Assessment of Building Electrification Technologies for New York State

NYISO Spring Economic Conference

Brandon Johnson
EPRI – Technical Leader

June 15, 2023

Presentation Outline

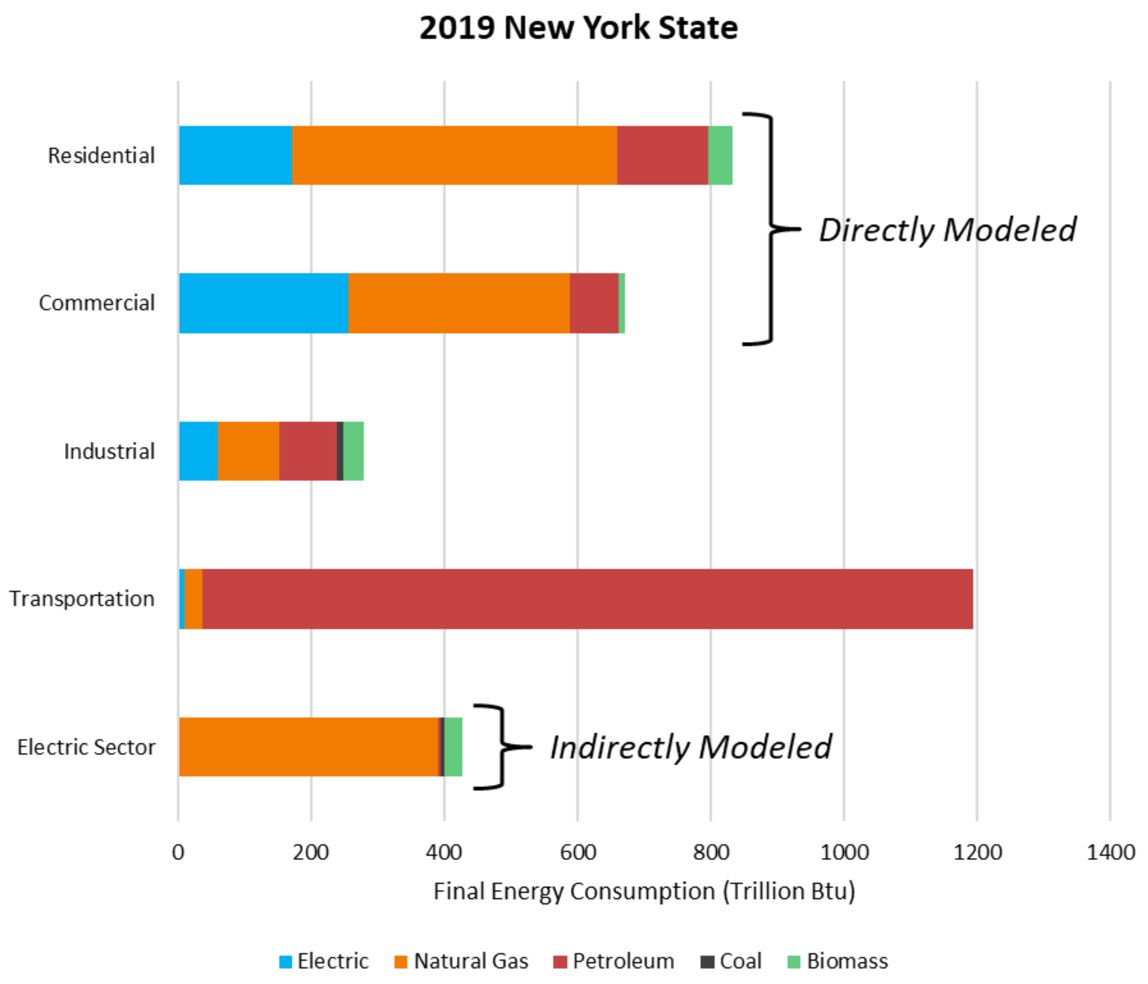
- Background Information
  - Modeling Framework and Scope
  - Baseline Consumption
- Scenario Analysis
  - Energy and Emissions Impacts
  - 2050 Demand Impacts
- Demand Flexibility and Energy Storage
- Climate Impacts (2-Sigma Analysis)

Background Information

Background Information

- EPRI has completed two end-use electrification studies for New York State
- 2018-2020: [Electrification Scenarios for New York's Energy Future]
  - Economy-wide evaluation of electrification opportunities within New York State
- 2021-2023: [Assessment of Building Electrification Technologies for New York State]
  - Follow-on effort to the initial study, with an emphasis on space and water heating
  - Better alignment of modeling to field data
  - Concentrated on peak mitigation scenarios
  - Participants: Central Hudson, Consolidated Edison, NYISO, NYPA, and NYSERDA (observer)

Modeling Framework and Scope



Potential = Service Metric × Energy Intensity × Saturation

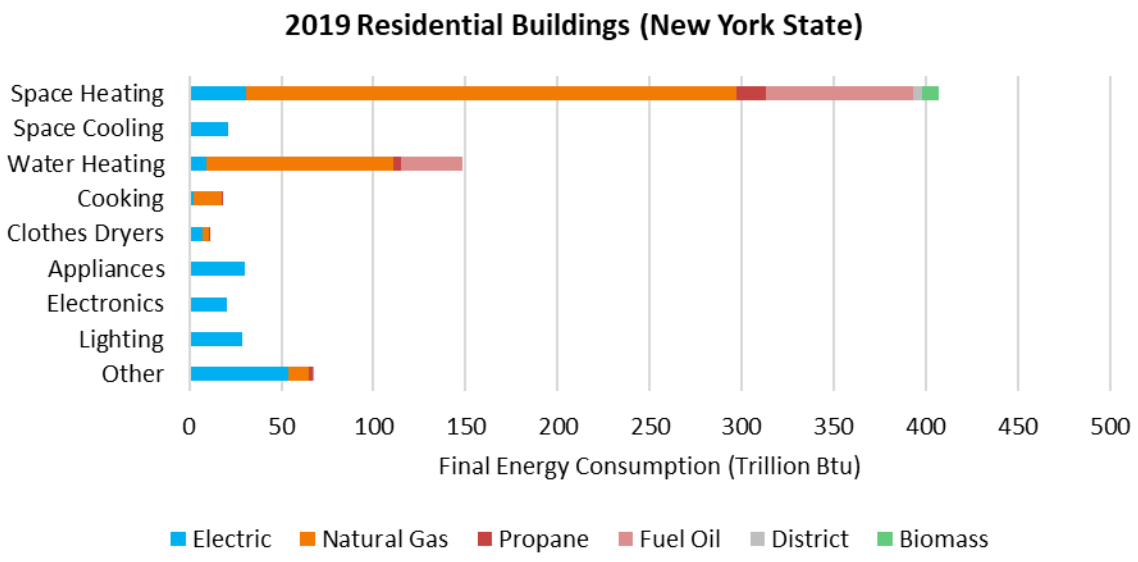
- Combines various public and private data sources to estimate final energy consumption at the end-use/equipment level for different geographies
  - Including data from the Census Bureau, EIA, NREL, and Socioeconomic Data and Applications Center
  - Ranging in granularity from regional to county-level

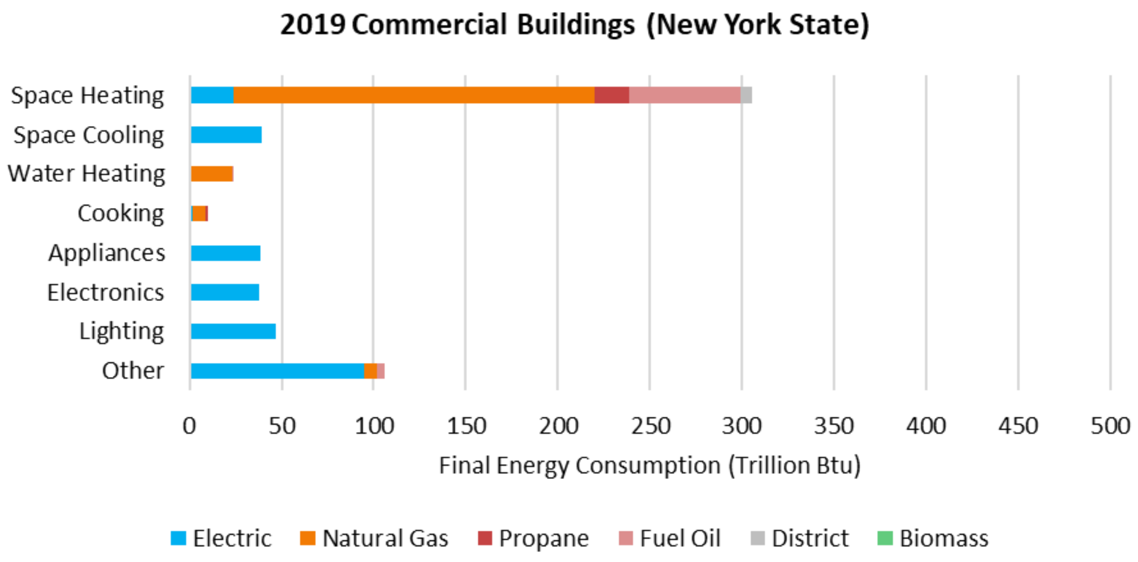
	Model Detail
Customer Segment	Residential and Commercial
Equipment Level Detail	Space Heating, Space Cooling, and Water Heating
End-Use Level Detail	Cooking and Clothes Dryers
Technologies	Based on RECS, CBECS, and NYSERDA Surveys
Geospatial Resolution	State or County
Temporal Resolution	Scenarios: Annual, Load Shapes: Hourly (8760)

Final energy consumption in the residential and commercial sector is modeled directly, while changes in electric sector generation is modeled indirectly through emission factors

Baseline Consumption

- Baseline estimates model all end-uses and fuel types, regardless of their electrification potential (e.g., space heating/cooling, water heating, cooking, appliances, electronics, lighting, etc.)
  - This allows for better optimization against historical energy consumption data
- Approach also allows for disaggregation by building type/vintage for space conditioning
- End-use estimates utilize meteorological data for a TMY, AMY, and historical (1998-2020)
- All results are mapped geospatially by county

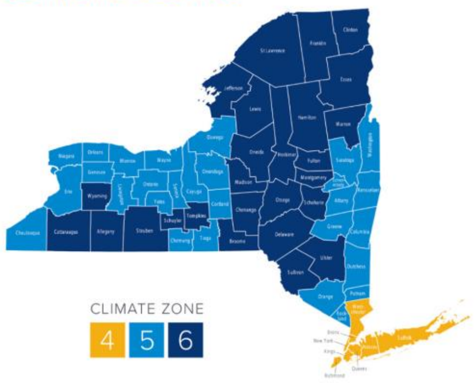




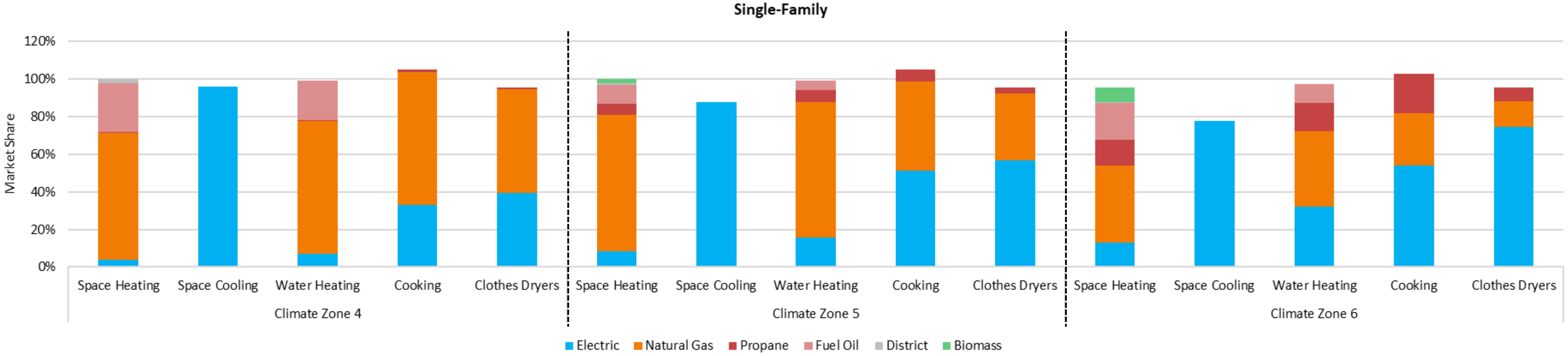
Default modeling detail is driven by NYSERDA's Residential Building Stock Assessment (RBSA), Residential Statewide Baseline Study (RSBS), and Commercial Statewide Baseline Study (CSBS) which inform baseline equipment saturation

2019 Residential Building Stock Assessment (RBSA)

Single-Family Homes



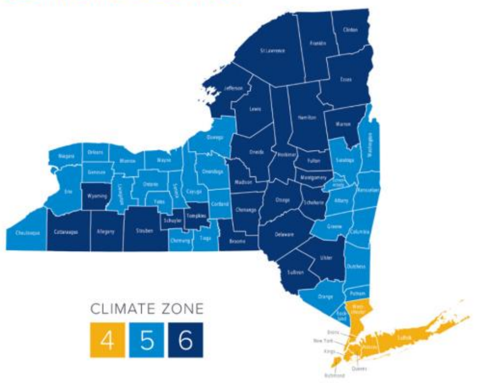
- Existing market share for electric is higher in climate zones 5 and 6
  - Likely due to limited availability of natural gas and/or historical pricing differences
- Fuel oil/propane utilization is correlated with urban/rural areas respectively
- Higher utilization of space cooling in warmer climate zones
- Electric water heating is more common in colder (more rural) climate zones



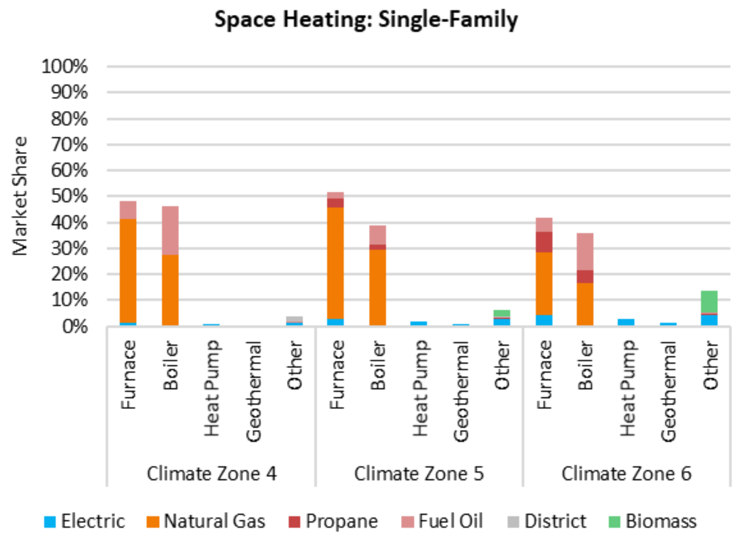
Data from the 2019 RBSA is used for sub-state allocation of end-uses technologies

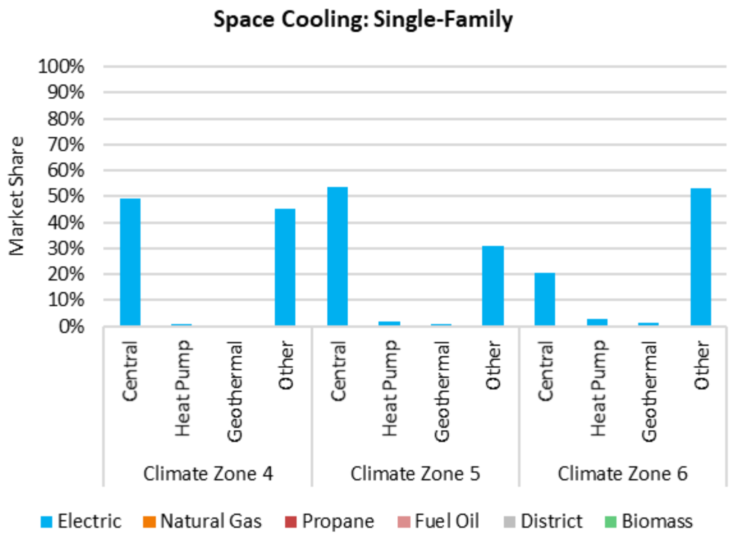
2019 Residential Building Stock Assessment (RBSA)

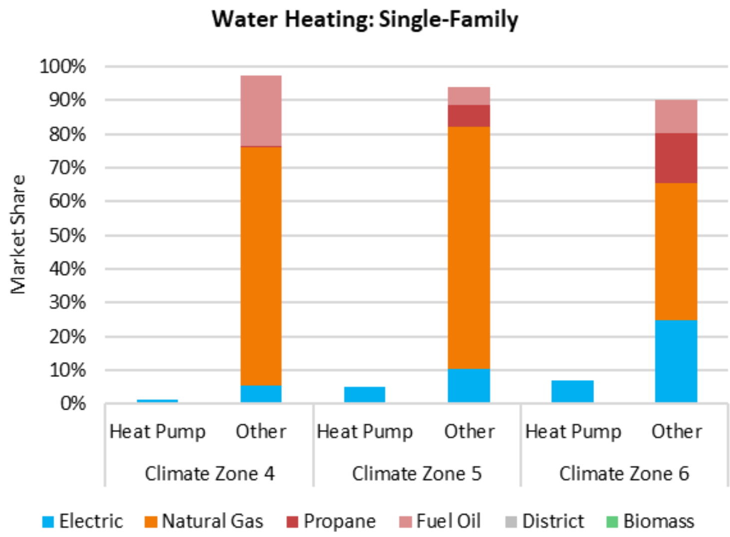
Single-Family Homes: Space Heating, Space Cooling, and Water Heating



