

2023 Long Term Preliminary Forecast Assumptions - Heat Pump Electrification

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March 3, 2023

NREL ResStock – 2018 Baseline Building Stocks

NREL Restock Database

- NREL ResStock database contains a representative baseline of housing stock and energy usage characteristics for electric, gas, oil, propane and other fuels. Building vintages are representative of 2018 housing stocks. All results are reported in kWh and kW, regardless of fuel type.
- The energy characteristics were obtained from the DOE EnergyPlus building simulation tool which accounts for weather, building size, construction type, building shell, window type and all other information needed to perform heat transfer calculations at 15 minute intervals.
- The sample for New York was about 33,700 individual building simulations, with sample weights for each site provided to expand to the population of the state.
- Annual natural gas results can be compared to EIA NY residential energy usage as a calibration benchmark of the sample expansion.

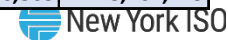
Number of Sample Sites

| Count of 8_weight | Column Lak | | | | | | | | | |
|---------------------------------|---------------|--------------|---------------|--------------|--------------|-----------------|-------------|------------------------|------------------------|---------------|
| Row Labels | 10 to 19 Unit | 2 Unit | 20 to 49 Unit | 3 or 4 Unit | 5 to 9 Unit | 50 or more Unit | Mobile Home | Single-Family Attached | Single-Family Detached | Grand Total |
| Central Hudson Gas and Electric | 24 | 61 | 21 | 58 | 52 | 19 | 44 | 36 | 644 | 959 |
| Consolidated Edison | 980 | 1,969 | 2,473 | 1,446 | 998 | 4,740 | 31 | 1,085 | 1,995 | 15,717 |
| Long Island Power Authority | 101 | 216 | 82 | 88 | 92 | 156 | 24 | 170 | 3,350 | 4,279 |
| National Grid | 140 | 519 | 109 | 313 | 243 | 169 | 329 | 165 | 3,534 | 5,521 |
| NYS Electric and Gas | 93 | 495 | 72 | 226 | 174 | 112 | 275 | 108 | 2,850 | 4,405 |
| Orange and Rockland Utilities | 41 | 61 | 23 | 77 | 67 | 34 | 20 | 74 | 611 | 1,008 |
| Rochester Gas and Electric | 47 | 105 | 41 | 99 | 106 | 74 | 53 | 88 | 1,209 | 1,822 |
| Grand Total | 1,426 | 3,426 | 2,821 | 2,307 | 1,732 | 5,304 | 776 | 1,726 | 14,193 | 33,711 |

Number of Population Households

| Sum of 8_weight | Column Lak | | | | | | | | | |
|---------------------------------|----------------|----------------|----------------|----------------|----------------|------------------|----------------|------------------------|------------------------|------------------|
| Row Labels | 10 to 19 Unit | 2 Unit | 20 to 49 Unit | 3 or 4 Unit | 5 to 9 Unit | 50 or more Unit | Mobile Home | Single-Family Attached | Single-Family Detached | Grand Total |
| Central Hudson Gas and Electric | 5,811 | 14,770 | 5,085 | 14,044 | 12,591 | 4,600 | 10,654 | 8,717 | 155,932 | 232,204 |
| Consolidated Edison | 237,288 | 476,756 | 598,790 | 350,121 | 241,647 | 1,147,701 | 7,506 | 262,712 | 483,051 | 3,805,573 |
| Long Island Power Authority | 24,455 | 52,300 | 19,855 | 21,308 | 22,276 | 37,772 | 5,811 | 41,162 | 811,139 | 1,036,079 |
| National Grid | 33,898 | 125,666 | 26,392 | 75,787 | 58,838 | 40,920 | 79,661 | 39,952 | 855,691 | 1,336,805 |
| NYS Electric and Gas | 22,518 | 119,855 | 17,433 | 54,722 | 42,131 | 27,119 | 66,586 | 26,150 | 690,073 | 1,066,587 |
| Orange and Rockland Utilities | 9,927 | 14,770 | 5,569 | 18,644 | 16,223 | 8,232 | 4,843 | 17,918 | 147,942 | 244,068 |
| Rochester Gas and Electric | 11,380 | 25,424 | 9,927 | 23,971 | 25,666 | 17,918 | 12,833 | 21,308 | 292,736 | 441,163 |
| Grand Total | 345,279 | 829,541 | 683,052 | 558,596 | 419,371 | 1,284,263 | 187,894 | 417,918 | 3,436,565 | 8,162,479 |

Source: NREL 2018 ResStock Database for New York



41_in.geometry_building_type_acs (All)
 69_in.hvac_heating_type_and_fuel (All)

NY Households By Utility and Space Heating Fuel Type

| Sum of 8_weight | Column Labels <input type="button" value="v"/> | | | | | | |
|---|--|------------------|------------------|---------------|----------------|----------------|------------------|
| Row Labels <input type="button" value="v"/> | Electricity | Fuel Oil | Natural Gas | None | Other Fuel | Propane | Grand Total |
| Central Hudson Gas and Electric | 29,298 | 117,676 | 52,058 | | 15,254 | 17,918 | 232,204 |
| Consolidated Edison | 434,625 | 857,870 | 2,365,862 | 52,542 | 46,973 | 47,700 | 3,805,573 |
| Long Island Power Authority | 57,143 | 458,838 | 496,853 | 969 | 5,085 | 17,191 | 1,036,079 |
| National Grid | 190,557 | 211,865 | 735,594 | 969 | 99,274 | 98,547 | 1,336,805 |
| NYS Electric and Gas | 123,971 | 163,923 | 634,383 | 242 | 71,187 | 72,881 | 1,066,587 |
| Orange and Rockland Utilities | 21,792 | 47,458 | 164,165 | | 3,874 | 6,780 | 244,068 |
| Rochester Gas and Electric | 62,470 | 18,402 | 326,877 | 726 | 13,559 | 19,128 | 441,163 |
| Grand Total | 919,856 | 1,876,031 | 4,775,792 | 55,448 | 255,206 | 280,146 | 8,162,479 |

