NREL
NATIONAL RENEWABLE ENERGY LABORATORY





Cost Effectiveness of Electrification with Air-Source Heat Pumps

Jack Mayernik

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Drivers of Cost Effective of Electrification

- Climate
- Operating Cost
- Cost of Equipment and Instillation
  - New Construction
  - Retrofit/Upgrade
  - Residential vs. Commercial

Climate

- Regional climatic variations impact cost effectiveness.
- **All else equal - greater HDD means that more efficient heating systems will be more cost effective.**
- Heat pumps have been shown to be effective and efficient at temperatures as low as –14º F.

US DOE: https://www.energy.gov/eere/buildings/downloads/split-system-cold-climate-heat-pump

Maryland - America in Miniature

Location	HDD	CDD
Cumberland	4619	1216
Frederick	4379	1382
Baltimore	4110	1580
St. Mary's	3551	1821
Princess Anne	3527	1731
US Average	4126	1459

US EPA: https://portfoliomanager.energystar.gov/pm/degreeDaysCalculator

Heating Degree Days (HDD) are a measure of how cold a location is over a period of time relative to a base temperature, most commonly specified as 65 degrees Fahrenheit. The measure is computed for each day by subtracting the average of the day's high and low temperatures from the base temperature (65 degrees), with negative values set equal to zero. Each day's heating degree days are summed to create a heating degree day measure for a specified reference period. Heating degree days are used in energy analysis as an indicator of space heating energy requirements or use.
(*US DOE, Energy Information Administration*)

Operating Costs - Energy

Residential Energy Prices - 2018

	Gas ($/thousand cu ft)	**Electric** (cents/kWh)
Maryland Average	11.79	13.30
US Average	10.50	12.87

Commercial Energy Prices - 2018

	Gas ($/thousand cu ft)	**Electric** (cents/kWh)
Maryland Average	9.57	10.43
US Average	7.78	10.67

US DOE: https://www.eia.gov/dnav/ng/ng_pri_sum_dcu_SMD_a.htm
US DOE: https://www.eia.gov/electricity/sales_revenue_price/pdf/table4.pdf

Operating Costs - Energy

To directly compare, we need to convert these to the same units.

Residential Energy Prices - 2018

	Gas ($/thousand cu ft)	**Electric** (cents/kWh)
Maryland Average	11.79	13.30
US Average	10.50	12.87

kWh -> Btu
Multiply by 3,412

Thousand cu ft -> Btu
Multiply by 1,037,000

Operating Costs - Energy

Values Reported by EIA

Residential Energy Prices - 2018

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Commercial Energy Prices - 2018

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Maryland Average	9.57	10.43
US DOE	7.78	10.67

Converted to cents/kBtu

Residential Energy Prices - 2018

	Gas (cents/kBtu)	**Electric** (cents/kBtu)
Maryland Average	1.14	3.90
US Average	1.01	3.77

