Energy Efficiency and Housing Advisory Panel

September 16, 2020

Meeting 1

NEW YORK STATE OF OPPORTUNITY. | Climate Action Council

Logistics and Meeting Procedures

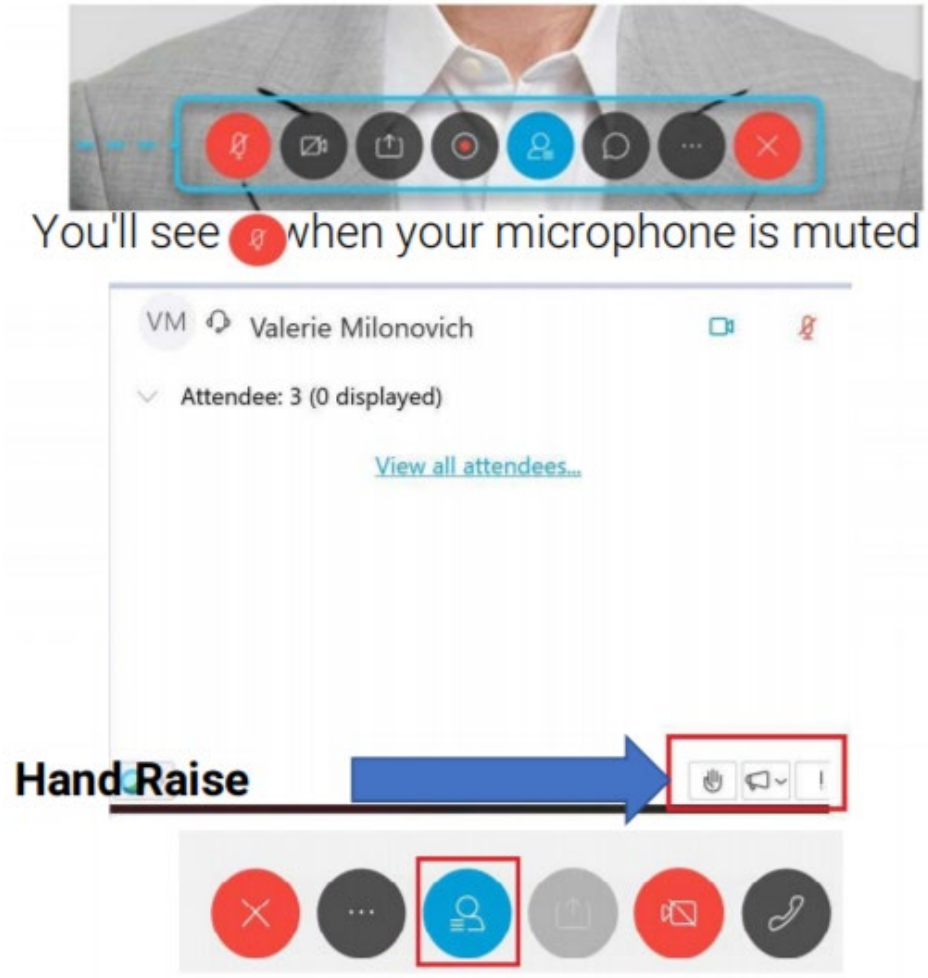
Before beginning, a few notes to ensure a smooth discussion:

> Panel Members should be on mute if not speaking
  - If using phone for audio, please tap the mute button
  - If using computer for audio, please click the mute button on the computer screen (1st visual)

> Video is encouraged for Panel Members, in particular when speaking

> In the event of a question or comment, please use the hand raise function (2nd visual). You can get to the hand raise button by clicking the participant panel button (3rd visual). The Chair will call on members individually, at which time please unmute.

> If technical problems arise, please contact Sal Graven at Sal.Graven@nyserda.ny.gov



Agenda

- Welcome and Objectives (5 minutes)
- Introductions and Panel Member Priorities (35 minutes)
- Decarbonization Pathways Presentation (30 minutes)
- State of the Sector in Brief (10 minutes)
- Scope Development Discussion (25 Minutes)
- Work Plan and Next Steps (15 minutes)

Objectives

Climate Leadership & Community Protection Act of 2019 (CLCPA)

- Mandates 85%+ emissions reduction
- 100% zero-carbon electricity by 2040
- Puts NY on a path to carbon neutrality by mid-century
- Codifies clean energy targets
- First statutory Climate Action Council

Energy Efficiency and Housing Advisory Panel

Develop recommendations specific to the buildings sector for emissions reducing policies, programs, or actions that contribute to achieving the statewide emissions reductions established in the CLCPA, for consideration by the Climate Action Council for inclusion in the Scoping Plan.

Objective today:

Share expectations for the priorities, scope, and approach to the work of this Advisory Panel.

Introductions

Energy Efficiency and Housing Panel Members

RuthAnne Visnauskas, Chair
Commissioner: Homes & Community Renewal

Janet Joseph
Senior Vice President for Strategy and Market Development: NYSERDA

Peggie Neville
Deputy Director of Efficiency & Innovation: Department of Public Service

Gina Bocra
Chief Sustainability Officer: NYC Dept. of Buildings

Kyle Bragg
President: 32BJ SEIU

Amy Sugimori
Director of Policy and Legislation

Dan Egan
Senior Vice President of Energy & Sustainability: Vornado Realty Trust

Bret Garwood
Chief Executive Officer: Home Leasing, LLC

Jin Jin Huang
Executive Director: Safari Energy, LLC

Clarke Gocker
Director of Policy and Strategy: PUSH Buffalo

Elizabeth Jacobs
Acting Executive Director: Akwesasne Housing Authority

Jamal Lewis
Sr. Policy & Technical Assistance Specialist: Green & Healthy Homes Initiative

Sadie McKeown
EVP & COO: The Community Preservation Corporation

Bill Nowak
Executive Director: NY Geothermal Energy Organization

Molly (Dee) Ramasamy
Head of Deep Carbon Reduction: Jaros, Baum & Bolles

Daphany Sanchez
Executive Director: Kinetic Communities Consulting

Laura Vulaj
Senior Vice President & Director of Sustainability: SL Green Realty Corp.

Staff Working Group Members

- **Homes and Community Renewal:** Simon McDonnell, Amy Zamenick, Grace Woodard, Rachel Wieder
- **NYSERDA:** Vanessa Ulmer, Emily Dean, John Lee, Leslie Green
- **Department of Environmental Conservation:** Michael Cronin
- **Dormitory Authority of the State of New York:** Jodi Smits Anderson
- **Department of Health:** Todd Crawford, Caitlin Norton, Deidre Astin, Udo Ammon
- **Department of Public Service:** Kevin Manz
- **Department of State:** John Addario, Kevin Duerr-Clark, Emma Gonzalez-Laders
- **Empire State Development:** Vincent Ravaschiere
- **Long Island Power Authority:** TJ Coates
- **New York Power Authority:** Dominick Luce, John Raudenbush

Decarbonization Pathways Presentation

Energy+Environmental Economics

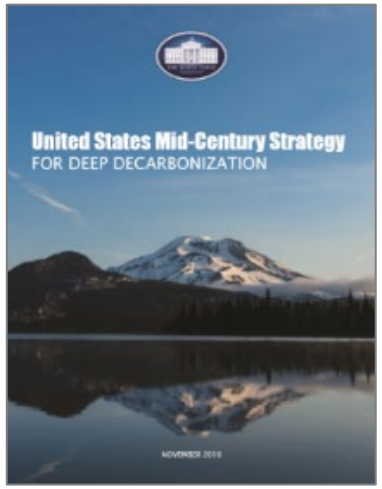
New York State Decarbonization Pathways Analysis

Energy Efficiency and Housing Panel Discussion

September 16, 2020

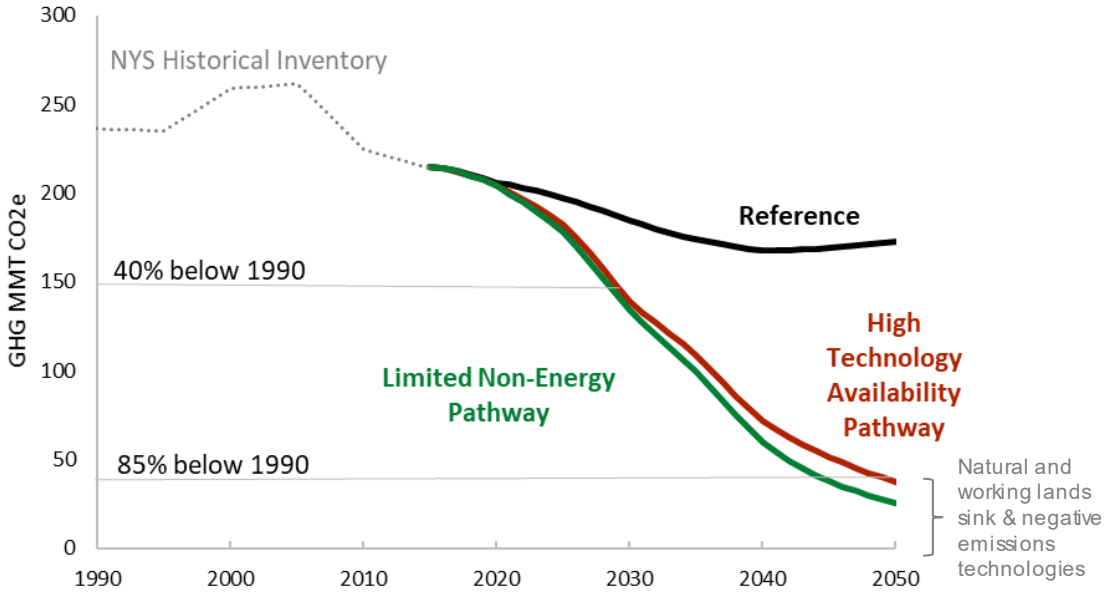
Analysis Overview

- NYSERDA engaged E3 to develop a strategic analysis of New York's decarbonization opportunities. This ongoing analytic work, initiated prior to the passage of the CLCPA, has modeled existing policies and explored additional actions needed to reach the State's 2030 and 2050 targets and provides a starting point to inform the work of the Climate Action Council
- E3 reviewed the literature on deep decarbonization and highly renewable energy systems and gained additional insights from discussions with leading subject matter experts
- Further work will be needed to fully incorporate GHG accounting requirements of the CLCPA and re-calibrate to DEC's forthcoming rulemaking establishing the statewide GHG emission limits



