Strategic Electrification

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Panelists

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@SynapseEnergy

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- Founded in 1996 by CEO Bruce Biewald
- Research and consulting firm specializing in energy, economic, and environmental topics
- Services include economic and technical analyses, regulatory support, research and report writing, policy analysis and development, representation in stakeholder committees, facilitation, trainings, and expert witness services for public interest and government clients
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Agenda

- Analyzing Strategic Electrification – The Big Picture
- Fuel Switching with Heat Pumps

Analyzing Strategic Electrification

The Big Picture

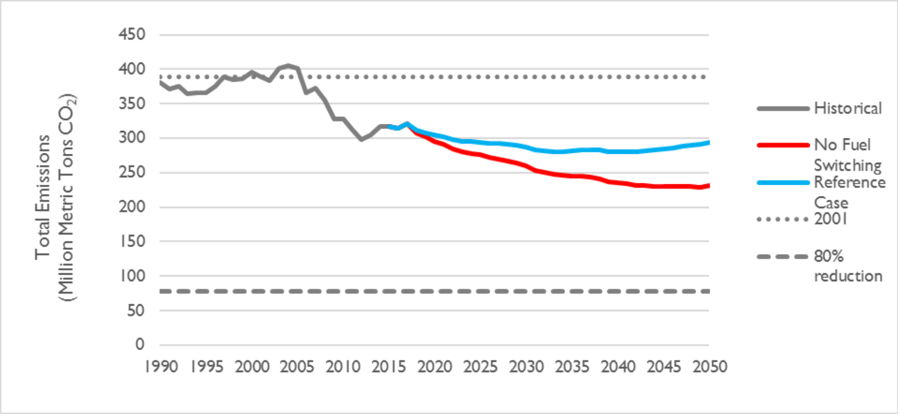
Outline

- Why electrification?
- Defining “strategic electrification”
- Hitting 2050 GHG goals
  - Markets transition
  - Resulting impacts and implications

- Based on work for the Northeast Energy Efficiency Partnerships (NEEP) on electrification in New England and New York
- Also draw upon Minnesota work supported by another client

Decarbonizing via EE and zero-carbon electricity falls short

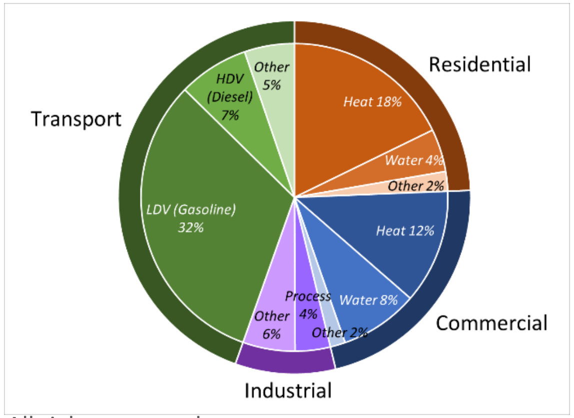
95% zero carbon electricity on the grid, plus aggressive electric and thermal energy efficiency (Northeast example):



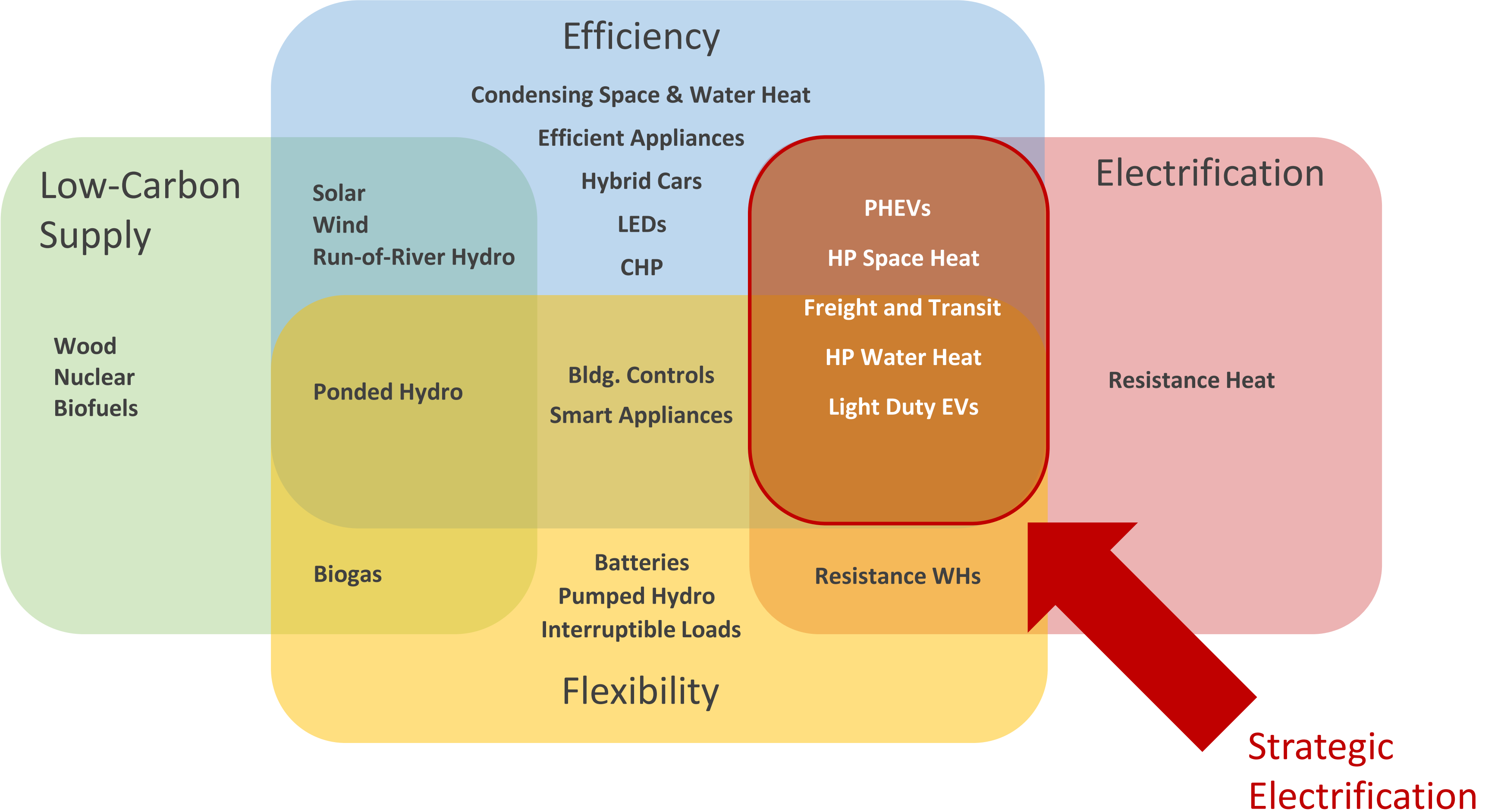
GHG reduction: 41% below 2001 levels

To get deep decarbonization, Northeast needs to switch direct fuel use to zero- or low-carbon sources, like electricity.