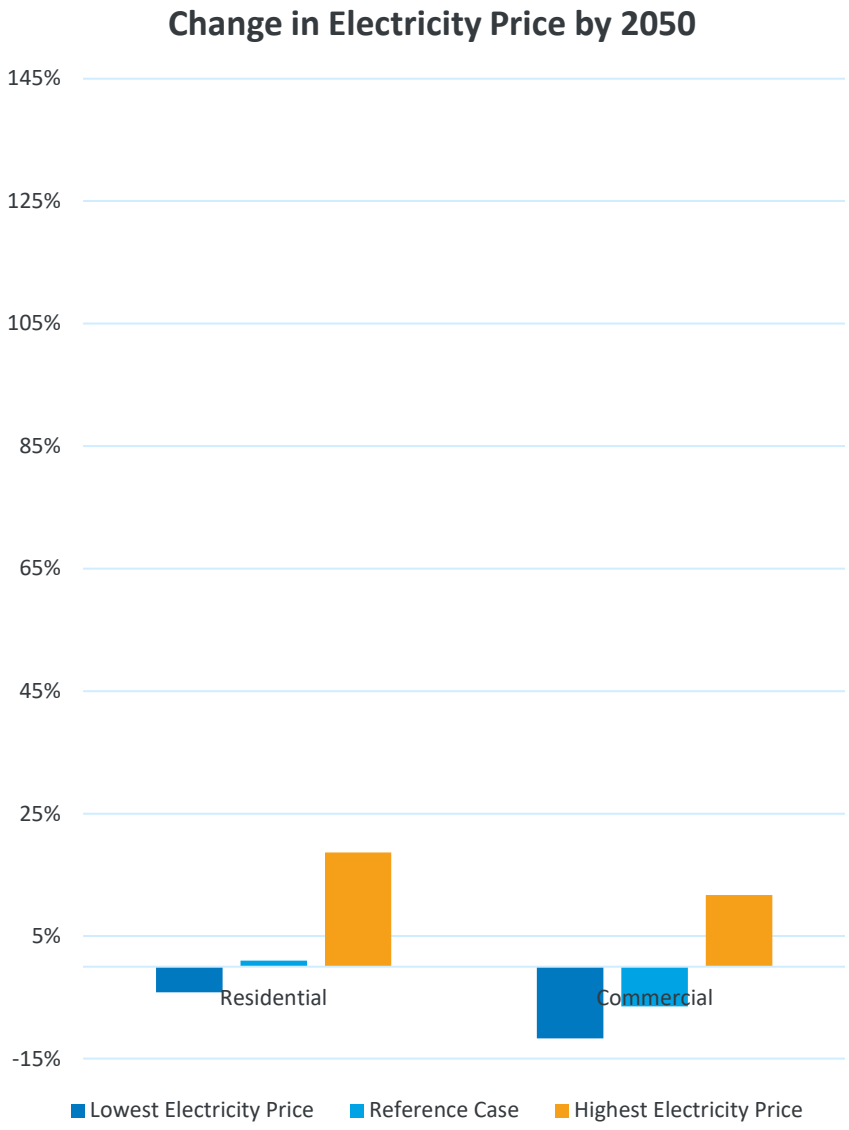
Commercial Energy Prices - 2018

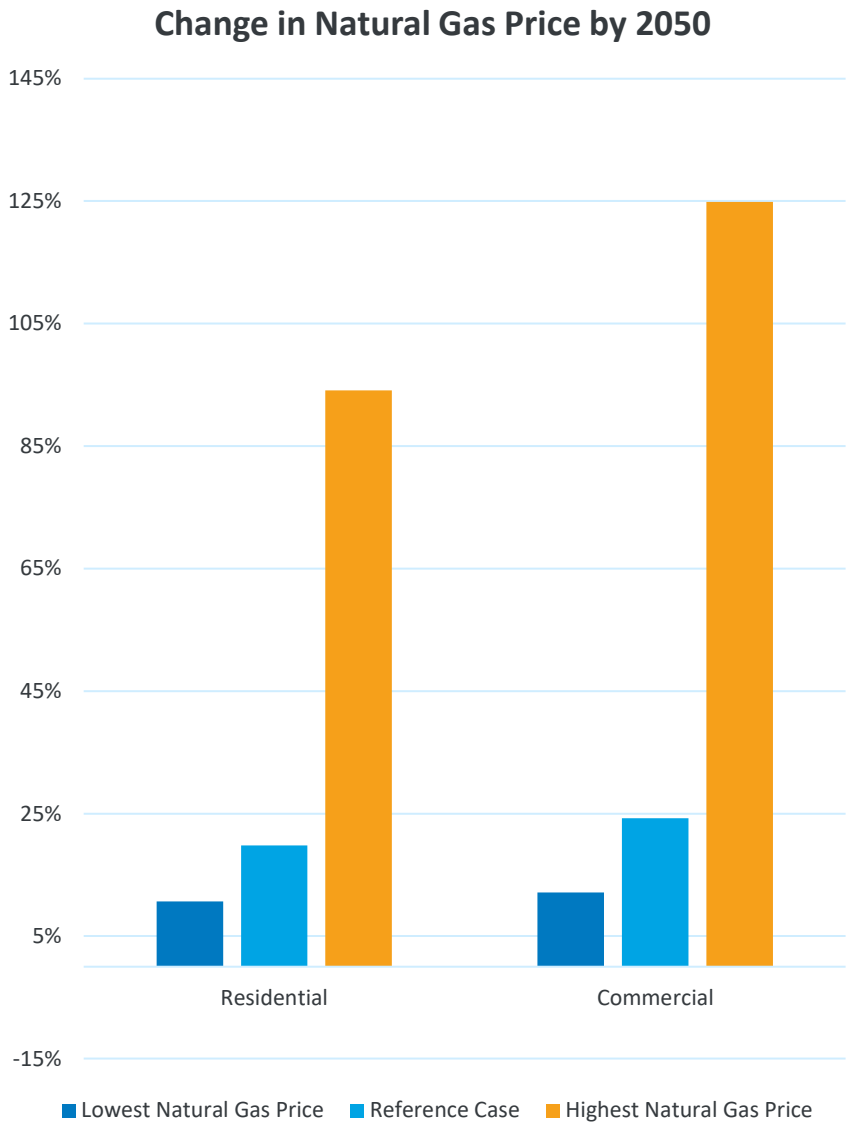
	Gas (cents/kBtu)	**Electric** (cents/kBtu)
Maryland Average	0.92	3.06
US Average	0.75	3.13