- Existing market share for electric is higher in climate zones 5 and 6
  - Likely due to limited availability of natural gas and/or historical pricing differences
- Fuel oil/propane utilization is correlated with urban/rural areas respectively
- Higher utilization of space cooling in warmer climate zones
- Electric water heating is more common in colder (more rural) climate zones



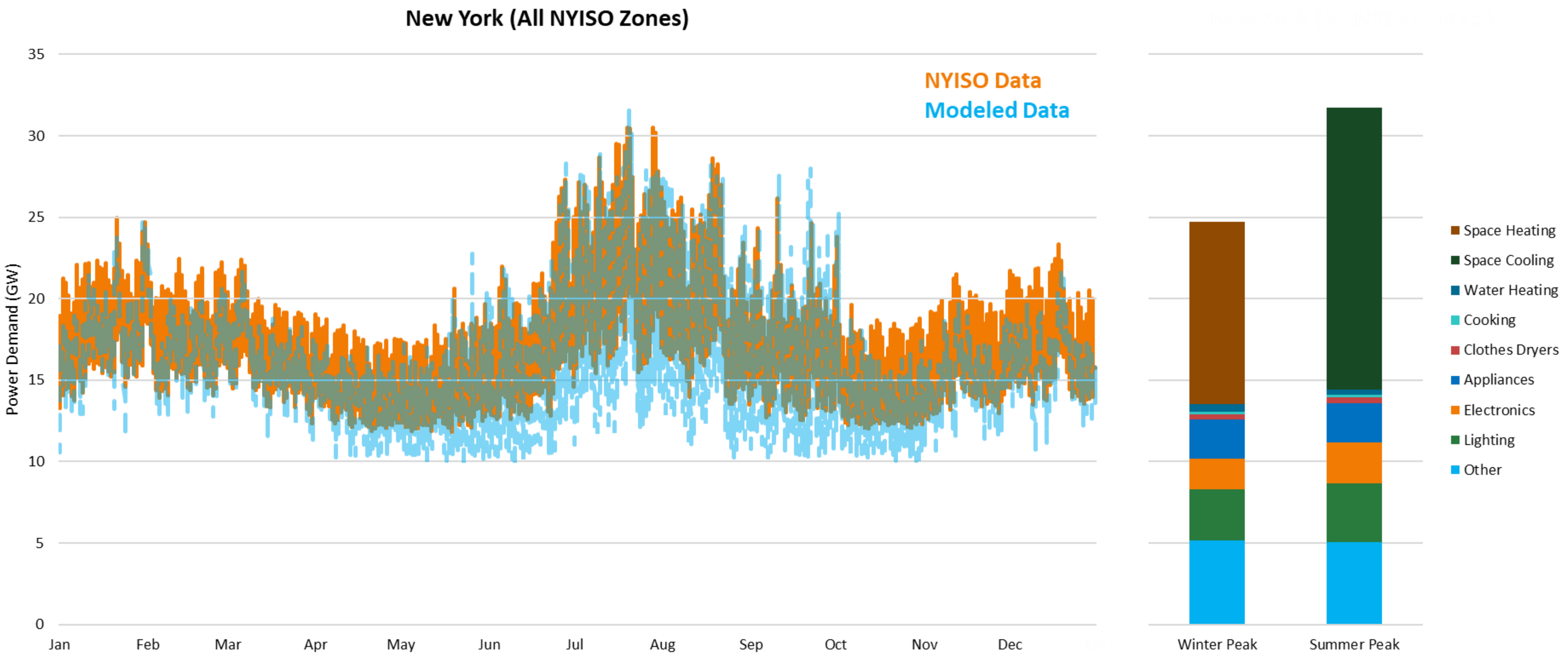




Data from the 2019 RBSA is used for sub-state allocation of end-uses technologies

Comparison with 2019 NYISO Load Data

Note: Modeled results do not include existing electric consumption from the industrial and transportation sectors



At a state-level, summer and winter peaks are captured relatively well, while the largest differences tend to occur during the evening hours of the summer (likely due to the unmodeled effects of thermal lag/inertia in buildings)

Scenario Analysis

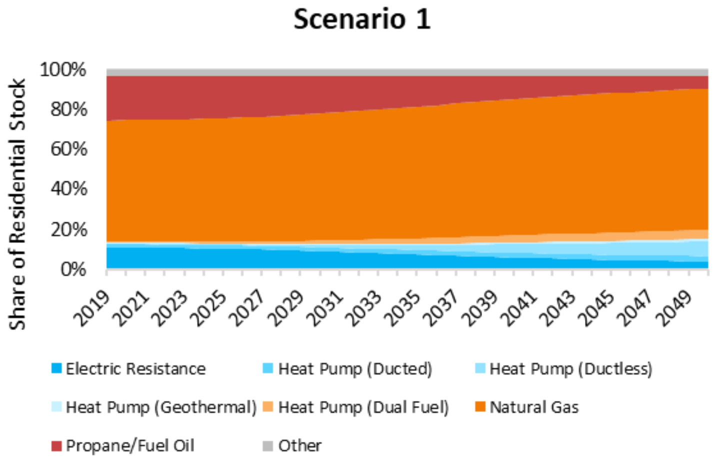
Scenario Descriptions

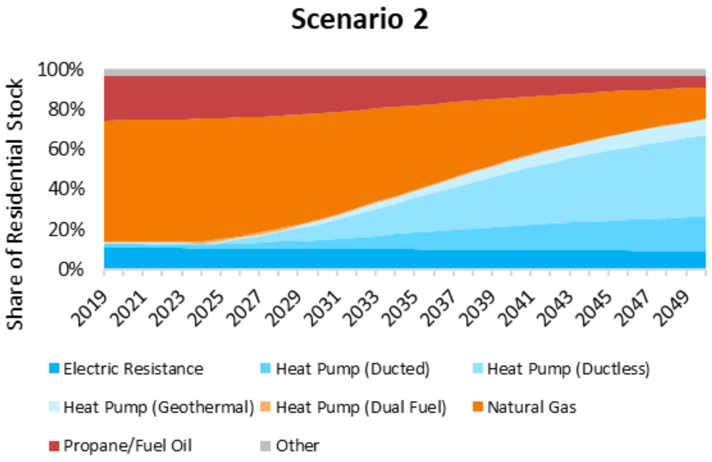
1. **Reference case:** Assumes no restrictions on technology choice except for those already adopted in NYC Local Law 154 of 2021. Here, future adoption is driven by an economic evaluation of electric and non-electric options (from the customer perspective), with more economically beneficial options gaining market share over time. Macroeconomic growth and energy cost projections draw from EI A's Annual Energy Outlook, while future electric sector emissions intensities assume 100% zero-emission electricity by 2040 (per the CLCPA).
2. **Widespread adoption of all-electric heat pumps (including supplemental resistance):** A restricted choice set is imposed beginning in 2025 in which customers may only adopt all-electric technology options. Under these restrictions, future adoption is driven by an economic evaluation of available electric options (once again from the customer perspective), which tends to favor the adoption of standard efficiency space and water heating equipment with electric resistance-based auxiliary systems under colder conditions. Based on recent market trends, with policies focusing on cold climate heat pumps, this scenario is unlikely to occur in the future.
3. **Increased adoption of dual fuel heat pumps:** A restricted choice set is imposed beginning in 2025 in which customers may adopt both all-electric and dual-fuel technology options. Once again, an economic evaluation of available options tends to favor the adoption of standard efficiency space and water heating equipment, however, the inclusion of dual-fuel options, which utilize fossil-fueled heating under colder conditions, greatly mitigate impacts to peak. Under this scenario, the number of hours being met by fossil-fueled technologies is greatly reduced than if customers choose fossil-fueled technologies to meet their entire heating needs, thus resulting in lower GHG emissions.
4. **Increased adoption of high-efficiency heat pumps:** A restricted choice set is imposed beginning in 2025 in which customers may only adopt all-electric technology options. Under this scenario, economic considerations are ignored, and higher efficiency space and water heating equipment, such as geothermal heat pumps, cold-climate air source heat pumps, and heat pump water heaters, are adopted. Due to the improved performance under colder conditions, impacts to peak demand are significantly reduced.
5. **Reduced utilization of supplemental resistance:** A restricted choice set is imposed beginning in 2025 in which customers may only adopt all-electric technology options. Under this scenario, economic considerations are ignored, and all space heating equipment is sized to meet a building's heating load, greatly reducing the need for resistance based auxiliary systems.

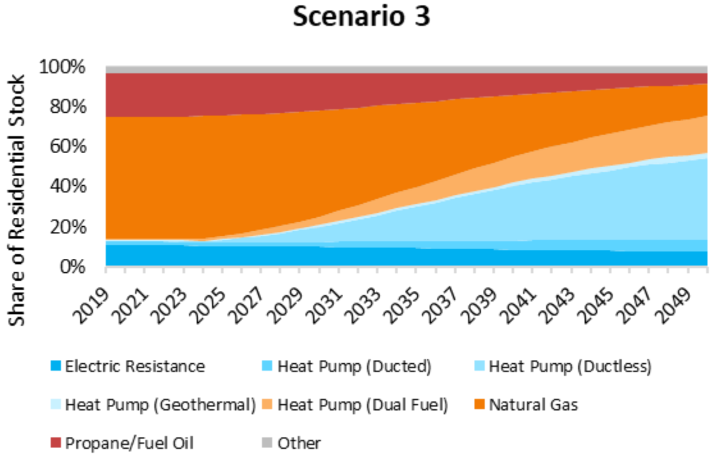
All scenarios include assumptions for baseline technology saturation (based on NYSERDA survey data) as well as market growth (adjusted by county), building attrition, future fuel prices (all based on data from the EIA's Annual Energy Outlook)

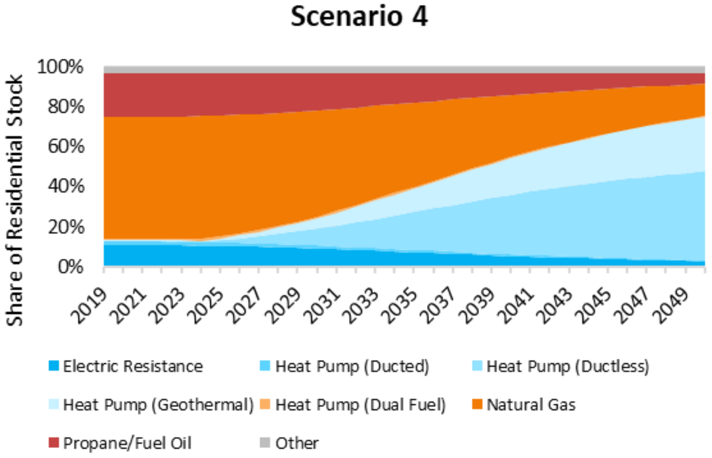
Space Heating Market Share

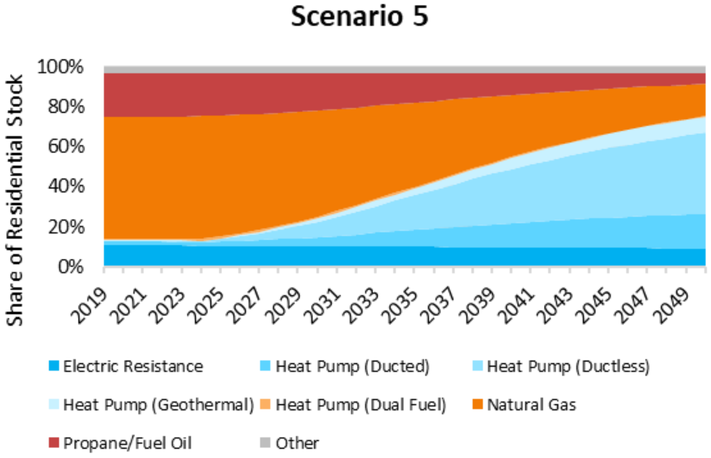
Residential Buildings







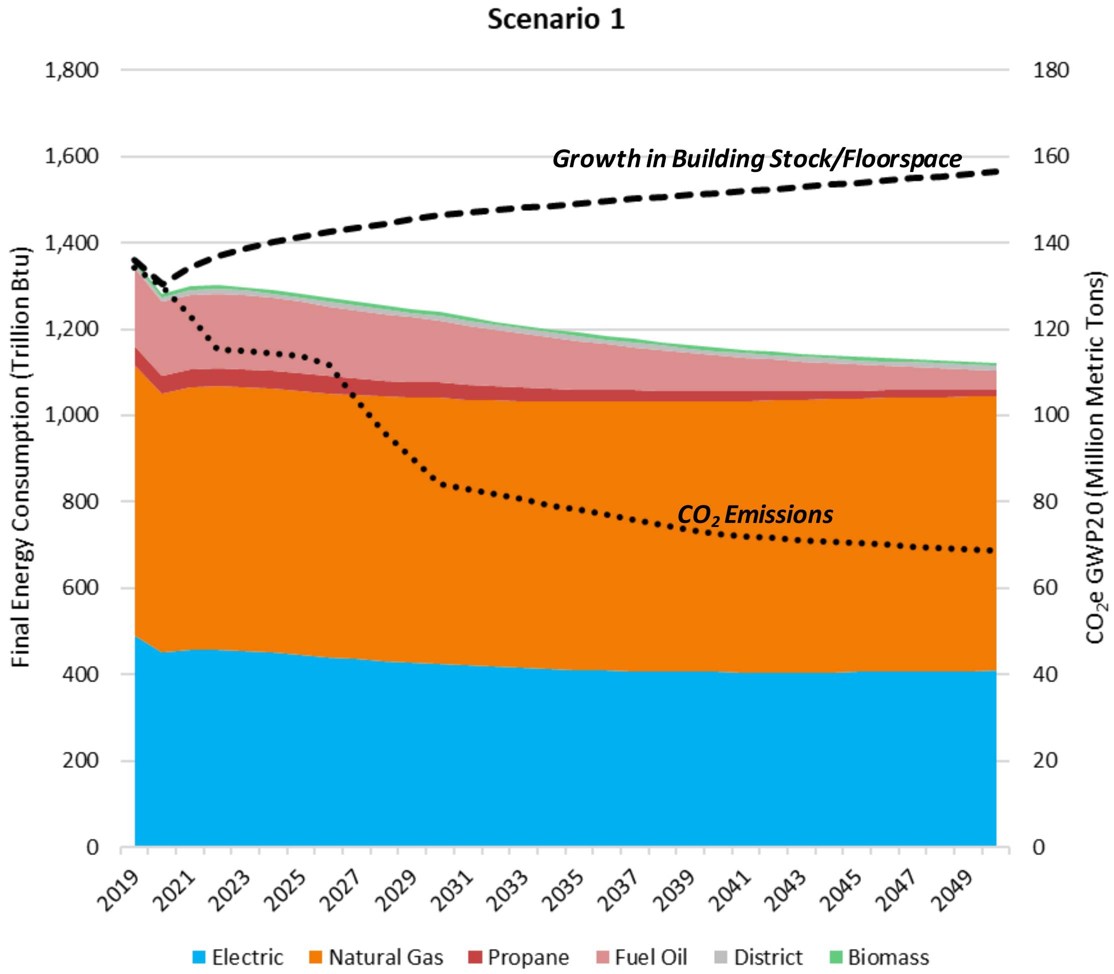


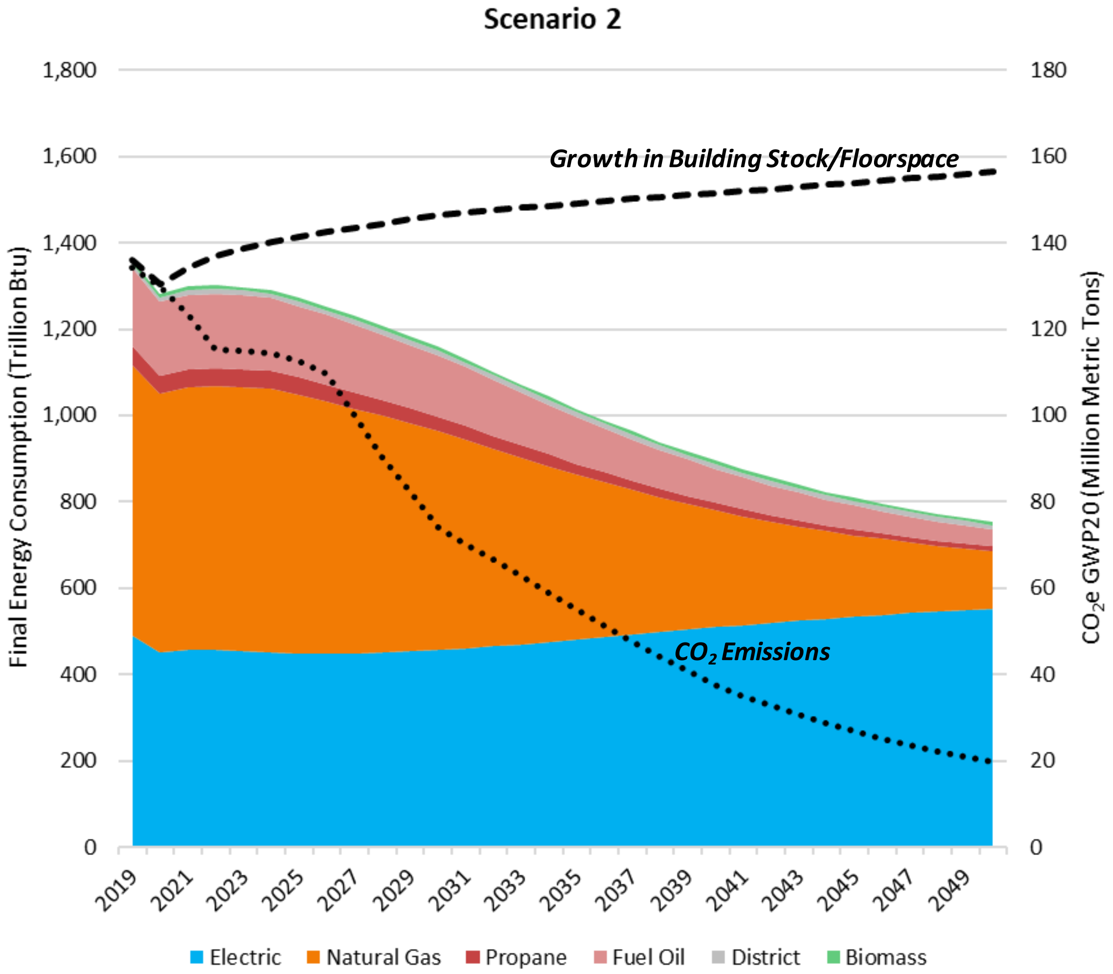


EPRI's modeling framework evaluates differences in baseline saturation (based on NYSERDA data), market growth (by county), and technology adoption (by county/equipment)