Fossil fuel used for space heat, water heat, and mobility:



Finding the sweet spot



“Strategic Electrification” means…

- powering end uses with electricity instead of fossil fuels
- in a way that increases energy efficiency and reduces pollution,
- while lowering costs to customers and society,
- as part of an integrated approach to deep decarbonization.

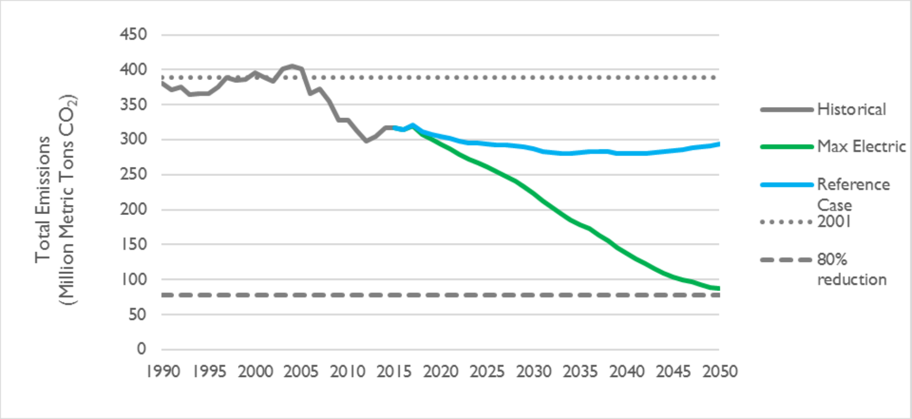
Getting to 80% GHG reduction by 2050

Assume we do the "right" things on efficiency, flexibility, and low-carbon electric supply:

- How fast do electrification markets need to transform to get to 80% GHG reduction?
- What if we also plan to use some bioenergy?
- What are the electric supply needs?
- What impacts should we expect on the grid, and on consumers?

“Max Electric” case: 80% via electrification

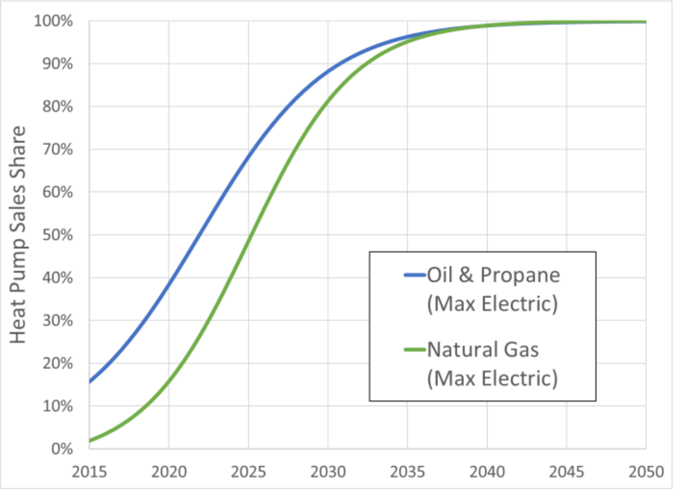
GHG emissions 77% below 2001 levels by 2050 electrifying heat and on-road transport (get the rest from miscellaneous uses)



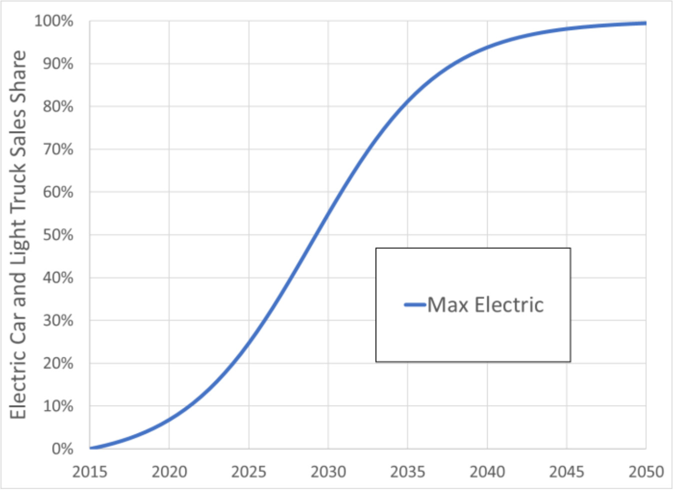
Electric consumption rises 55% from current levels

Markets need to transform *fast*

Residential Heat Pump Market

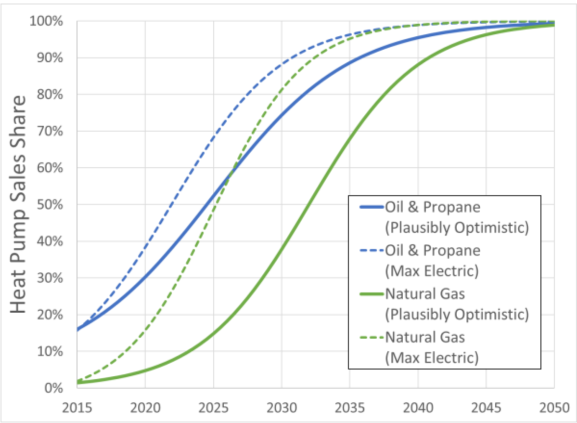


Electric Car & Light Truck Market

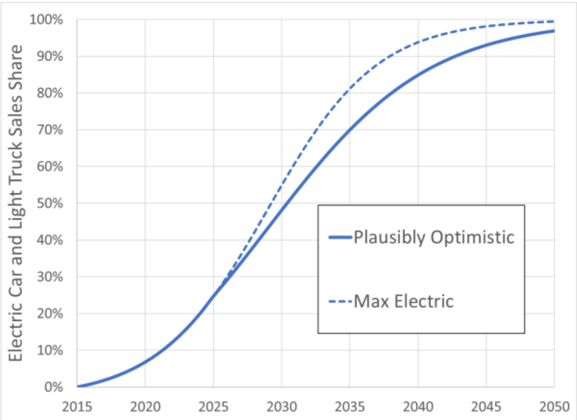


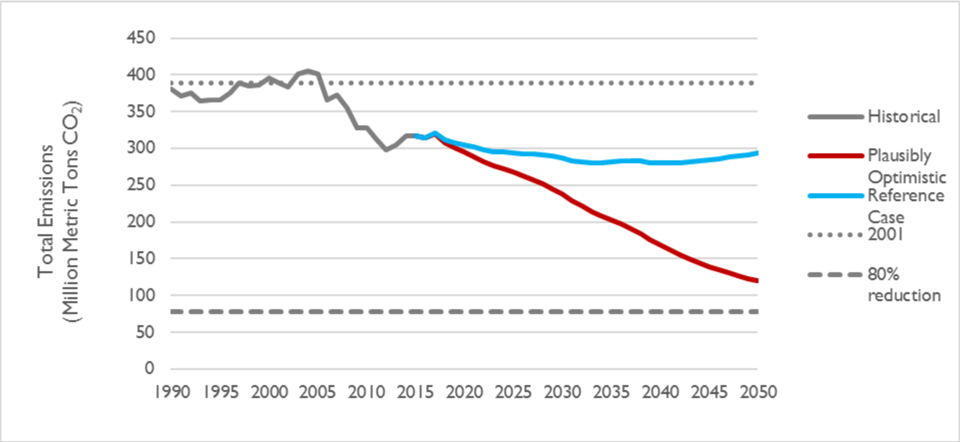
"Plausibly Optimistic" case: 69% from electrification