Scenario Development

- **Reference Case** includes **pre-** CLCPA adopted policies & goals, including 50x30 Clean Energy Standard, 2025 and 2030 energy efficiency targets, zero-emission vehicle mandate
- Range of **pathways** designed to achieve CLCPA GHG targets that include CLCPA electric sector provisions (e.g., 70x30, 100x40, offshore wind & solar)
- **Two "Starting Point" Pathways:**
  - **High Technology Availability Pathway:** Emphasizes efficiency and electrification at "natural" end-of-life asset replacement schedule, while also utilizing advanced biofuels, carbon capture and storage (CCS), bioenergy with carbon capture and storage (BECCS), and a high natural and working lands (NWL) sink
  - **Limited Non-Energy Pathway:** Accelerates electrification with more rapid ramp-up of new sales, along with early retirements of older fossil vehicles and building equipment. Additional fossil fuel displacement by advanced biofuels. Greater energy sector emission reductions in case of more limited non-energy reductions and NWL sink contribution



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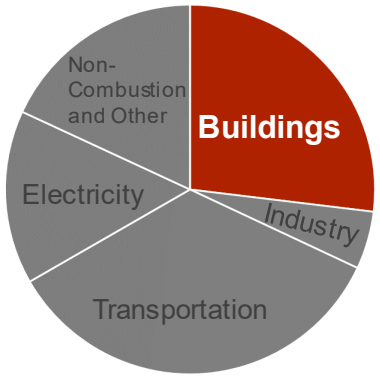
Characterization of the Buildings Sector

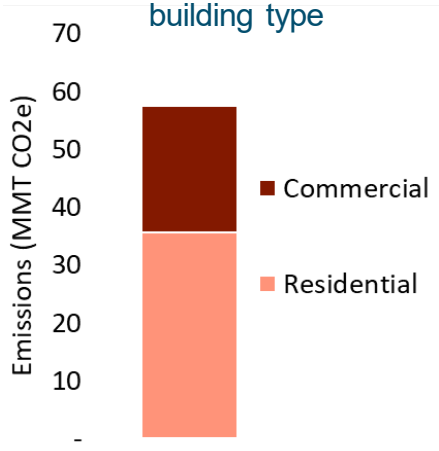
Residential and Commercial Building Emissions

+ **Buildings emissions have decreased over 25% relative to 1990 levels**
  - CLCPA directs New York State to adopt a 20-year global warming potential and incorporate upstream emissions associated with fossil fuels into its GHG emissions accounting framework. Work to develop this emissions accounting framework is underway. Under this new emissions accounting framework, fossil fuel use, as well as all sources of short-lived climate pollutants, which include methane and HFCs, will carry a higher GHG impact on a tons of carbon dioxide equivalent basis than in the current accounting framework used in this analysis
+ **GHG emissions in residential and commercial buildings are dominated by space heating and water heating, with other uses including appliances, cooking, and other (e.g., fireplaces, lawnmowers, secondary heating)**
  - Upstate region in particular has larger homes with greater space heat demand than downstate region
  - Although there is a significant amount of home heating oil used in current day, majority of energy-related emissions are from natural gas use
+ **Emissions associated with electricity consumption is currently tracked in the electricity generation sector**

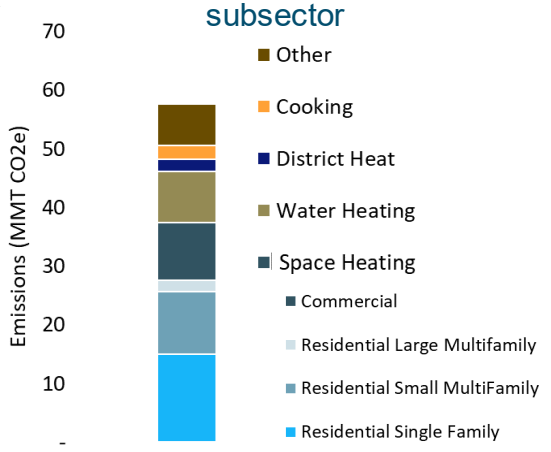
Economy-wide emissions in 2016



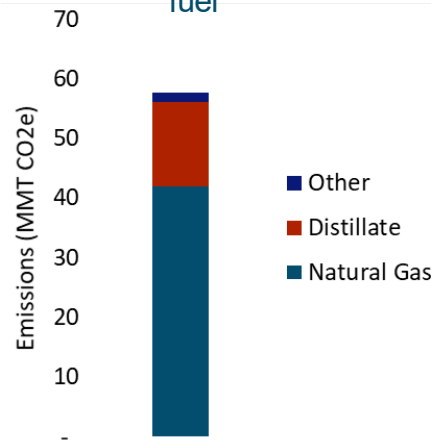
Buildings emissions by building type



Buildings emissions by subsector



Buildings emissions by fuel



Notes: HFCs (also called ODS substitutes) are categorized in Industrial Processes in the current NY GHG Inventory

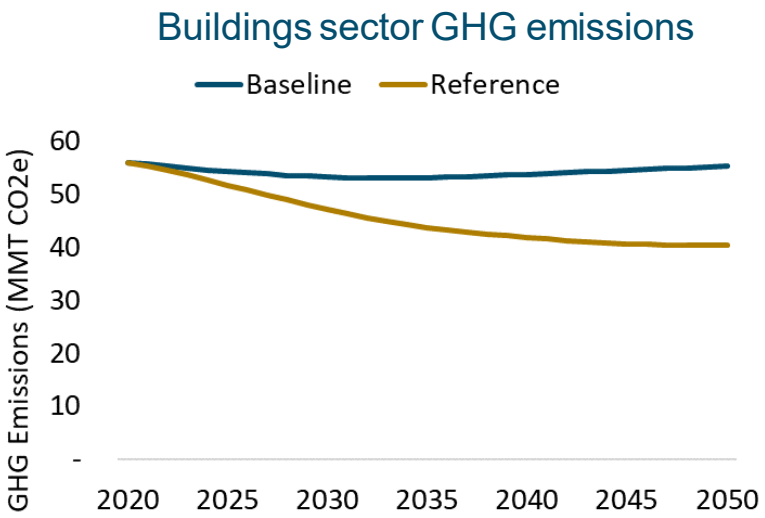
Key Drivers

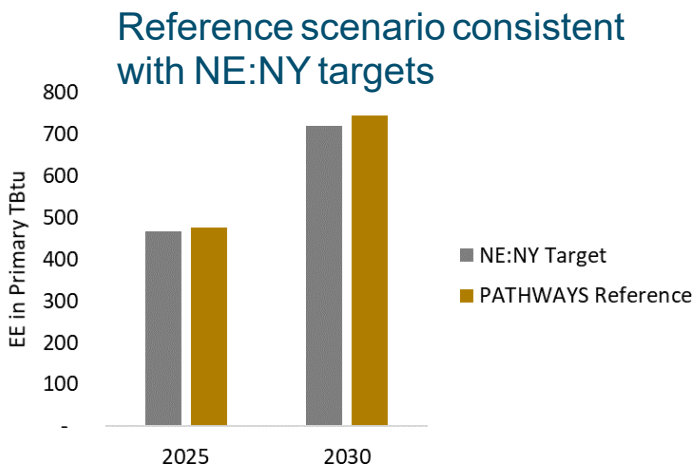
- **Population, household, and commercial growth rates drive energy demand and GHG emissions**
  - Population growth rate is projected to be .19% per year[1]
  - Commercial growth rate is projected to be .44% per year[2]
- **Appliance efficiency improvements, behavioral conservation, and codes and standards, including:**
  - Level of ambition of federal and state appliance codes and standards
  - Stringency of new building codes and rate of existing building retrofits
  - Consumer adoption of high efficiency appliances or smart devices
- **Use of high-GWP refrigerant gases in air conditioning and heat pump technologies[3]**

[1] Source: Cornell population study
[2] Calculated using historical relationship between square footage and population growth for Mid-Atlantic region from EIA NEMS
[3] Hydrofluorocarbons (HFC) are ODS substitutes, which are non-combustion emissions that are tracked as part of the Industrial Process and Product Use source category

Buildings Sector Emissions Over Time

- **Baseline scenario represents a business as usual future, with federal appliance efficiency standards, energy efficiency, and oil to gas switching consistent with Annual Energy Outlook**
- **Reference scenario includes significant incremental decarbonization measures, consistent with achieving New Efficiency New York 2025/2030 targets and NYC LL97 downstate building emissions intensities through 2030**
  - Significant building shell weatherization measures
  - Energy efficiency and behavioral conservation measures
  - Small amounts of heat pump space heater sales
- **Emissions associated with electricity consumption is currently tracked in the electricity generation sector**





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Opportunities for Decarbonization

Pillars of Deep Decarbonization in Buildings

Energy Efficiency and Conservation

- Device Efficiency
  - Federal and state appliance codes and standards
  - Appliance efficiency improvements (EnergySTAR+)
- Reductions in energy service demand
  - Efficient building shell and weatherization measures
  - Behavioral conservation and smart devices (e.g. smart thermostats)

Switching to Low Carbon Fuels

- Electrification
  - Cold climate heat pump space heaters (e.g. ASHPs, GSHPs, HPs with fuel backup)
  - Heat pump water heaters
- Bioenergy
  - Renewable natural gas
  - Renewable diesel
  - Pipeline hydrogen (up to blend limit)