US DOE: https://www.eia.gov/dnav/ng/ng_pri_sum_dcu_SMD_a.htm
US DOE: https://www.eia.gov/electricity/sales_revenue_price/pdf/table4.pdf

Electricity is 3.3-3.4 times more expensive per kBtu in Maryland.

Future Cost of Energy





US DOE: https://www.eia.gov/outlooks/aeo/data/browser/

Operating Costs - Efficiency

- Furnace Efficiency:
  - Federal Minimum Standard: 80% AFUE
  - EnergyStar: 90% AFUE

US DOE: https://www.ecfr.gov/cgi-bin/text-idx?SID=a9921a66f2b4f66a32ec851916b7b9d9&mc=true&node=se10.3.430_132&rgn=div8
US EPA: https://www.energystar.gov/sites/default/files/Furnaces%20Version%204.1_Program%20Requirements.pdf

- Heat Pump Efficiency:
  - A basic air-source heat-pump (ASHP) may have a SCOP of ~2 while a mid-tier ASHP have a SCOP of ~3
  - To achieve NEEP's Tier-2 rating requires a SCOP of at least 3.81 (~7% of ASHPs meet this performance level)

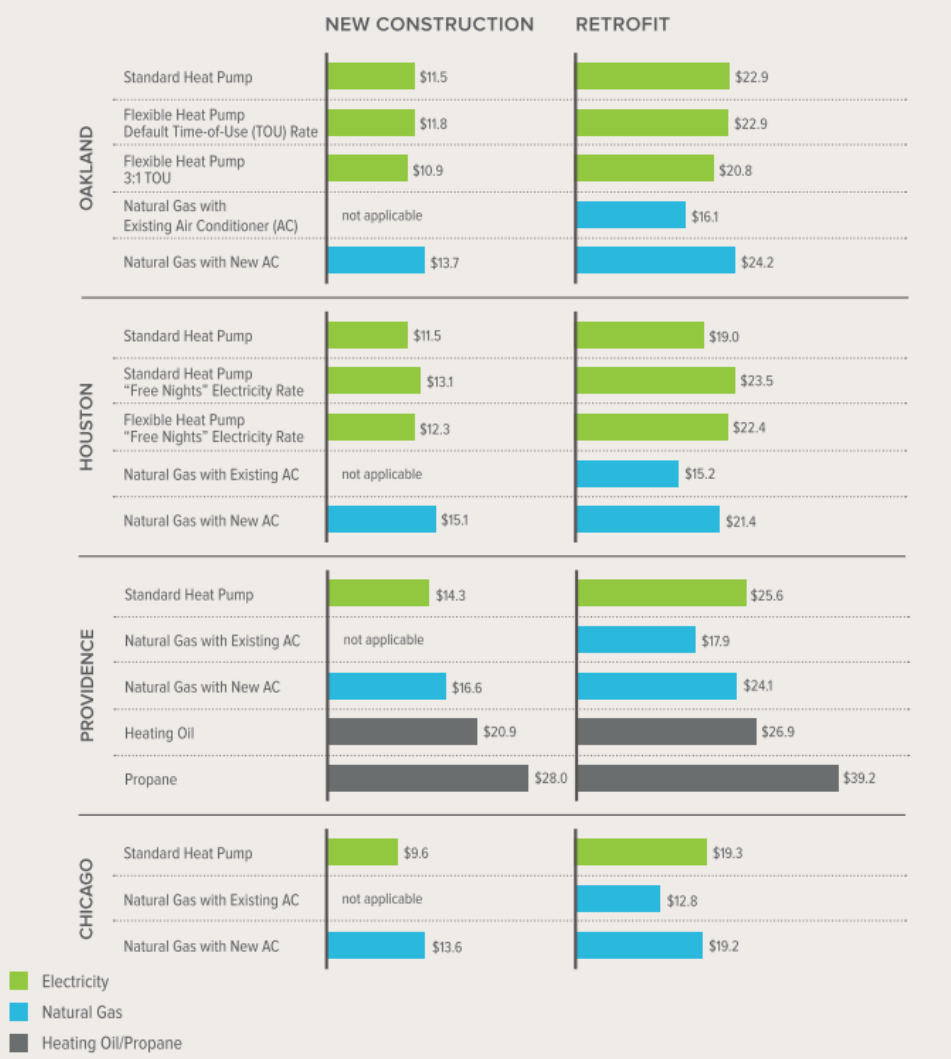
NREL: https://www.nrel.gov/docs/fy13osti/56393.pdf
IEA Heat Pump Technologies TCP: https://heatpumpingtechnologies.org/annex41/