Res. HP market penetration: 5-15 years slower than "all-in" case



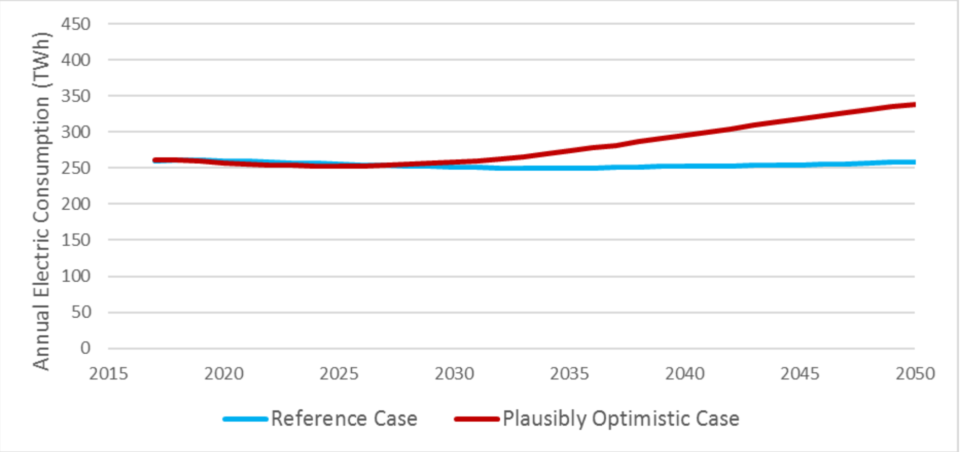
Light EV same through 2025, but slower after





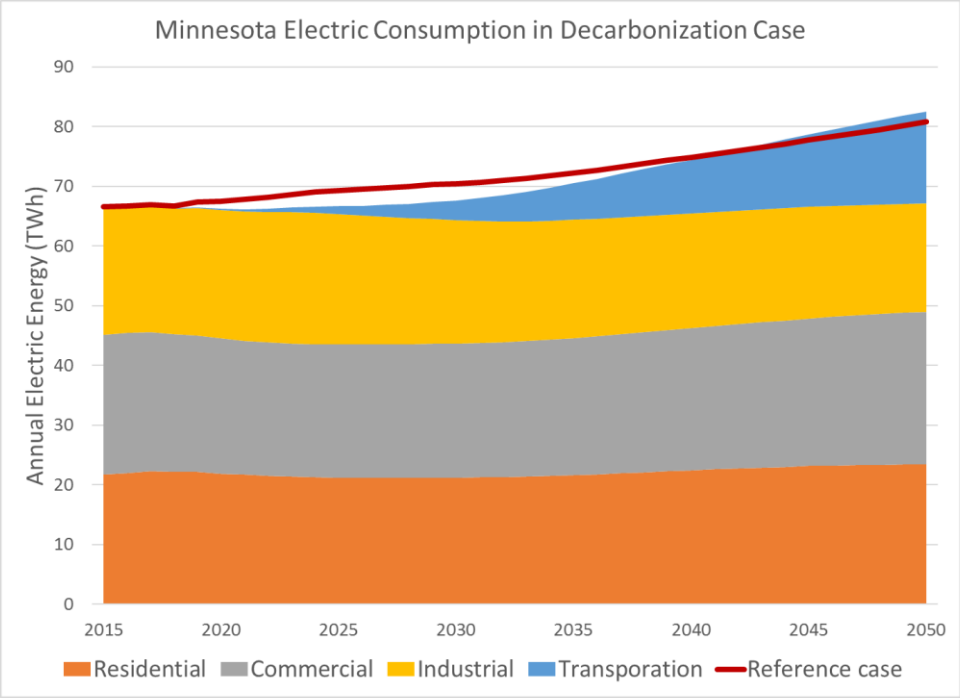
Need biogas/biofuels to get to 80% reduction

Annual electric consumption rises 30% from current



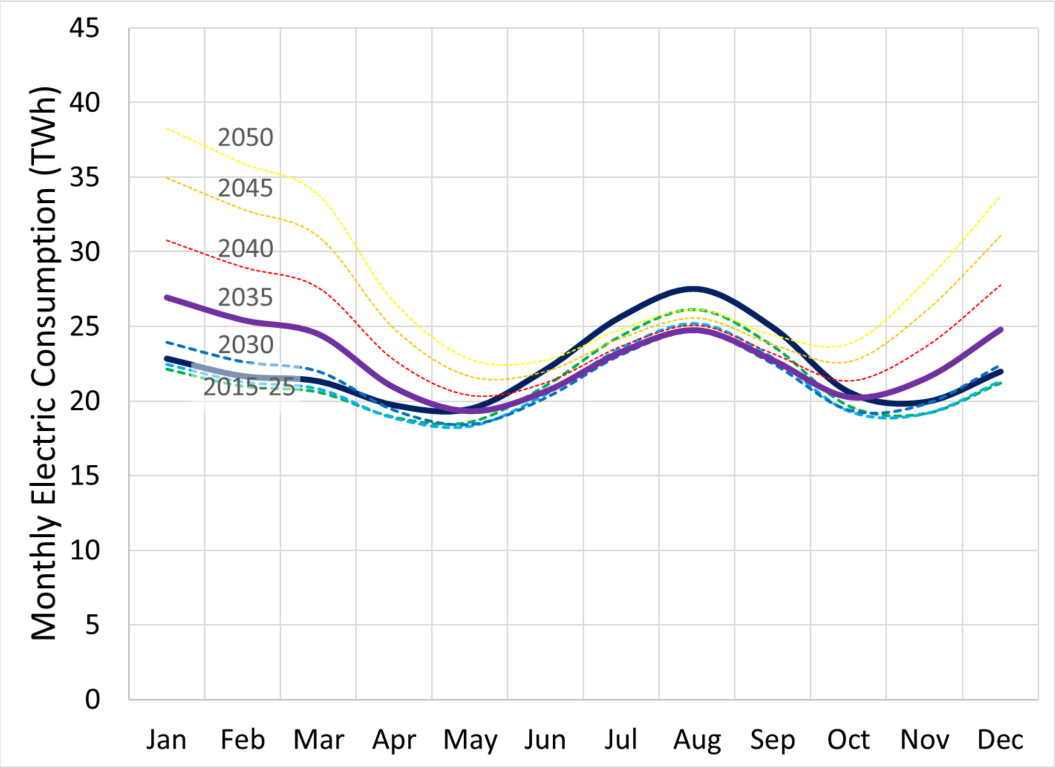
Results vary by region: Minnesota example