Decarbonizing Electricity Supply

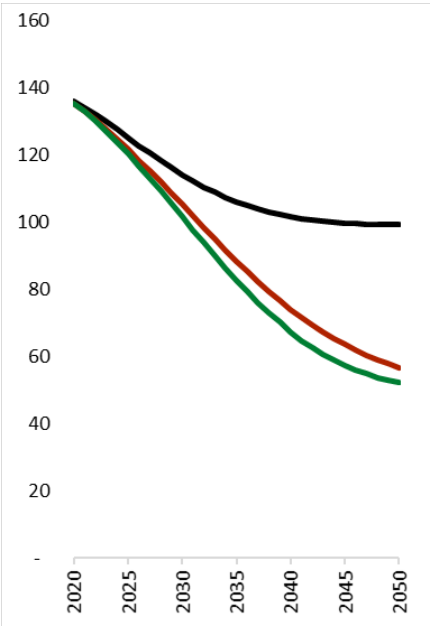
- Reducing indirect emissions associated with electrification
- Flexible building load operations to improve operations of the grid

Pillars of Carbon Neutrality

Energy Efficiency and Conservation

[site energy consumed per person]

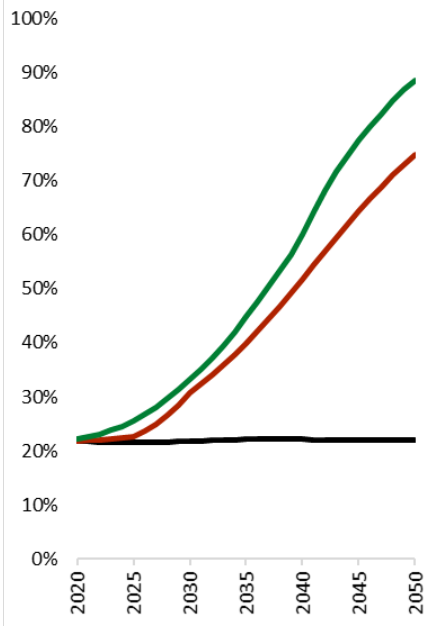
Unit: MMBTU/capita



Switching to Low Carbon Fuels

[% site energy consumed as electricity, biofuels, hydrogen, synthetic fuels]

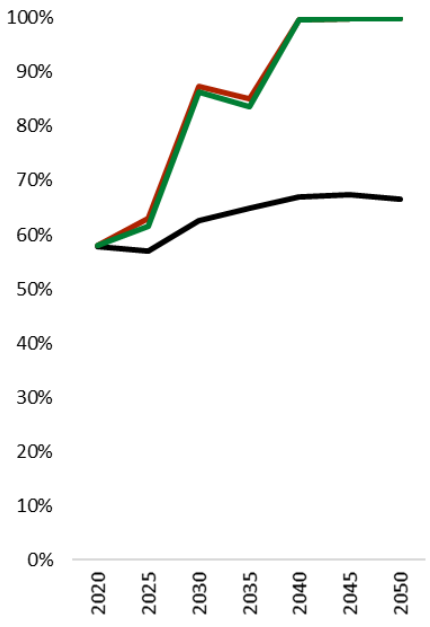
Unit: % site energy consumed



Decarbonizing Electricity Supply

[% electricity supplied by wind, solar, hydro, nuclear, CCS, biofuels, hydrogen]

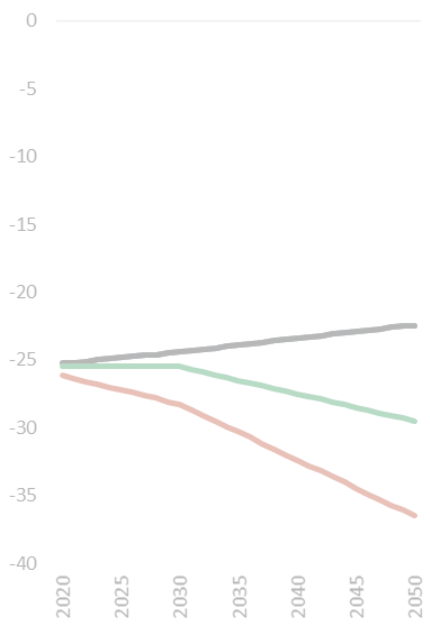
Unit: % electricity supplied



Negative Emissions

[total emission reductions from net land use sink, BECCS, DAC]

Unit: MMT CO2e



Reference Case — High Technology Availability Pathway — Limited Non-Energy Pathway

Opportunities to Decarbonize the Buildings Sector

- **Key emitters today: 65% of direct emissions are from space heating**
- **Key decarbonization options include energy efficiency, electrification, and fuel substitution:**
  - Adoption of efficient appliances (e.g. through appliance standards, direct incentives, etc.)
  - Efficient building shell and building weatherization to reduce space heating demands (for new construction and deep home retrofits)
  - Electrifying space and water heating (large-scale adoption of cold-climate heat pumps)
  - Blend renewable natural gas or hydrogen (up to ~7% by energy) into pipelines
  - Climate-friendly refrigerants
- **Key challenges:**
  - Back up heating, either with hybrid systems such as natural gas/propane or with electric resistance backup, will be needed to complement air source heat pumps at very low temperatures
  - Flexible space heating (e.g., pre-heating or pre-cooling) can avoid stressing the electricity system during peak cold snaps and can help lower costs for electricity generation, transmission, and distribution

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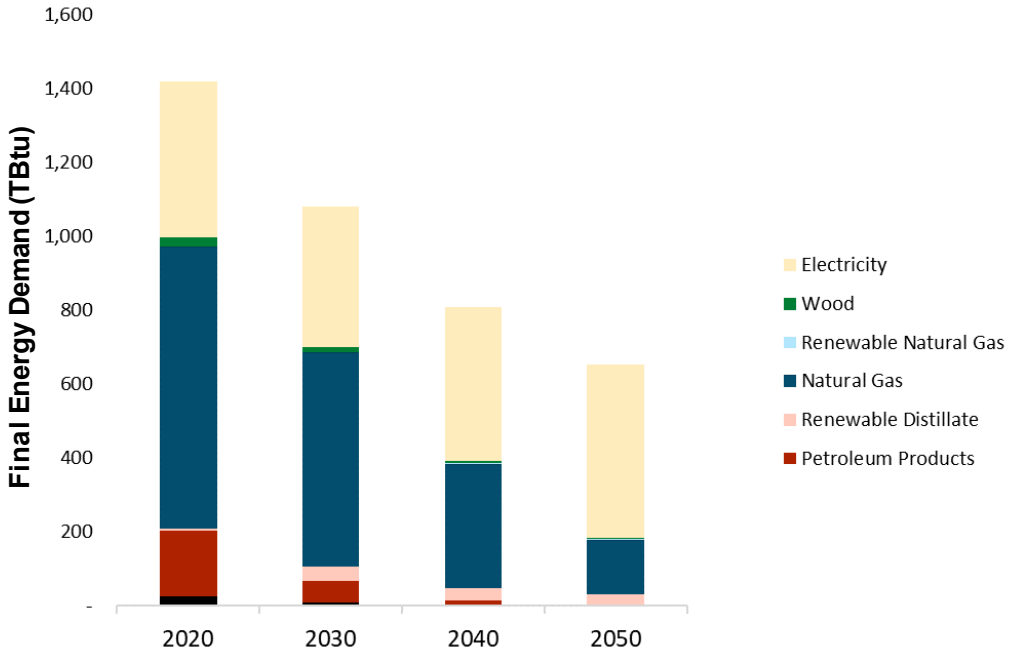
Sectoral Findings

Buildings

- Efficiency across all end-uses and building shell scales dramatically
- Major shift to end-use electrification, particularly in space and water heating
  - 50%-70% new heating system sales by 2030 with increasing rates of adoption thereafter
  - End-use electrification drives trend toward a winter peaking system
  - Magnitude of winter peak varies by study, but investment in ground-source heat pumps or onsite combustion backup systems using fossil fuel, bioenergy, or synthesized fuel, such as hydrogen, may mitigate excessive peak electricity demand
- Flexibility of end-use electric loads helps to maintain system-wide reliability
- Shift to low-GWP refrigerants crucial to ensure maximum GHG emissions benefits from heat pump adoption
  - Further analysis needed to explore full range of mitigation options, timing, and potential barriers
- Electricity consumption in buildings is shown here, but emissions associated with electricity consumption is currently tracked in the electricity generation sector

High Technology Availability Pathway

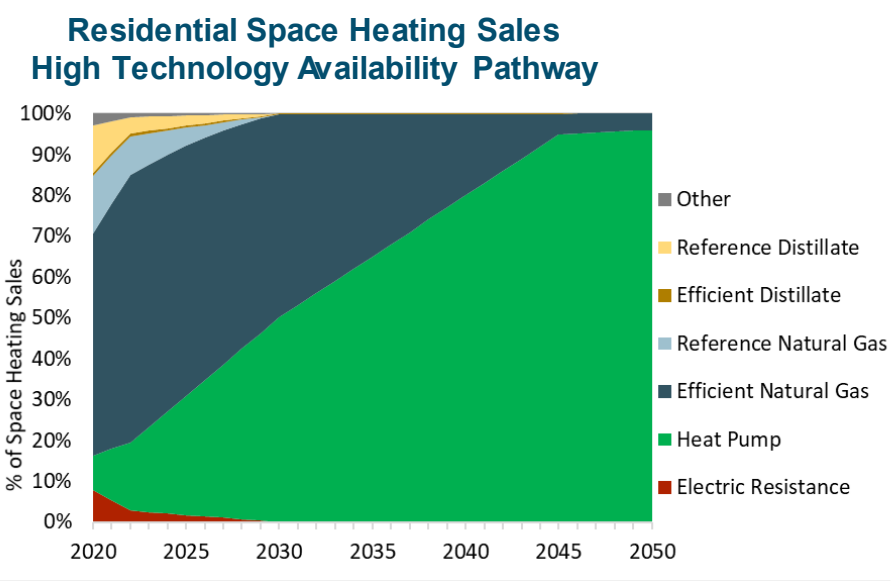


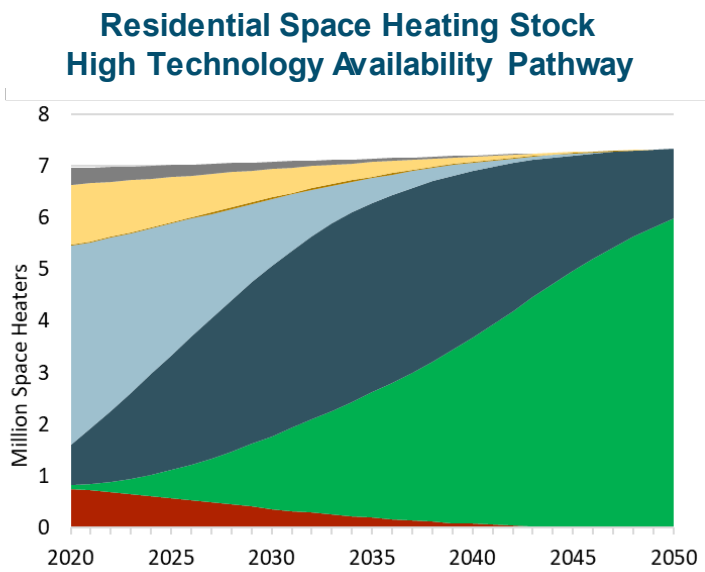
Metric	2030**	2050**
Percent GHG emissions reduction*	31%-39%	85%-93%
Percent reduction in final energy demand*	26%-31%	55%-59%