Energy and Emissions Impacts

Residential & Commercial Buildings

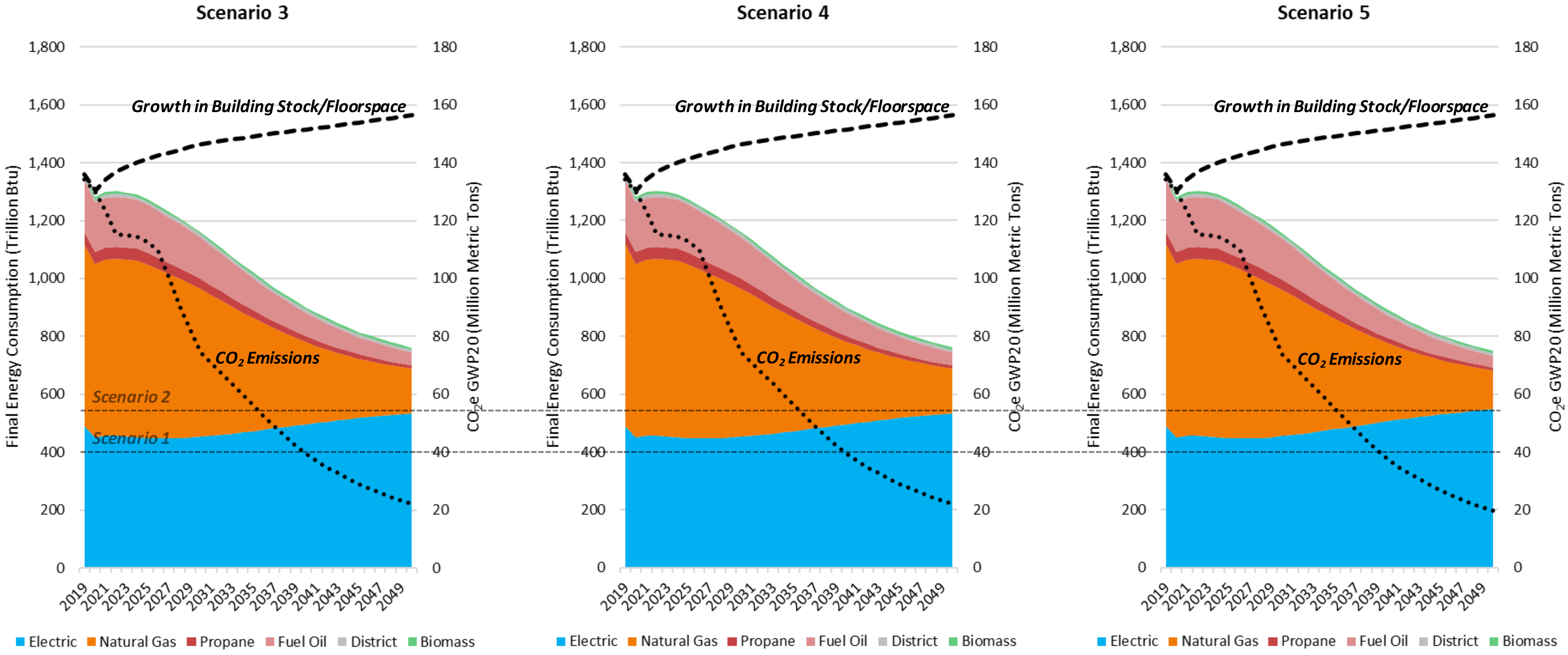




EPRI's modeling framework evaluates differences in baseline saturation (based on NYSERDA data), market growth (by county), and technology adoption (by county/equipment)

Energy and Emissions Impacts

Residential & Commercial Buildings

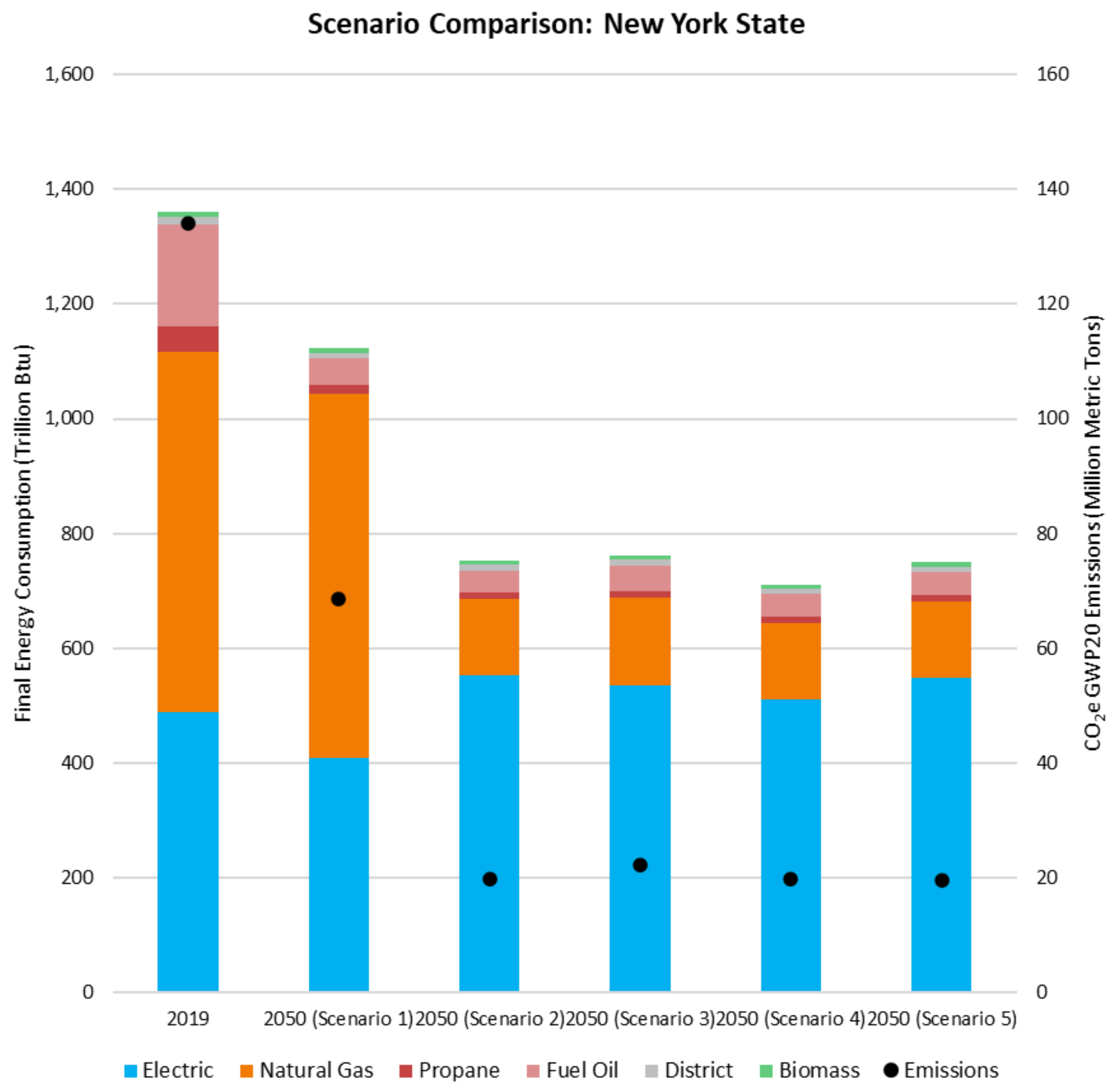


EPRI's modeling framework evaluates differences in baseline saturation (based on NYSERDA data), market growth (by county), and technology adoption (by county/equipment)

Energy and Emissions Impacts: Key Takeaways

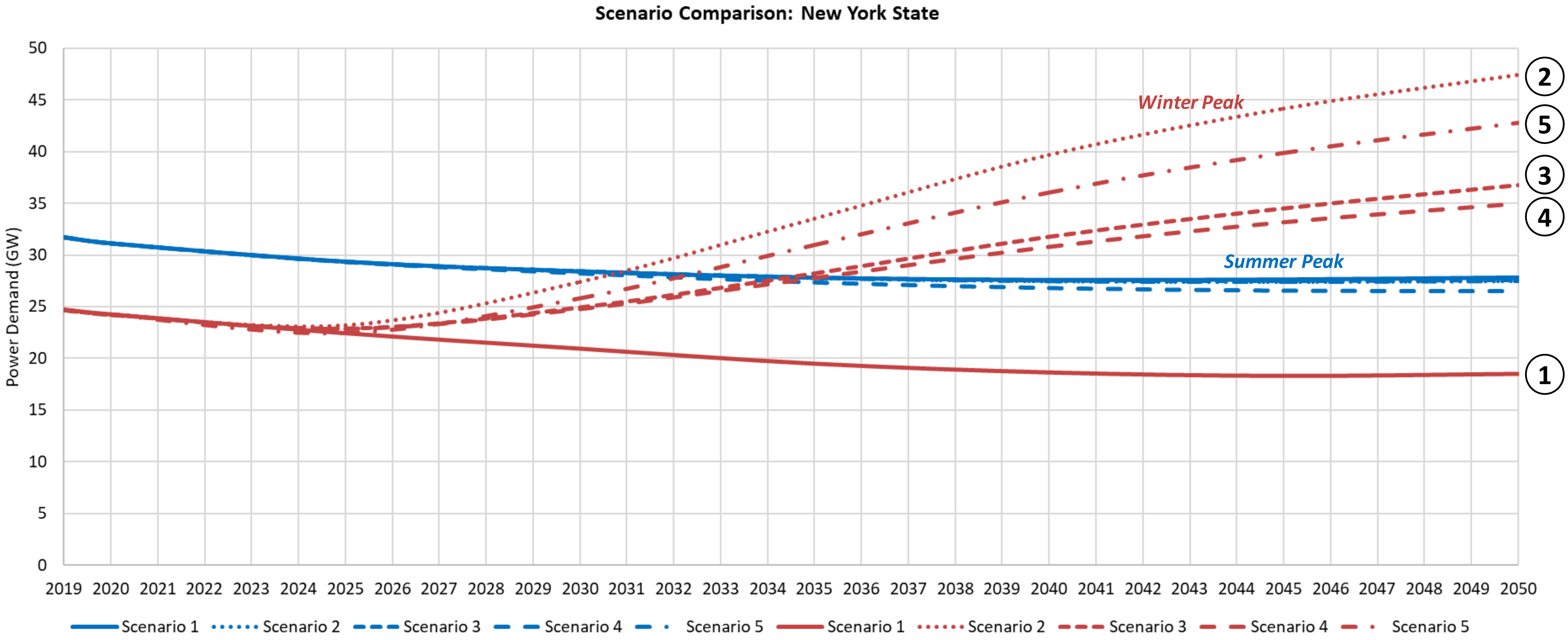
Residential & Commercial Buildings

- Under the reference scenario, changes in consumption due to energy efficiency (including building envelope and end-use energy intensity improvements) are expected to offset increases in consumption due to electrification
- More aggressive electrification scenarios, could lead to significant changes in the overall energy mix used in buildings (increases in electric and decreases in fossil fuel consumption), allowing New York to meet its 2050 carbon goals