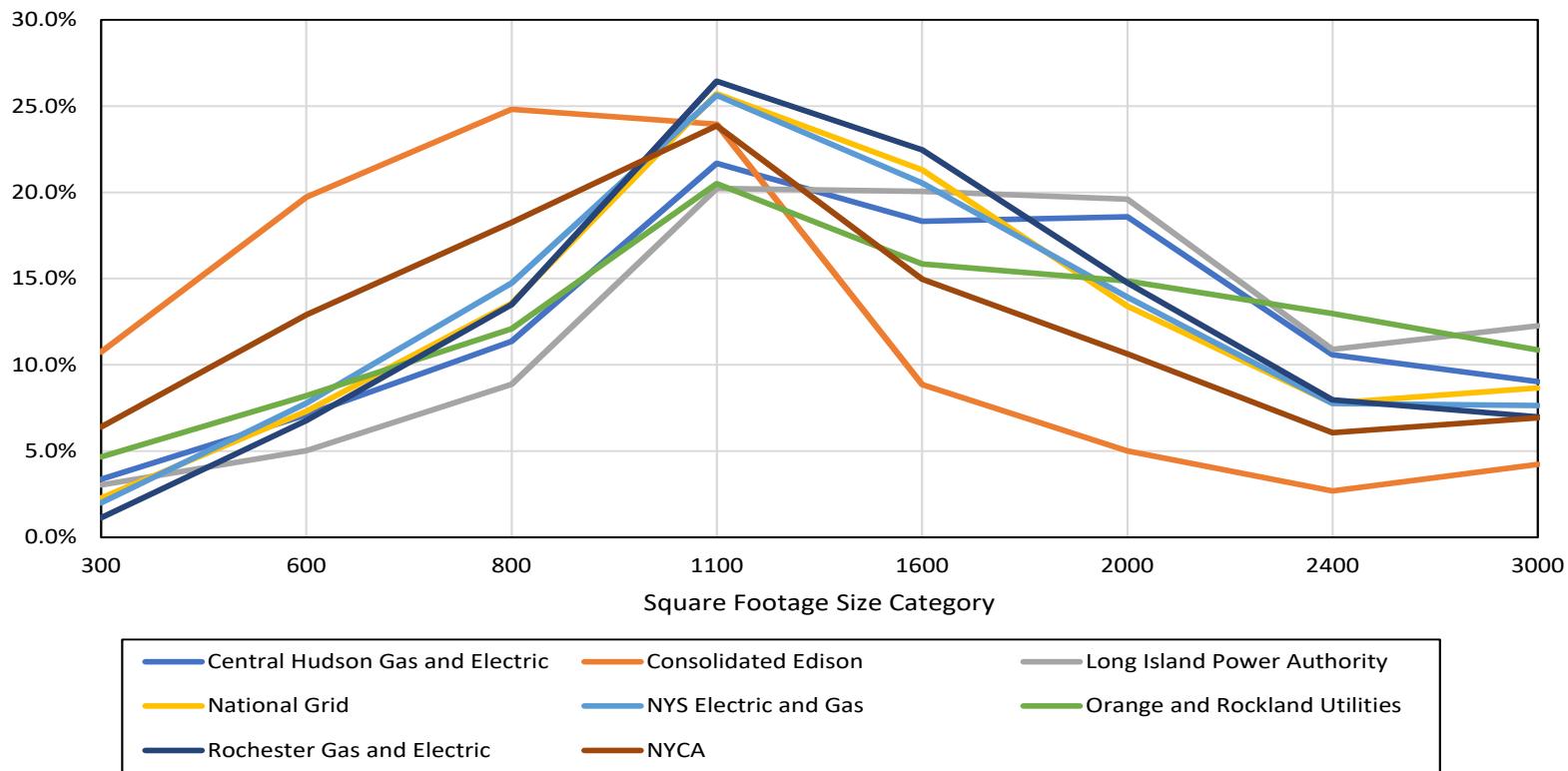
The households with fossil fuel heating define the pool from which electrification impacts are determined, less any households which have switched to electric heat since 2018 (a small number).

Number of Homes Heated by Fossil Fuel, by Size - Sq Ft

| Size of Home or Apartment - Sq | Central Hudson Gas and Electric | Consolidated Edison | Long Island Power | National Grid | NYS Electric and Gas | Orange and Rockland | Rochester Gas and Electric | NYCA |
|--------------------------------|---------------------------------|---------------------|-------------------|------------------|----------------------|---------------------|----------------------------|------------------|
| 300 | 6,295 | 351,332 | 29,540 | 23,729 | 17,433 | 10,170 | 4,116 | 442,615 |
| 600 | 13,317 | 645,037 | 48,910 | 76,513 | 67,797 | 17,918 | 24,697 | 894,190 |
| 800 | 21,308 | 811,865 | 86,199 | 141,889 | 128,329 | 26,392 | 49,153 | 1,265,135 |
| 1100 | 40,678 | 783,294 | 196,853 | 269,008 | 223,245 | 44,794 | 96,368 | 1,654,239 |
| 1600 | 34,383 | 289,589 | 195,158 | 222,761 | 178,935 | 34,625 | 81,840 | 1,037,289 |
| 2000 | 34,867 | 163,923 | 190,799 | 140,194 | 121,308 | 32,446 | 53,753 | 737,289 |
| 2400 | 19,855 | 88,136 | 106,053 | 81,356 | 67,555 | 28,329 | 29,056 | 420,339 |
| 3000 | 16,949 | 138,257 | 119,371 | 90,557 | 66,586 | 23,729 | 25,424 | 480,872 |
| Total | 187,652 | 3,271,432 | 972,882 | 1,046,006 | 871,187 | 218,402 | 364,407 | 6,931,969 |

Subsequent analysis will be performed by utility and size of home.

Percentage of Homes in Each Size Category Single Family & Multi Family Homes



Source: NREL 2018 ResStock Database for New York

Space Heating Requirements, Fossil Fuels - Average Annual kBTU

| Size of Home or Apartment - Sq Ft | Central Hudson | Consolidated Edison | LIPA | National Grid | NYS Electric & Gas | Orange & Rockland | Rochester Gas & Electric | NYCA |
|-----------------------------------|----------------|---------------------|---------------|----------------|--------------------|-------------------|--------------------------|---------------|
| 300 | 17,900 | 16,298 | 18,123 | 22,432 | 21,163 | 18,653 | 21,402 | 17,065 |
| 600 | 29,700 | 30,154 | 31,362 | 42,443 | 46,010 | 31,054 | 41,566 | 32,800 |
| 800 | 44,258 | 42,062 | 44,232 | 59,375 | 60,271 | 44,293 | 55,835 | 46,618 |
| 1,100 | 63,733 | 58,918 | 66,471 | 84,763 | 86,794 | 61,248 | 84,949 | 69,480 |
| 1,600 | 95,699 | 90,560 | 98,817 | 118,299 | 116,274 | 90,618 | 113,569 | 104,494 |
| 2,000 | 91,482 | 118,327 | 110,421 | 131,524 | 132,998 | 109,047 | 130,152 | 120,388 |
| 2,400 | 104,873 | 131,697 | 125,878 | 143,955 | 148,420 | 124,961 | 148,503 | 134,730 |
| 3,000 | 150,327 | 201,594 | 179,867 | 213,395 | 213,037 | 180,989 | 206,543 | 197,445 |
| Total | 80,756 | 58,255 | 96,765 | 105,959 | 105,316 | 87,770 | 104,010 | 80,717 |

Space Heating Requirements, Fossil Fuels - Peak Capacity, BTU per Hour

Based on average of 10 coldest days of heating season. Maximum hourly capacity will be higher

| Size of Home or Apartment - Sq Ft | Central Hudson | Consolidated Edison | LIPA | National Grid | NYS Electric and Gas | Orange & Rockland | Rochester Gas & Electric | NYCA |
|-----------------------------------|----------------|---------------------|---------------|---------------|----------------------|-------------------|--------------------------|---------------|
| 300 | 30,624 | 30,857 | 45,149 | 47,079 | 37,763 | 39,104 | 32,843 | 33,293 |
| 600 | 40,730 | 29,668 | 38,154 | 43,530 | 50,307 | 32,034 | 44,526 | 33,922 |
| 800 | 32,004 | 30,988 | 33,996 | 49,074 | 55,953 | 33,254 | 52,558 | 37,149 |
| 1100 | 46,606 | 33,736 | 39,310 | 58,296 | 58,007 | 30,752 | 63,434 | 43,886 |
| 1600 | 54,521 | 41,518 | 44,079 | 67,446 | 66,240 | 48,351 | 62,135 | 54,455 |
| 2000 | 58,130 | 43,713 | 50,124 | 62,596 | 67,027 | 48,791 | 70,053 | 56,006 |
| 2400 | 55,031 | 46,257 | 50,232 | 71,866 | 68,113 | 47,429 | 65,685 | 57,862 |
| 3000 | 63,156 | 58,260 | 58,889 | 76,508 | 71,497 | 73,019 | 75,851 | 65,998 |
| Total | 47,738 | 34,730 | 44,771 | 60,325 | 61,017 | 43,139 | 61,996 | 45,506 |