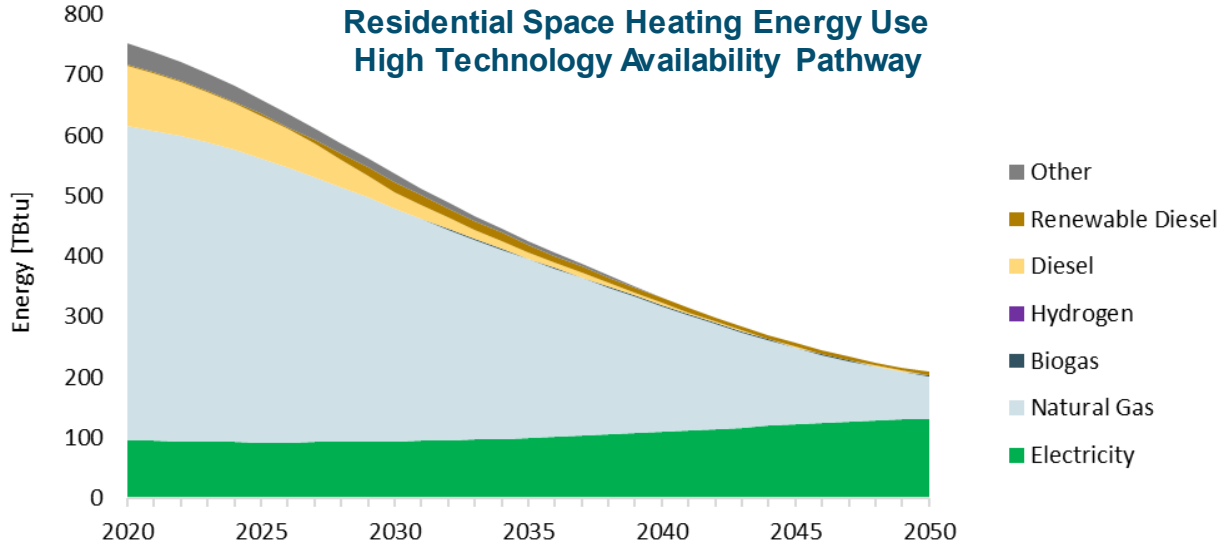
** Relative to 2016*

*** Range of values includes limited non-energy pathway*

Timing of Building Electrification

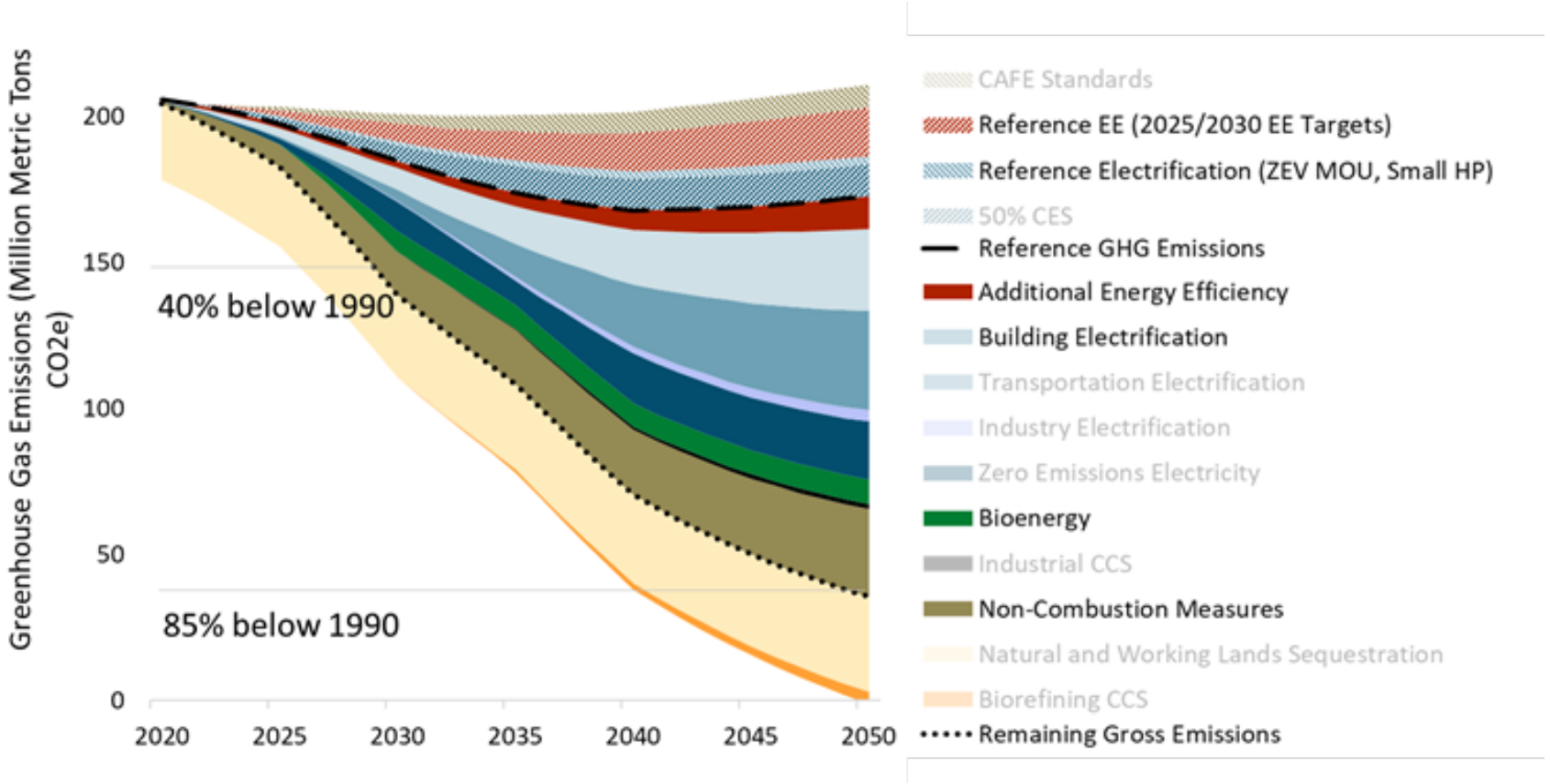






Emissions Reductions by Measure

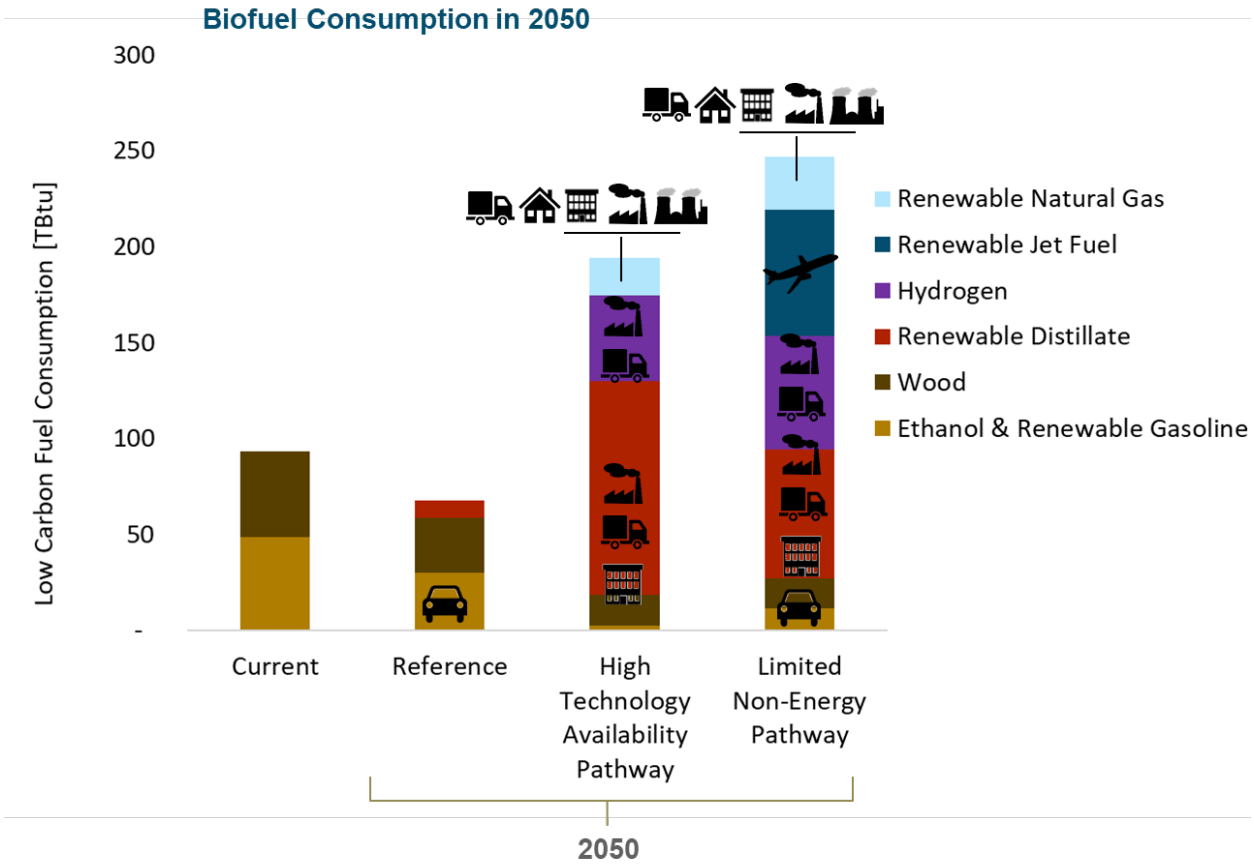
High Technology Availability Pathway



+ **Building efficiency and electrification measures make up significant portion of reductions to reach CLCPA goals**

