New York ISO
Independent System Operator

Climate Change Impact and Resilience Study – Phase 1 Overview

Chuck Alonge

Manager, Demand Forecasting & Analysis

New York State Reliability Council - Executive Committee

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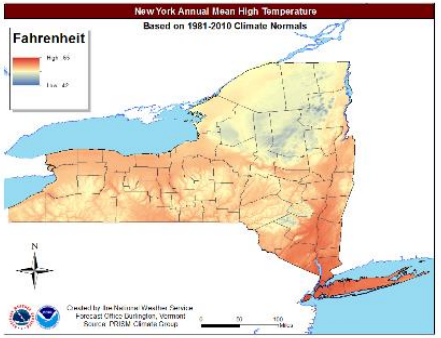
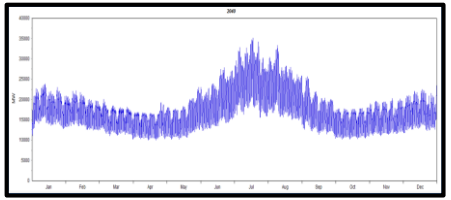
Study Objectives

- Evaluate temperature trends and state climate impact studies
- Develop long-term energy, peak, and 8,760 hourly load shapes that reflect the potential impact of climate change
  - In addition to the NYCA forecast, also produce Zonal and Transmission District level forecasts
- Construct additional forecast scenarios that reflect state policy goals that include climate change impacts
  - Policy Case (Clean Energy Standard)
  - Climate Leadership and Community Protection Act (CLCPA)
- Apply results to Phases 2 & 3 of Climate Study, and to future Gold Book forecasts, RNA, & other NYISO studies





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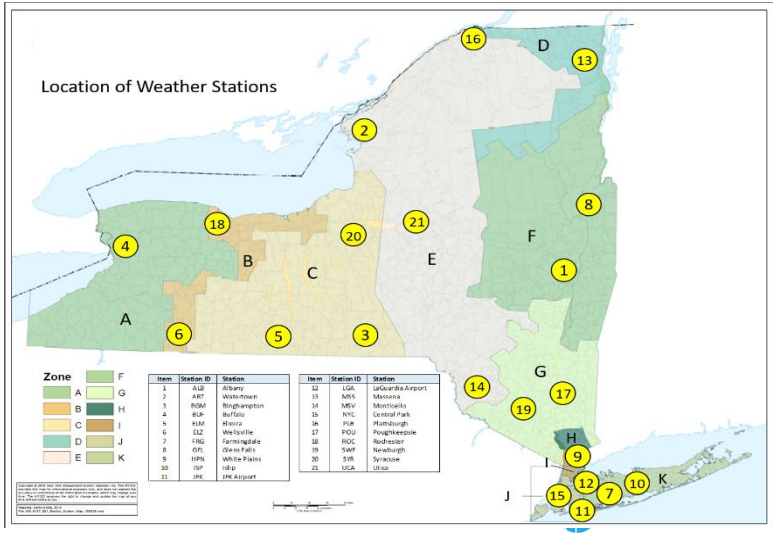
Weather Trend Analysis

- Evaluated temperature trends from 21 NY Weather Stations (1950-2018)
- Average temperature increase has varied across the state (0.5°F to 1.1°F per decade)
- No statistically significant increase in the maximum hourly heat index, but the average value of the heat index on the hottest days is getting warmer
- Most of the temperature change is coming from increasing minimum temperatures in winter months

TO	AvgTemp	MaxTemp	MinTemp	*CTHI
NIMO	0.71	0.52	1.07	0.64
ConEd	0.69	0.56	0.86	0.59
Cen Hudson	0.90	0.78	1.78	0.80
LIPA	0.85	0.93	0.79	0.75
NYSEG	0.60	0.44	1.07	0.55
O & R	0.59	0.41	0.99	0.64
RG&E	0.78	0.45	1.12	0.68
NYCA	**0.71**	**0.58**	**0.98**	**0.63**