Source: NREL 2018 ResStock Database for New York



Space Heating Requirements - Electric Resistance Heating - Average Annual kWh

Based on average annual fossil-fuel furnace efficiency of 80%

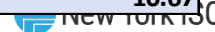
| Size of Home or Apartment - Sq Ft | Central Hudson | Consolidated Edison | LIPA | National Grid | NYS Electric and Gas | Orange & Rockland | Rochester Gas & Electric | NYCA |
|-----------------------------------|----------------|---------------------|---------------|---------------|----------------------|-------------------|--------------------------|---------------|
| 300 | 4,197 | 3,821 | 4,249 | 5,260 | 4,962 | 4,374 | 5,018 | 4,001 |
| 600 | 6,964 | 7,070 | 7,353 | 9,951 | 10,788 | 7,281 | 9,746 | 7,690 |
| 800 | 10,377 | 9,862 | 10,371 | 13,921 | 14,132 | 10,385 | 13,091 | 10,930 |
| 1,100 | 14,943 | 13,814 | 15,585 | 19,874 | 20,350 | 14,361 | 19,918 | 16,291 |
| 1,600 | 22,438 | 21,233 | 23,169 | 27,737 | 27,262 | 21,247 | 26,628 | 24,500 |
| 2,000 | 21,449 | 27,744 | 25,890 | 30,838 | 31,183 | 25,568 | 30,516 | 28,227 |
| 2,400 | 24,589 | 30,878 | 29,514 | 33,753 | 34,800 | 29,299 | 34,819 | 31,590 |
| 3,000 | 35,247 | 47,267 | 42,173 | 50,034 | 49,950 | 42,436 | 48,427 | 46,294 |
| Total | 18,935 | 13,659 | 22,688 | 24,844 | 24,693 | 20,579 | 24,387 | 18,925 |

Space Heating Requirements, Electric Resistance Heat - Peak Capacity, kW

Based on average of 10 coldest days of heating season. Maximum hourly capacity will be higher

| Size of Home or Apartment - Sq Ft | Central Hudson | Consolidated Edison | LIPA | National Grid | NYS Electric and Gas | Orange & Rockland | Rochester Gas & Electric | NYCA |
|-----------------------------------|----------------|---------------------|--------------|---------------|----------------------|-------------------|--------------------------|--------------|
| 300 | 7.18 | 7.23 | 10.59 | 11.04 | 8.85 | 9.17 | 7.70 | 7.81 |
| 600 | 9.55 | 6.96 | 8.95 | 10.21 | 11.80 | 7.51 | 10.44 | 7.95 |
| 800 | 7.50 | 7.27 | 7.97 | 11.51 | 13.12 | 7.80 | 12.32 | 8.71 |
| 1100 | 10.93 | 7.91 | 9.22 | 13.67 | 13.60 | 7.21 | 14.87 | 10.29 |
| 1600 | 12.78 | 9.73 | 10.34 | 15.81 | 15.53 | 11.34 | 14.57 | 12.77 |
| 2000 | 13.63 | 10.25 | 11.75 | 14.68 | 15.72 | 11.44 | 16.43 | 13.13 |
| 2400 | 12.90 | 10.85 | 11.78 | 16.85 | 15.97 | 11.12 | 15.40 | 13.57 |
| 3000 | 14.81 | 13.66 | 13.81 | 17.94 | 16.76 | 17.12 | 17.78 | 15.47 |
| Total | 11.19 | 8.14 | 10.50 | 14.14 | 14.31 | 10.11 | 14.54 | 10.67 |

Source: NREL 2018 ResStock Database for New York



Space Heating Requirements - Air Source Heat Pump - Average Annual kWh

COP - Coefficient of Performance. HSPF is Heating Season Performance Factor. Each measures the ration energy provided to energy consumed over the heating season.

Based on Seasonal COP of 2.5, or HSPF of 8.5

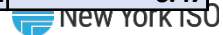
| Size of Home or Apartment - Sq Ft | Central Hudson | Consolidated Edison | LIPA | National Grid | NYS Electric and Gas | Orange & Rockland | Rochester Gas & Electric | NYCA |
|-----------------------------------|----------------|---------------------|--------------|---------------|----------------------|-------------------|--------------------------|--------------|
| 300 | 1,679 | 1,529 | 1,700 | 2,104 | 1,985 | 1,749 | 2,007 | 1,600 |
| 600 | 2,785 | 2,828 | 2,941 | 3,981 | 4,315 | 2,912 | 3,898 | 3,076 |
| 800 | 4,151 | 3,945 | 4,148 | 5,569 | 5,653 | 4,154 | 5,237 | 4,372 |
| 1,100 | 5,977 | 5,526 | 6,234 | 7,950 | 8,140 | 5,744 | 7,967 | 6,516 |
| 1,600 | 8,975 | 8,493 | 9,268 | 11,095 | 10,905 | 8,499 | 10,651 | 9,800 |
| 2,000 | 8,580 | 11,098 | 10,356 | 12,335 | 12,473 | 10,227 | 12,206 | 11,291 |
| 2,400 | 9,836 | 12,351 | 11,806 | 13,501 | 13,920 | 11,720 | 13,928 | 12,636 |
| 3,000 | 14,099 | 18,907 | 16,869 | 20,014 | 19,980 | 16,974 | 19,371 | 18,518 |
| Total | 7,574 | 5,464 | 9,075 | 9,938 | 9,877 | 8,232 | 9,755 | 7,570 |

Space Heating Requirements, Air Source Heat Pump - Peak Capacity, kW

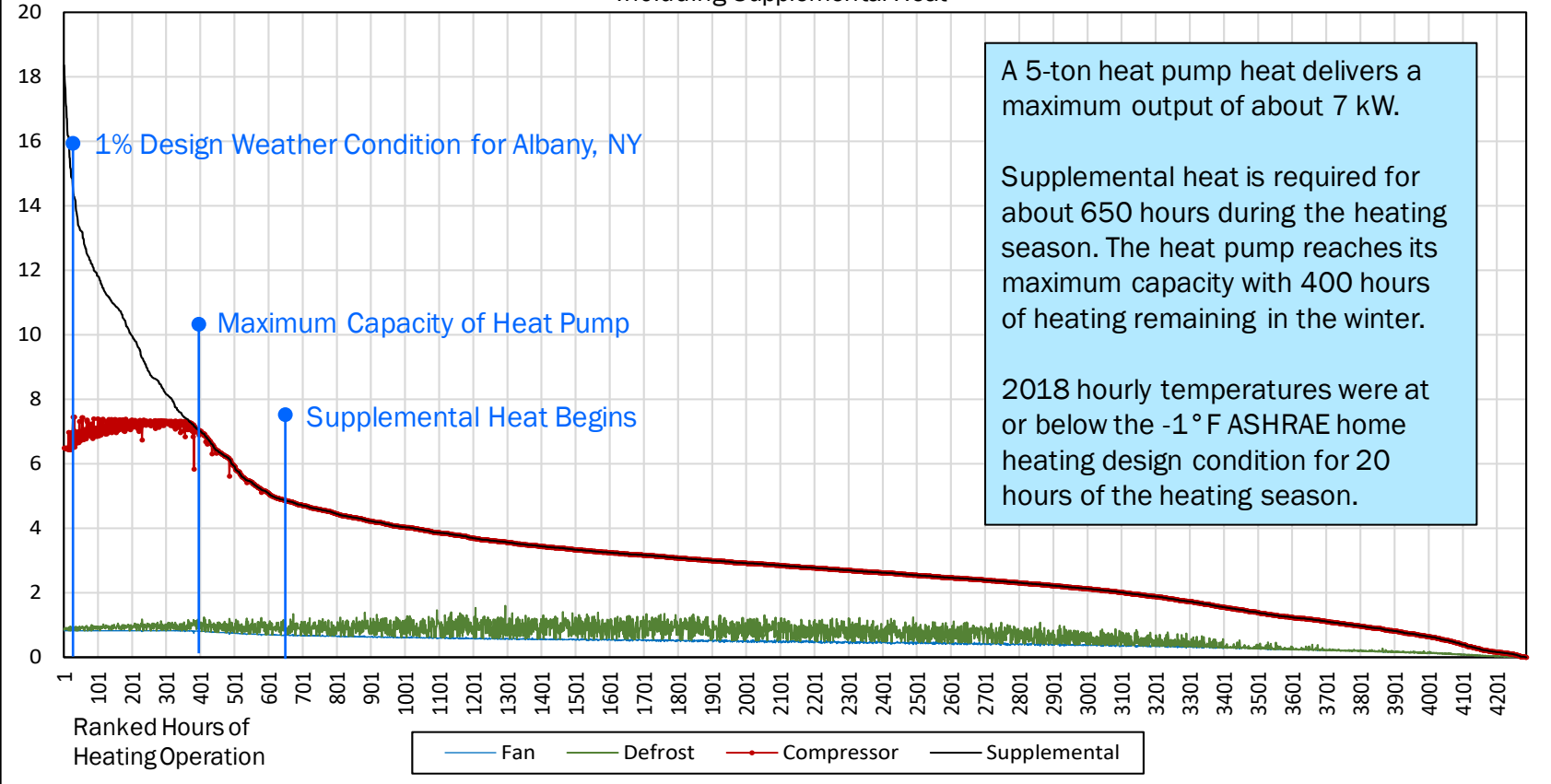
Based on average of 10 coldest days of heating season. Maximum hourly capacity will be higher. Peak COP is 1.65