- Accelerate energy efficiency (20%-33% reduction from the Reference case by 2050)
- By 2050:
  - Heat pumps provide 63%-75% of space and water heat
  - 89% of light-duty miles on electricity
- 80% GHG reduction from 2015 levels if electricity is 90+% zero-carbon

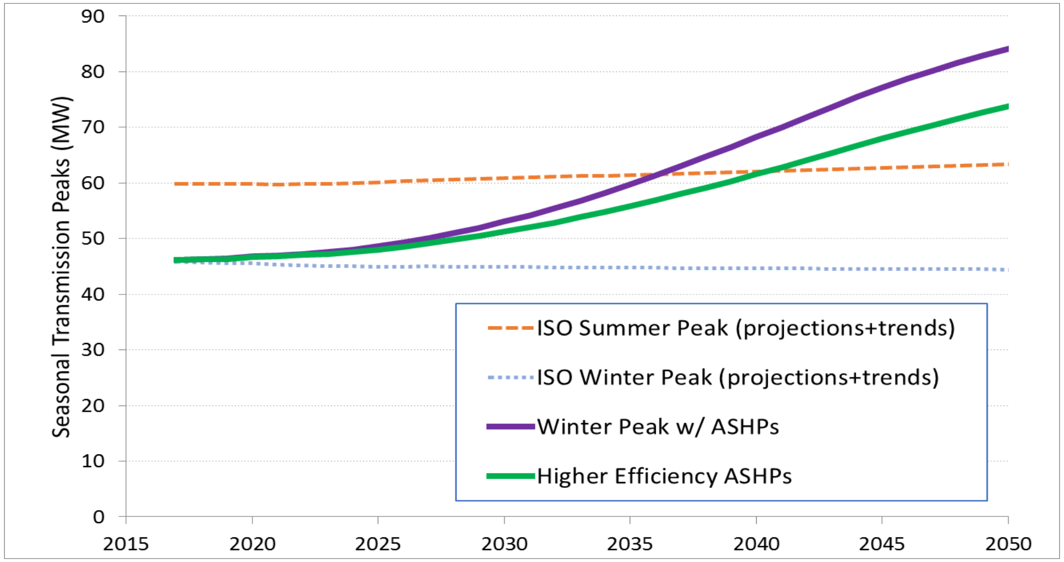


Shifting Northeastern seasonal load shape

- January consumption passes August in the mid-2030s
- Need new low-carbon electricity supplies, biased toward winter
- One grid challenge: Reach and integrate new variable supplies



Higher efficiency HPs have grid benefits



- Illustrative calculation indicates that higher-efficiency HPs can delay the region's shift to winter peaking by 4-5 years
- Clustering on distribution system ➡ winter peaks sooner
- Potential for substantial T&D cost savings from winter EE

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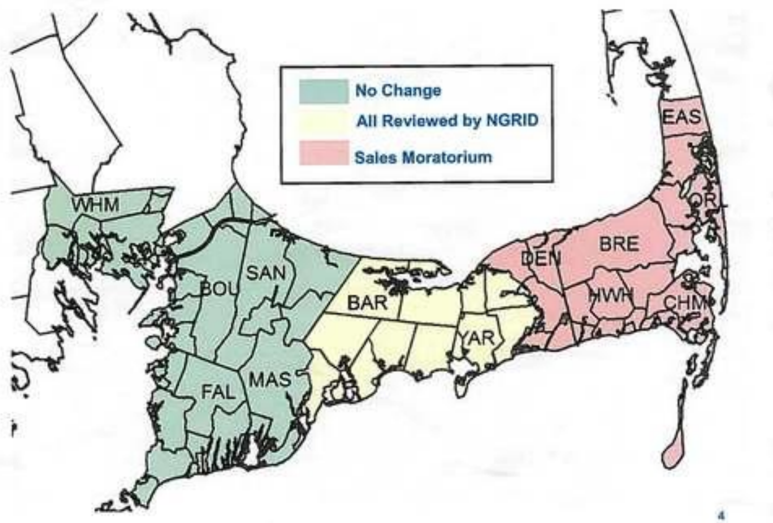
Future work

- What about other regions, climate zones, relative fuel prices, and electric emissions?
  - What about a two-week “arctic” period like we just had?
- How good do building shells need to be to allow heat pumps to shine for customers and be good citizens on the grid?
  - How much electrification before distribution circuits require upgrades?
- How will the grid and power supply meet the need for a very different seasonal load shape, supplied by low-carbon resources?
- What rates and incentive structures are best suited to move electrification markets at the pace required?
- What’s the relative cost-effectiveness of electrification vs. renewable gas?

Fuel Switching with Heat Pumps

Background

- Massachusetts state policies and regulations support strategic electrification
- The Cape Light Compact asked Synapse to assess the cost-effectiveness of fuel switching with heat pumps for the 2019-2021 Three-Year Energy Efficiency Plan
- Cape residents have limited access to natural gas
- Alternatives to oil, propane, and electric resistance heating systems



Conventional HVAC Options

Air Source Heat Pumps

Scenarios for Heating Options

Keep Existing	Replace-on-Failure	Early Retirement
• Keeps their existing system as supplemental heating	• Removes the existing heating system completely at the end of its useful life	• Removes the existing heating system completely before the end of its useful life