Compared to furnace meeting the Federal Minimum Standard we need a SCOP of at least 2.7

Assuming we're comparing against an EnergyStar compliant natural gas furnace, we'd need an SCOP of at least 3.1

Cost Effectiveness - New vs. Existing

FIGURE 1
COMPARISON OF 15-YEAR NET PRESENT COSTS OF WATER HEATING AND SPACE CONDITIONING (THOUSAND $)



RMI: https://rmi.org/wp-content/uploads/2018/06/RMI_Economics_of_Electrifying_Buildings_2018.pdf

Climate Comparison

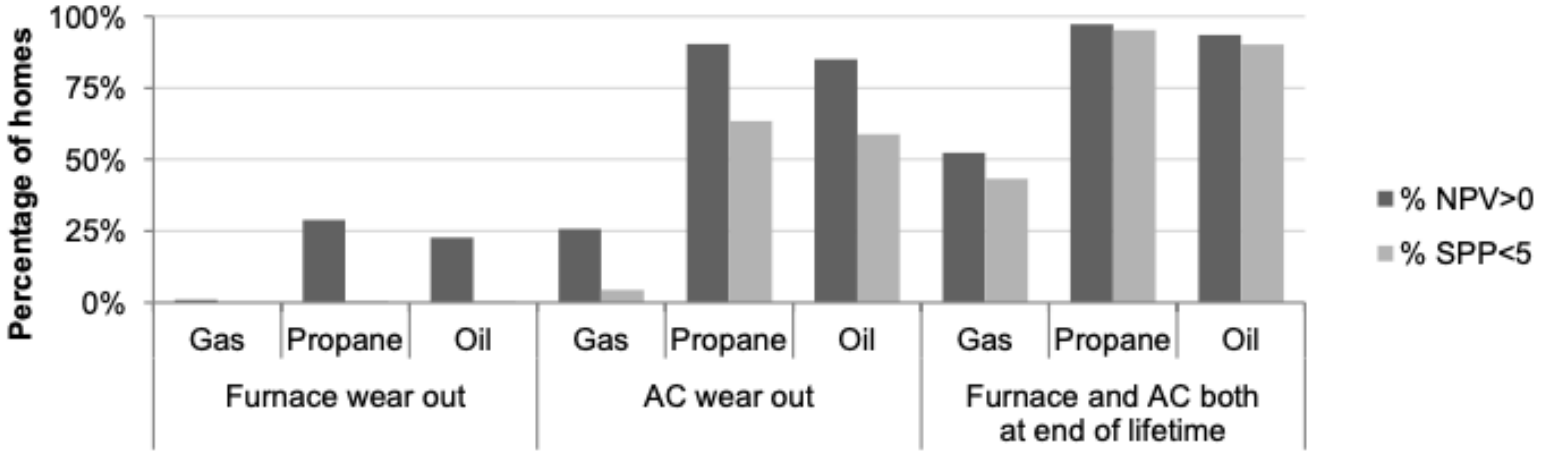
Location	HDD	CDD
Oakland	2425	252
Houston	1197	3304
Providence	5427	795
Chicago	6198	909
US Average	4126	1459

