- ❑ Need for more nuanced incentives (no over-subsidies).

New Construction - Passivhaus



152-158 Broadway
Somerville, MA | 45 Units
PHIUS Pre-certified, In Construction



Front St.
Portland, ME | 100 Units
PHIUS Pre-certified, In Construction



3371 Washington St.
Boston, MA | 39 Units
In Design, PHIUS-Registered



1200 Montello
Brockton, MA | 94 Units
In Design, PHIUS-Registered



25 Sixth St.
Chelsea, MA | 62 Units
PHIUS Pre-certified



1599 Columbus Ave.
Boston, MA | 65 Units
PHIUS Pre-certified



Walnut St. Housing
Foxborough, MA | 282 Units
PHIUS Pre-certified



1005 Broadway
Chelsea, MA | 38 Units
PHIUS Pre-certified, In Construction

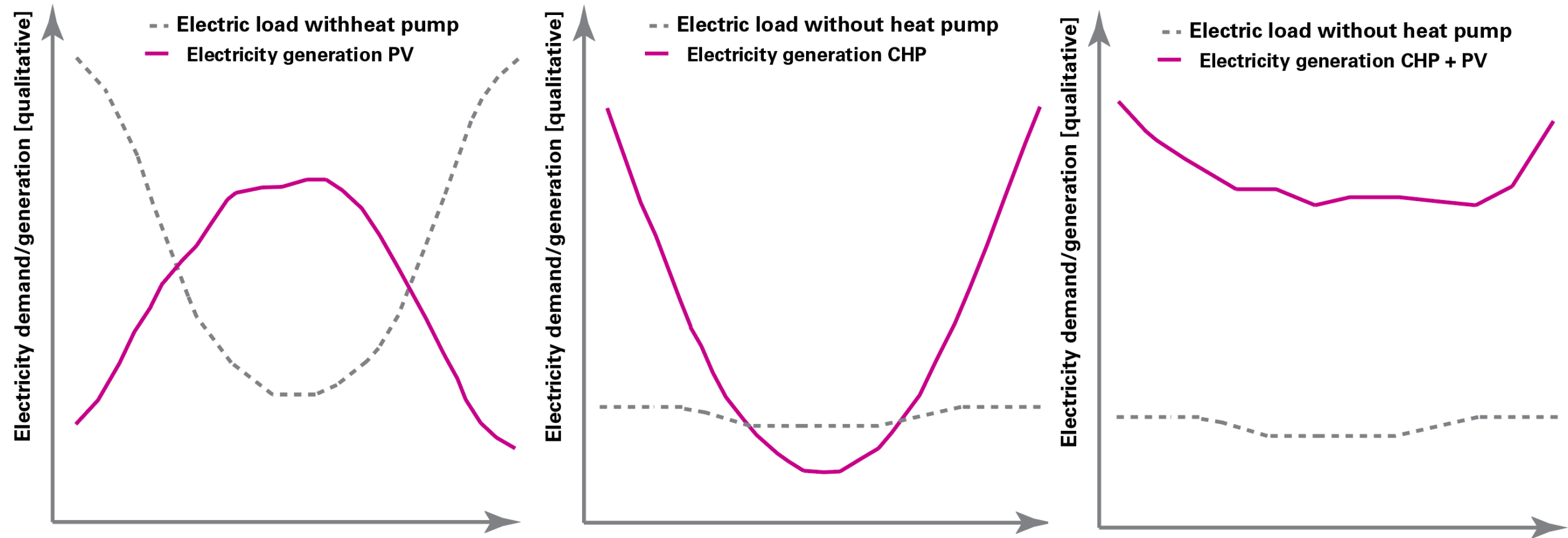
- ❑ Passivhaus is stringent building standard that requires tight construction with excellent envelope properties and controlled ventilation
- ❑ Multi-unit residential in New England is attractive for this technology.

Net Zero Commercial New Construction



- ❑ Net zero construction also includes on site PV generation.
- ❑ Commercial buildings require careful internal load management.

Matching Electricity Demand & Generation



Final Thoughts

- ❑ Technologies to improve building operation are **available today**.
- ❑ We need decision support tools and more **nuanced incentive structures** to allow all members of society to become net zero.
- ❑ Net zero in new construction is within reach for many buildings but requires thoughtful, **innovative design**.
- ❑ We need to secure additional renewable **heat sources during winter**.

Questions?