| Size of Home or Apartment - Sq Ft | Central Hudson | Consolidated Edison | LIPA | National Grid | NYS Electric and Gas | Orange & Rockland | Rochester Gas & Electric | NYCA |
|-----------------------------------|----------------|---------------------|-------------|---------------|----------------------|-------------------|--------------------------|-------------|
| 300 | 4.35 | 4.38 | 6.42 | 6.69 | 5.37 | 5.56 | 4.67 | 4.73 |
| 600 | 5.79 | 4.22 | 5.42 | 6.19 | 7.15 | 4.55 | 6.33 | 4.82 |
| 800 | 4.55 | 4.40 | 4.83 | 6.97 | 7.95 | 4.73 | 7.47 | 5.28 |
| 1100 | 6.62 | 4.79 | 5.59 | 8.28 | 8.24 | 4.37 | 9.01 | 6.24 |
| 1600 | 7.75 | 5.90 | 6.26 | 9.58 | 9.41 | 6.87 | 8.83 | 7.74 |
| 2000 | 8.26 | 6.21 | 7.12 | 8.89 | 9.52 | 6.93 | 9.95 | 7.96 |
| 2400 | 7.82 | 6.57 | 7.14 | 10.21 | 9.68 | 6.74 | 9.33 | 8.22 |
| 3000 | 8.97 | 8.28 | 8.37 | 10.87 | 10.16 | 10.38 | 10.78 | 9.38 |
| Total | 6.78 | 4.94 | 6.36 | 8.57 | 8.67 | 6.13 | 8.81 | 6.47 |

Source: NREL 2018 ResStock Database for New York

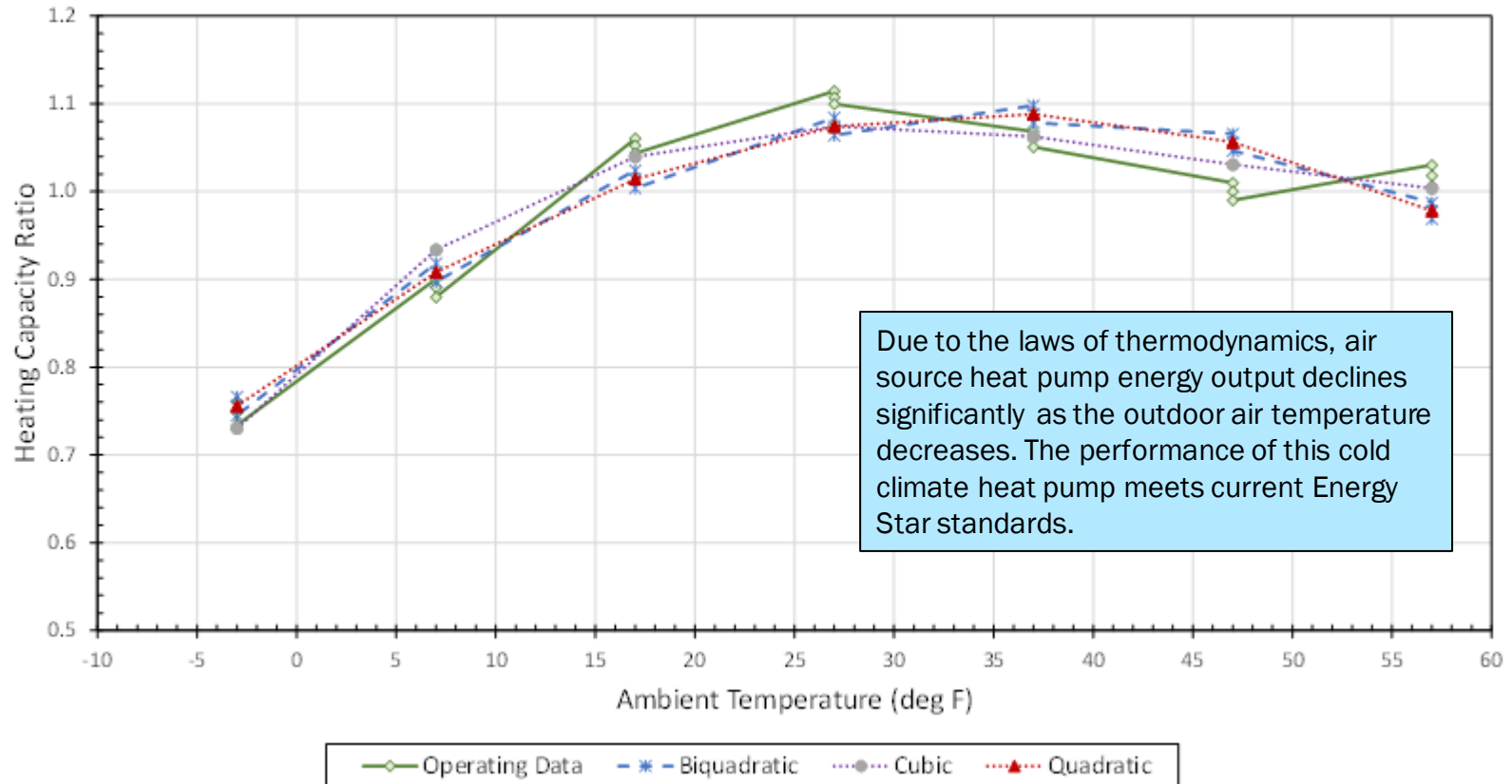


Load Duration of Heat Pump System - Heating Season - kW Including Supplemental Heat