US EPA: https://portfoliomanager.energystar.gov/pm/degreeDaysCalculator

Cost Effectiveness - Existing

Energy Efficiency Potential in the U.S. Single-Family Housing Stock

Figure C-3. National percentage of homes passing cost-effectiveness thresholds for replacement of furnace/air conditioner with variable-speed heat pump, under three wear-out scenarios



When replacing only an AC at wear out (the furnace is removed or left in place as back up), variable-speed heat pumps are cost-effective (SPP<5) in a majority of homes using propane or oil for heating.

NREL: https://www.nrel.gov/docs/fy18osti/68670.pdf

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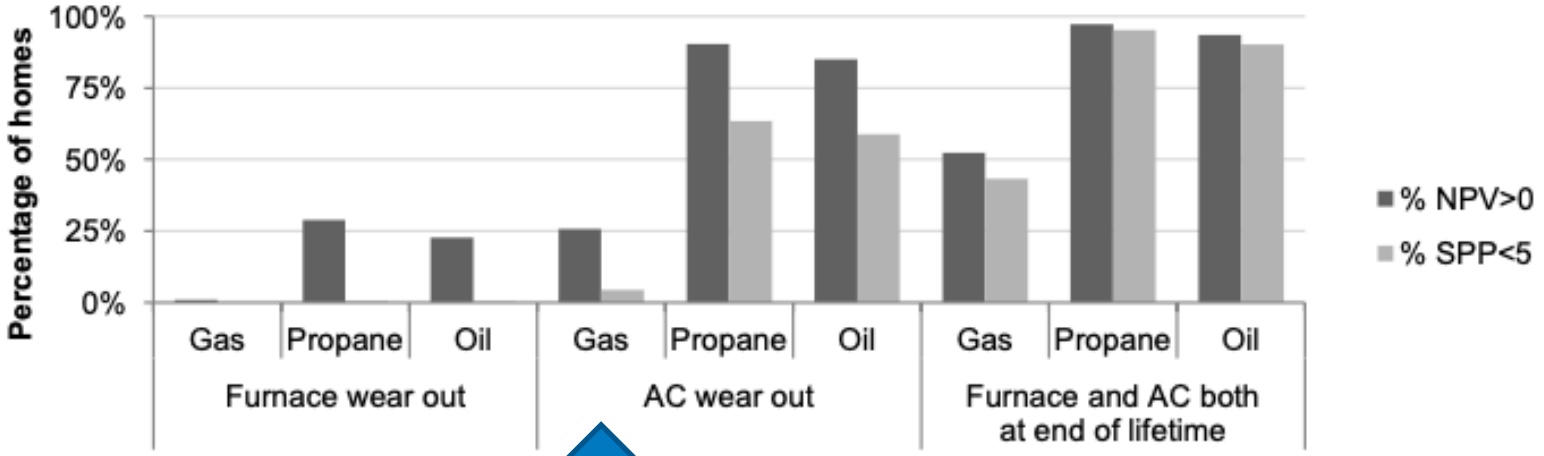

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State level analysis shows the share of homes in Maryland that can cost effectively (NPV>0) switch to a highly efficient ASHP at the point of AC replacement is ~20%.