Fuel Types

Heating options

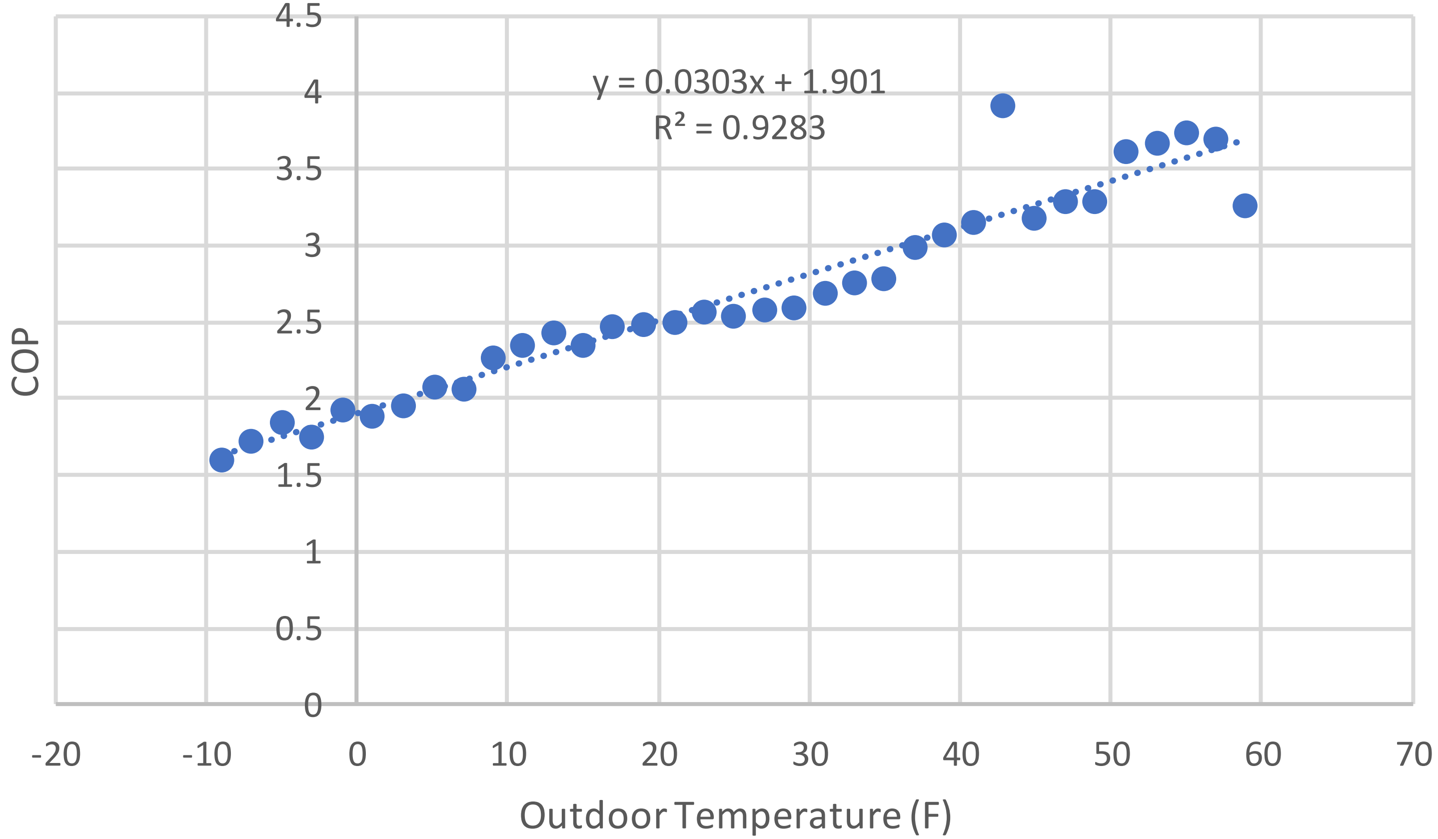
- Oil
- Electric
  - Electric Baseline
  - Gas Baseline
- Propane

Cooling options

- ENERGYSTAR Central AC
- ENERGYSTAR Window AC
- Standard Central AC
- Standard Window AC
- No AC