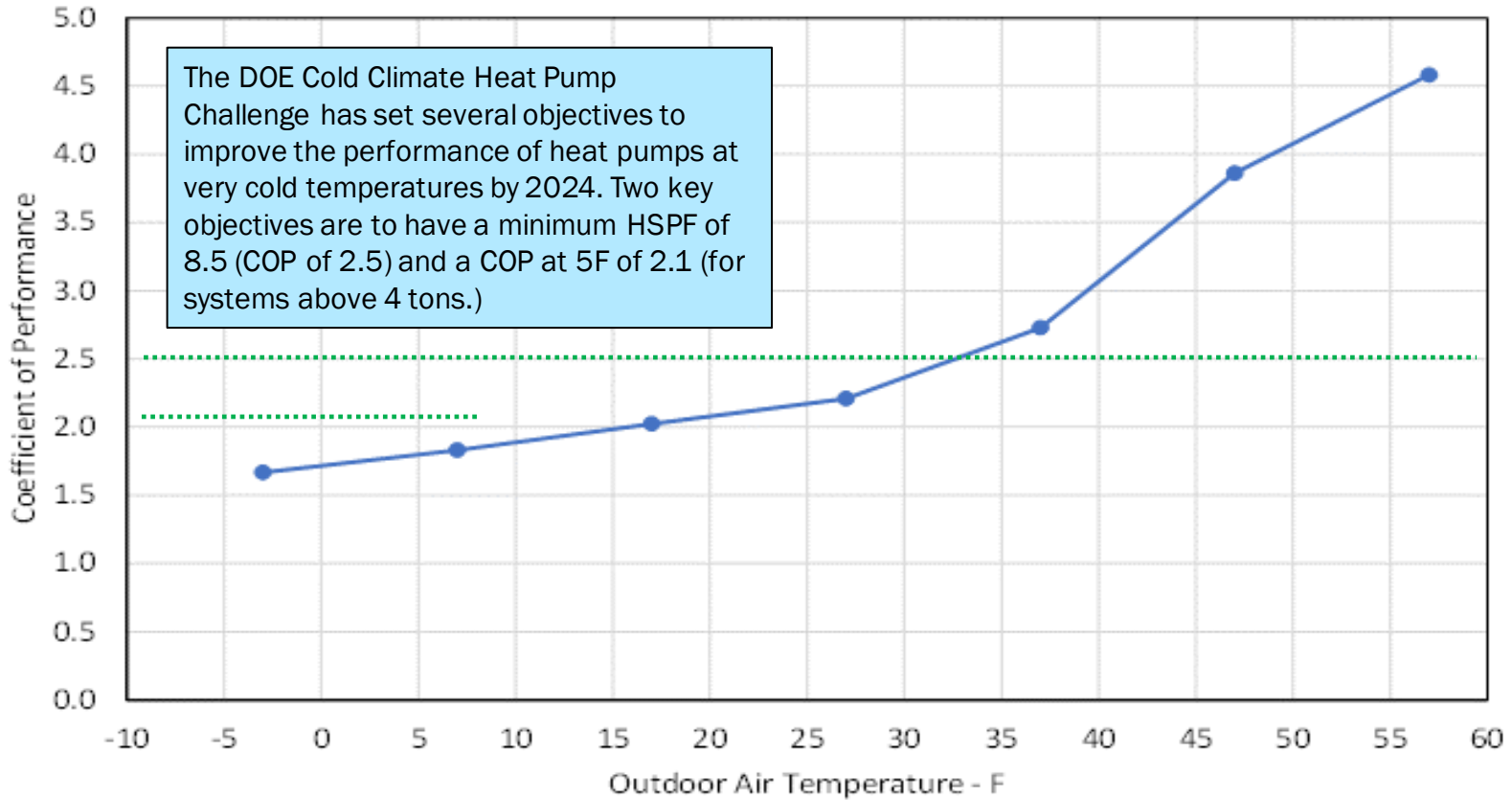
Heating Capacity Ratios at Median Compressor Speed

Model Capacity = 1.0 at 47 F

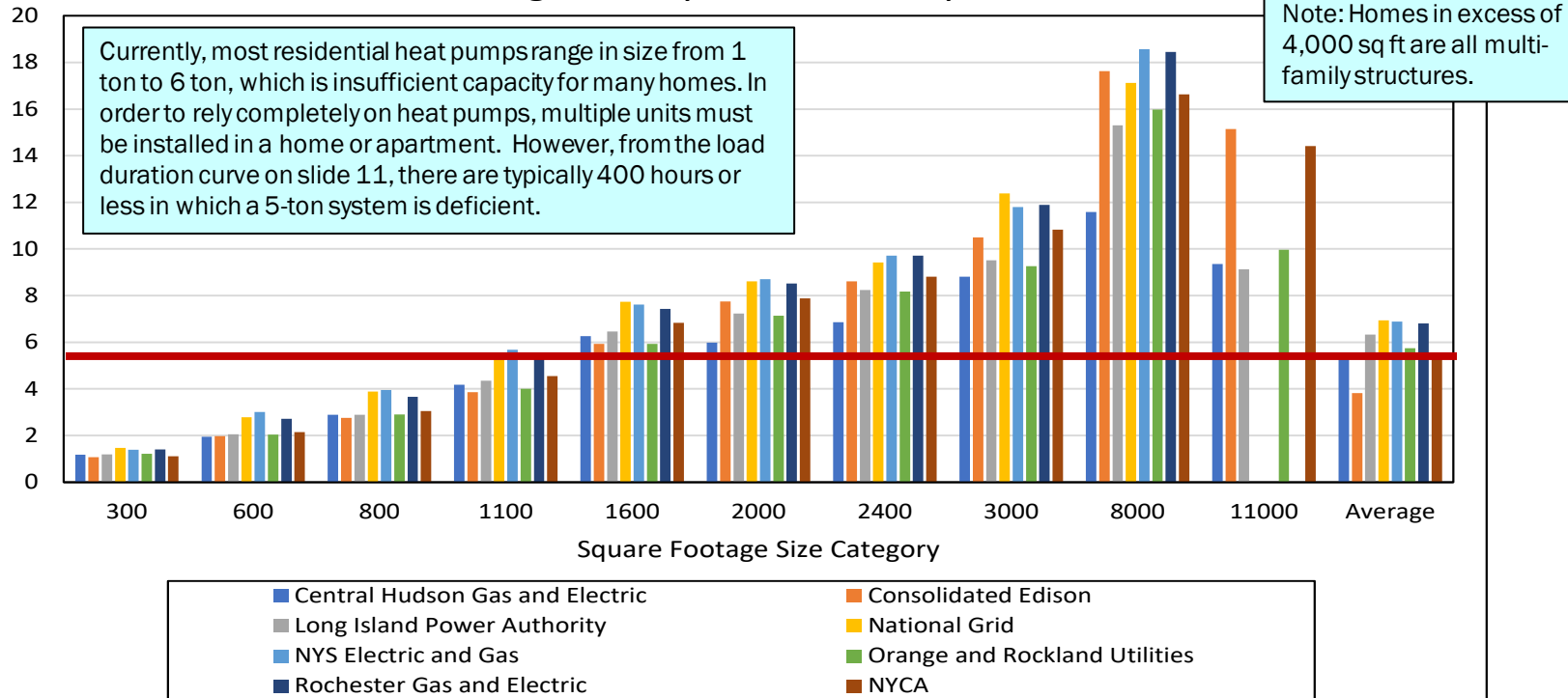


Due to the laws of thermodynamics, air source heat pump energy output declines significantly as the outdoor air temperature decreases. The performance of this cold climate heat pump meets current Energy Star standards.