*Cumulative Temperature and Humidity Index



Forecast Scenarios

- **All forecast scenarios include the following assumptions and projections:**
  - 2018 Moody's Economic Forecast
  - 2018 U.S. Energy Information Administration end use intensities
  - 24,360 GWh of Electric Vehicle (EV) Use by 2050
  - 6398 GWh of Solar (PV) and 29,468 GWh of Energy Efficiency Savings by 2050

Scenario	Temperature Increase	Additional PV / EV (2050)	Additional Energy Efficiency (2050)	Electrification Assumptions
Reference	0.7°F / decade	None	None	None
Reference Accelerated	1.4°F / decade	None	None	None
Policy Case	0.7°F / decade	9,000 MW / 6,000 GWh	2,200 GWh / year	25% of existing homes converting to heat pumps
CLCPA	0.7°F / decade	9,000 MW / 6,000GWh	2,200 GWh / year	Aggressive greenhouse gas reduction goals (85% reduction from 1990 levels)

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Climate Impacts on Summer Peak Forecast

- The Accelerated Trend Case assumes that the hottest temperatures and coldest day temperatures are increasing twice as fast as the Reference Case scenario
- Climate trend accounts for a 1,600 MW to 3,800MW increase in Summer Peak

	Summer Peak Demand (MW)			Weather Impact (MW)	
	Normal	Reference	Accelerated	Reference	Accelerated
2020	32,652	32,696	33,205	44	553
2030	32,899	33,405	34,393	506	1,494
2040	36,396	37,403	38,911	1,007	2,514
2050	41,700	43,317	45,479	1,617	3,779

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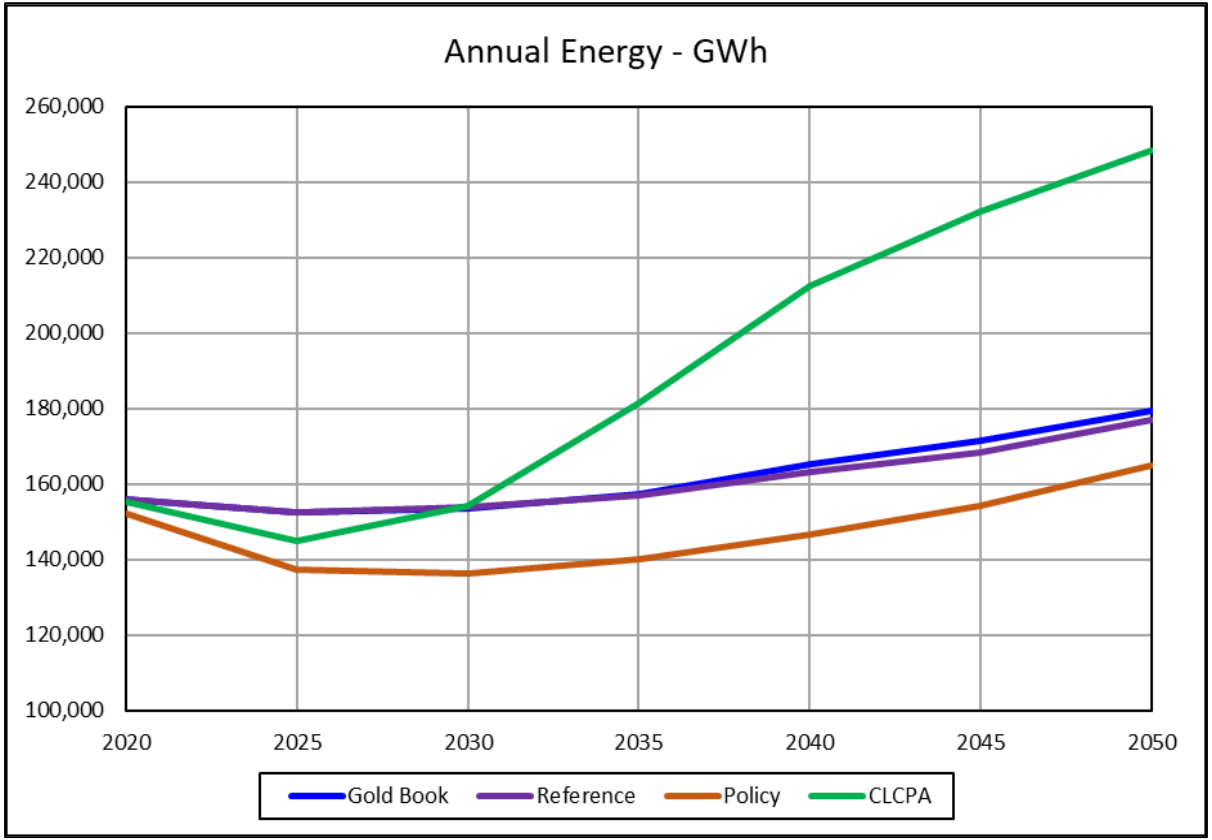
Scenario Comparisons