→ ccASHP

Heat Pump Performance

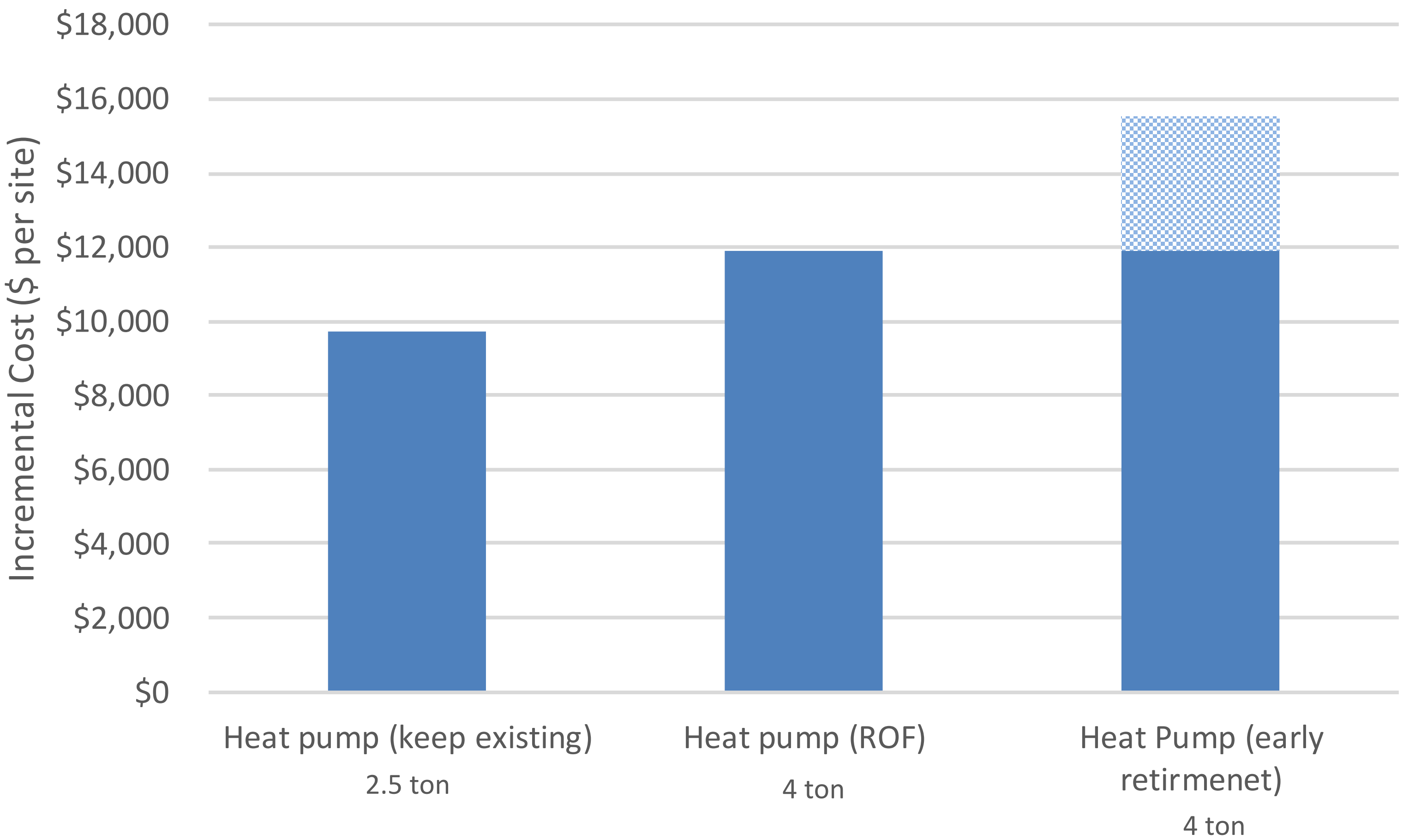


Source: Cadmus (2016), Ductless Mini-Split Heat Pump Impact Evaluation

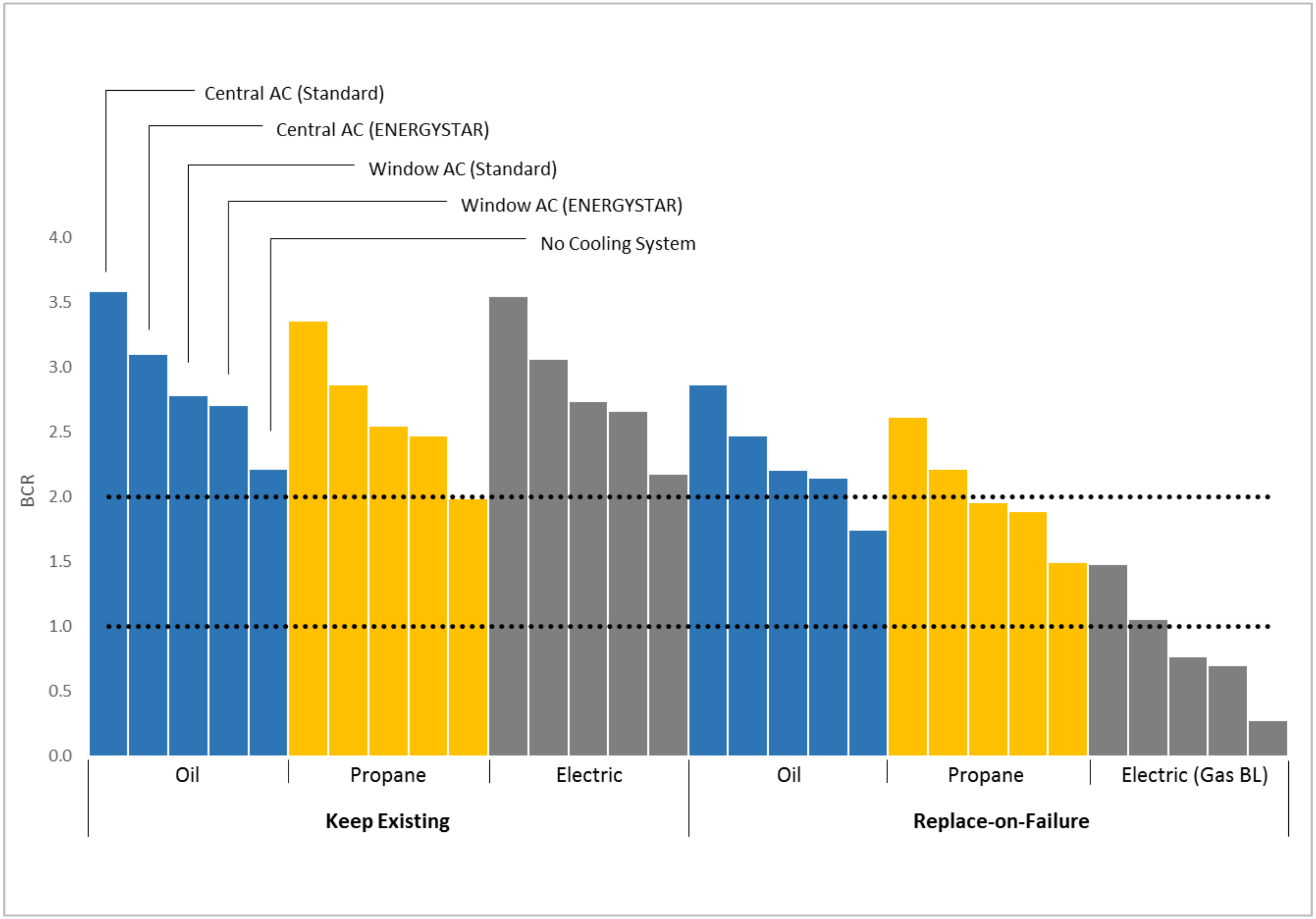
Benefit Cost Analysis Framework

- **Total Resource Cost (TRC) test** - Massachusetts' primary cost-effectiveness screening test for energy efficiency programs
- **Upfront Costs**
  - Incremental cost of a new heat pump
- **Key Benefit Costs**
  - Avoided cost of fossil fuels (heating)
  - Avoided cost of electricity (heating & cooling)
  - Avoided cost of generation capacity (cooling)
  - Avoided transmission and distribution (cooling)
  - DRIPE (demand reduction induced price effects) (heating & cooling)