Peak Demand Impacts

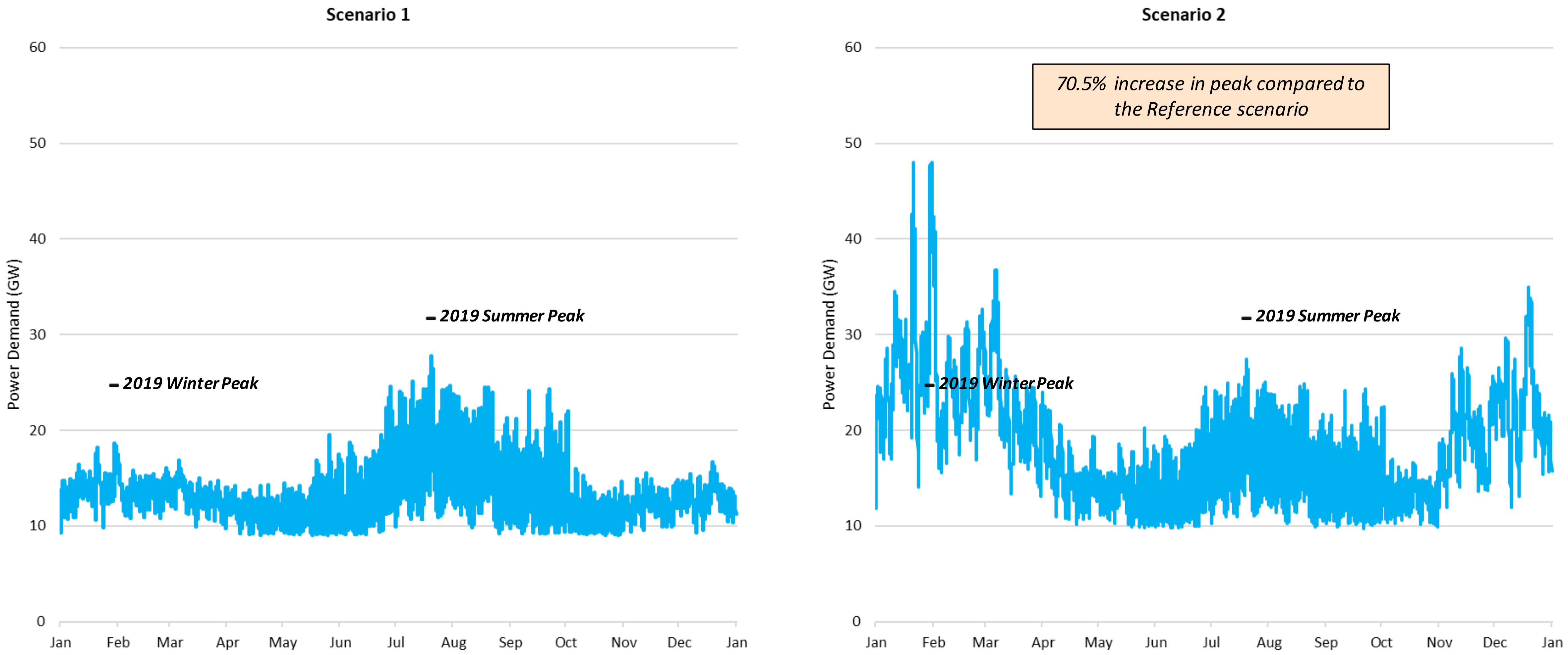
Residential & Commercial Buildings



System transitions from summer to winter peaking between 2030 and 2035

Peak Demand Impacts

Residential & Commercial Buildings

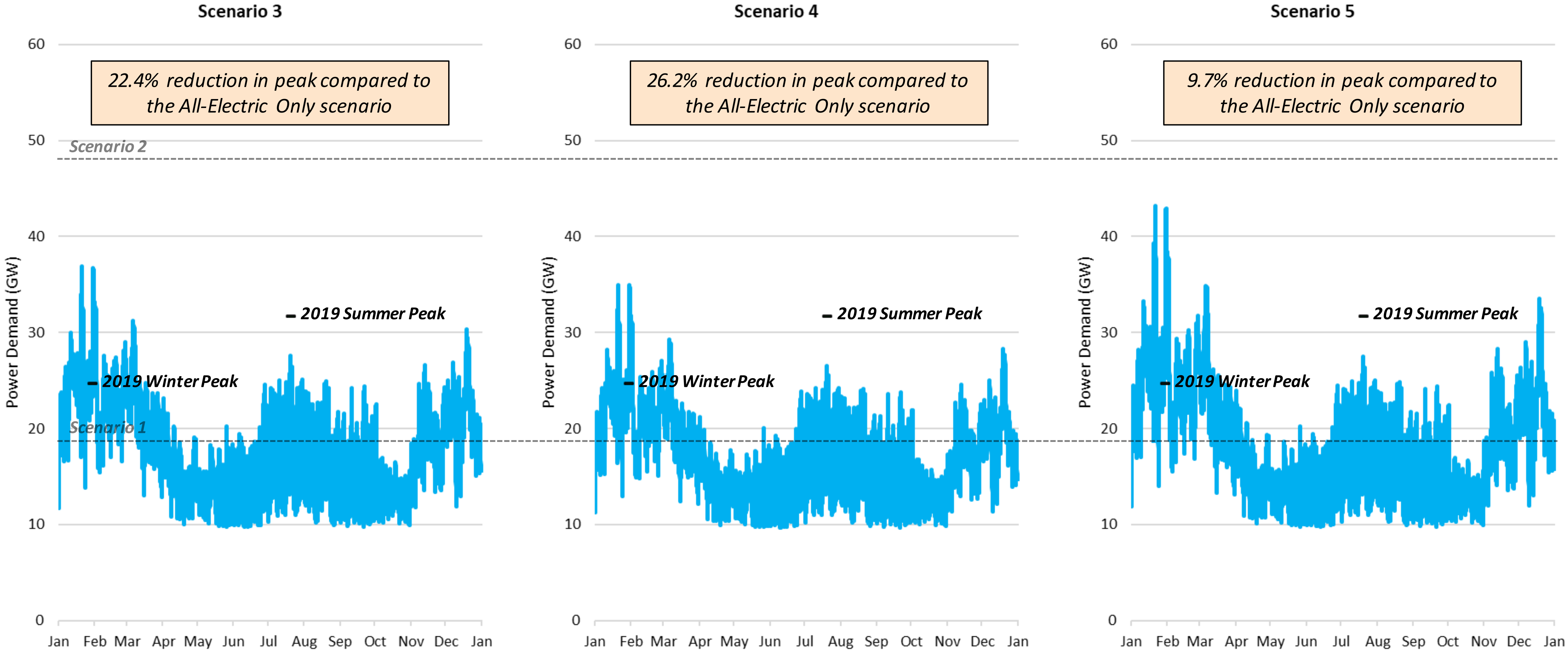


EPRI's modeling framework evaluates differences in baseline saturation (based on NYSERDA data), market growth (by county), and technology adoption (by county/equipment)

EPRI

Peak Demand Impacts

Residential & Commercial Buildings

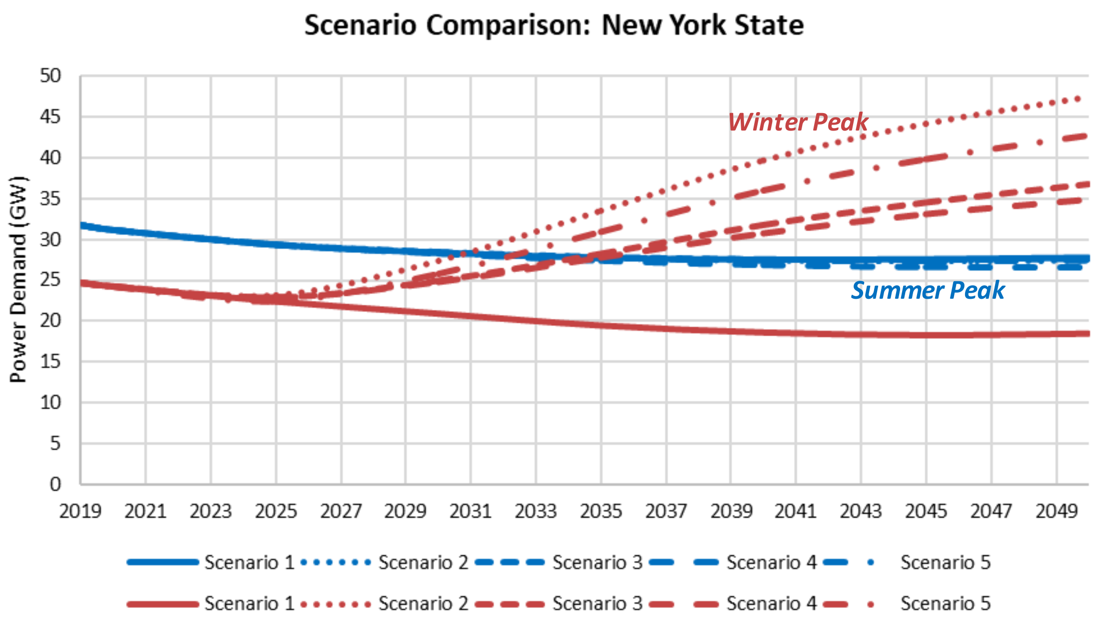


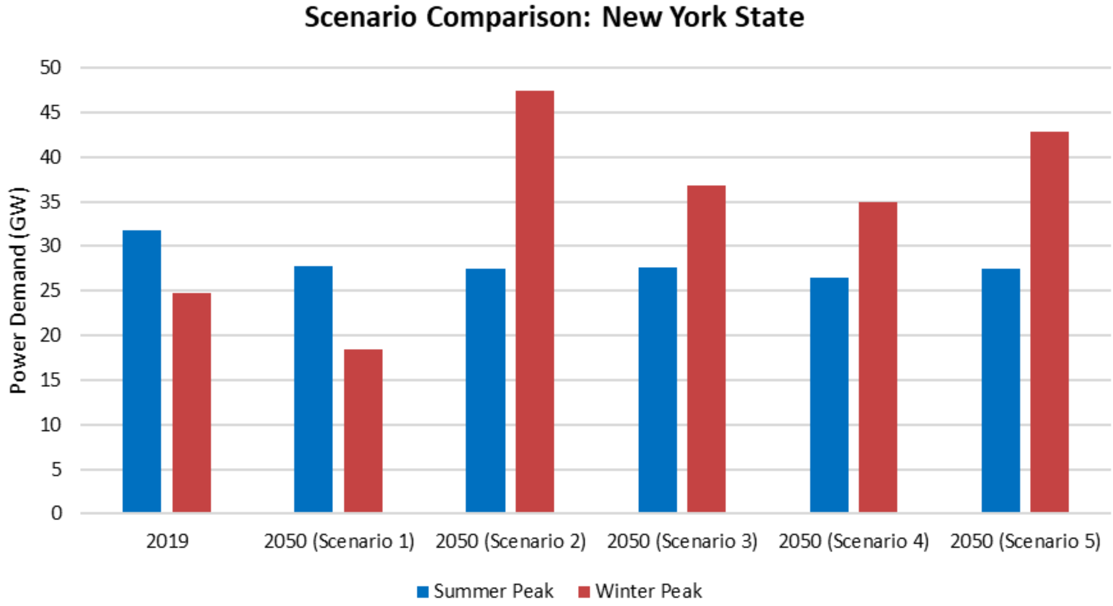
EPRI's modeling framework evaluates differences in baseline saturation (based on NYSERDA data), market growth (by county), and technology adoption (by county/equipment)

Peak Demand Impacts: Key Takeaways

Residential & Commercial Buildings

- Overall, New York State was modeled to transition from a summer peaking to a winter peaking system between 2030 and 2035
- While unrestricted adoption of all-electric heating solutions may lead to significant increases in peak demand, these impacts can be mitigated through strategic electrification initiatives:
  - Dual Fuel Heating: 22.4% reduction in peak compared to an unrestricted all-electric scenario
  - All-Electric, High Efficiency: 26.2% reduction in peak compared to an unrestricted all-electric scenario
  - All-Electric, Sized for Heat: 9.7% reduction in peak compared to an unrestricted all-electric scenario

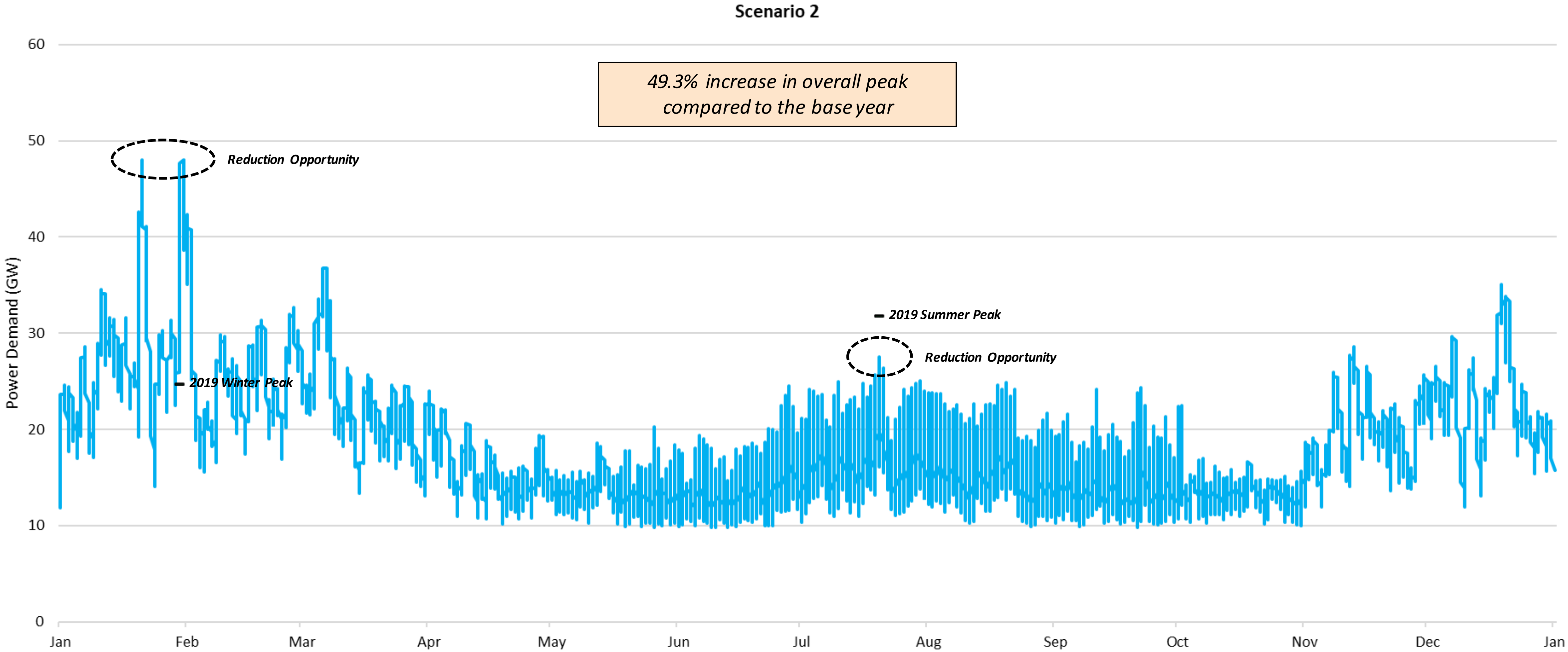




Demand Flexibility and Energy Storage

Residential & Commercial Buildings

Demand Flexibility and Energy Storage

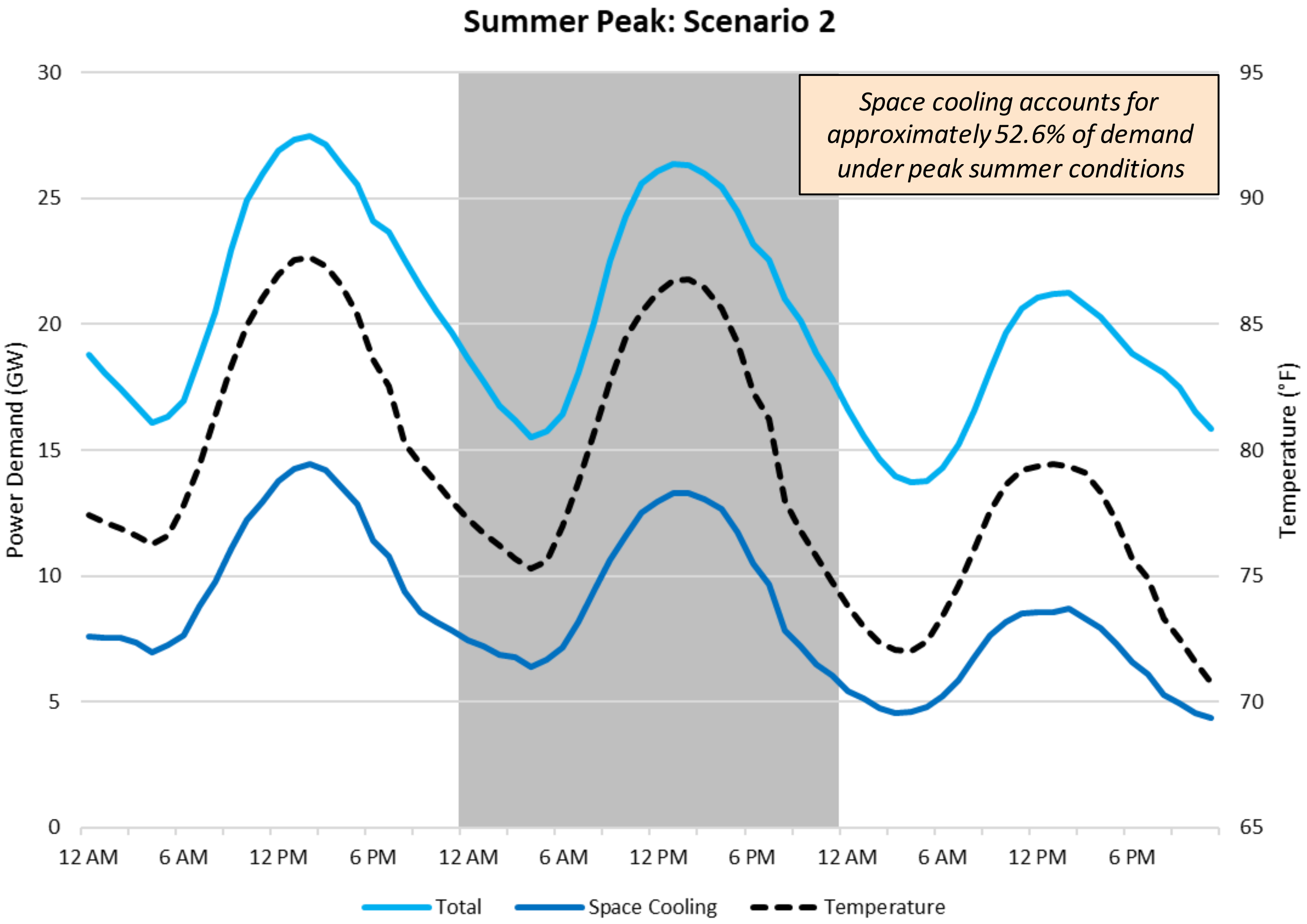


Unrestricted adoption of all-electric heating solutions may lead to significant increases in peaks

Residential & Commercial Buildings

Summer Peak: Demand Flexibility and Energy Storage

- Summer peaks tend to be more predictable with environmental conditions following a diurnal pattern (hotter during the day and cooler in the morning and evening)
  - Opportunities for peak reduction are typically spread over a ~12-hour window
  - While load shifting approaches can have a marginal impact on peaks without significantly effecting customer comfort and/or behavior, more aggressive demand reduction approaches may reduce peaks by approximately 5-10%
- Energy storage can be charged during off-peak hours for utilization during the day
- Capacity required to reduce peak to:
  - 25 GW: Requires 11.7 GWh of energy storage capacity (~0.9 million Tesla Powerwalls)
  - 20 GW: Requires 67.3 GWh of energy storage capacity (~5.0 million Tesla Powerwalls)