Coefficient of Performance versus Outdoor Air Temperature



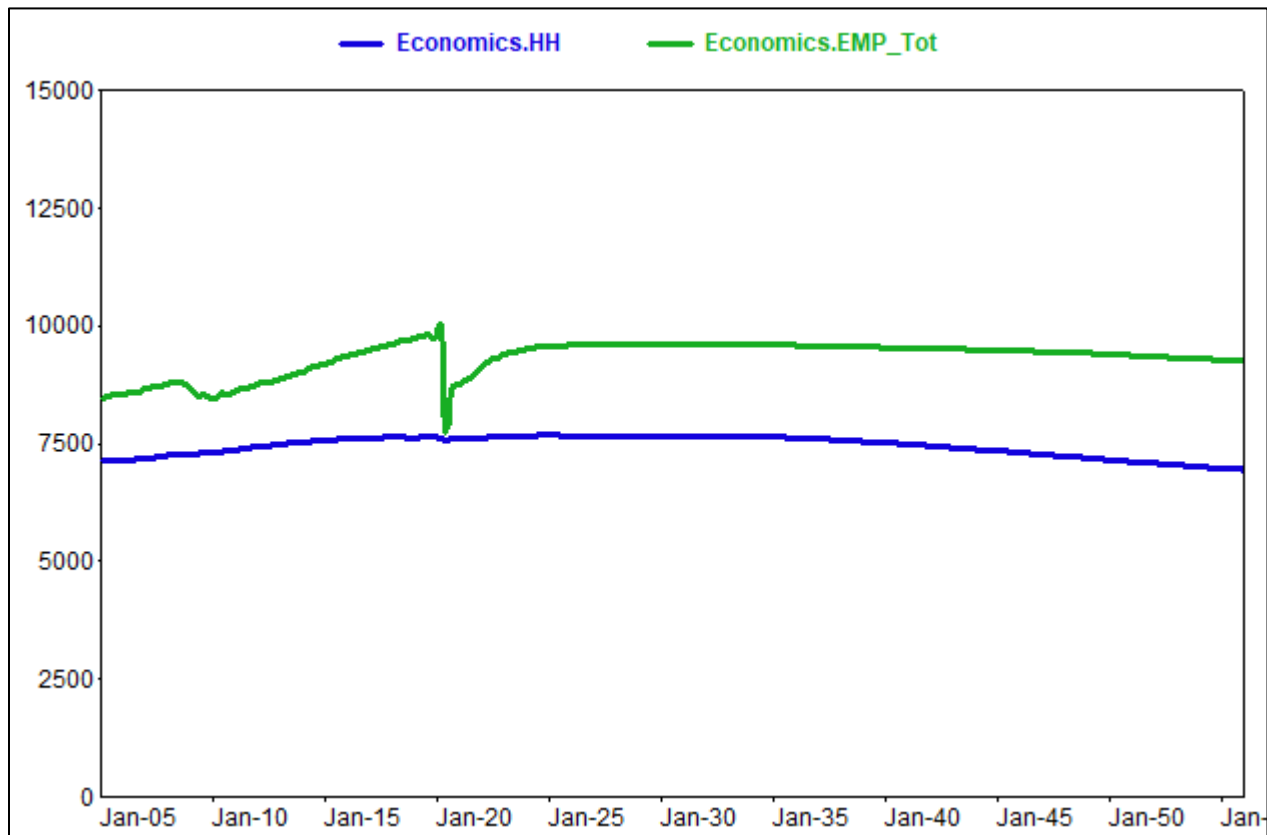
Average Rated Size of Air Source Heat Pump - Tons Single Family & Multi Family Homes



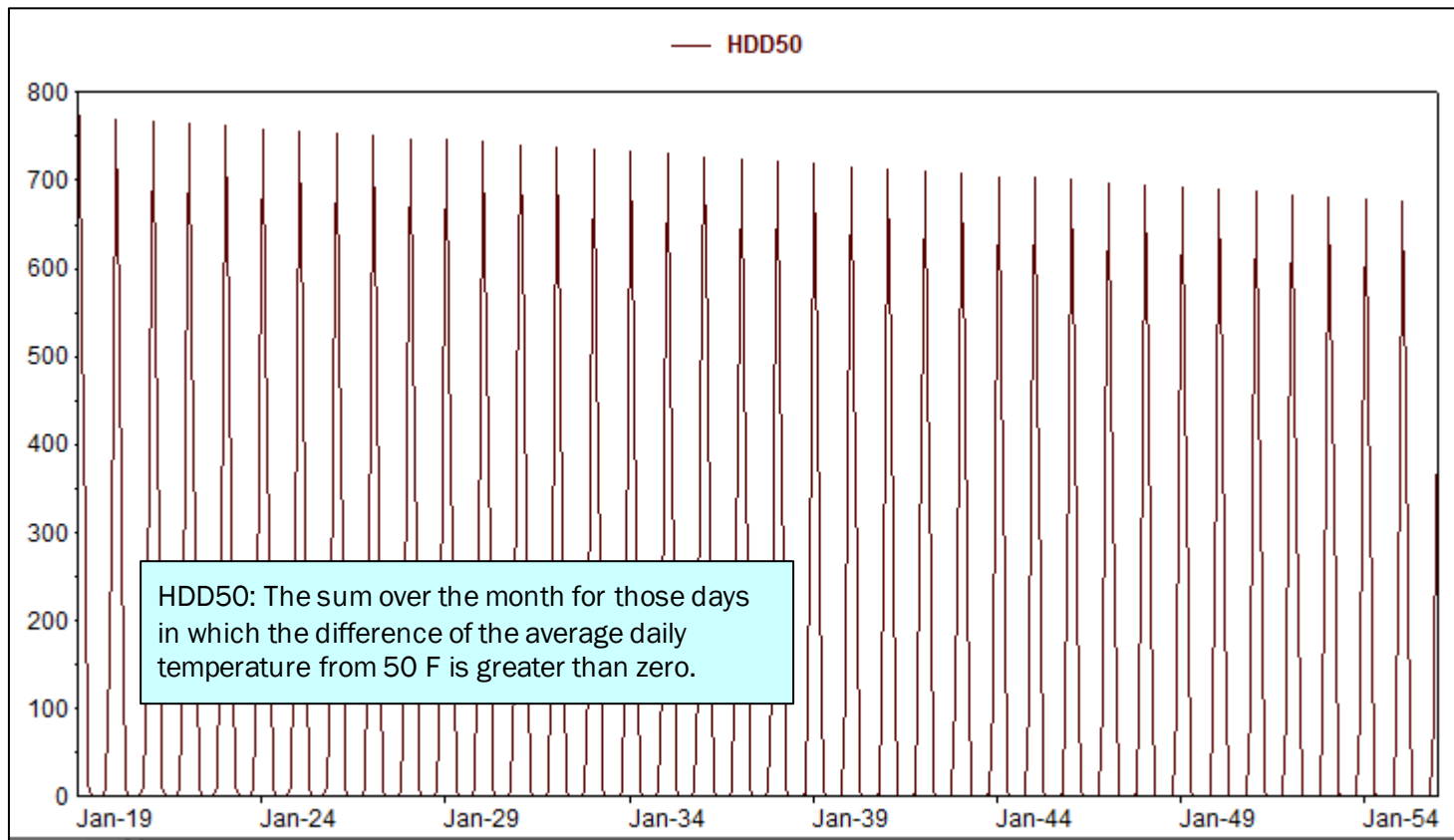
Note: This analysis excludes electric T&D losses, so that the required capacity is that of the home or apartment.