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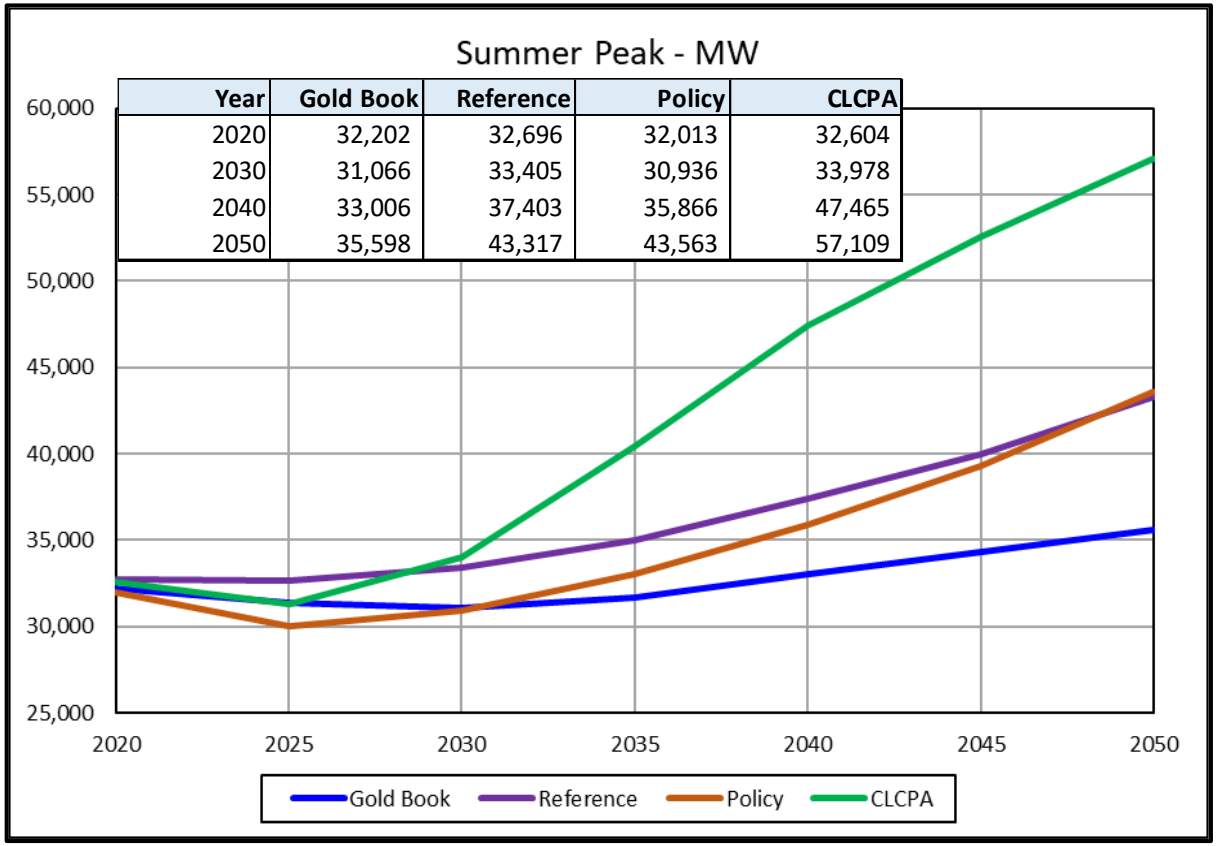