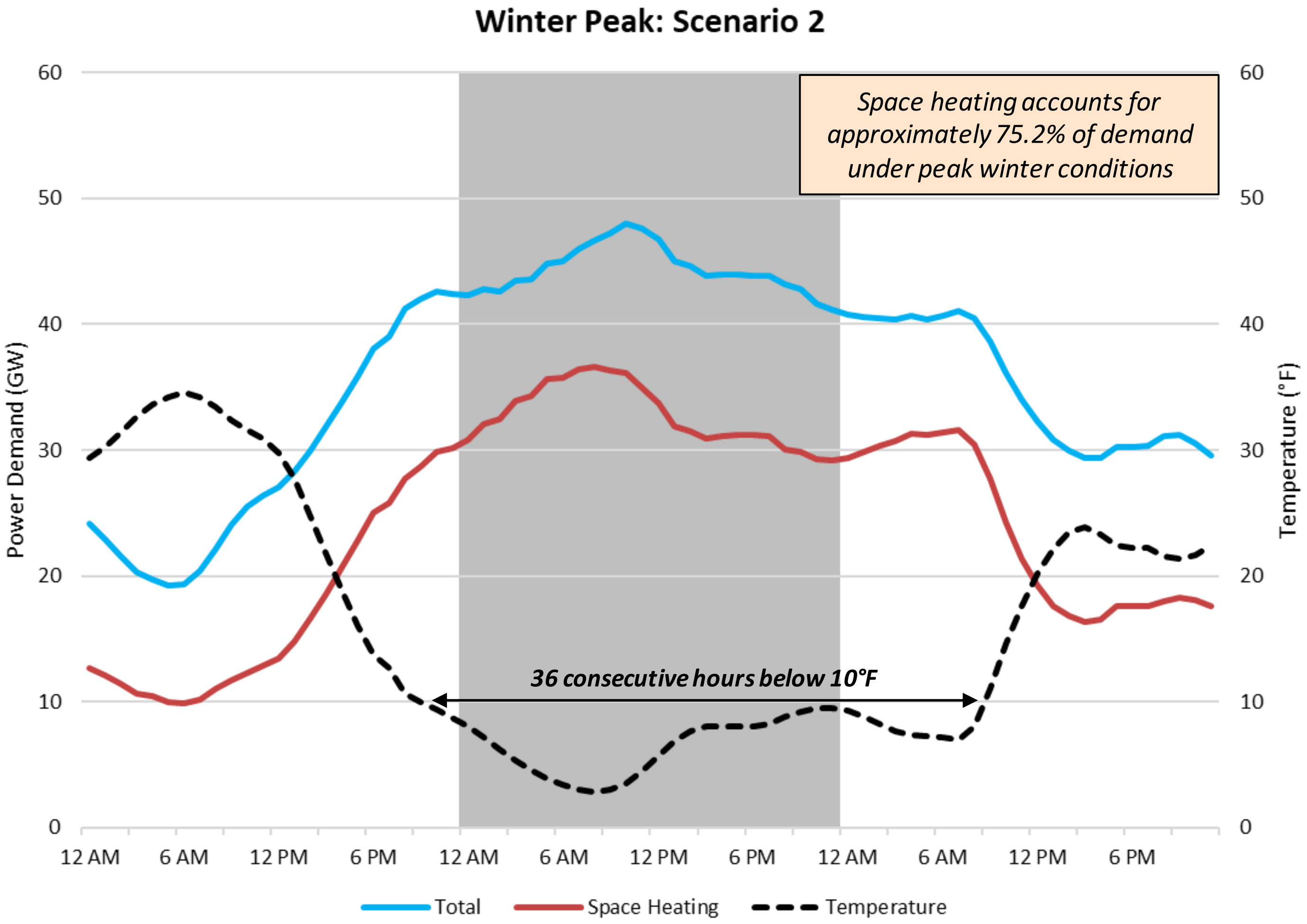


Summer peaks tend to be more predictable (following a consistent diurnal pattern) which allows for the utilization of a wider range of strategies for reducing peak demand

Residential & Commercial Buildings

Winter Peak: Demand Flexibility and Energy Storage

- Winter peak events can last significantly longer than similar summer events (in 2019, the weighted average temperature across the entire state of New York was less than 10°F for 36 consecutive hours)
  - Traditional approaches to demand flexibility (e.g., load shifting) will only have a minimal impact on peaks over such an extended timeframe without significantly impacting customer comfort and/or behavior
  - More aggressive approaches (i.e., demand reduction) may reduce peaks by 5-10%
- Energy storage may offer flexibility over longer timeframes, but at an additional cost
- Capacity required to reduce peak to:
  - 45 GW: Requires 12.3 GWh of energy storage capacity (~0.9 million Tesla Powerwalls)
  - 40 GW: Requires 118.2 GWh of energy storage capacity (~8.8 million Tesla Powerwalls)
  - 35 GW: Requires 316.0 GWh of energy storage capacity (~23.4 million Tesla Powerwalls)



Load shifting may not be feasible over extended timeframes, and significant reductions in winter peaks may require impacts to customer comfort/behavior (demand reduction) or utilization of more expensive energy storage technologies

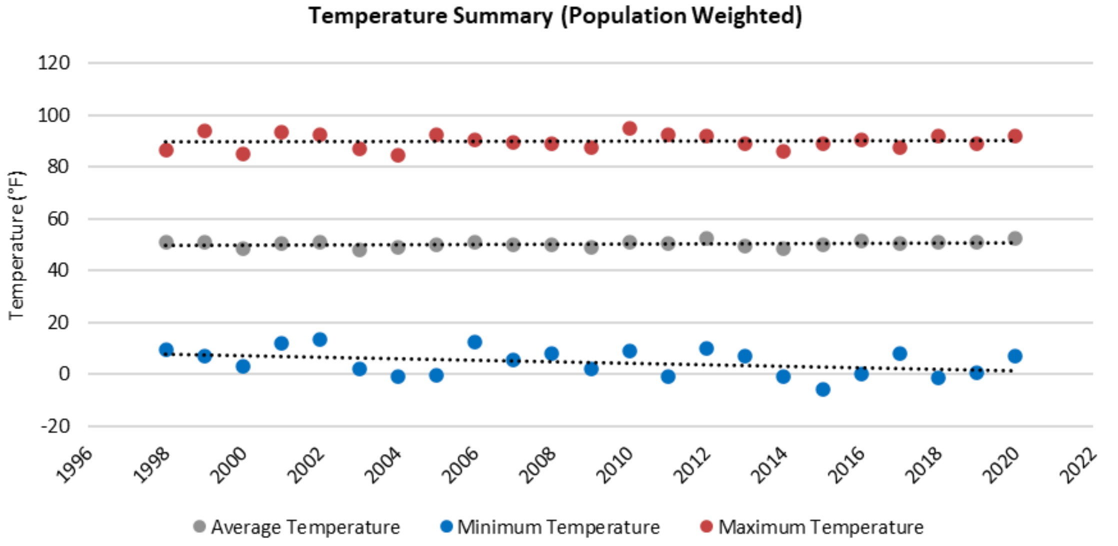
EPRI

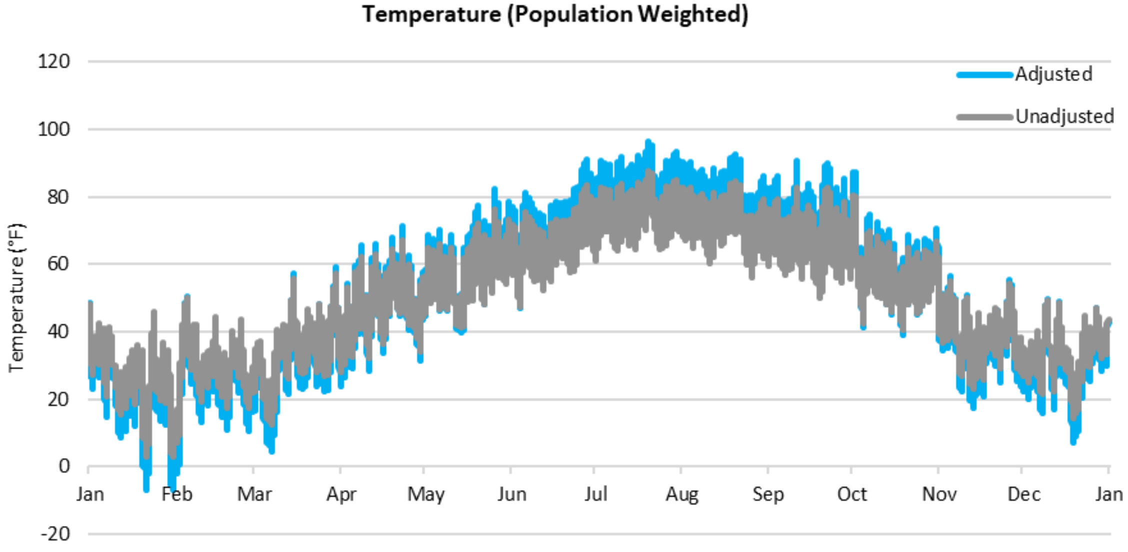
Climate Impacts (2-Sigma Analysis)

Residential & Commercial Buildings

Climate Impacts (2-Sigma Temperature Variation)

- Weighted annual average temperatures for the state of New York were calculated from 1998 to 2020 using data from NREL's National Solar Radiation Database
  - Average Temperature: 50.3 °F (σ = 1.1 °F)
  - Minimum Temperature: 4.7 °F (σ = 5.8 °F)
  - Maximum Temperature: 89.8 °F (σ = 3.2 °F)
- Peak meteorological conditions were adjusted to match the average minimum (minus two standard deviations) for winter and the average maximum (plus two standard deviations) for summer





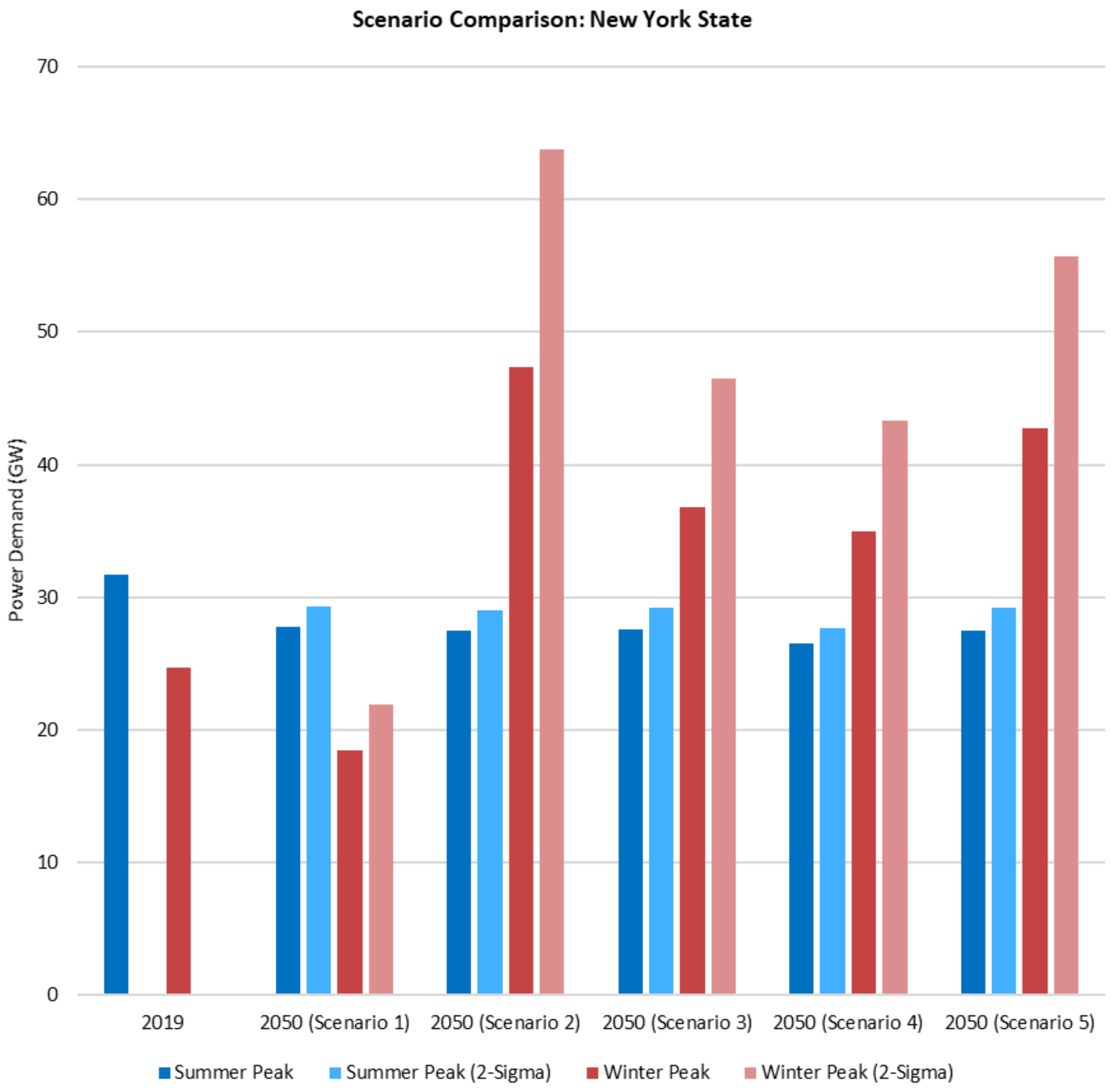
Gridded meteorological data for New York State has been collected from NREL's National Solar Radiation Database for 1998-2020 and for a TMY

Residential & Commercial Buildings

2050 Demand Impacts (2-Sigma Temperature Variation)

- Under this modified meteorological scenario, new summer and winter peak conditions lead to changes in demand:
  - Summer peaks were estimated to increase by approximately 1.2 to 1.8 GW (4.5 to 6.4%)
  - Winter peaks were estimated to increase by approximately 3.5 to 16.3 GW (18.7 to 34.5%)

	Scenario	Technology Adoption
1	Reference Case	None (Includes NYC Local Law 154 of 2021)
2	Widespread adoption of all-electric heat pumps (including supplemental resistance)	Electric Options Only (Beginning in 2025)
3	Increased adoption of dual fuel heat pumps	Electric and Dual Fuel Options Only (Beginning in 2025)
4	Increased adoption of high-efficiency heat pumps	Most Efficient Electric Options Only (Beginning in 2025)
5	Reduced utilization of supplemental resistance	Electric Options Only, Systems Sized for Heating Load (Beginning in 2025)



Together…Shaping the Future of Energy®

Contact Information

- **Allen Dennis**
  Sr. Program Manager
  (865) 218-8192
  adennis@epri.com

- **Baskar Vairamohan**
  Program Manager
  (865) 218-8189
  bvairamohan@epri.com

- **Perry Stephens**
  Principal Technical Leader
  (864) 764-1025
  pstephens@epri.com

- **Rick Ranhotra**
  Principal Technical Leader
  (980) 495-7413
  rranhotra@epri.com

- **Brandon Johnson**
  Technical Leader
  (865) 218-8198
  bjjohnson@epri.com

- **Sreenidhi Krishnamoorthy**
  Technical Leader
  (650) 855-7940
  skrishnamoorthy@epri.com

- **Manali Zantye**
  Engineer/Scientist III
  (650) 855-2144
  mzantye@epri.com

- **Aparna Menon**
  Engineer/Scientist II
  (650) 855-1017
  amenon@epri.com

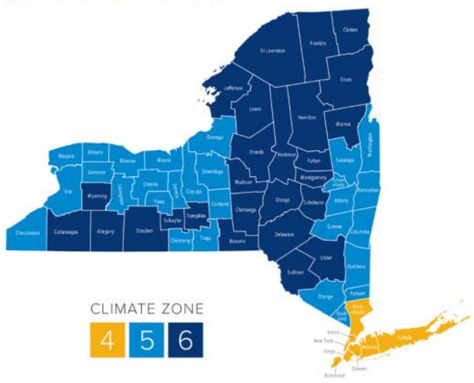
- **Alison Station**
  Sr. Technical Assistant
  (865) 218-5948
  astation@epri.com

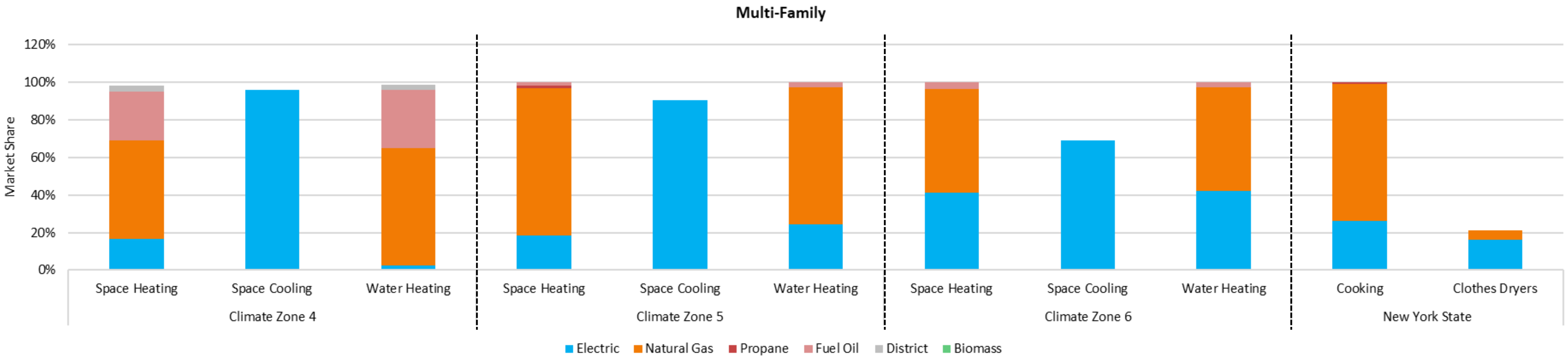
Appendix: Saturation Surveys

2015 Residential Statewide Baseline Study (RSBS)

Multi-Family Dwellings

- Existing market share for electric is higher in climate zones 5 and 6
  - Likely due to limited availability of natural gas and/or historical pricing differences
- Propane utilization is uncommon in multi-family compared to single-family
- Higher utilization of space cooling in warmer climate zones
- Electric water heating is more common in colder (more rural) climate zones