NREL ResStock – Forecasting Residential Space Heating

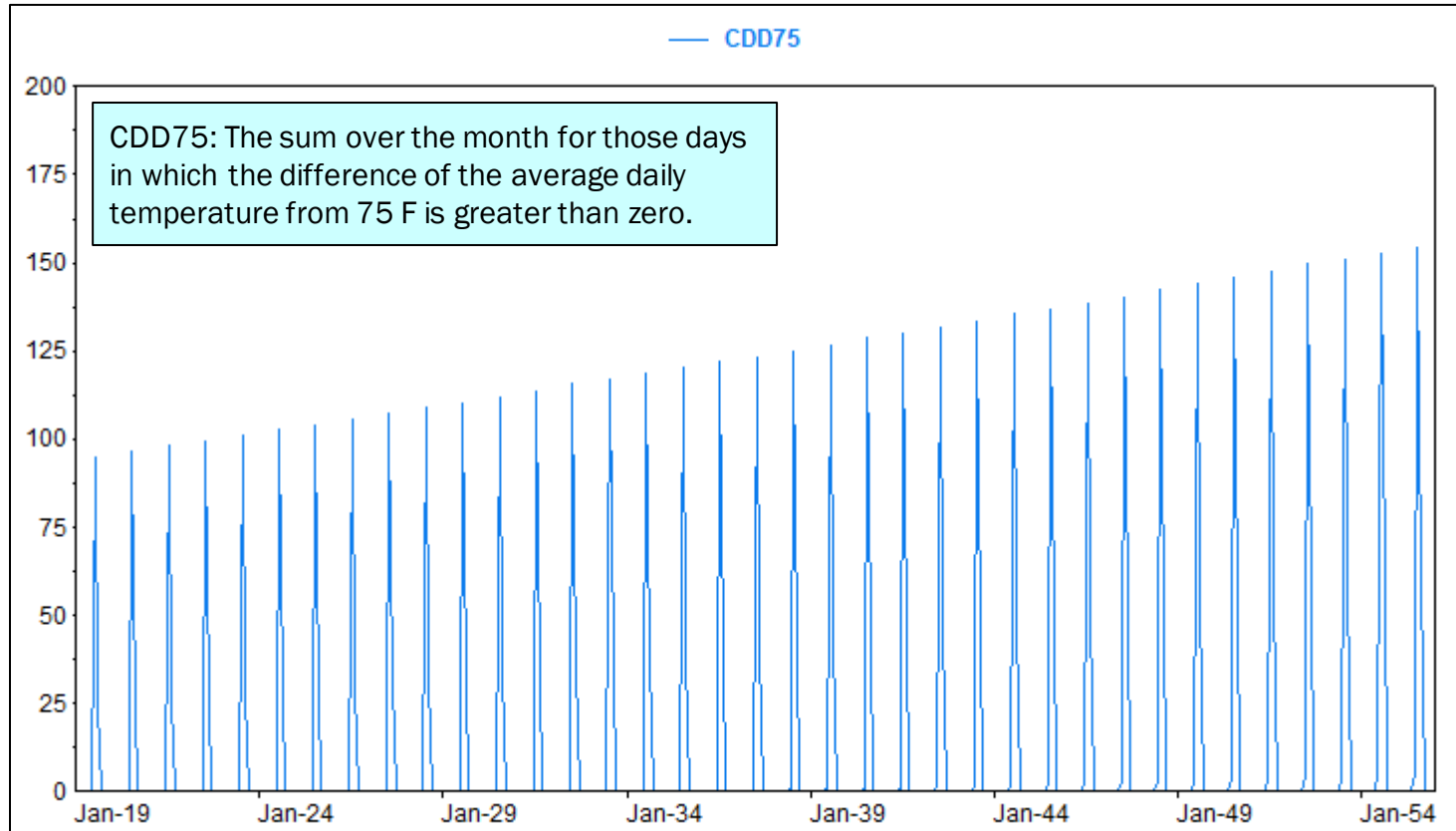
Employment and Household Growth Is Essentially Flat Until 2035 and Then Gradually Declines



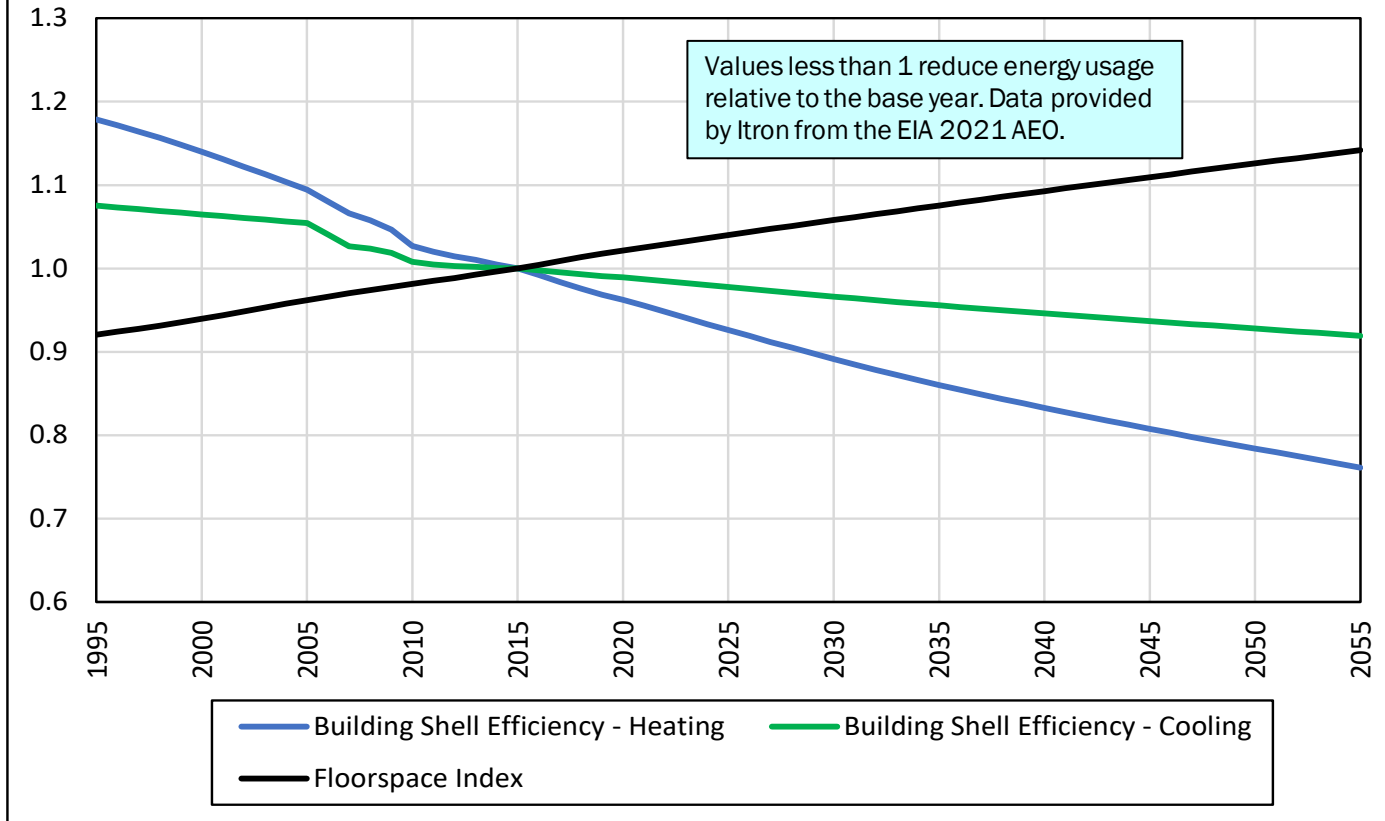
Downward Trend in Heating Degree Days Will Reduce Winter Energy and Winter Peaks



