Hybrid Heat Pumps

Midwest Energy Solutions Conference
February 1, 2022

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Decarbonizing Buildings

Two Branches for Decarbonization Pathways

More than half of homes & businesses have fuel-fired heating. Broad decarbonization pathways are:

Primarily Fuel-fired Pathway

Mostly Applicable to	Technology Needs
Existing Buildings	Gas Energy Efficiency ✓
Cold/Very-cold Climate Regions	Thermally-driven Heat Pumps ≈
Thermally Intensive Loads	Micro-CHP / Fuel Cells
Regions Rich With Decarb. Fuels	Hydrogen-fueled Equipment ?

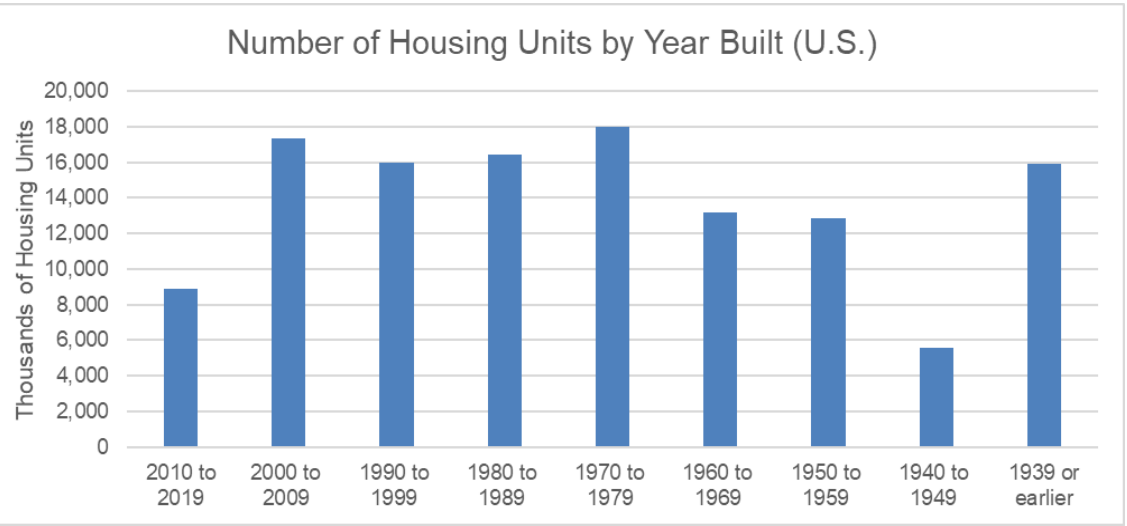
Primarily Electric Pathway

Mostly Applicable to	Technology Needs
New Construction	Grid-interactive Controls
Mild/Hot Climates	Dist. Energy Resources
Low Energy/Net-zero Design	**Hybrid Equipment/Systems**
Renewable Electricity-Rich Regions	BTM Energy Storage

?

Decarb. pathways differ by **age**, size, and location:

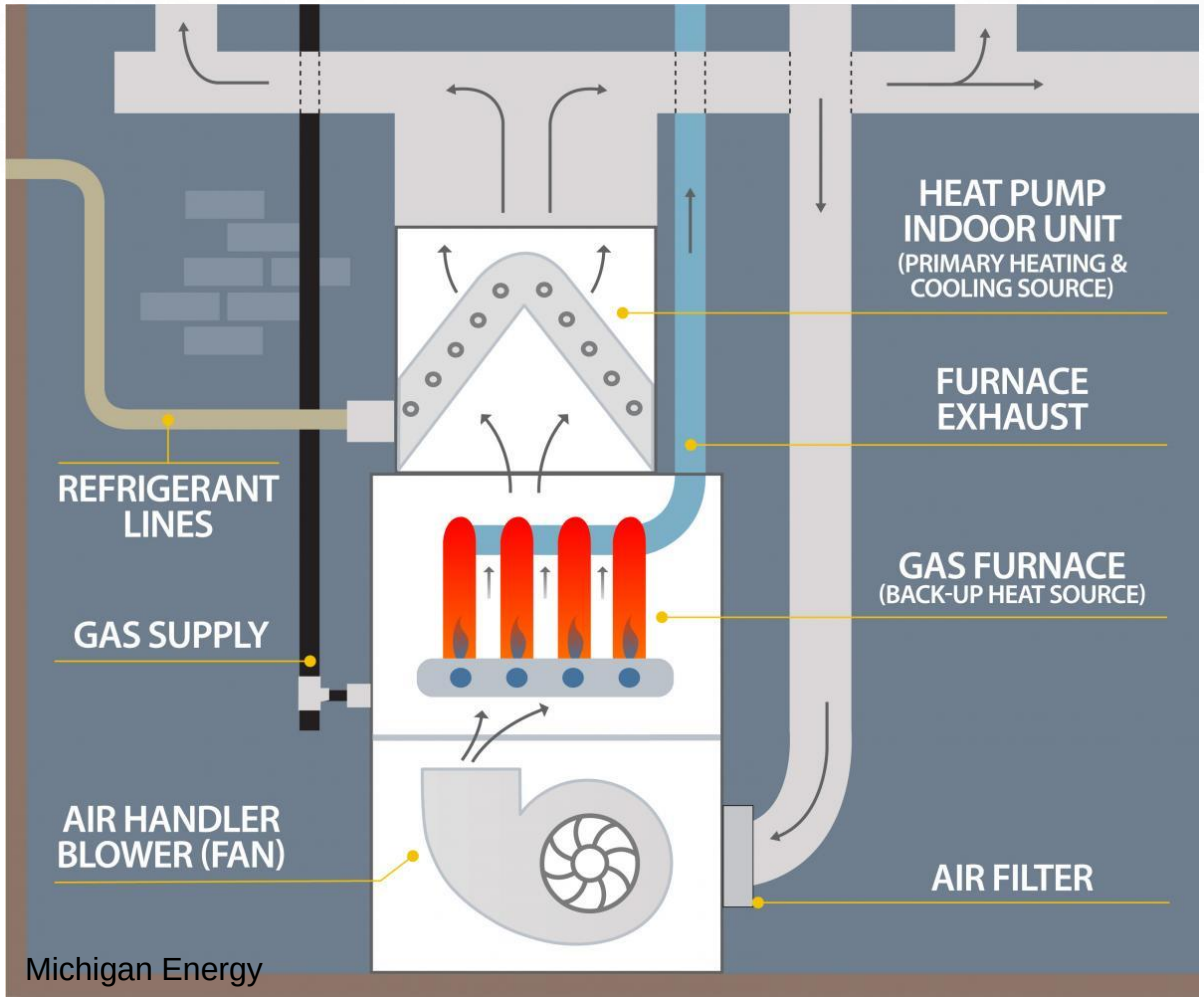
- 80% of US homes were built **before 2000***
- Average lifespan of US home is **130 years****