Low-Carbon Fuels

+ Advanced low-carbon liquid and gaseous fuels are key to decarbonizing sectors where electrification is challenging, such as pipeline renewable natural gas for cold weather space heat backup or renewable distillate use in buildings



+ "Starting Point" pathways can achieve deep decarbonization using in-state feedstocks for advanced biofuels

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Next Steps

Next Steps

- ***Adding CLCPA GHG accounting viewpoint***
  - *Upstream emissions from imported fuels*
  - *20-year Global Warming Potential*
- ***Review of performance and cost assumptions***
- ***Incorporation of Panel input into integrated, economy-wide pathways analysis***

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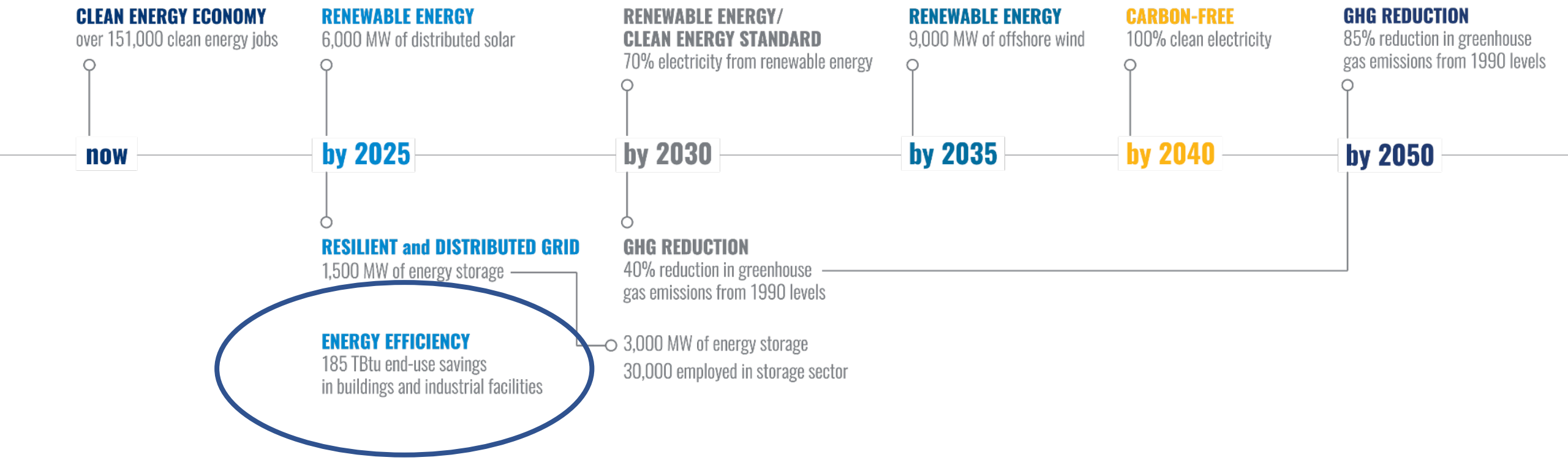
Questions?

State of the Sector in Brief

Upcoming meeting will address in greater depth

New York State Clean Energy Goals

Climate Leadership and Community Protection Act (CLCPA)



35% - 40% of the benefits of state CLCPA investments must flow to disadvantaged communities

2025 Statewide Energy Efficiency Target

2025 statewide energy efficiency target

185 TBtu

end-use savings in buildings and industrial sector

below 2025 forecast

equivalent to fueling and powering more than **1.8 million New York homes** by 2025

delivering **nearly one-third** of the greenhouse gas emissions reductions needed to meet **40% reduction by 2030**

New Efficiency: New York Strategies

- Enable market-based energy efficiency and building decarbonization
- Accelerated and better coordinated energy efficiency programs
- NYS Clean Heat – statewide support for building electrification
- Statewide Low-and Moderate-Income (LMI) Portfolio
- Build a skilled workforce
- Broad-based impact via building codes and appliance standards
- Lead by example in State buildings



CLCPA raises the bar for energy efficiency and building decarbonization

Need for a step change in ambition

- 185 TBtu energy savings target is projected to achieve an ~ 10 percent reduction in final energy demand in buildings* by 2025 – with support for ~ 100,000 homes and businesses to adopt heat pumps.
- Pathways work projects 26 to 31 percent reduction in final energy demand in buildings* by 2030, and 55 to 59 percent reduction by 2050 – with major shift to end-use electrification in space and water heating.

**relative to 2016 baseline*

NYS Residential Building Stock Snapshot

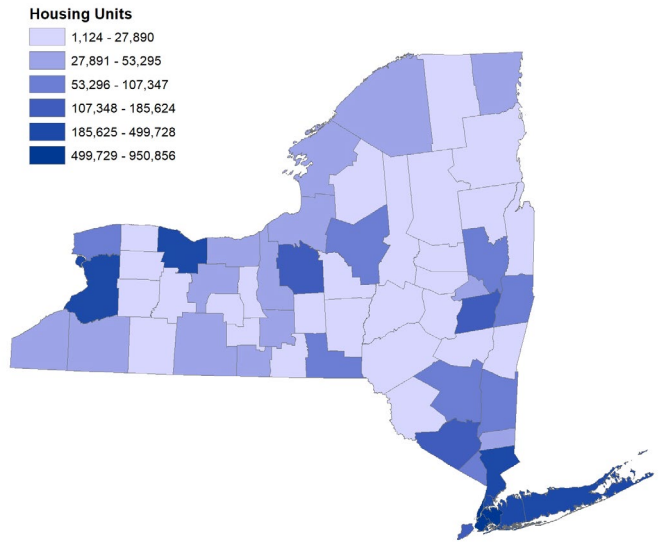
Housing: older, more diverse, more likely to be rentals...

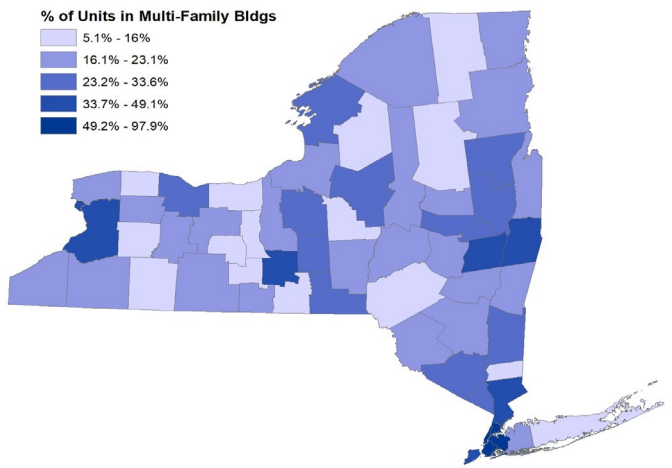
19 million New Yorkers live in 7.3 million owner- and renter-occupied units.*

> Almost 11m people live in 3.9m owner-occupied units.
  - Over ¾ of these units are single-family buildings, 9% are 2-4 unit buildings.

> ~8.3m people live in 3.4m renter-occupied units (2.1m in NYC).
  - Most rental-occupied units are in larger buildings (over 60% are in buildings with 5+ residential units; 50% in 10+ residential units).

> The state's housing stock – regardless of size or tenure – is relatively old.
  - Approximately 40,000 new units are authorized per year (most in multifamily buildings).**
  - 92% of housing stock is over 40 years old; more than a third is over 80 years old.
    - 27% of single-family owner-occupied units and 35% of 5+ rental unit buildings pre-date 1940.