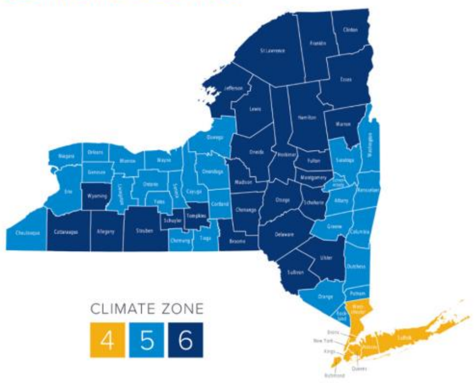


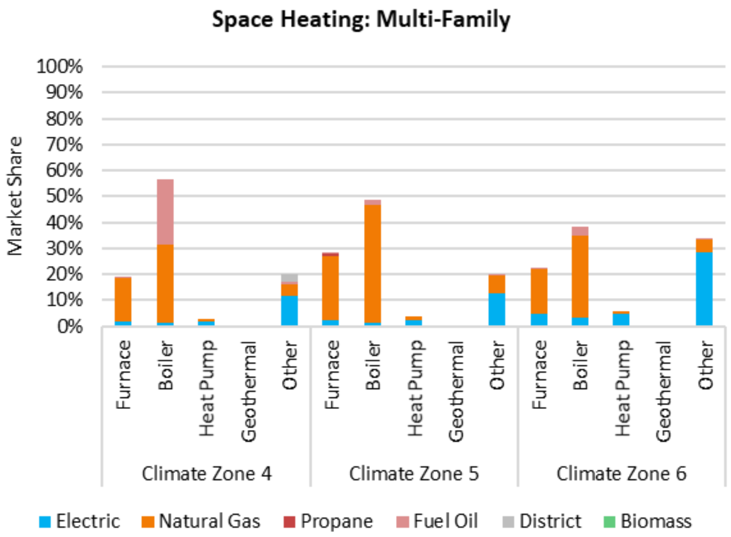
Data from the 2015 RSBS is used for sub-state allocation of end-uses technologies

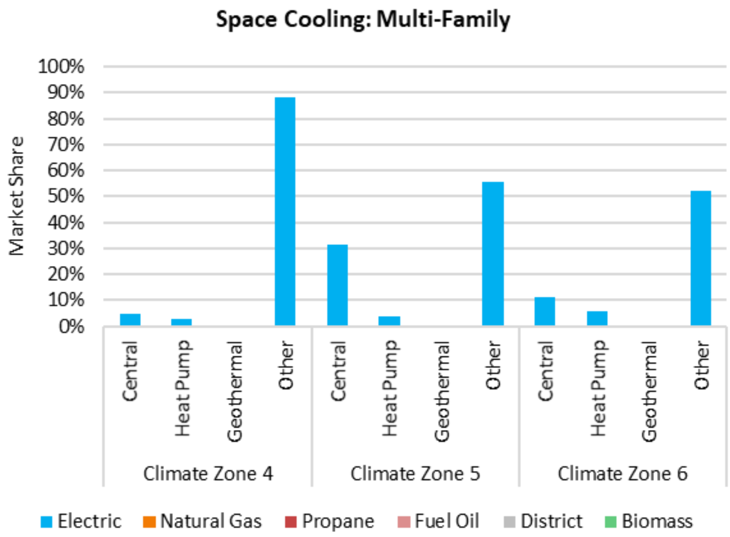
2015 Residential Statewide Baseline Study (RSBS)

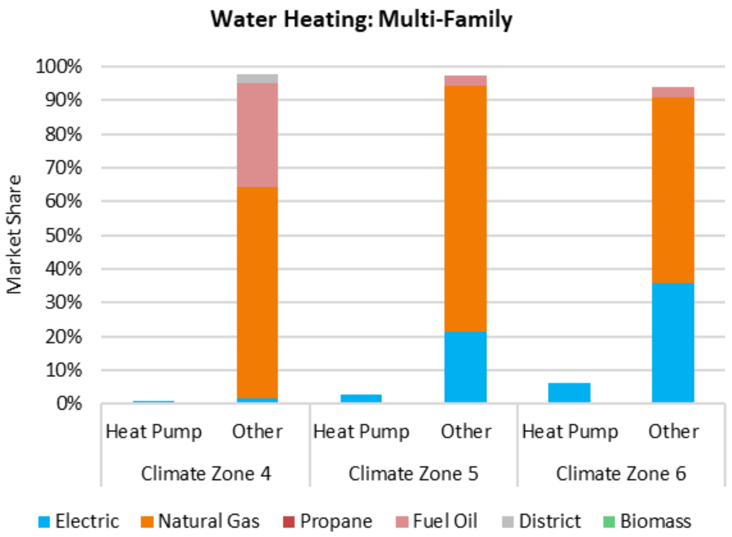
Multi-Family Dwellings: Space Heating, Space Cooling, and Water Heating

- Existing market share for electric is higher in climate zones 5 and 6
  - Likely due to limited availability of natural gas and/or historical pricing differences
- Propane utilization is uncommon in multi-family compared to single-family
- Higher utilization of space cooling in warmer climate zones
- Electric water heating is more common in colder (more rural) climate zones





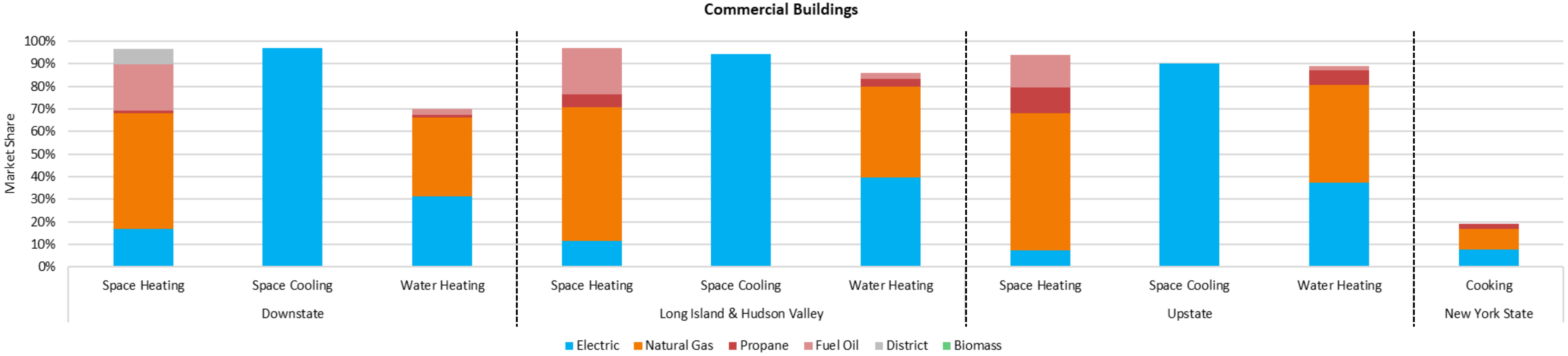




Data from the 2015 RSBS is used for sub-state allocation of end-uses technologies

Commercial Statewide Baseline Study (CSBS)

- Existing market share for electric is higher in Downstate New York
  - The opposite was found for single-family and multi-family buildings
- Fuel oil/propane utilization is correlated with urban/rural areas respectively
- Higher utilization of space cooling in warmer climate zones
- Electric water heating is slightly less common in colder climate zones



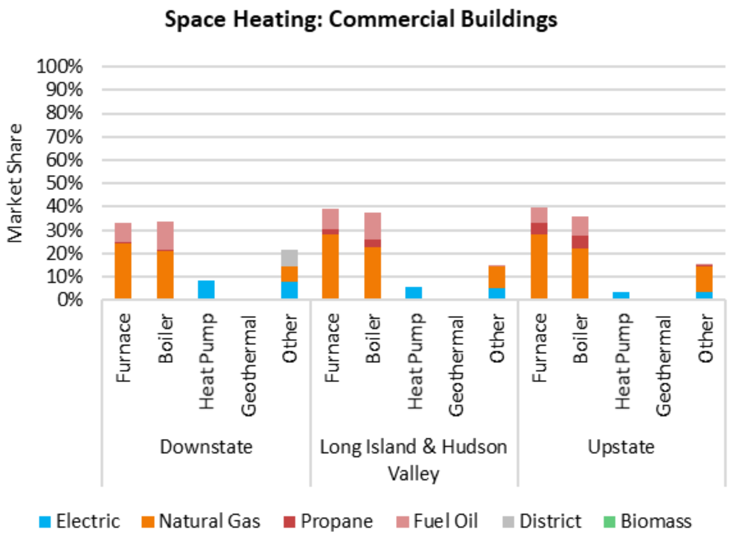
Data from the CSBS is used for sub-state allocation of end-uses technologies

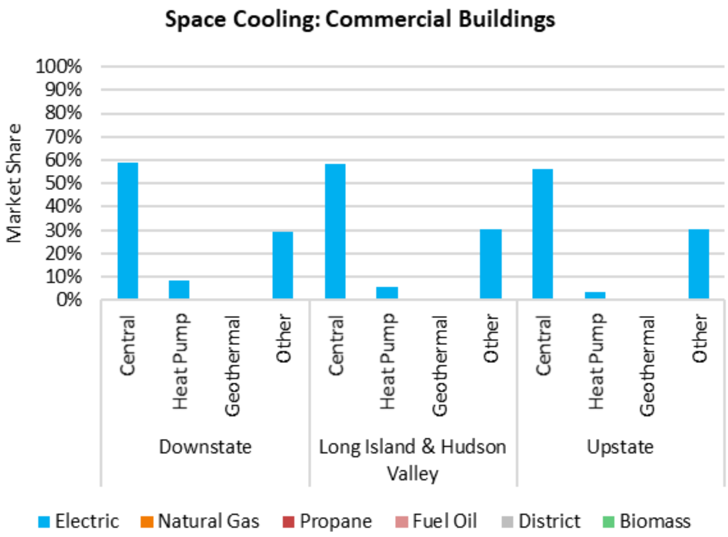
EPRI

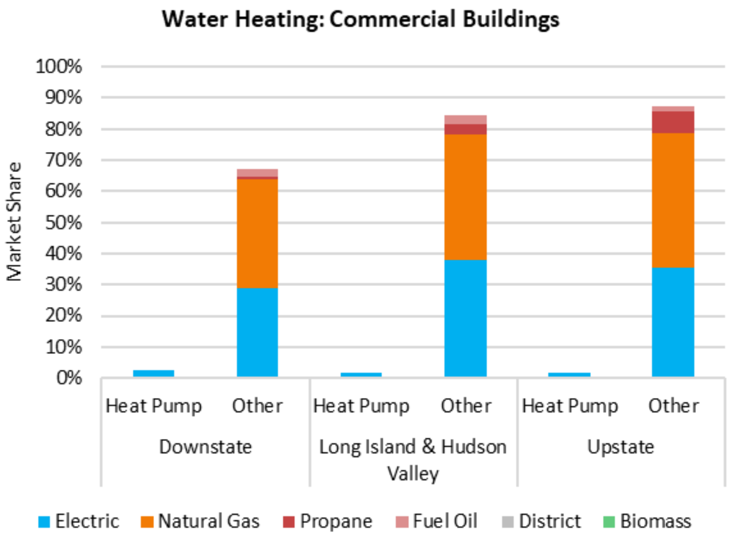
Commercial Statewide Baseline Study (CSBS)

Space Heating, Space Cooling, and Water Heating

- Existing market share for electric is higher in Downstate New York
  - The opposite was found for single-family and multi-family buildings
- Fuel oil/propane utilization is correlated with urban/rural areas respectively
- Higher utilization of space cooling in warmer climate zones
- Electric water heating is slightly less common in colder climate zones