Source: *US Census, *2019 American Housing Survey*, **https://doi.org/10.1061/(ASCE)AE.1943-5568.0000401 ; Image Source: Chicago Bungalow Association, zeroenergyproject.org

Decarbonize now with Dual-Fuel Hybrid HVAC

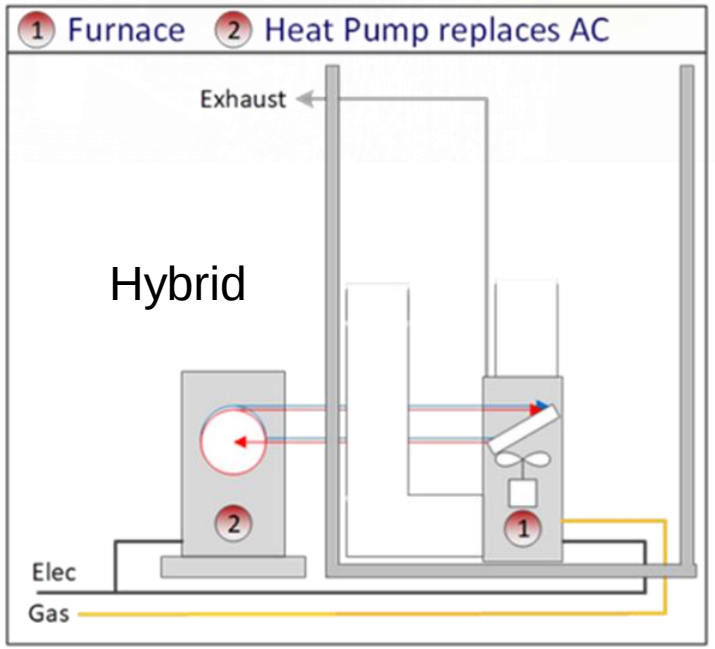
Example ASHP paired with Low-capacity furnace = 15,000 BTU modulating to 6,000 BTU



Key Concept: Cutoff Point for fuel crossover

What might be the rationale for hybrid heat pumps?

- **Society**
  - Reduce CO_2 emissions cost-effectively
  - Utilizes existing infrastructure
- **Utility**
  - Strategic Electrification
  - Adding winter load with a safety net
  - Opportunity to develop non-wires solutions
- **Customer**
  - Leverage best attributes of two heating technologies
  - Ready retrofit (AC replacement)
  - Opportunity to control for different objectives (cost, efficiency, emissions)