Cost Assumptions by Scenario

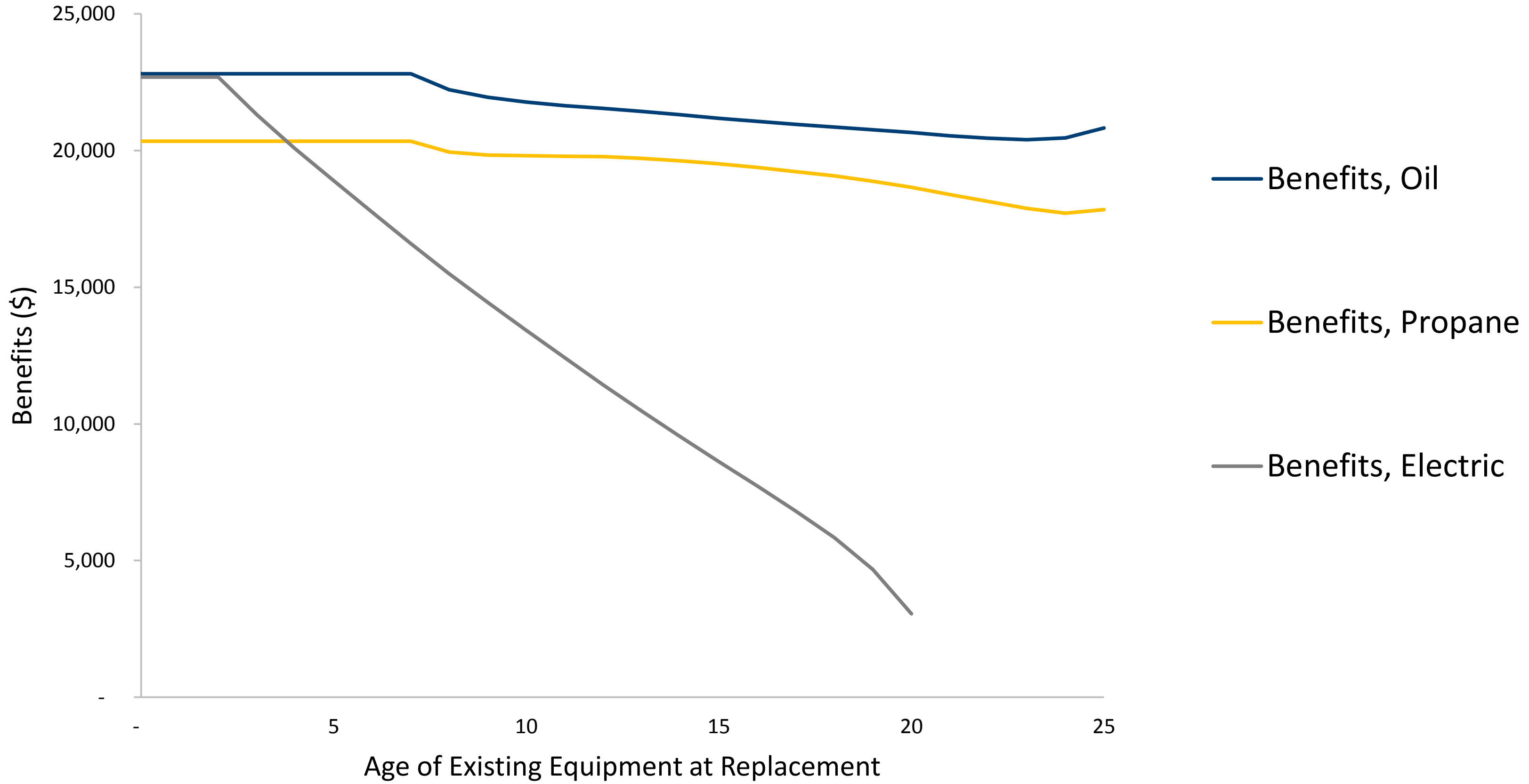


Keep Existing and ROF Results

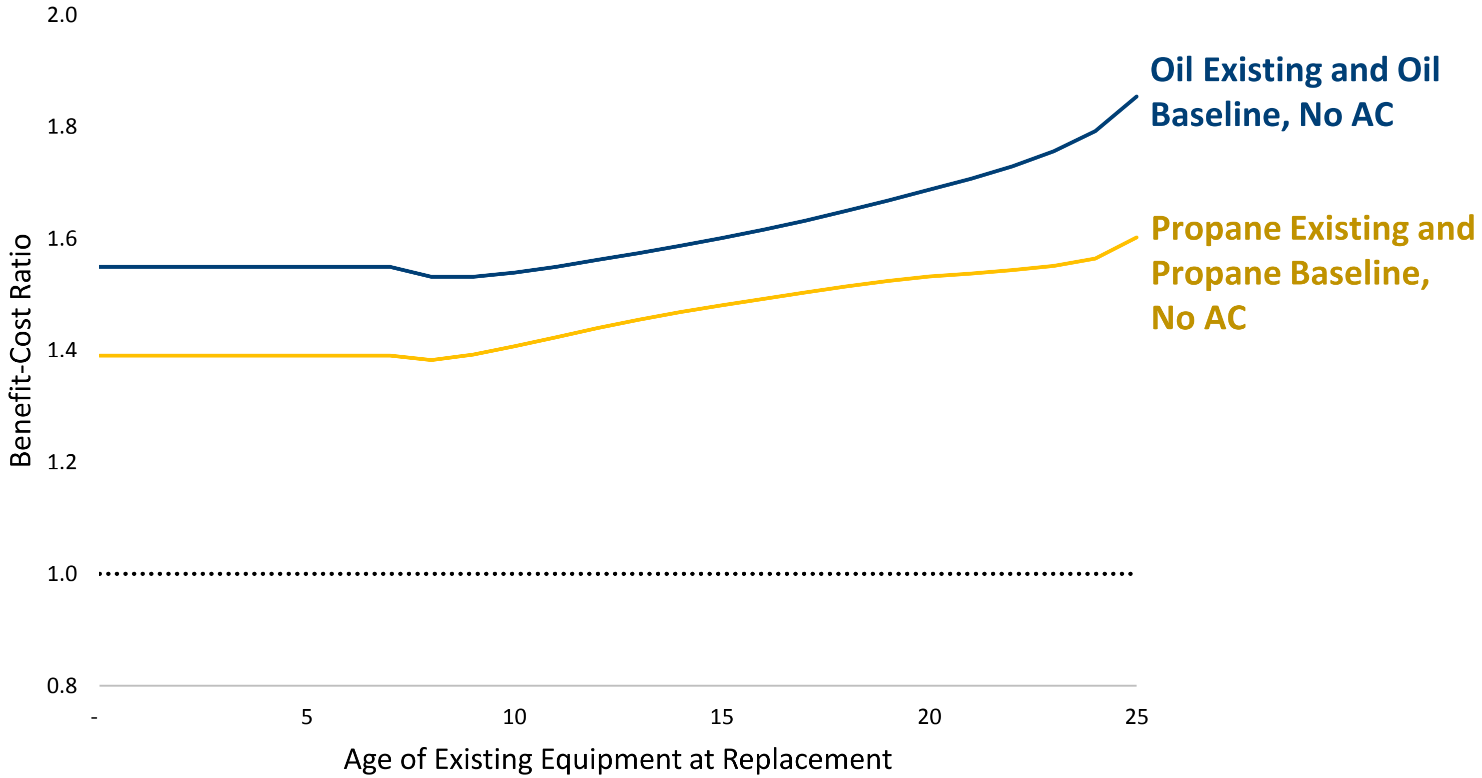


*We modeled both boilers and furnaces, but these results are specific to furnaces. Boilers were uniformly more cost-effective to replace.