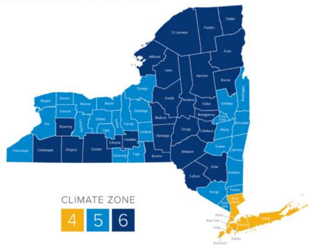


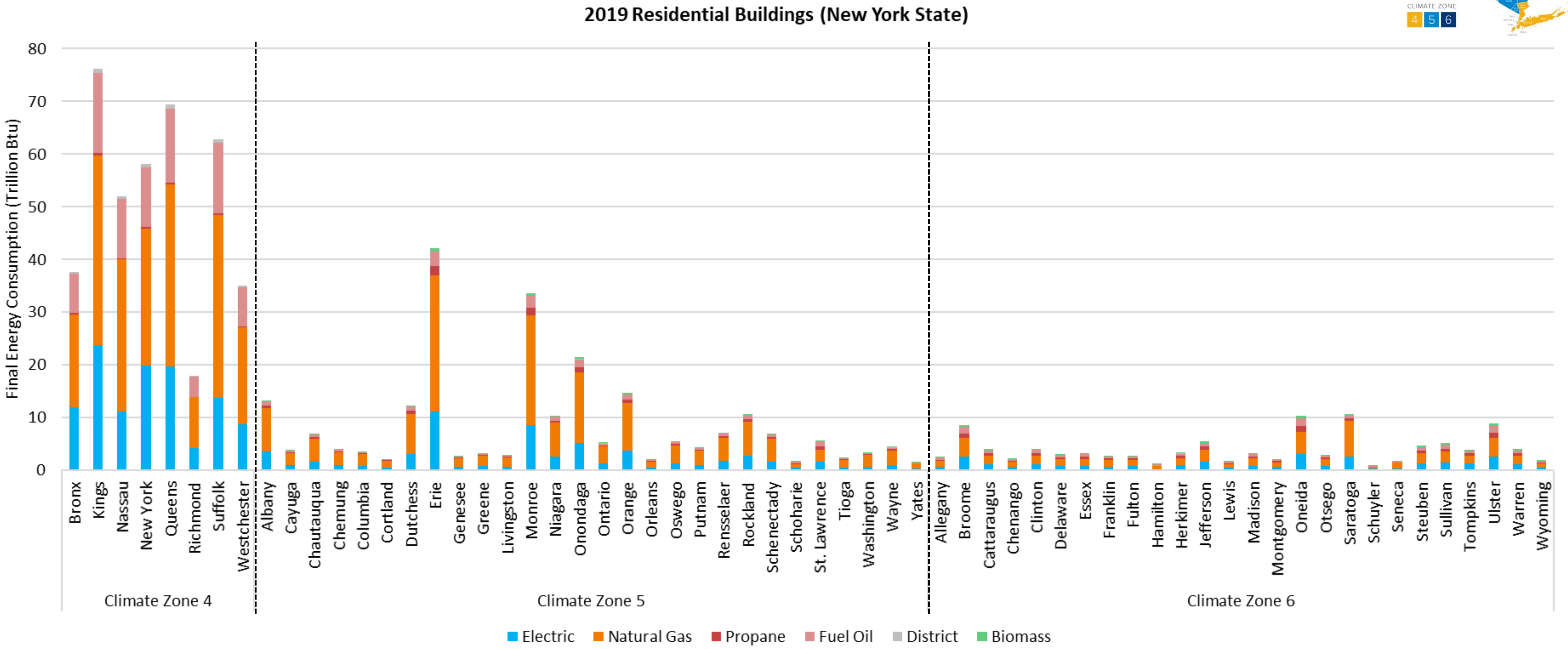


Data from the CSBS is used for sub-state allocation of end-uses technologies

Appendix: Baseline Consumption

Baseline Consumption: Residential Buildings

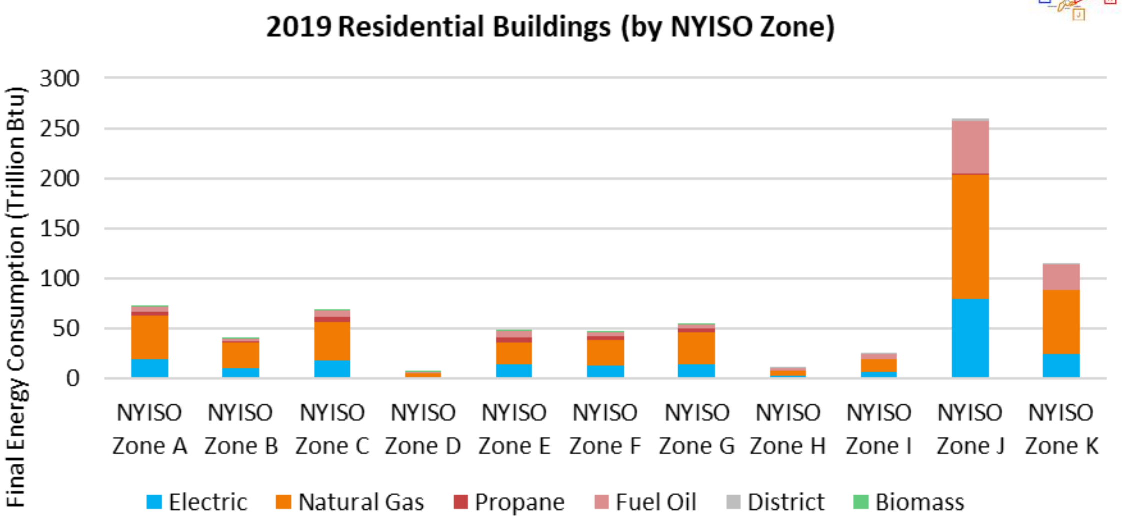


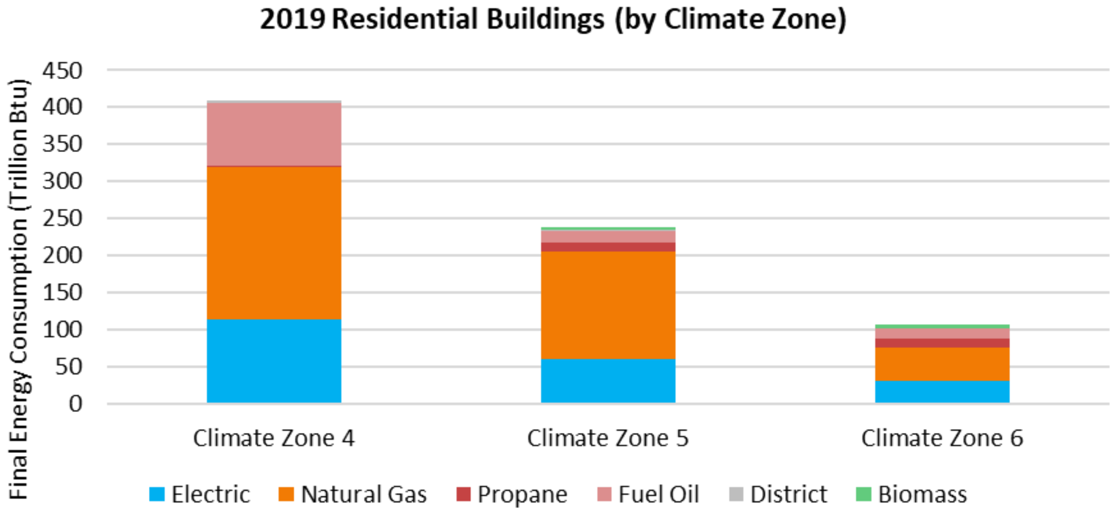


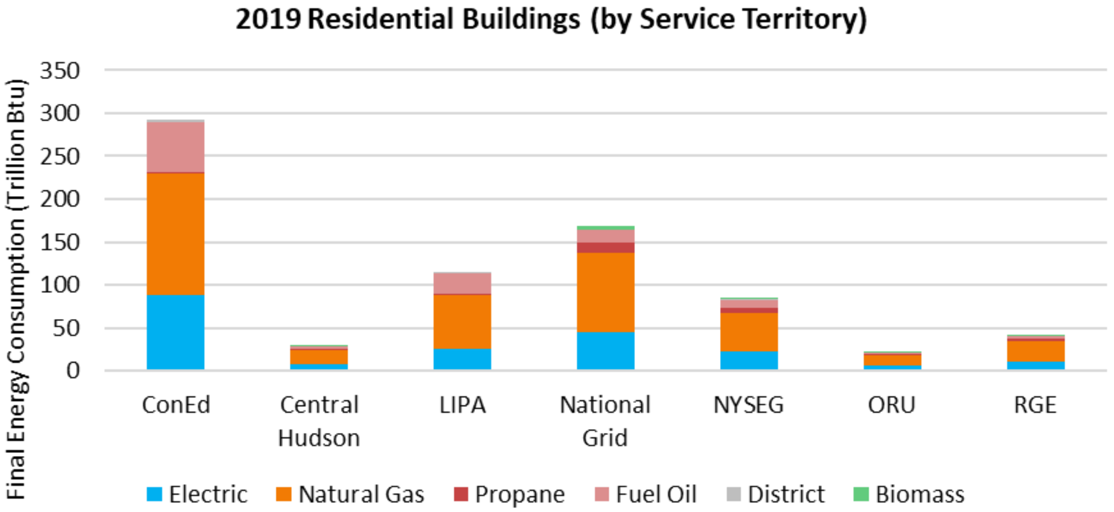
Lowest modeling granularity is county-level, which can be mapped to NYISO zones/service territories

Baseline Consumption: Residential Buildings

- Market penetration of electric technologies is not correlated with climate conditions, with electric heating being more common in rural areas of the state
  - Likely due to limited availability and historical pricing differences
- Space heating and water heating represent approximately 73.7% of final energy consumption in residential buildings with natural gas and fuel oil used most often
  - Space Heating: ~7.7% of existing consumption is electric
  - Water Heating: ~6.3% of existing consumption is electric

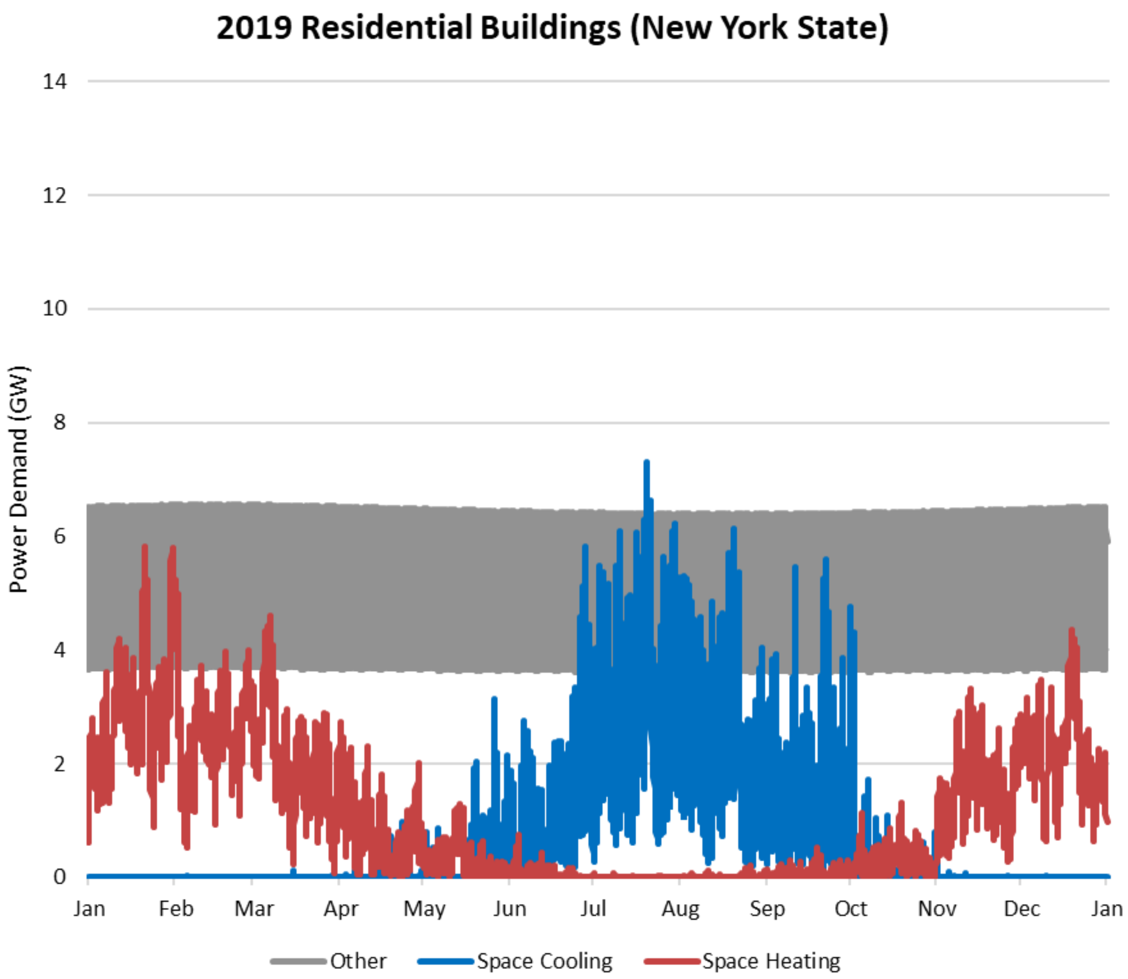


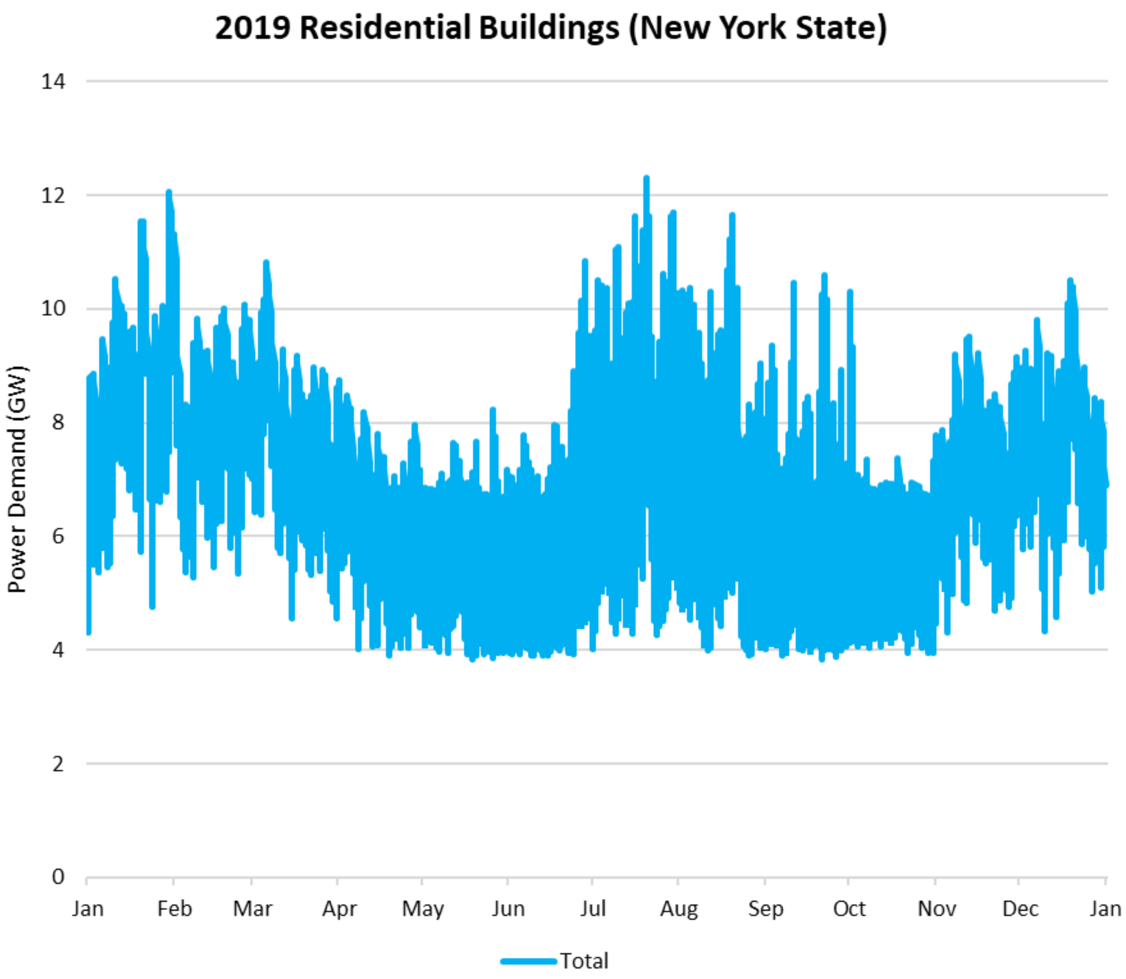




EPRI

Baseline Demand: Residential Buildings

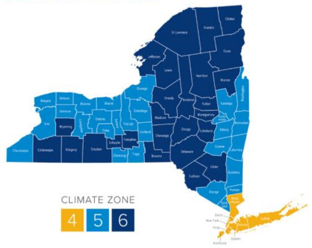


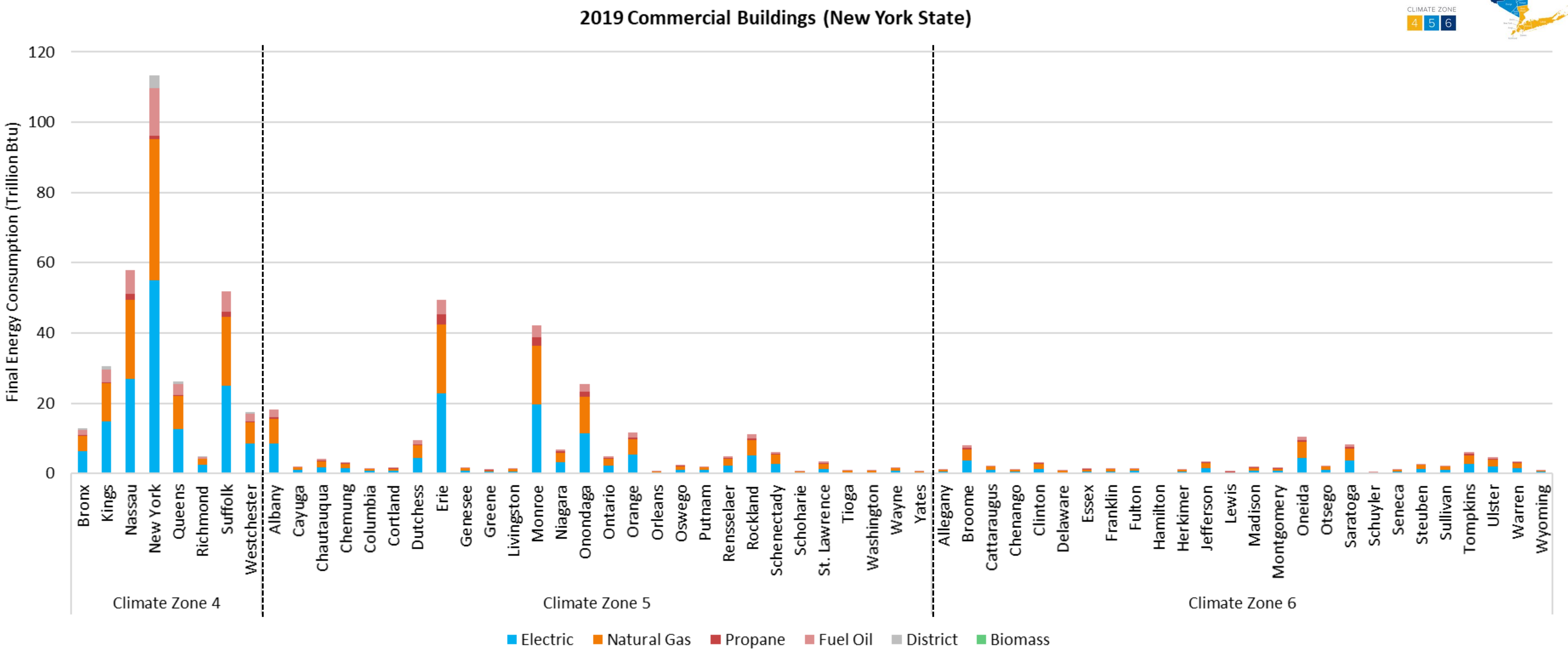


Baseline demand estimates show a slightly higher summer peak for residential buildings