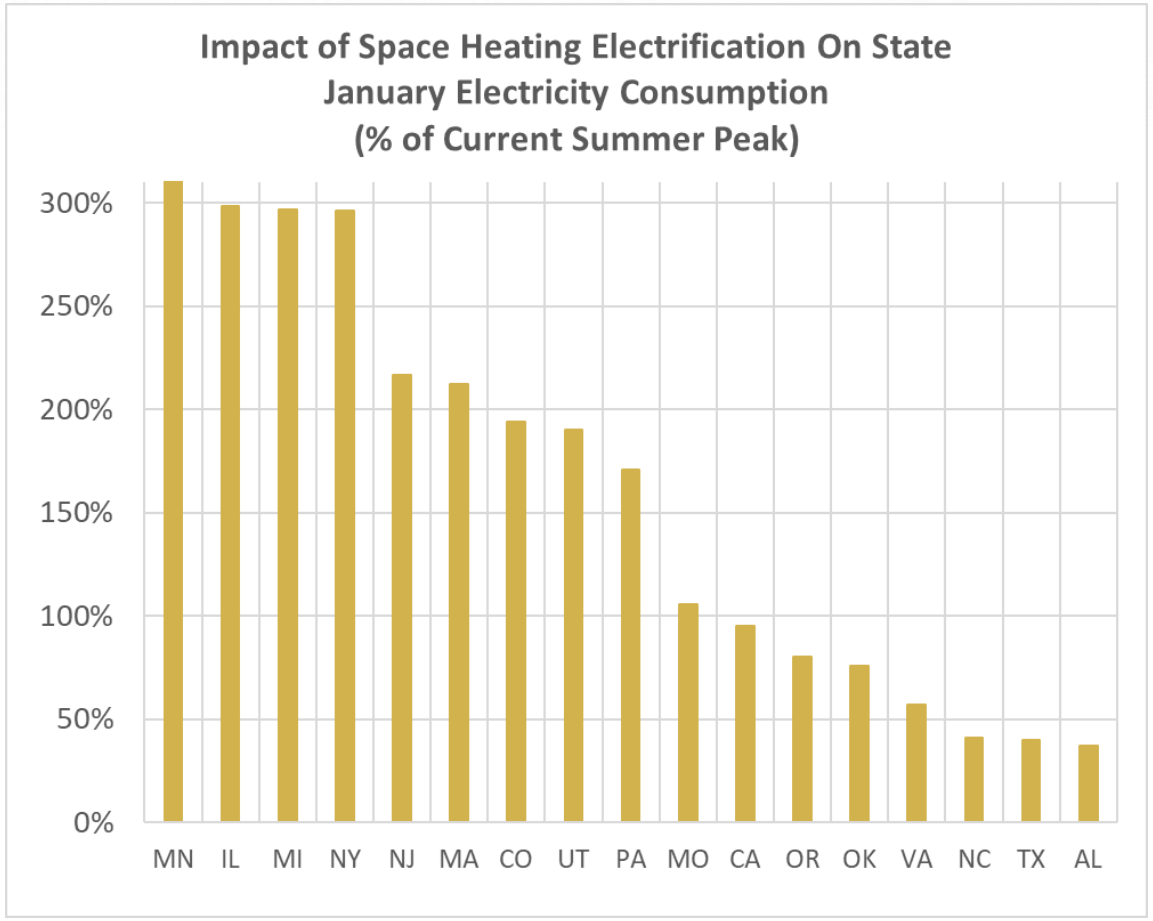
Partial List of Residential Hybrid HVACs

System Name	Heat Pump Brand / Part # / Manual	Furnace Brand / Part # / Manual	Thermostat Brand / Part # / Manual	Operating Strategy
Dettson	Dettson COND-**-01	Dettson C**-M-V	Dettson R02P032	Outdoor air temp
Carrier	Carrier 25VNA4	Carrier 59MN7	Carrier SYSTXCCITC	**Cost**
Rheem	Rheem RP20	Rheem R98V	Rheem RETST700SYS	Outdoor air temp
York	York YZV24	York YP9C	York Hx3	Outdoor air temp
Goodman	Goodman GVZC20	Goodman GMVM97	Goodman CTK04	Outdoor air temp
Amana	Amana AVZC20	Amana AMVM97	Amana CTK04	Outdoor air temp
Venstar – Goodman	Goodman GSZC18	Goodman GMES96	Venstar T7850	Outdoor air temp
Amazon – Goodman	Goodman GSZC18	Goodman GMES96	Amazon Ecobee	Outdoor air temp
Google – Goodman	Goodman GSZC18	Goodman GMES96	Google Nest	Outdoor air temp
Honeywell – Goodman	Goodman GSZC18	Goodman GMES96	Honeywell VisionPRO 8000	Outdoor air temp
Many More				
Many More				

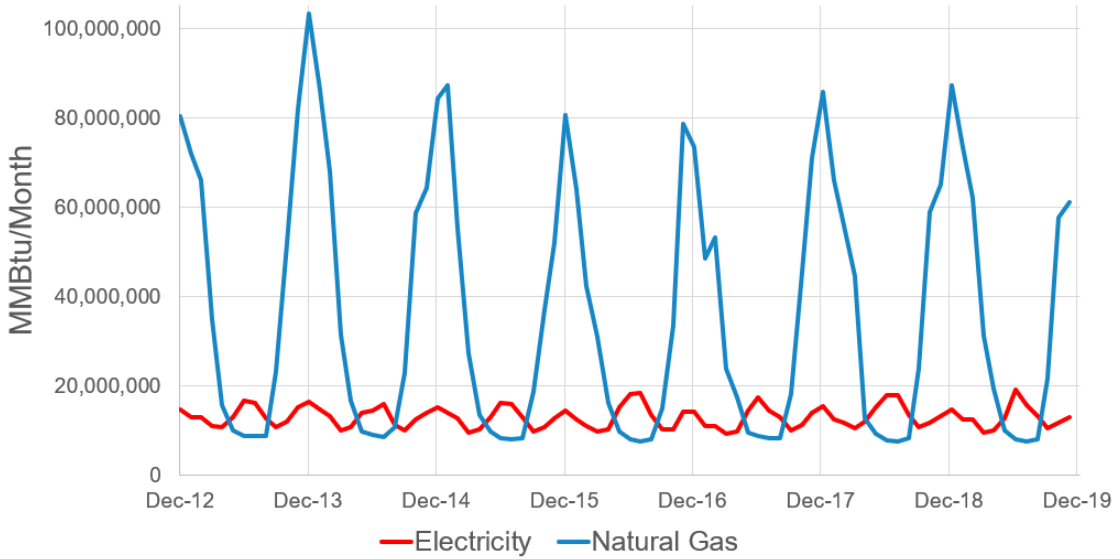
Some commercial Hybrid HVACs emerging too…