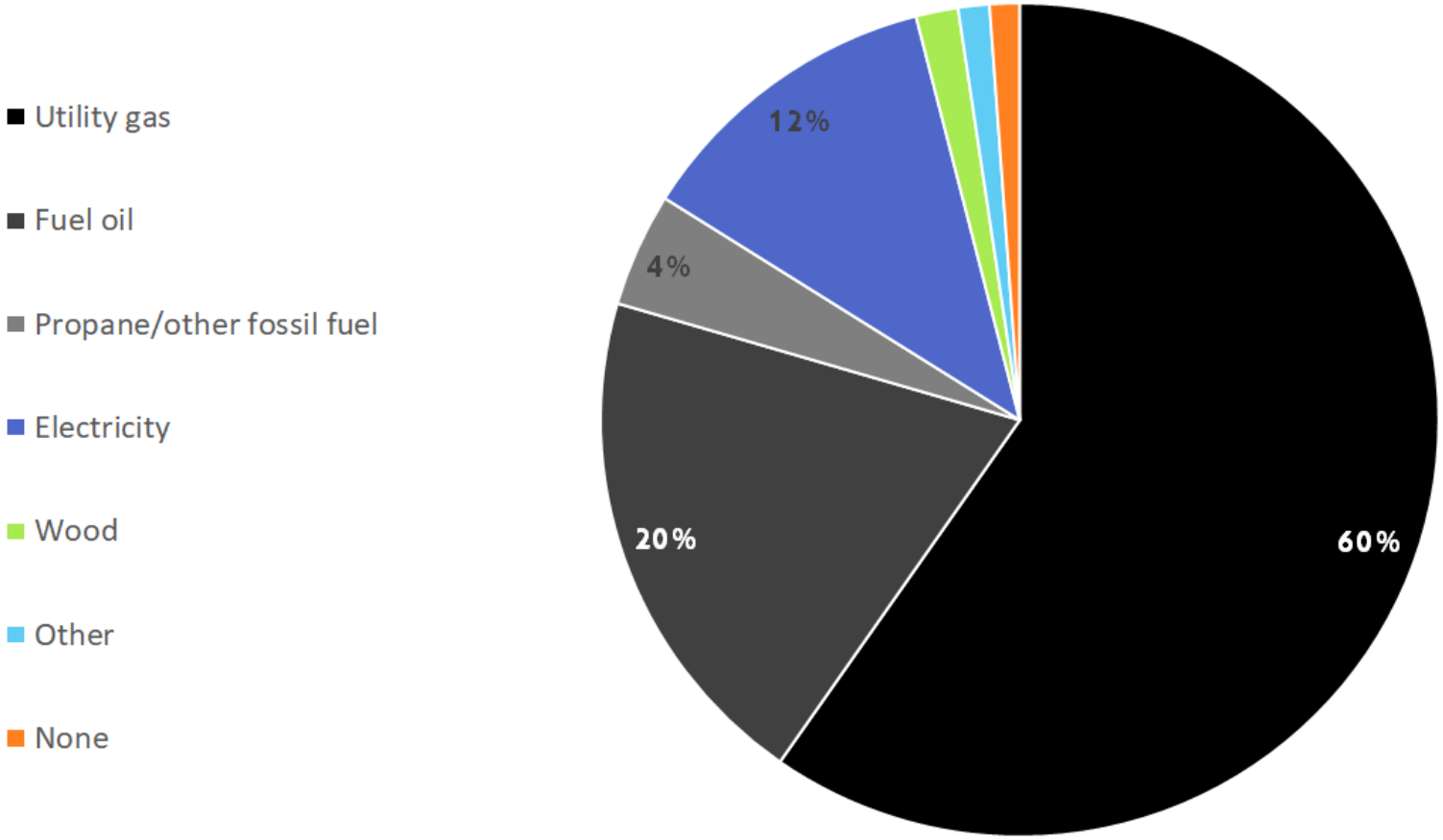
**US Census 2018 American Community Survey, 5-year sample*

*** US Census 2018 Building Permits Survey*

NYS Residential Building Stock Snapshot (continued)

Housing: Fueled by fossils

> ~85% of homes are heated with fossil fuels today (60% utility gas, 20% fuel oil).*
  - 12% of households are heated by electricity, but typically less efficient furnaces or room heaters.
  - Only 2% of homes are primarily heated by electric heat pumps.



US Census 2018 American Community Survey

Advisory Panel Scope Development

Energy Efficiency and Housing Advisory Panel

BACKGROUND

Buildings-specific strategies to achieve ~31-39% emission reduction from 2016 level by 2030 (85-93% by 2050), to contribute to achieving the CLCPA statewide emissions reductions targets

- **Investments in buildings needed to achieve emissions reduction goal:**

Energy Efficiency and Conservation	+	Switching to Low Carbon Fuels	+	Decarbonizing Electricity Supply
• **Codes and standards improve efficiencies of new appliances** • **High adoption rates of efficient building shell and weatherization measures** • **Behavioral conservation and smart devices**		• **Electrification of space heating (e.g., efficient cold climate heat pumps)** • **Electrification of domestic hot water** • Bioenergy		• Zero-emissions electricity reduces indirect emissions of electrified heat and hot water • **Flexible building loads improves grid management**

Energy Efficiency and Housing Advisory Panel

SCOPE DEVELOPMENT

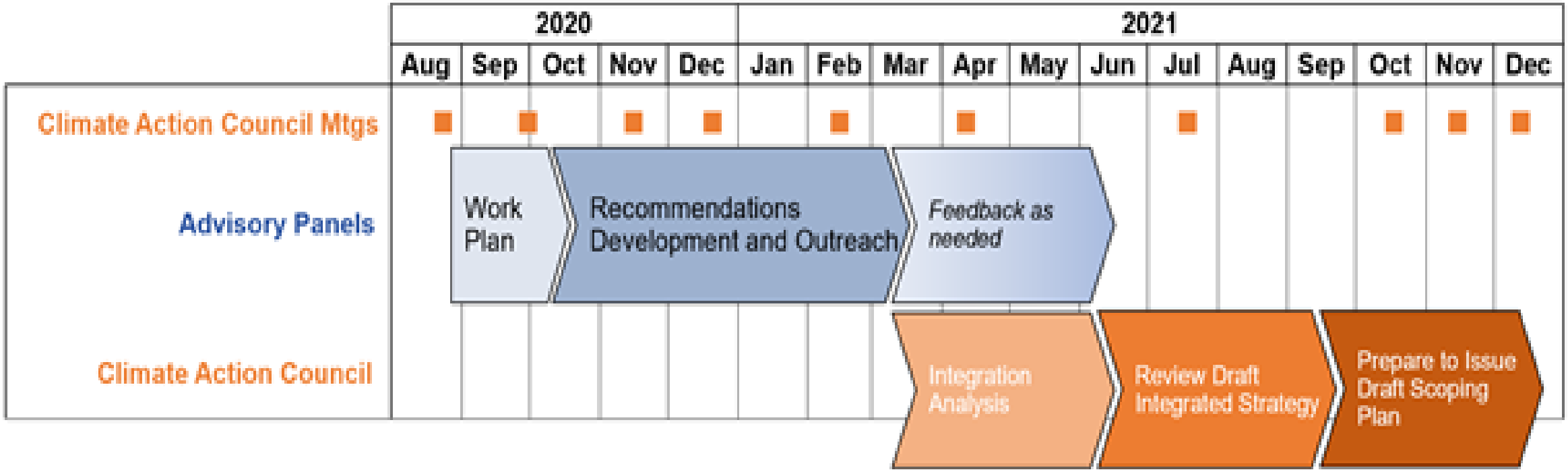
Define the policies to induce investments in efficiency and electrification at scale

- Applicable to new and existing homes, multi-family residential, commercial and institutional
- Consider impacts to property owners, building operators, tenants, affordability, and disadvantaged communities
- Identify measures to make heat pumps and energy efficiency projects cheaper and cost competitive with fossil fuels
- Identify workforce impacts
- Estimate the number of buildings impacted by building type and the associated emissions reduction, public health benefits, economic benefits, and implementation costs
- Describe the implementation strategy, with attention to feasibility and commercial availability
- Possible cross panel collaboration opportunities: Power Generation, Land Use and Local Government, Just Transition Working Group

Scope Development - Policy White Board

Work Plan

Timeline Overview



Work Plan Milestones through 2020

- Major milestones
  - **October** – Brief Climate Action Council (CAC) on scope, work plan, and criteria for evaluating recommendations; seek external input on potential strategies/policies.
  - **November** – Define high potential strategies/policies and present to CAC; collaborate with outside experts; refine recommendations and assess against criteria; assess benefits and impact on disadvantaged communities.
  - **December** – First draft of recommendations delivered to CAC and Climate Justice Working Group
- Anticipated meetings
  - Advisory Panel convenes monthly, at minimum
  - Advisory Panel briefs CAC monthly
  - Consult Climate Justice Working Group and Environmental Justice Working Group
  - Collaborate with other Advisory Panels, as needed

Next Steps: For Discussion

- Schedule next meeting and establish regular cadence for full Panel meetings
  - 2nd Panel meeting anticipated in late September, followed by ~ monthly meetings
- Develop workplan by early October
  - Draft will be circulated by September 23
- Identify Panel members with specific interest and expertise on defined work plan components, and plan for sub-group discussions as appropriate.
- Other input as we plan for the work

Appendix

Full Energy Efficiency and Housing Panel Presentation – E3

Energy+Environmental Economics

New York State Decarbonization Pathways Analysis

Energy Efficiency and Housing Panel Discussion

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Analysis Overview

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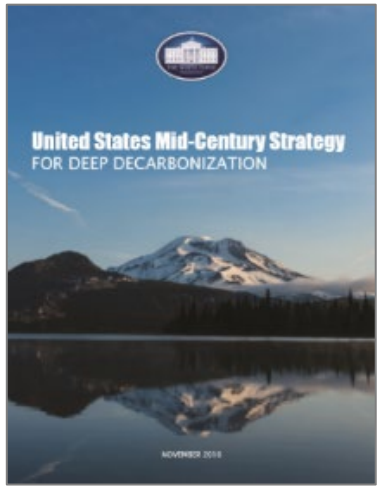

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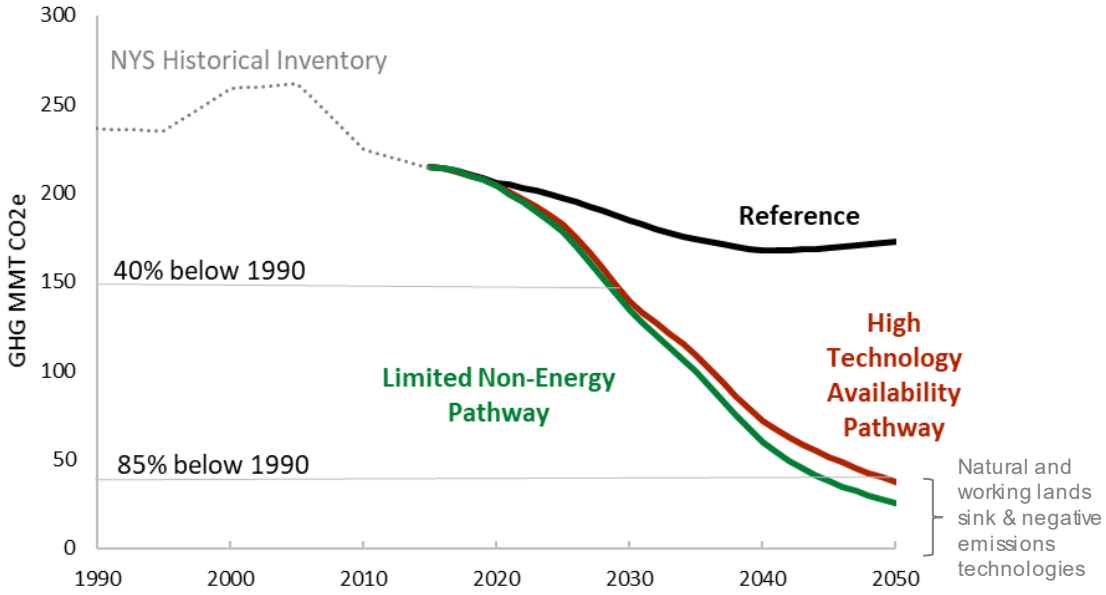
- **Reference Case** includes **pre-**CLCPA adopted policies & goals, including 50x30 Clean Energy Standard, 2025 and 2030 energy efficiency targets, zero-emission vehicle mandate
- Range of **pathways** designed to achieve CLCPA GHG targets that include CLCPA electric sector provisions (e.g., 70x30, 100x40, offshore wind & solar)
- **Two "Starting Point" Pathways:**