Upward Trend in Cooling Degree Days Will Increase Summer Energy and Summer Peaks

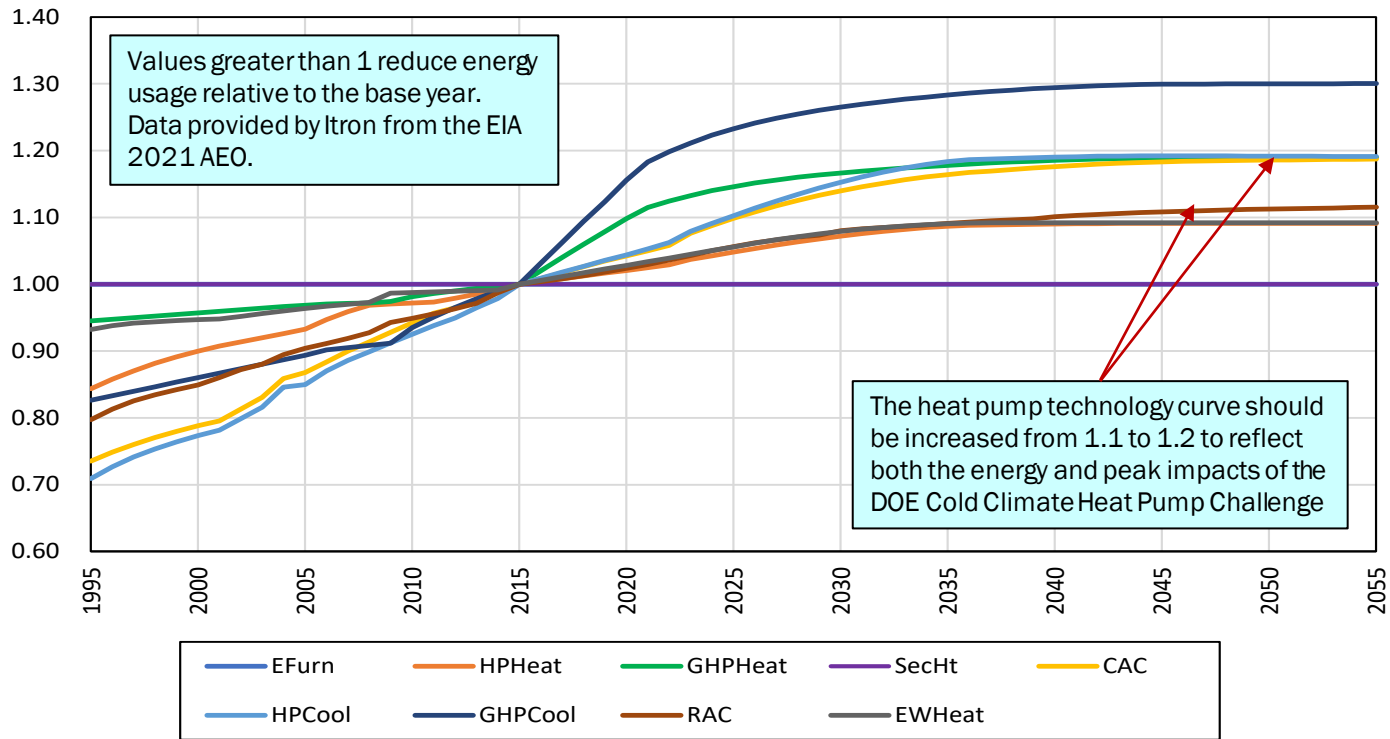


Building Shell Efficiency Indexes

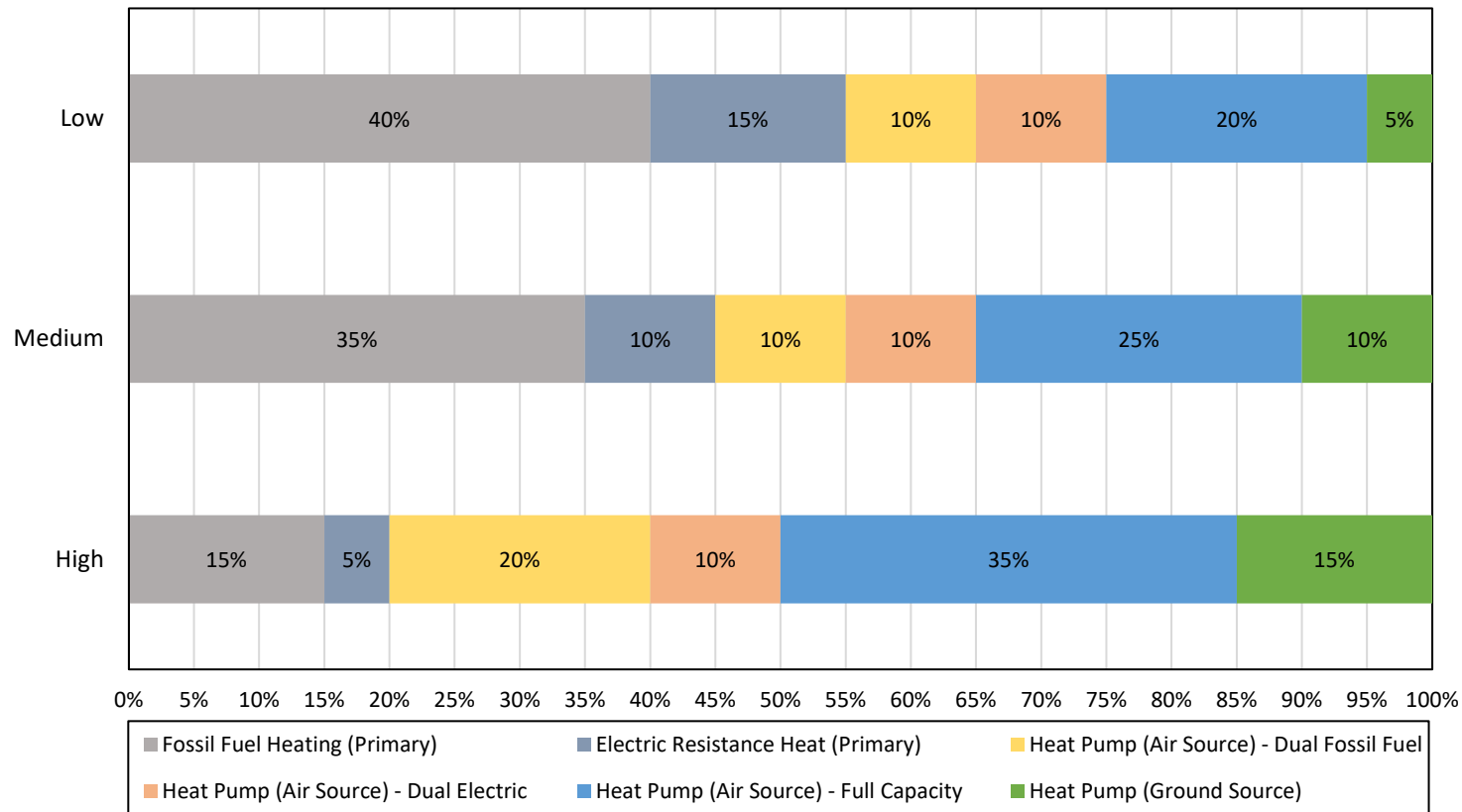


Source: ITRON & EIA 2021 AEO

Energy Efficiency Indexes for Space Heating & Cooling Technologies



Three Electrification Pathways Residential Space Heating Technology Shares in 2050



Three Scenarios for Residential Space Heating Electrification

| Technology Cases | Technology Pathways | High | Medium | Low |
|------------------|---|------|--------|------|
| 1 | Fossil Fuel Heating (Primary) | 15% | 35% | 40% |
| 2 | Electric Resistance Heat (Primary) | 5% | 10% | 15% |
| 3 | Heat Pump (Air Source) - Dual Fossil Fuel | 20% | 10% | 10% |
| 4 | Heat Pump (Air Source) - Dual Electric | 10% | 10% | 10% |
| 6 | Heat Pump (Air Source) - Full Capacity | 35% | 25% | 20% |
| 7 | Heat Pump (Ground Source) | 15% | 10% | 5% |
| | Total | 100% | 100% | 100% |

Our Mission & Vision



Mission

Ensure power system reliability and competitive markets for New York in a clean energy future



Vision

Working together with stakeholders to build the cleanest, most reliable electric system in the nation