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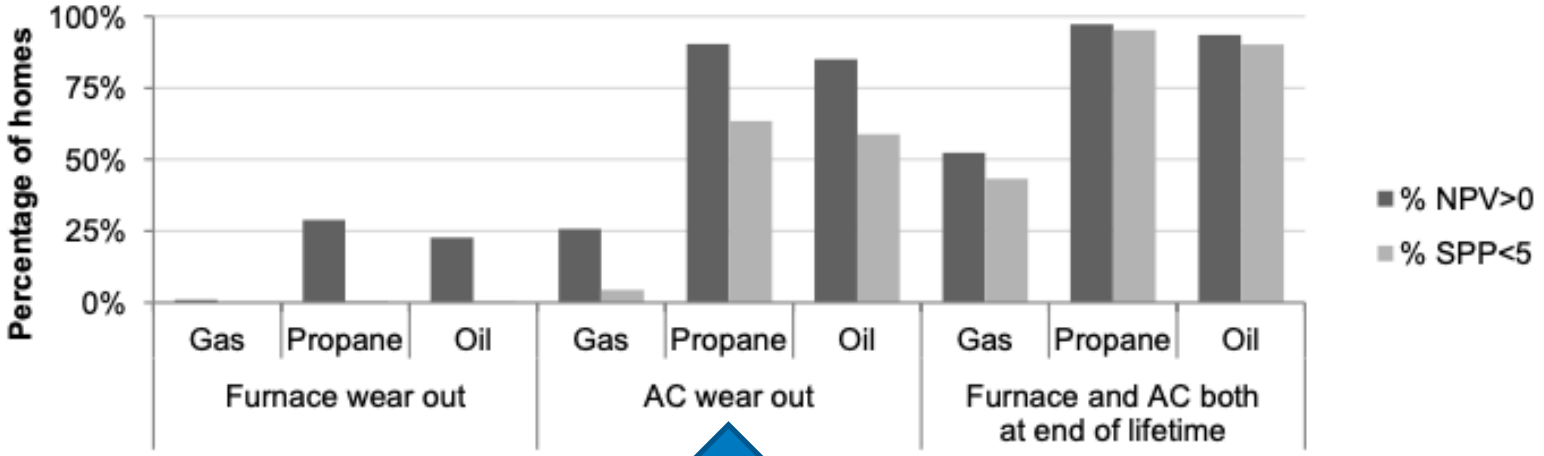

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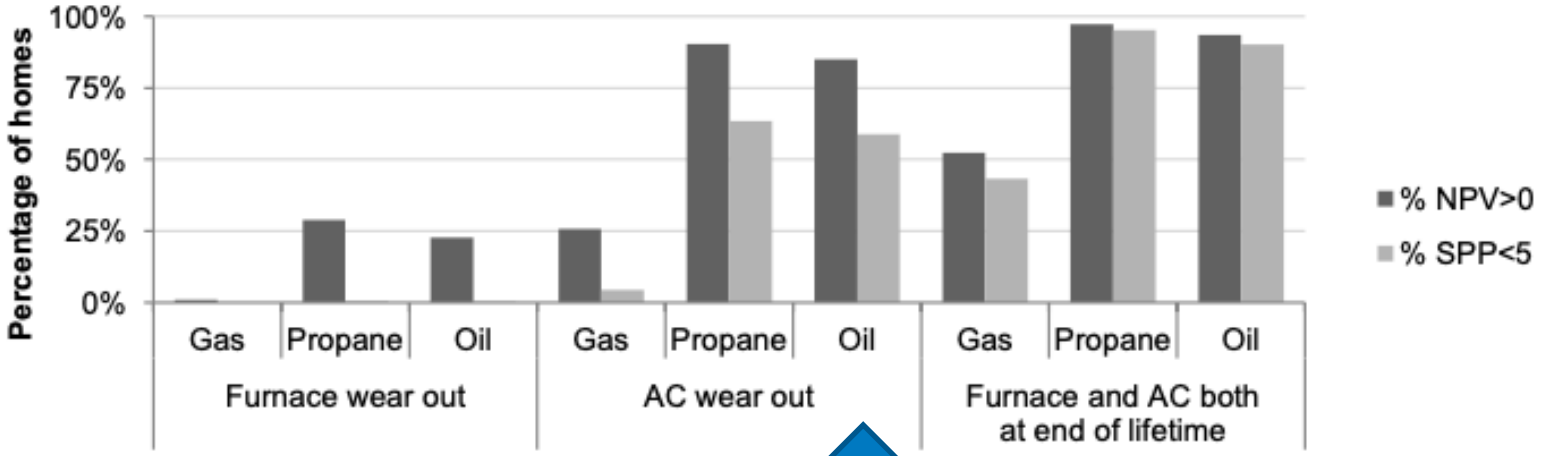