  - **High Technology Availability Pathway:** Emphasizes efficiency and electrification at "natural" end-of-life asset replacement schedule, while also utilizing advanced biofuels, carbon capture and storage (CCS), bioenergy with carbon capture and storage (BECCS), and a high natural and working lands (NWL) sink
  - **Limited Non-Energy Pathway:** Accelerates electrification with more rapid ramp-up of new sales, along with early retirements of older fossil vehicles and building equipment. Additional fossil fuel displacement by advanced biofuels. Greater energy sector emission reductions in case of more limited non-energy reductions and NWL sink contribution

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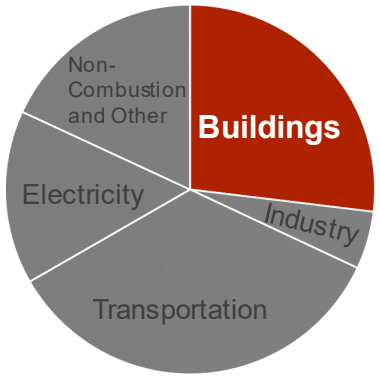
Characterization of the Buildings Sector

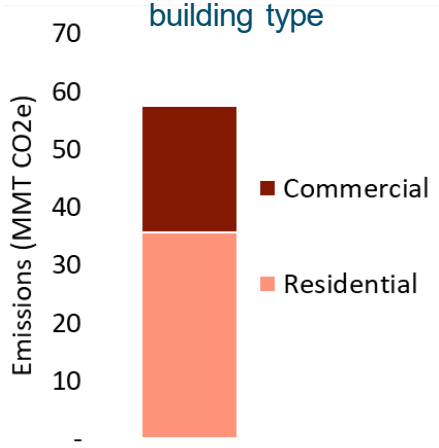
Residential and Commercial Building Emissions

+ **Buildings emissions have decreased over 25% relative to 1990 levels**
  - CLCPA directs New York State to adopt a 20-year global warming potential and incorporate upstream emissions associated with fossil fuels into its GHG emissions accounting framework. Work to develop this emissions accounting framework is underway. Under this new emissions accounting framework, fossil fuel use, as well as all sources of short-lived climate pollutants, which include methane and HFCs, will carry a higher GHG impact on a tons of carbon dioxide equivalent basis than in the current accounting framework used in this analysis
+ **GHG emissions in residential and commercial buildings are dominated by space heating and water heating, with other uses including appliances, cooking, and other (e.g., fireplaces, lawnmowers, secondary heating)**
  - Upstate region in particular has larger homes with greater space heat demand than downstate region
  - Although there is a significant amount of home heating oil used in current day, majority of energy-related emissions are from natural gas use
+ **Emissions associated with electricity consumption is currently tracked in the electricity generation sector**

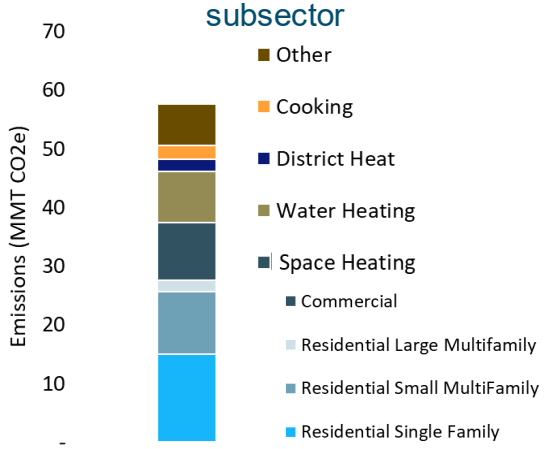
Economy-wide emissions in 2016



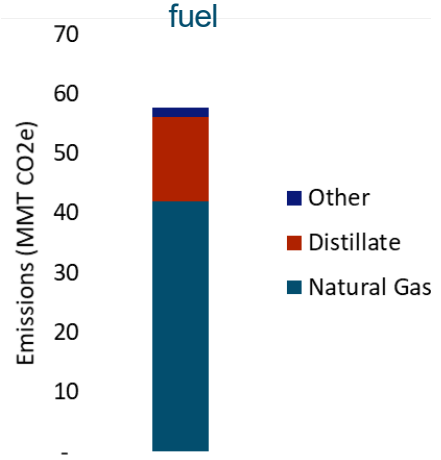
Buildings emissions by building type



Buildings emissions by subsector



Buildings emissions by fuel



Notes: HFCs (also called ODS substitutes) are categorized in Industrial Processes in the current NY GHG Inventory

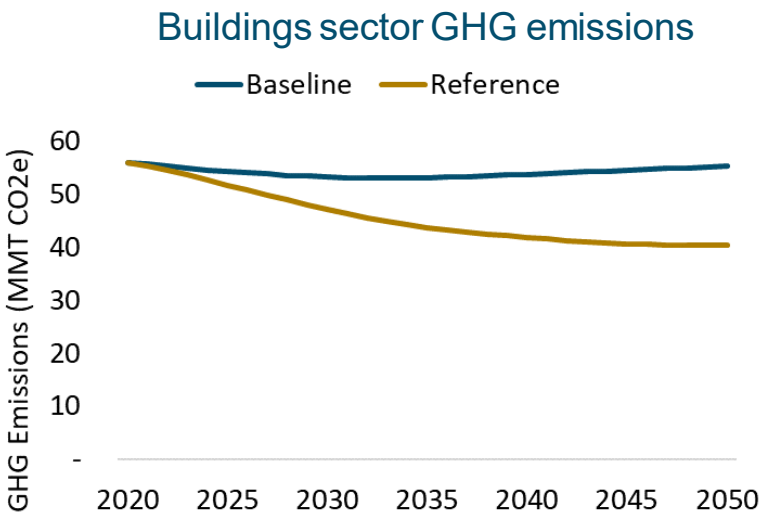
Key Drivers

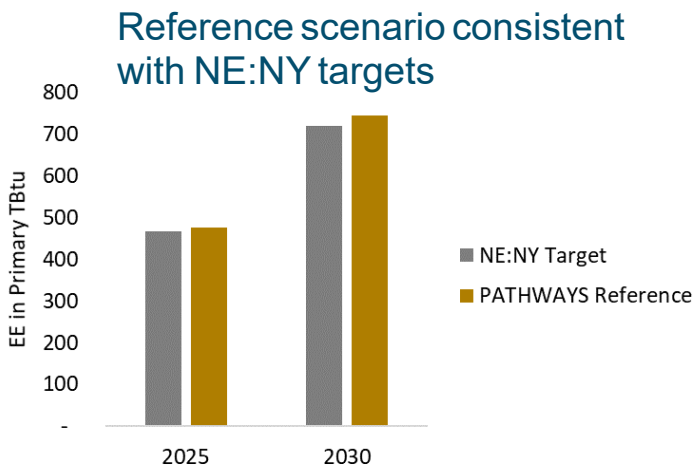
- **Population, household, and commercial growth rates drive energy demand and GHG emissions**
  - Population growth rate is projected to be .19% per year[1]
  - Commercial growth rate is projected to be .44% per year[2]
- **Appliance efficiency improvements, behavioral conservation, and codes and standards, including:**
  - Level of ambition of federal and state appliance codes and standards
  - Stringency of new building codes and rate of existing building retrofits
  - Consumer adoption of high efficiency appliances or smart devices
- **Use of high-GWP refrigerant gases in air conditioning and heat pump technologies[3]**

[1] Source: Cornell population study
[2] Calculated using historical relationship between square footage and population growth for Mid-Atlantic region from EIA NEMS
[3] Hydrofluorocarbons (HFC) are ODS substitutes, which are non-combustion emissions that are tracked as part of the Industrial Process and Product Use source category

Buildings Sector Emissions Over Time

- **Baseline scenario represents a business as usual future, with federal appliance efficiency standards, energy efficiency, and oil to gas switching consistent with Annual Energy Outlook**
- **Reference scenario includes significant incremental decarbonization measures, consistent with achieving New Efficiency New York 2025/2030 targets and NYC LL97 downstate building emissions intensities through 2030**
  - Significant building shell weatherization measures
  - Energy efficiency and behavioral conservation measures
  - Small amounts of heat pump space heater sales
- **Emissions associated with electricity consumption is currently tracked in the electricity generation sector**





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Opportunities for Decarbonization

Pillars of Deep Decarbonization in Buildings

Energy Efficiency and Conservation

- Device Efficiency
  - Federal and state appliance codes and standards
  - Appliance efficiency improvements (EnergySTAR+)
- Reductions in energy service demand
  - Efficient building shell and weatherization measures
  - Behavioral conservation and smart devices (e.g. smart thermostats)

Switching to Low Carbon Fuels

- Electrification
  - Cold climate heat pump space heaters (e.g. ASHPs, GSHPs, HPs with fuel backup)
  - Heat pump water heaters
- Bioenergy
  - Renewable natural gas
  - Renewable diesel
  - Pipeline hydrogen (up to blend limit)