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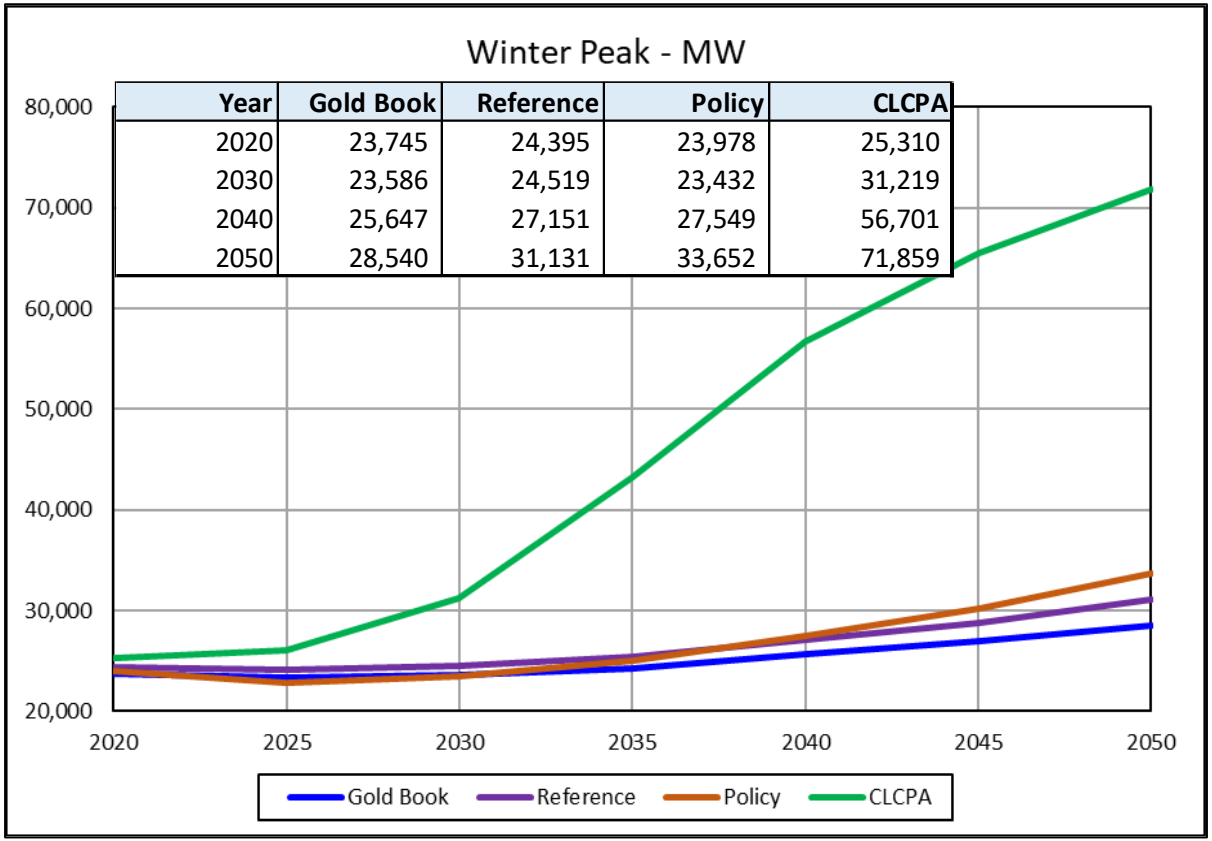