Application	Brand	Part #	Ratings	Capacities
Light-commercial	Carrier	48VR	SEER 15.5 HSPF 8.5 AFUE 80	2 – 5 ton 40 – 130 MBH
	Trane (American Standard)	XL16c (4DCZ60)	SEER 16 HSPF 9 AFUE 80	2 – 5 ton 75 – 120 MBH
	Goodman (Amana)	GPD (APD)	SEER 14.5 HSPF 8 AFUE 80	2 – 5 ton 60 – 140 MBH
Commercial	Trane	RT-PRC087	SEER 15 HSPF 9 AFUE 80	3 – 10 ton 48 – 200 MBH
	Allied Commercial	KDB	SEER 15 HSPF 9 AFUE 80	7.5 – 10 ton 13 – 240 MBH

Peak Energy Comparison



Illinois Monthly Residential Energy Use



Winter Heating from 0°F to 70°F

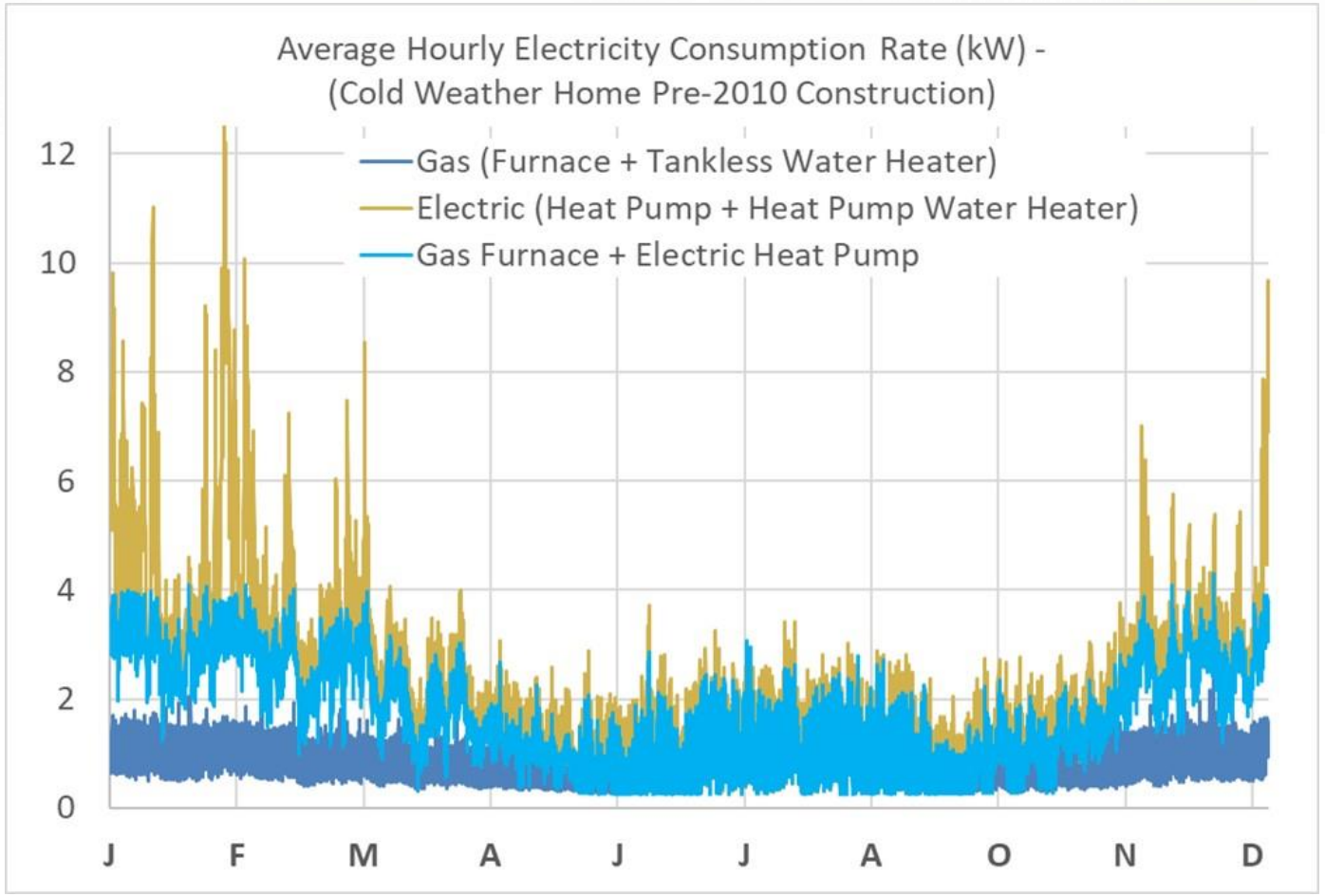
…is like…

Summer Cooling from 145°F to 75°F

Source: Analysis of DOE Energy Information Administration data

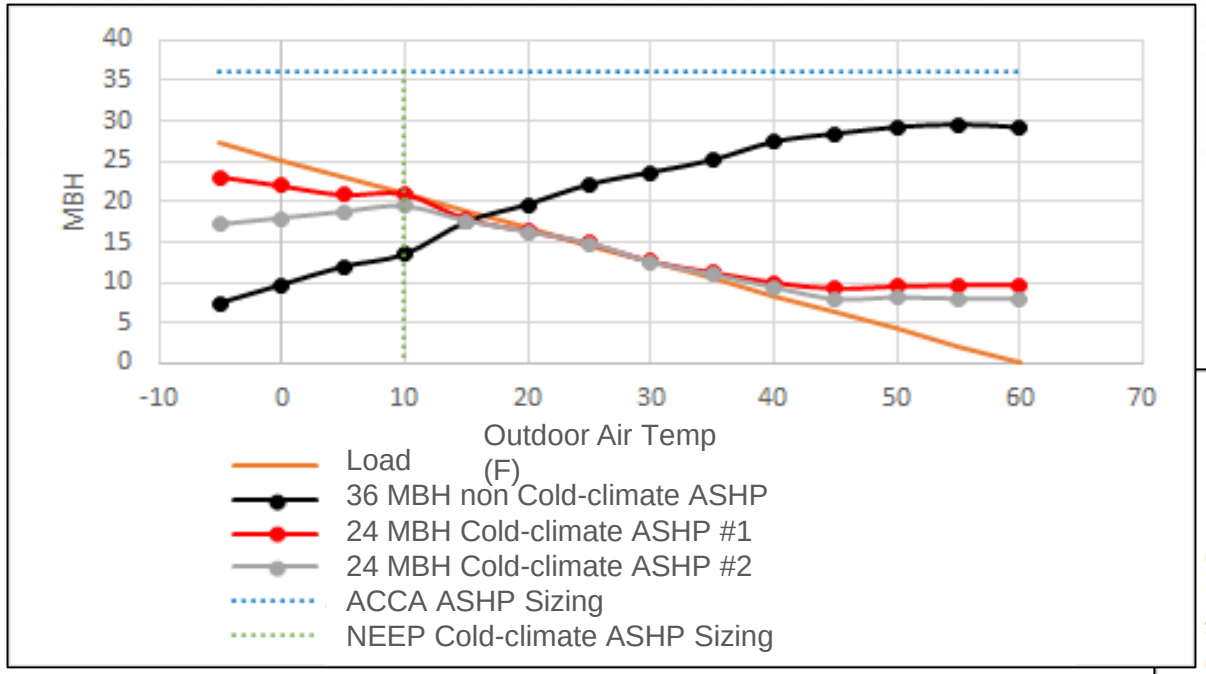
Source: DOE-EIA

Residential Hybrid (Dual-fuel) Space Heating



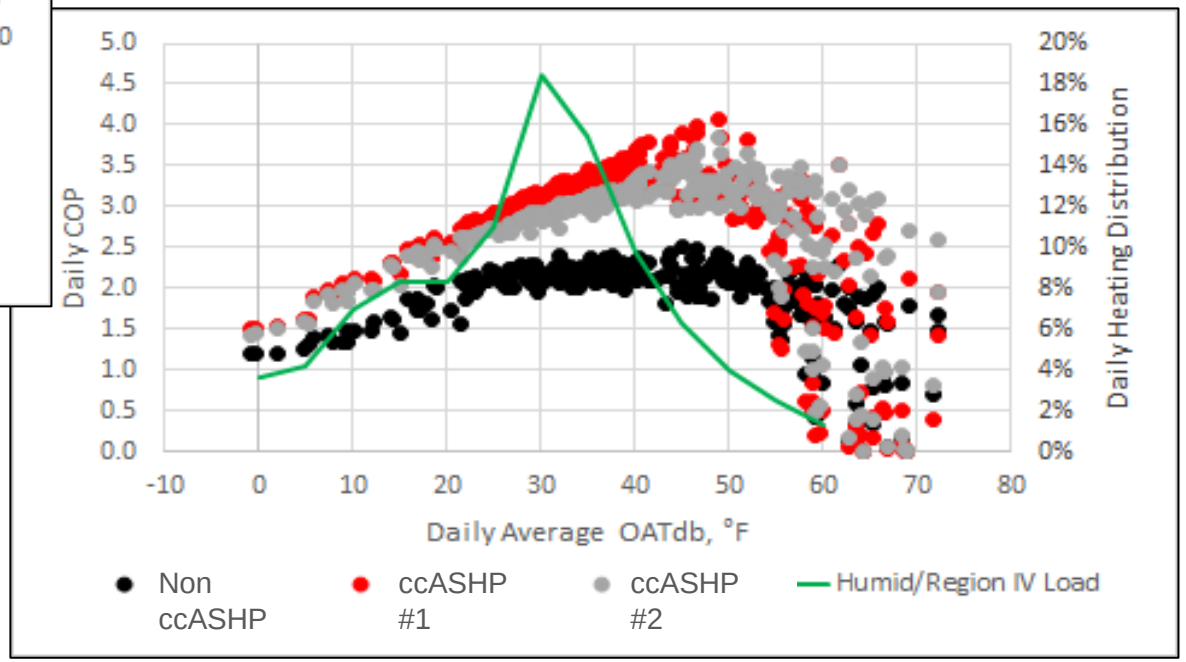
Source: GTI Analysis

Air Source Heat Pump (ASHP) Performance



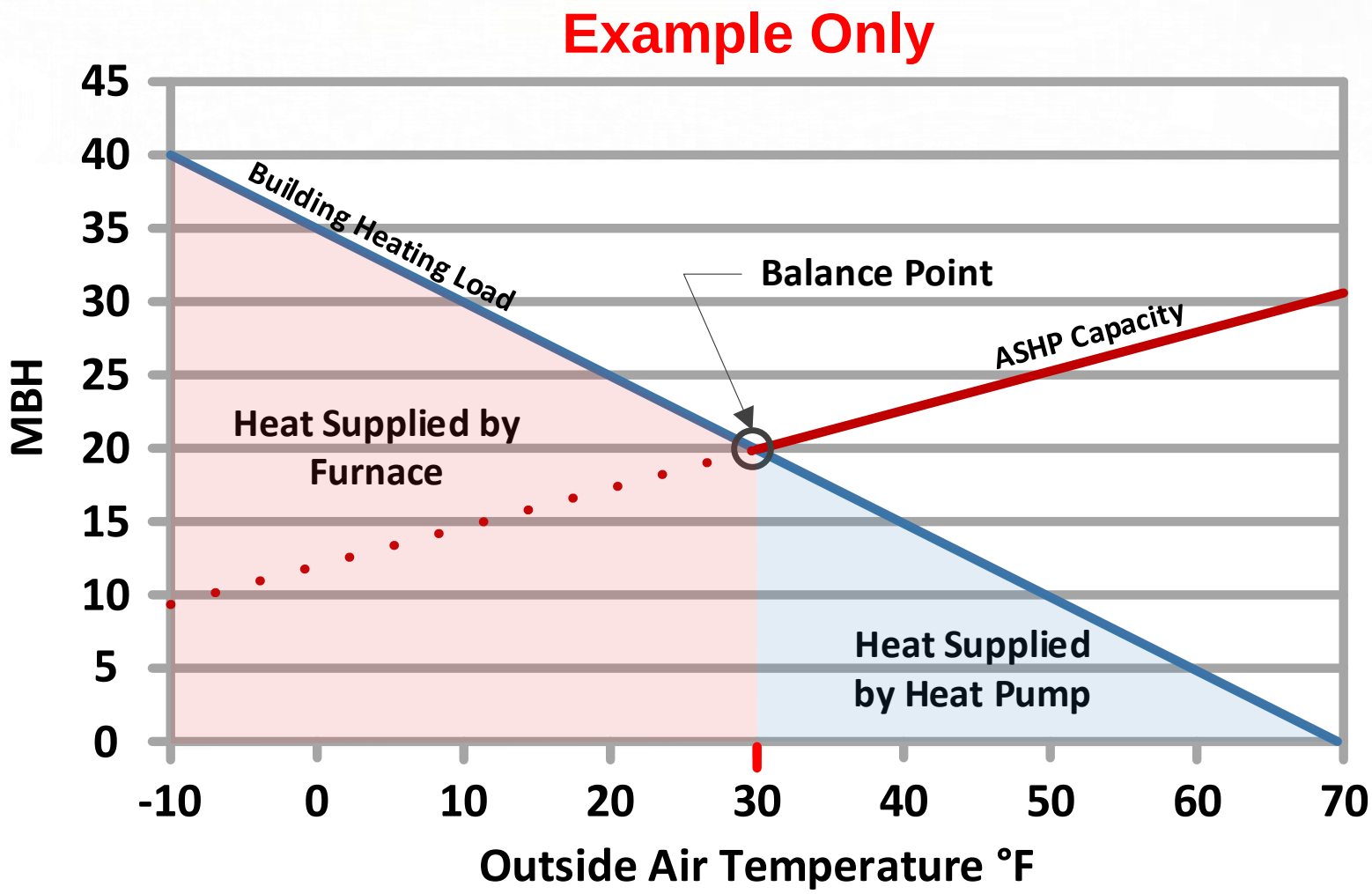
Capacities

Efficiencies

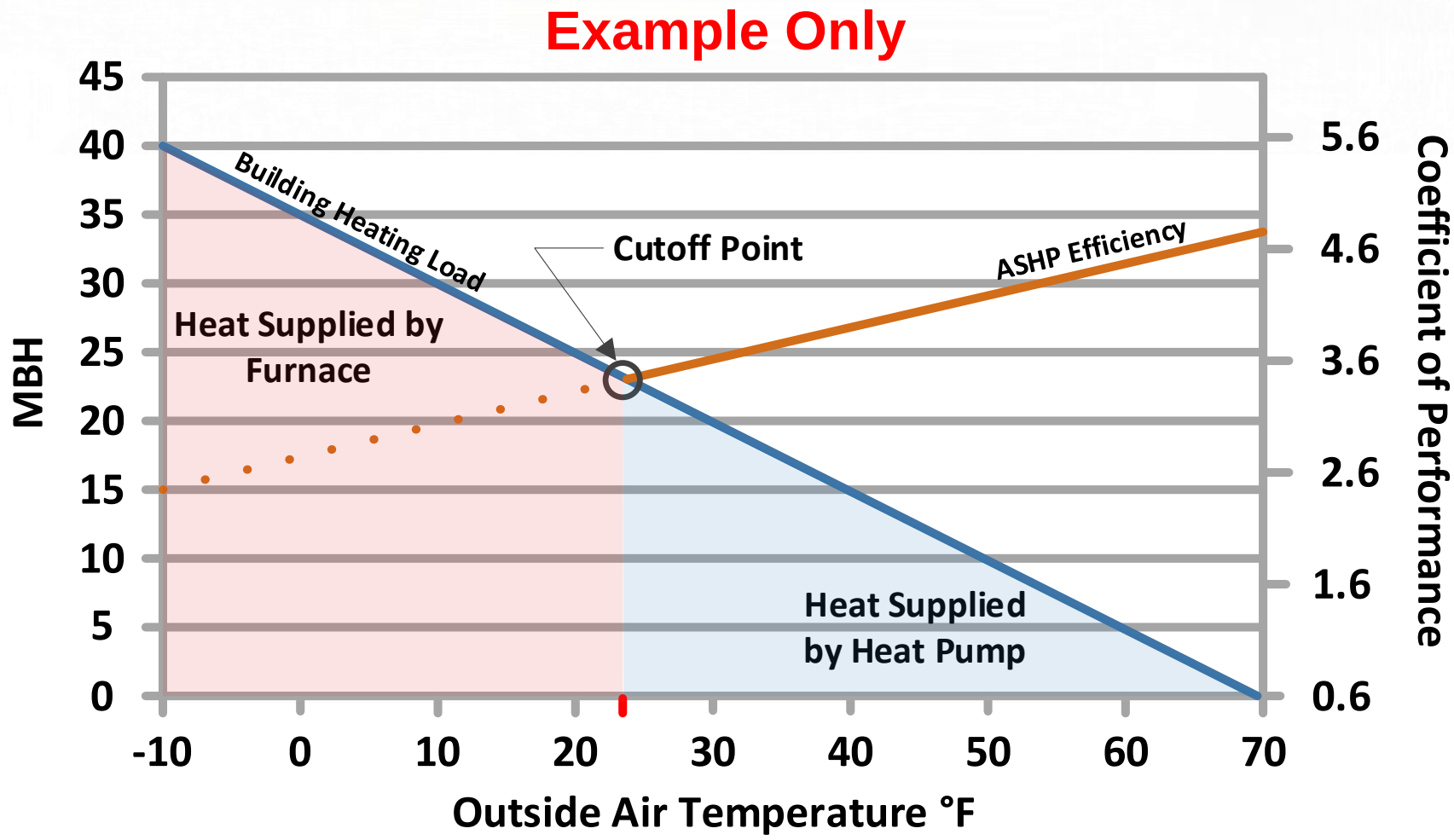


Source: GTI Lab Data

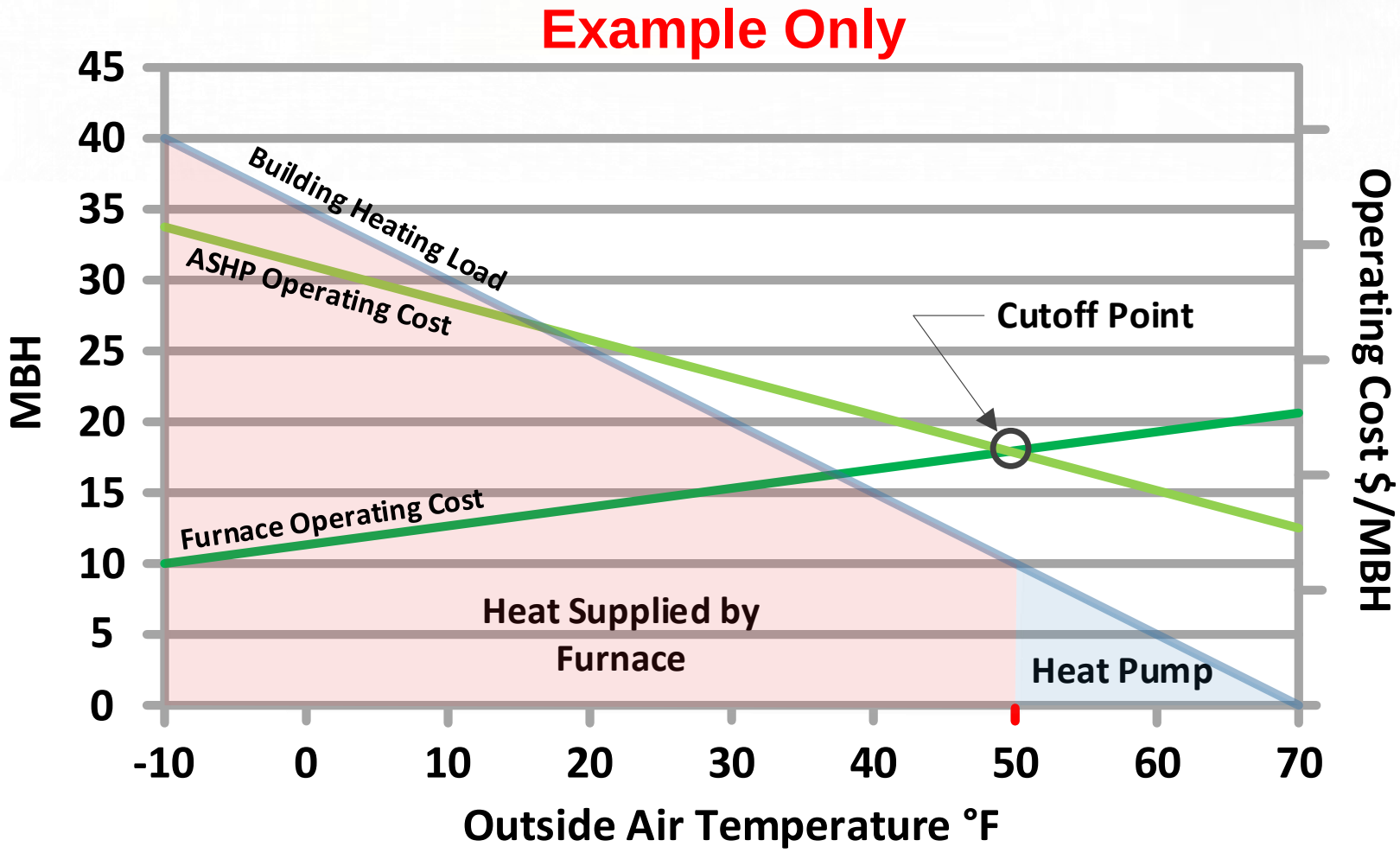