EPRI

Baseline Consumption: Commercial Buildings



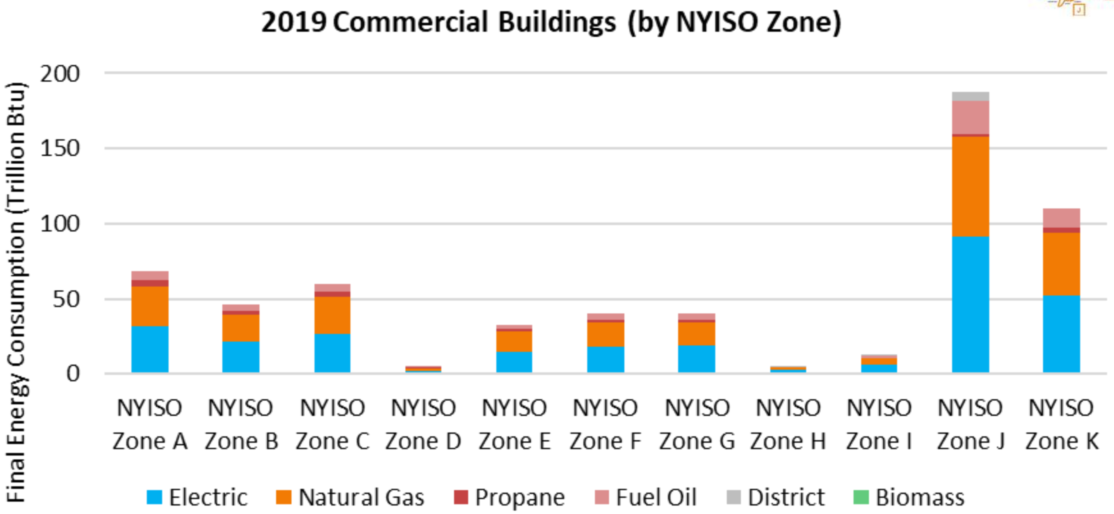


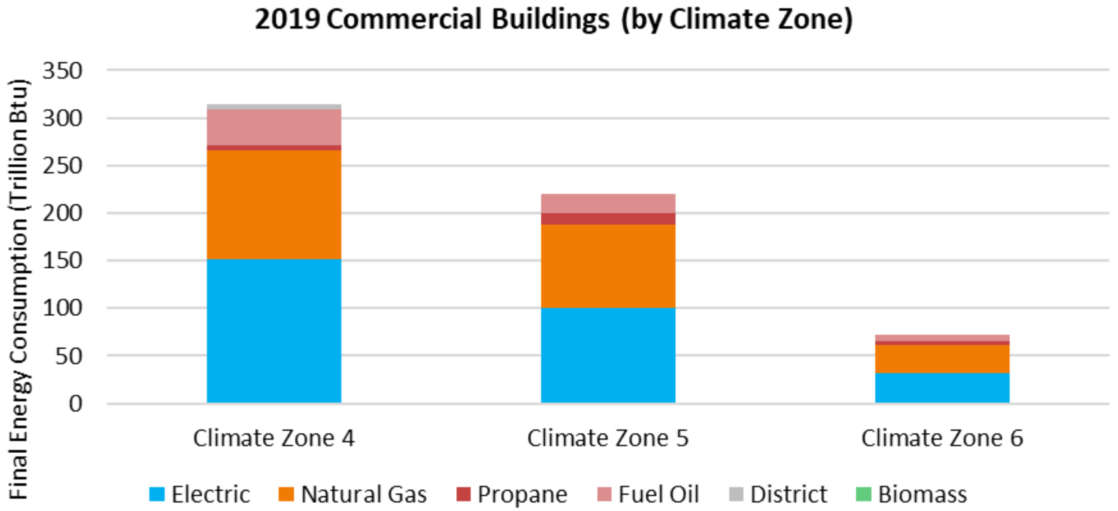
Lowest modeling granularity is county-level, which can be mapped to NYISO zones/service territories

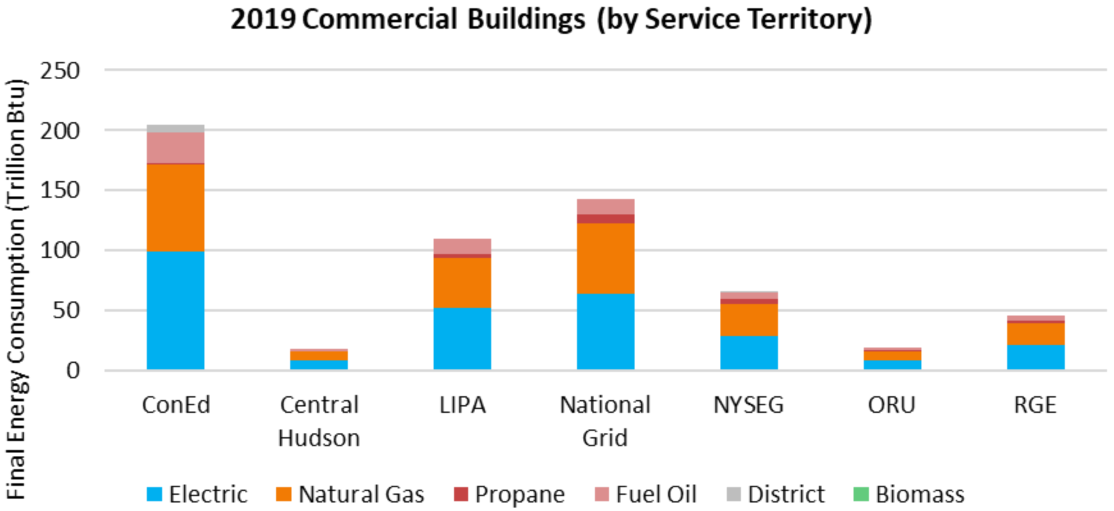
Baseline Consumption: Commercial Buildings

- Market penetration of electric technologies is correlated with climate conditions, with electric heating being more common in warmer areas of the state
  - The opposite was found for single/multi-family buildings

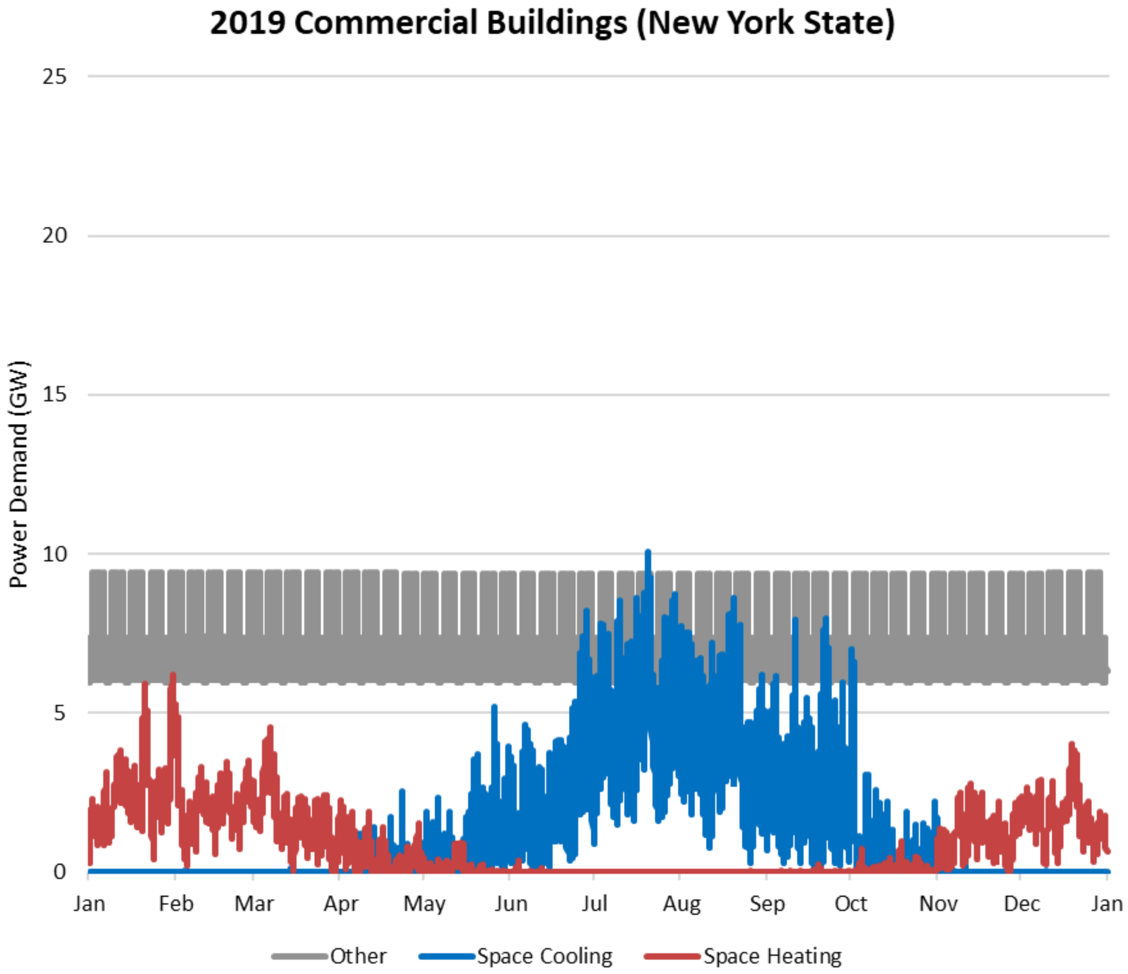
- Space heating and water heating represent approximately 54.1% of final energy consumption in commercial buildings with natural gas and fuel oil used most often
  - Space Heating: ~7.9% of existing consumption is electric
  - Water Heating: ~4.0% of existing consumption is electric

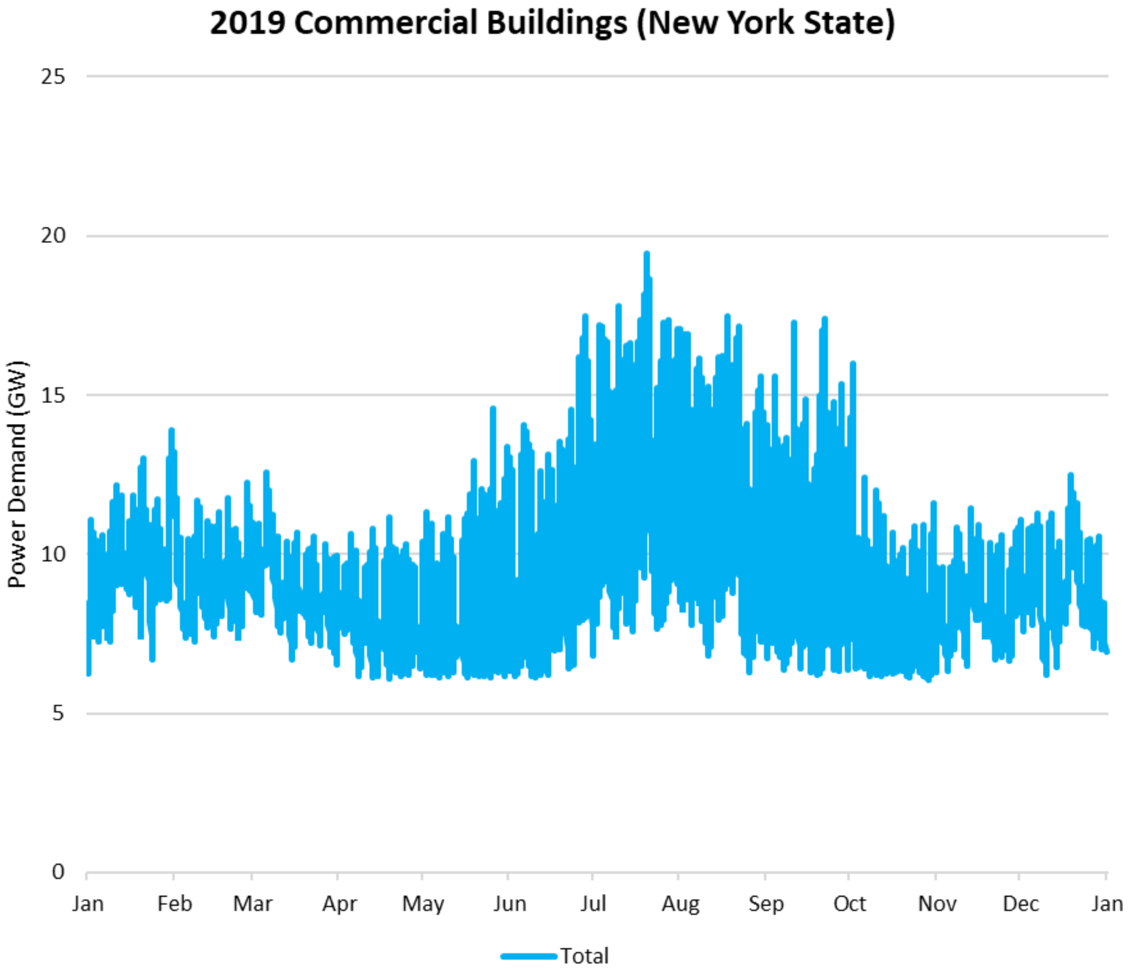






Baseline Demand: Commercial Buildings



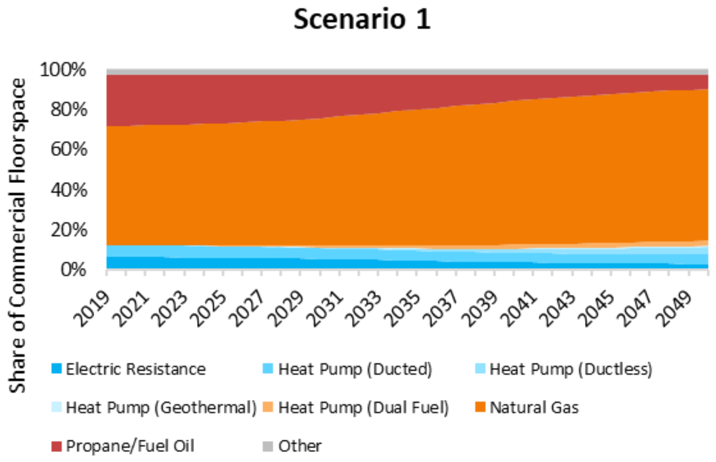


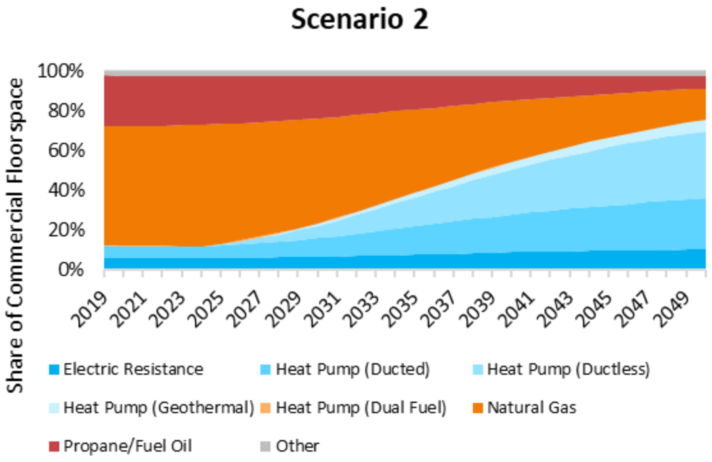
Baseline demand estimates show a higher summer peak for commercial buildings

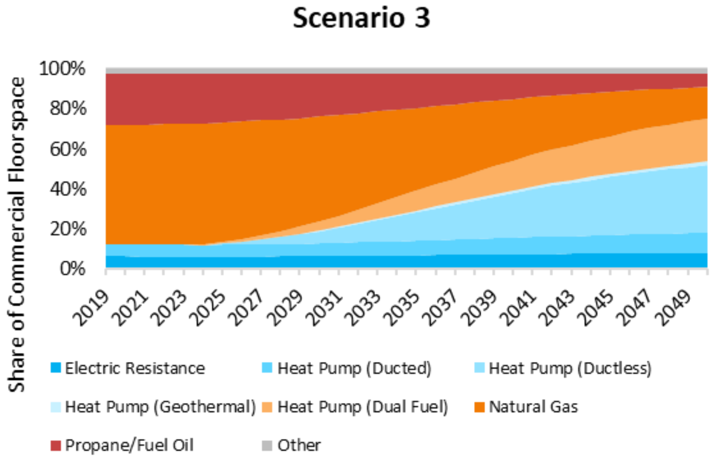
Appendix: Scenario Analysis

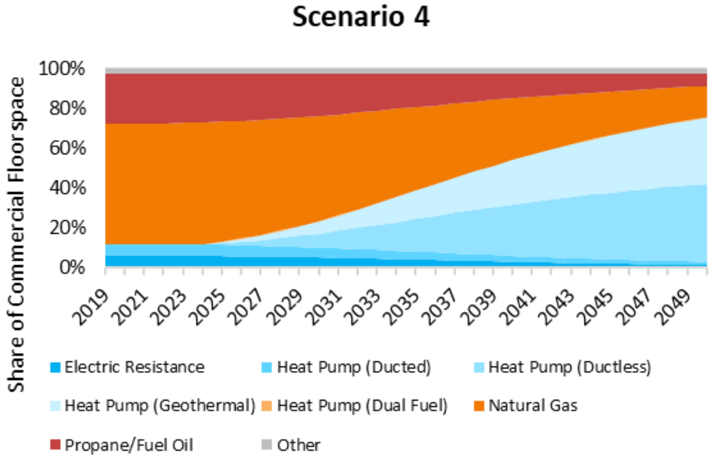
Space Heating Market Share

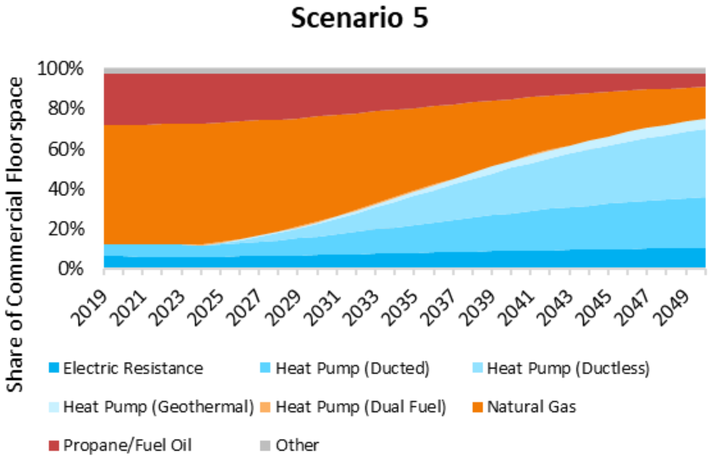
Commercial Buildings











EPRI's modeling framework evaluates differences in baseline saturation (based on NYSERDA data), market growth (by county), and technology adoption (by county/equipment)