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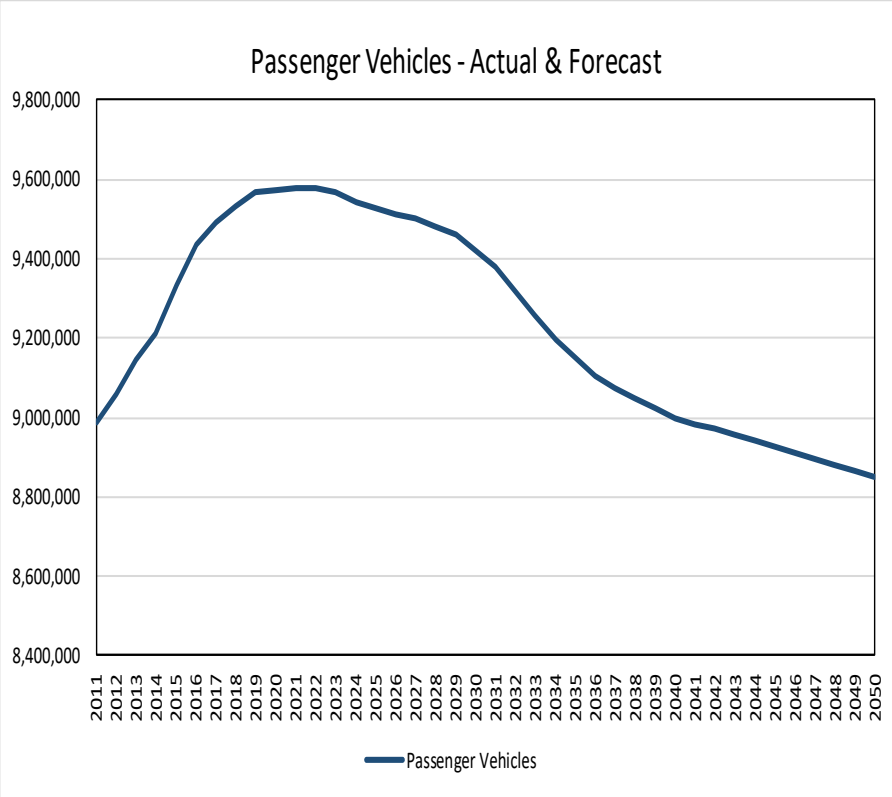
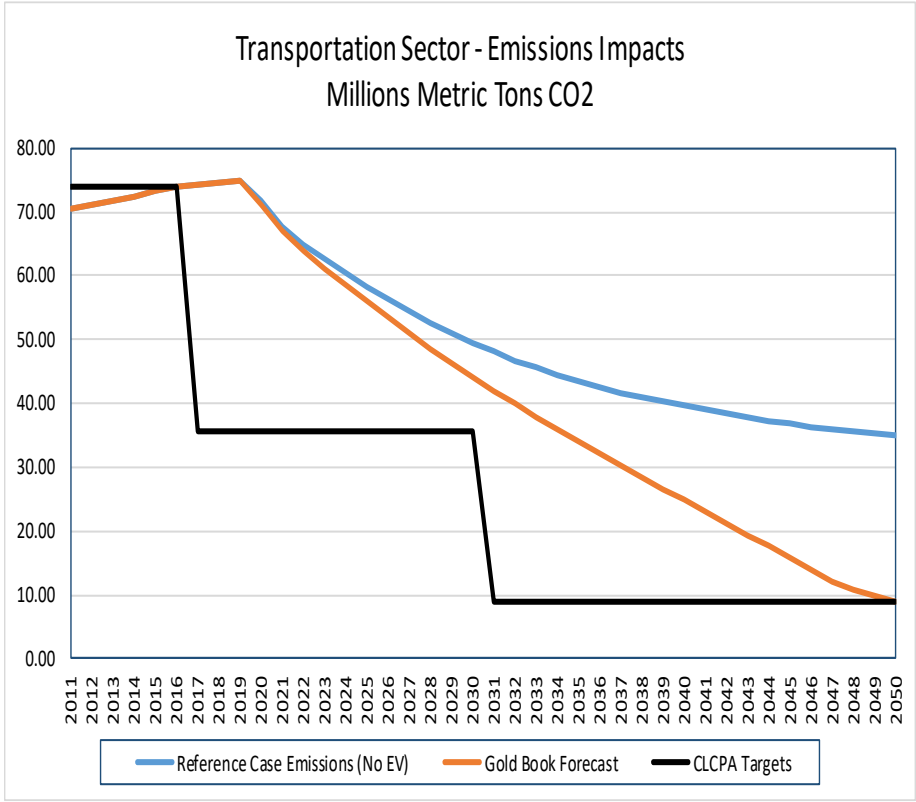
Electric Vehicle Forecast