Hybrid Controls – Capacity Balance Point



Hybrid Controls – Efficiency Cutoffs



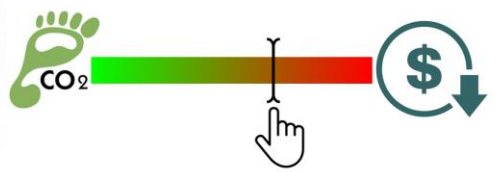
Hybrid Controls – Cost Cutoffs



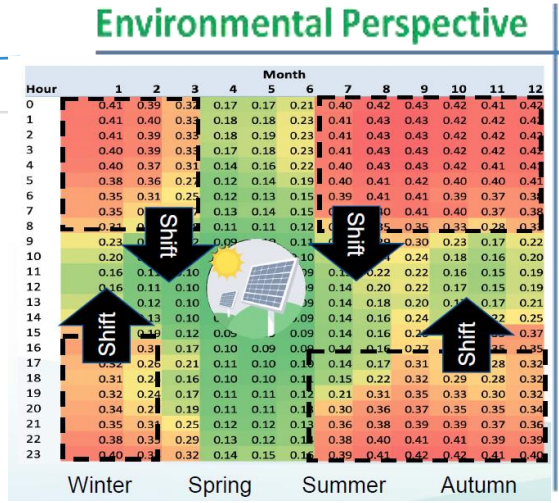
Smart(er) Hybrid HVAC Control

Smart (Connected)

Smarter (AI)



Works with any connected thermostat to make it smarter



Real time pricing

2021 Hourly Marginal Emissions Intensity (MT/ CO_2)
Source: Angela Tanghetti, CEC

Current GTI Hybrid R&D

Current and Prior work:

- **Deep Energy Retrofits with Hybrids (2019):** In IL, seven affordable housing units received envelope and mechanical retrofits with hybrid systems. Field monitoring showed **unanticipated large electric use** from heat pump units and associated **high utility bills**.
- **Low-Capacity Hybrid HVAC (2021):** In NY, five-site demo supplemented with GTI virtual test home approach yielded knowledge on how hybrids perform in three very different electric grid subregions with different operating cost drivers and GHG impacts.
- **Smart Fuel-Switching Controller – Lab Evaluation for Nicor Gas:** Just getting underway, this lab project will evaluate BKR Energy system and build out US capabilities for cost or GHG-driven control strategies.

What are Your Hybrid Research Needs?

- Market landscape assessment
- Manufacturer Engagement
- Developing Methods of Test
- Laboratory evaluation of controls (VTH)
- Field demonstration of controls
- Design and Operating Guidelines
- Proving grid responsiveness (DR)
- Integrating grid backup
- Sharing results and details of hybrid pilots