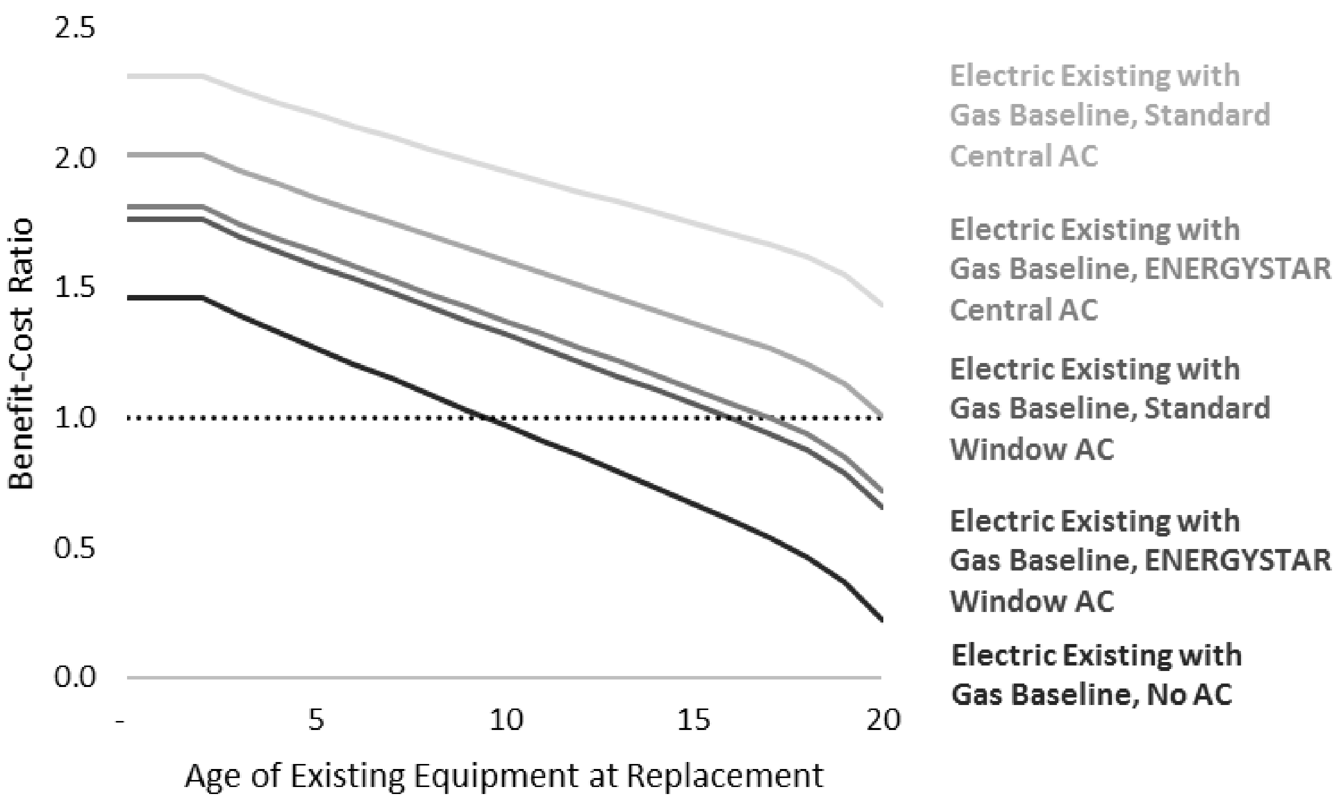
Early Retirement - Benefits



Early Retirement – Oil and Propane



Early Retirement – Electric



Customer Payback Period

Heating and Cooling Scenarios	Annual Bill Savings ($)	Payback Period without Incentive (Years)
Heating, ROF, Oil	$255	25+
Heating, ROF, Electric (Gas BL)	-$261	None
Heating, ROF, Propane	$1,462	9
Heating, Keep, Oil	$410	24
Heating, Keep, Electric	$2,799	4
Heating, Keep, Propane	$1,654	6

Questions?

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- Development of analytical tools

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Extra Slides

Extra - Heating Costs and Savings

Heating Scenario	Baseline System	Gross Annual Electricity Saved (kWh)	Gross Annual Fuel Saved (MMBtu)	Installed Cost: Baseline ($)	Installed Cost: ccASHP ($)	Total Resource Cost ($)	Replacement Discount Credit ($)
Heating, ROF, Oil	Oil Baseline	(5,752)	84	3,640	15,543	11,903	3,640
Heating, ROF, Electric (Gas BL)	Gas Baseline	(6,852)	82	4,541	15,543	11,002	4,541
Heating, ROF, Propane	Propane Baseline	(5,752)	82	3,640	15,543	11,903	3,640
Heating, Keep, Oil	Oil Existing	(5,375)	83	-	9,714	9,714	-
Heating, Keep, Electric	Electric Existing	12,740	-	-	9,714	9,714	-
Heating, Keep, Propane	Propane Existing	(5,375)	83	-	9,714	9,714	-
Heating, Early Retire, Replace, Oil (EE)	Oil Baseline	(5,752)	84	3,640	15,543	15,543	-
Heating, Early Retire, Replace, Oil (RE)	Oil Existing	(5,752)	90	-	-	-	-
Heating, Early Retire, Replace, Electric (EE) (Gas BL)	Gas Baseline	(6,852)	82	4,541	15,543	15,543	-
Heating, Early Retire, Replace, Electric (RE) (Gas BL)	Electric Existing	13,664	-	-	-	-	-
Heating, Early Retire, Replace, Propane (EE)	Propane Baseline	(5,752)	82	3,640	15,543	15,543	-
Heating, Early Retire, Replace, Propane (RE)	Propane Existing	(5,752)	90	-	-	-	-

Cooling Scenario	Annual Consumption (kWh)	Incremental Savings to Heat Pumps (kWh)
Window AC (Standard)	445	301
Window AC (Energy Star)	404	260
Central AC (Standard), 2.5 ton	1,080	936
Central AC (Energy Star), 2.5 ton	745	601
Heat Pump	144	-

Extra - Key Inputs

Cooling System	Cooling Capacity (BTU/Hr)	EER/SEER (BTU/W-h)	EFLH (Eqivalent Full Load Hours) (Hr)
Cooling, Retire, Window (Standard)	10,000	9.8	218
Cooling, Retire, Window (ENERGY STAR)	10,000	10.8	218
Cooling, Retire, Central (Standard)	30,000	10.0	360
Cooling, Retire, Central (ENERGY STAR)	30,000	14.5	360
Heat Pump	14,680	22.3	218

Cooling System	Units/Household	Incremental Cost/Unit ($)
Cooling, Retire, Window (Standard)	2	$ -
Cooling, Retire, Window (ENERGY STAR)	2	$ -
Cooling, Retire, Central (Standard)	1	$ -
Cooling, Retire, Central (ENERGY STAR)	1	$ -
Heat Pump	1	$ -

Extra - Key Inputs

Heat Pump Data - Single Family Application

	ccASHP + Existing System	ccASHP only System
ccASHP size		
Temp threshold for sizing ccASHP operation (F)	20.0	13.0
Manual S system size safety margin/buffer (%)	100%	130%
ccASHP capacity adjustment factor for a 47 F level (%)	120%	120%
ccASHP heating size with a size buffer (kBtu/h)	23.1	34.7
Peak heating load at temp threshold (kbtu/h)	23.1	26.7
ccASHP heating size at 47 F (kbtu/h)	27.8	41.8
ccASHP heating size at 47 F (ton)	2.5	4.0
# of hours for supplemental heating operation	216.0	N/A
% supplemental heating operation	2.5%	N/A
Total load served by supplemental heating (MMBtu)	5.5	N/A
ccASHP efficiency		
COP	3.1	3.0
ccASHP price		
ccASHP price per house	9,714	15,543
Heating load		
Annual heating load* (MMBtu)	70.0	70.0
Annual load served by ccASHP (MMbtu)	64.5	70.0