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CLCPA Scenario - Electrification

- **Goal: Achieve 85% reduction in greenhouse gases by 2050 in residential, commercial, industrial and transportation sectors from 1990 emission levels**
- **Replaces fossil-based technologies with electric technologies**
  - End uses include space heat, water heat, clothes dryers and cooking in residential & commercial sectors. Industrial sector sees modest improvements in energy intensity.
  - Residential electric space heat technology is primarily air source heat pump, with resistance heating for supplemental and secondary heating needs.
- **85% reduction in transportation greenhouse gases via transition to electric vehicles**

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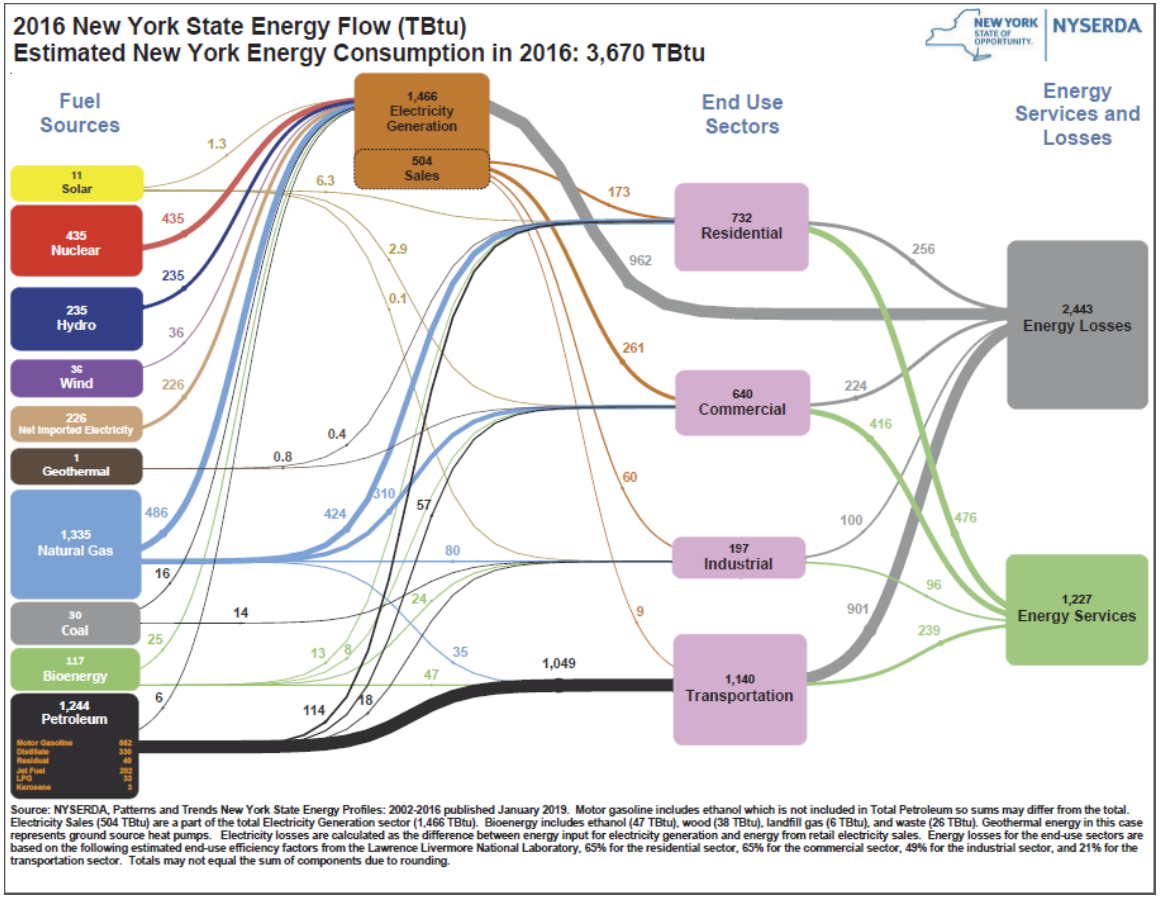
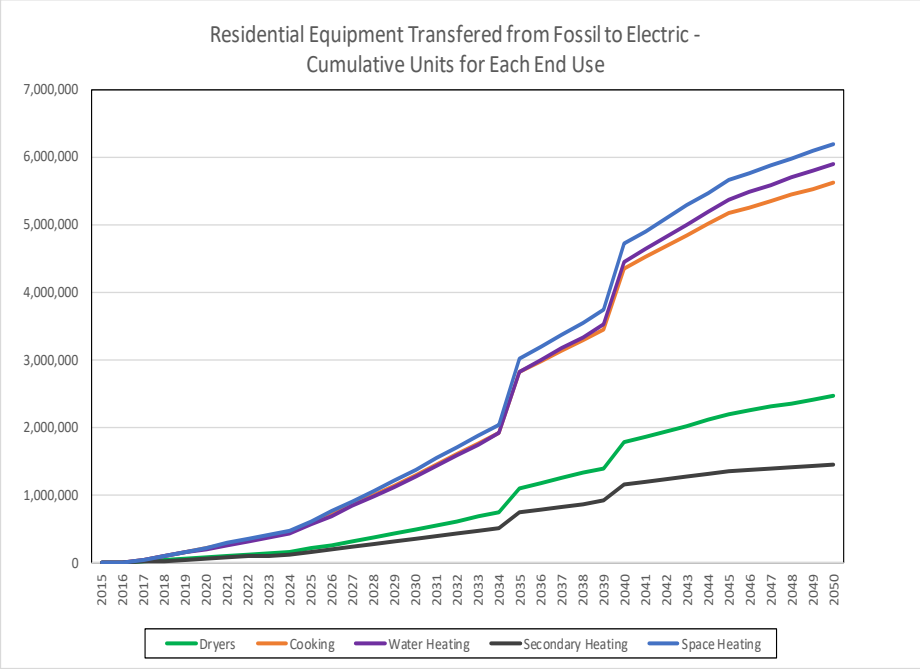
Energy Flow Chart for New York