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Electrification Futures Study

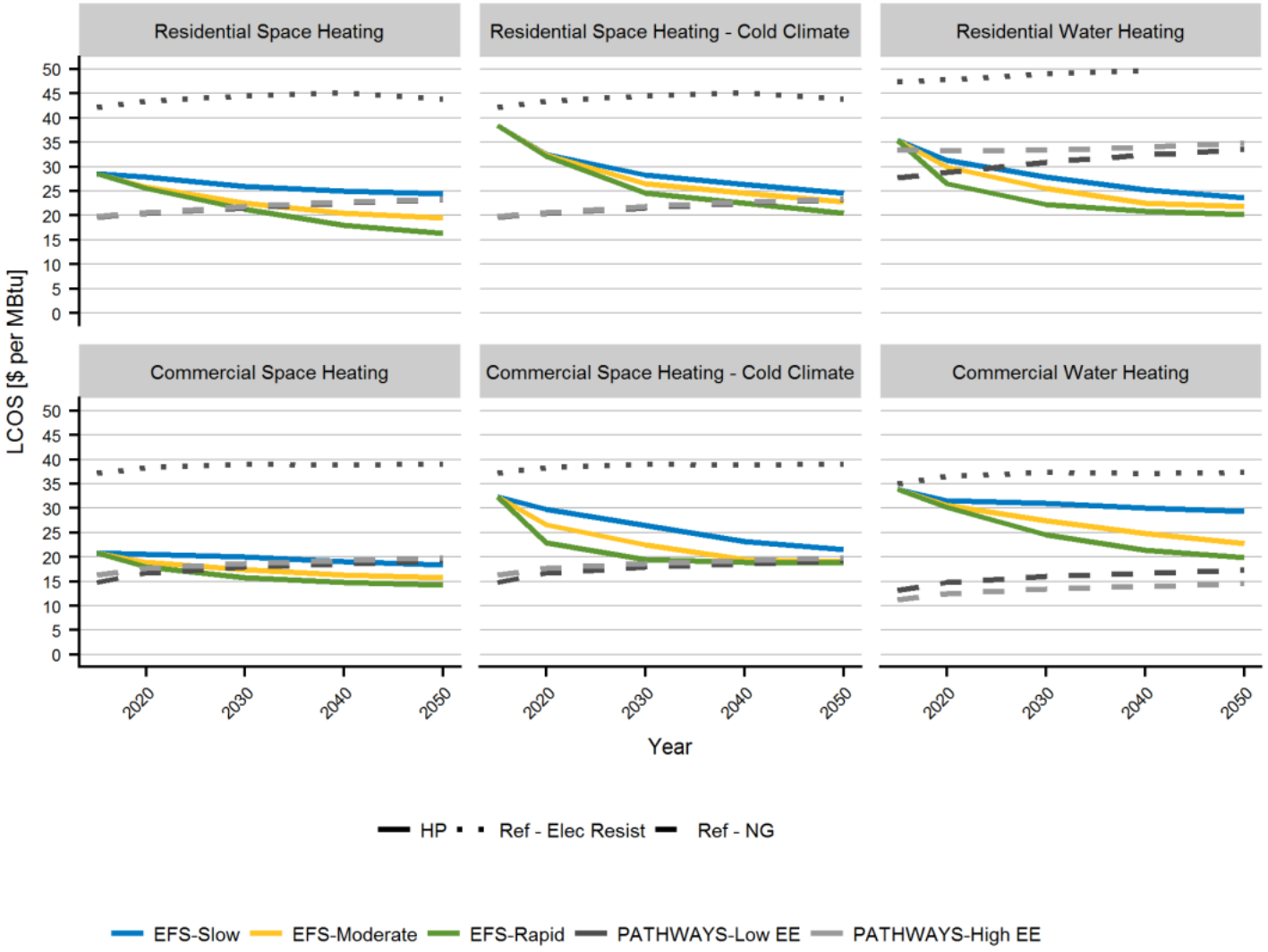
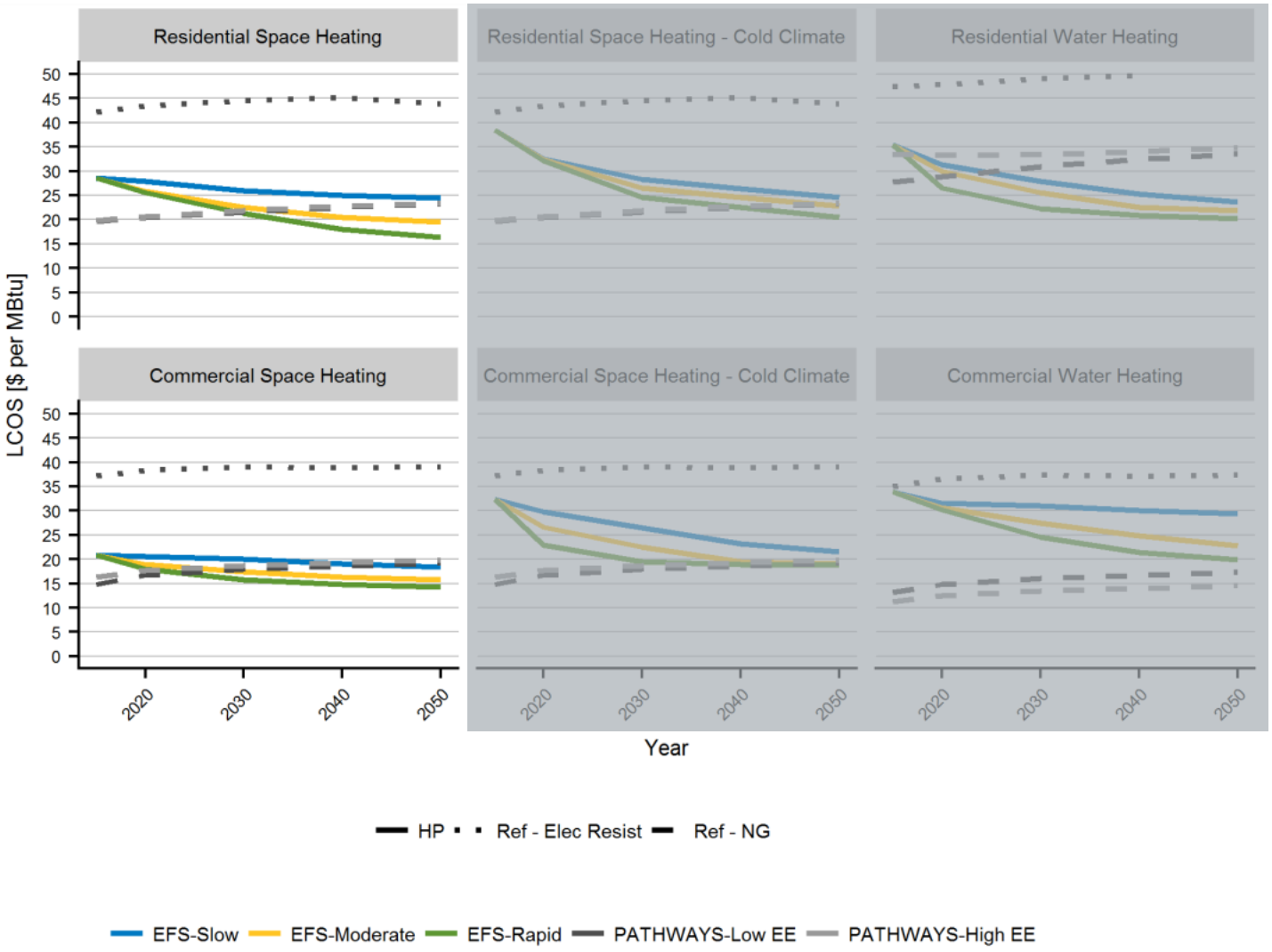


Figure 25. The evolution of the LCOS from heat pumps and natural gas-fired reference technologies for residential and commercial space and water heating

NREL: https://www.nrel.gov/docs/fy18osti/70485.pdf

Electrification Futures Study



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Thank You

Contact Information:
Jack Mayernik
John.Mayernik@nrel.gov

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