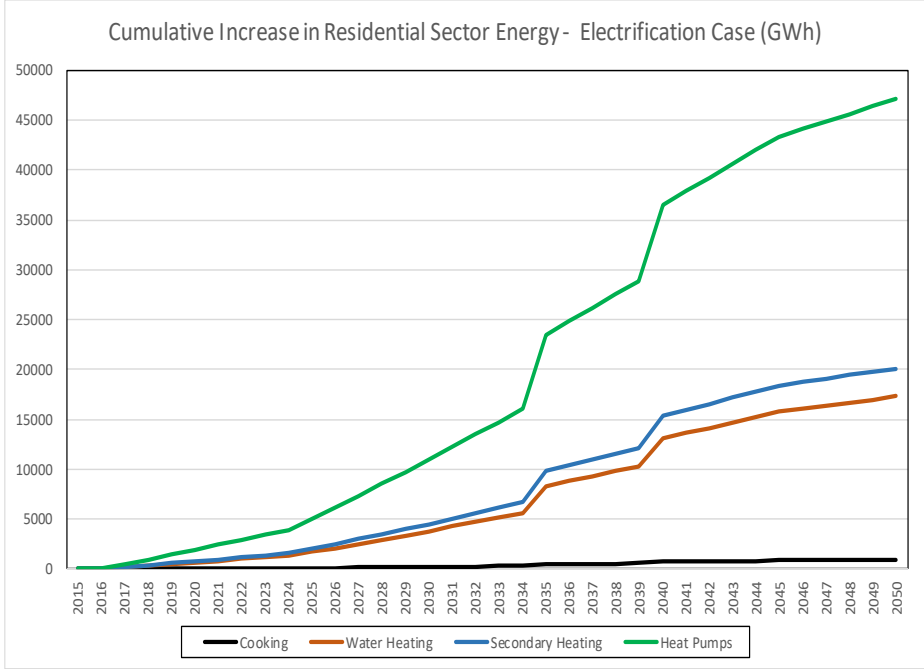
Source: NYSERDA, Patterns and Trends New York State Energy Profiles: 2002-2016 published January 2019. Motor gasoline includes ethanol which is not included in Total Petroleum so sums may differ from the total. Electricity Sales (504 TBtu) are a part of the total Electricity Generation sector (1,466 TBtu). Bioenergy includes ethanol (47 TBtu), wood (38 TBtu), landfill gas (6 TBtu), and waste (26 TBtu). Geothermal energy in this case represents ground source heat pumps. Electricity losses are calculated as the difference between energy input for electricity generation and energy from retail electricity sales. Energy losses for the end-use sectors are based on the following estimated end-use efficiency factors from the Lawrence Livermore National Laboratory, 65% for the residential sector, 65% for the commercial sector, 49% for the industrial sector, and 21% for the transportation sector. Totals may not equal the sum of components due to rounding.

Emissions reductions are obtained from four end use sectors by switching from fossil fuels to electricity

Step 1: Determine the number of residential appliances converting to electricity



Step 2: Multiply by kWh use per appliance, taking future efficiency trends into consideration. In particular, assume heat pumps for heating.



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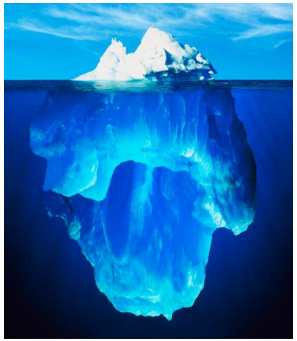
Summary and Future Work



- **Analysis of weather trends across NY show statistically significant increase in average temperatures of 0.5 to 1.1 degree per decade**
  - State average 0.7 degrees per decade
  - Temperatures on the coldest days are increasing faster than temperatures on the hottest days
  - Trend likely to continue through the future and could be faster or slower depending on long-term greenhouse gas path
- **State policy to address greenhouse gas emissions will have more impact on loads than temperature trends. The end-use modeling approach provides a framework for translating energy policy into impacts on energy, hourly loads, seasonal peak demands, and changes in emissions of greenhouse gases.**
- **Enhancements planned include:**
  - Augmentation of end-use data (increased spatial-temporal resolution)
  - Additional work on modeling commercial and industrial electrification
  - Improving estimates of emission reductions as a result of increased electrification
  - Additional end-use data (saturation, square footage, building shell integrity, technology profiles for both electric and non-electric fuel types) from in-state and national sources

Phase 1 Report: https://www.nyiso.com/documents/20142/10773574/NYISO-Climate-Impact-Study-Phase1-Report.pdf

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