Decarbonizing Electricity Supply

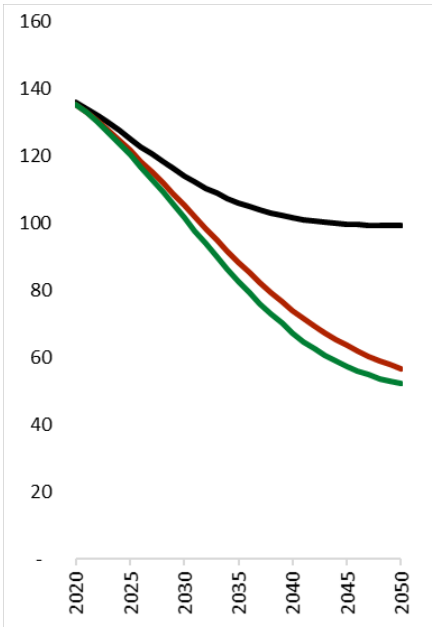
- Reducing indirect emissions associated with electrification
- Flexible building load operations to improve operations of the grid

Pillars of Carbon Neutrality

Energy Efficiency and Conservation

[site energy consumed per person]

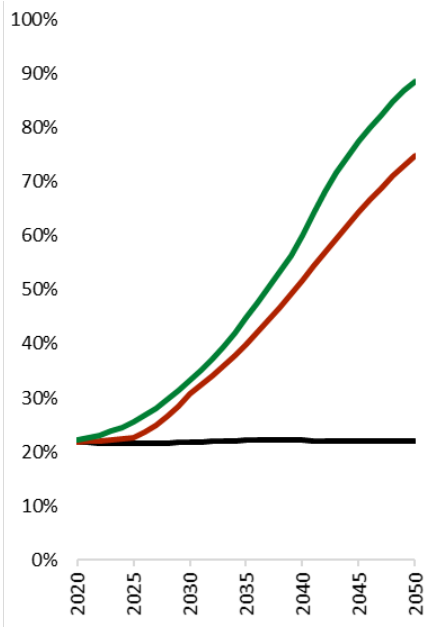
Unit: MMBTU/capita



Switching to Low Carbon Fuels

[% site energy consumed as electricity, biofuels, hydrogen, synthetic fuels]

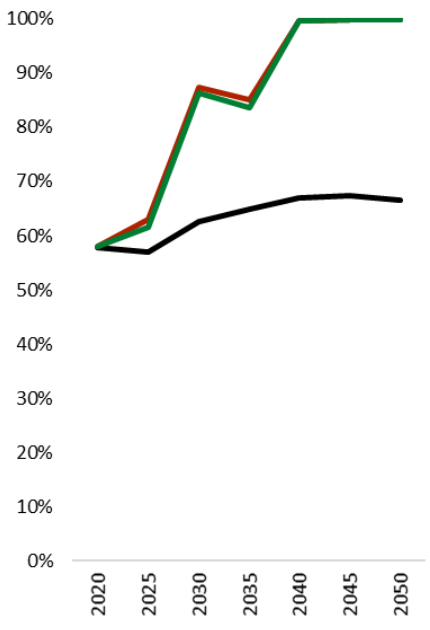
Unit: % site energy consumed



Decarbonizing Electricity Supply

[% electricity supplied by wind, solar, hydro, nuclear, CCS, biofuels, hydrogen]

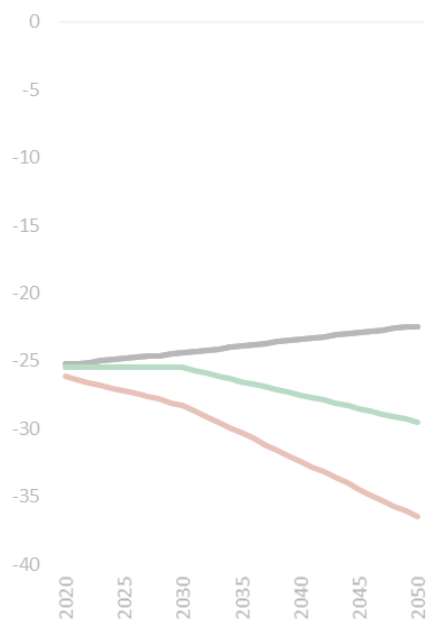
Unit: % electricity supplied



Negative Emissions

[total emission reductions from net land use sink, BECCS, DAC]

Unit: MMT CO2e



Reference Case High Technology Availability Pathway Limited Non-Energy Pathway

Opportunities to Decarbonize the Buildings Sector

- **Key emitters today: 65% of direct emissions are from space heating**
- **Key decarbonization options include energy efficiency, electrification, and fuel substitution:**
  - Adoption of efficient appliances (e.g. through appliance standards, direct incentives, etc.)
  - Efficient building shell and building weatherization to reduce space heating demands (for new construction and deep home retrofits)
  - Electrifying space and water heating (large-scale adoption of cold-climate heat pumps)
  - Blend renewable natural gas or hydrogen (up to ~7% by energy) into pipelines
  - Climate-friendly refrigerants
- **Key challenges:**
  - Back up heating, either with hybrid systems such as natural gas/propane or with electric resistance backup, will be needed to complement air source heat pumps at very low temperatures
  - Flexible space heating (e.g., pre-heating or pre-cooling) can avoid stressing the electricity system during peak cold snaps and can help lower costs for electricity generation, transmission, and distribution

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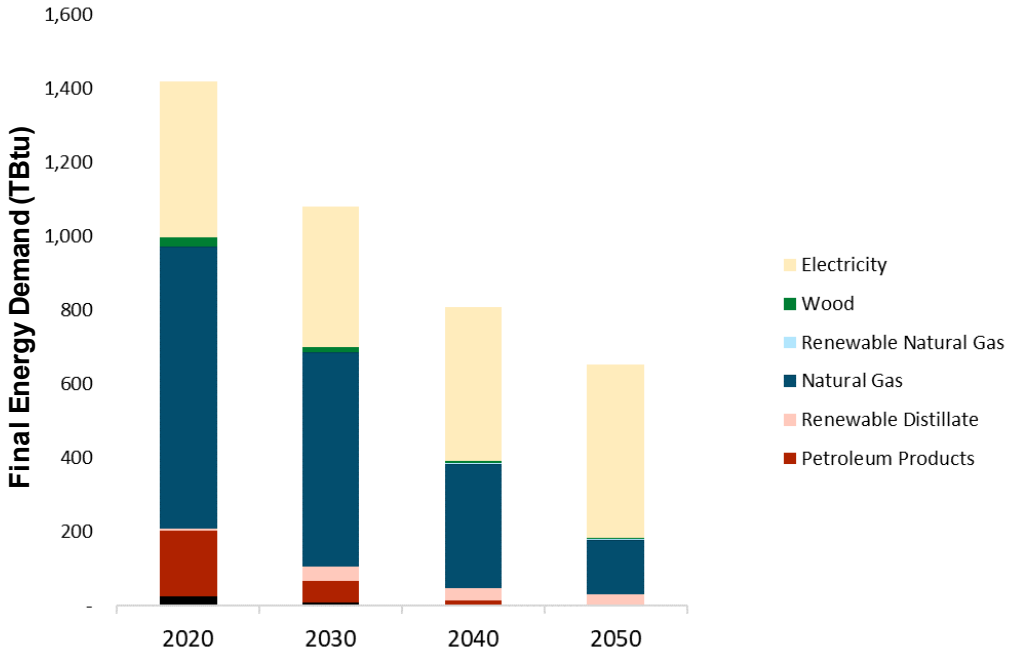
Sectoral Findings

Buildings

- Efficiency across all end-uses and building shell scales dramatically
- Major shift to end-use electrification, particularly in space and water heating
  - 50%-70% new heating system sales by 2030 with increasing rates of adoption thereafter
  - End-use electrification drives trend toward a winter peaking system
  - Magnitude of winter peak varies by study, but investment in ground-source heat pumps or onsite combustion backup systems using fossil fuel, bioenergy, or synthesized fuel, such as hydrogen, may mitigate excessive peak electricity demand
- Flexibility of end-use electric loads helps to maintain system-wide reliability
- Shift to low-GWP refrigerants crucial to ensure maximum GHG emissions benefits from heat pump adoption
  - Further analysis needed to explore full range of mitigation options, timing, and potential barriers
- Electricity consumption in buildings is shown here, but emissions associated with electricity consumption is currently tracked in the electricity generation sector

High Technology Availability Pathway

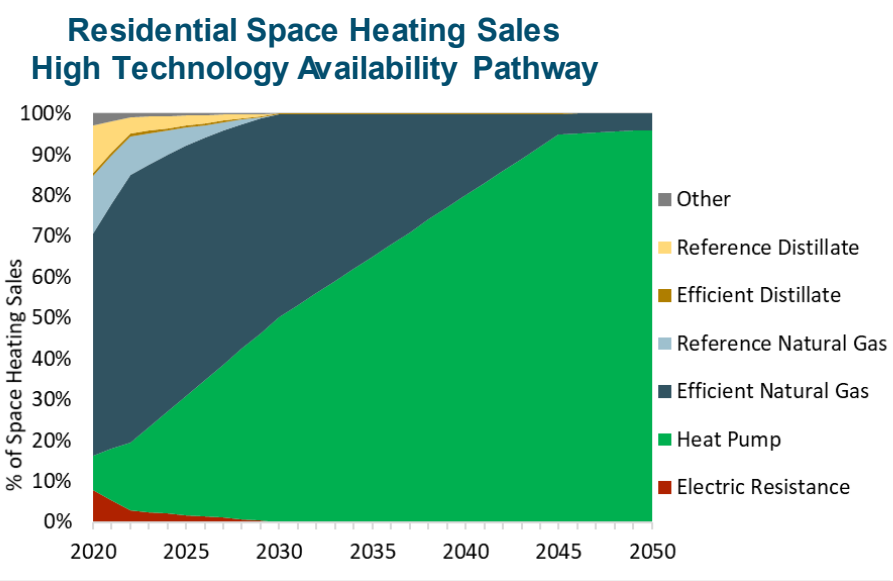


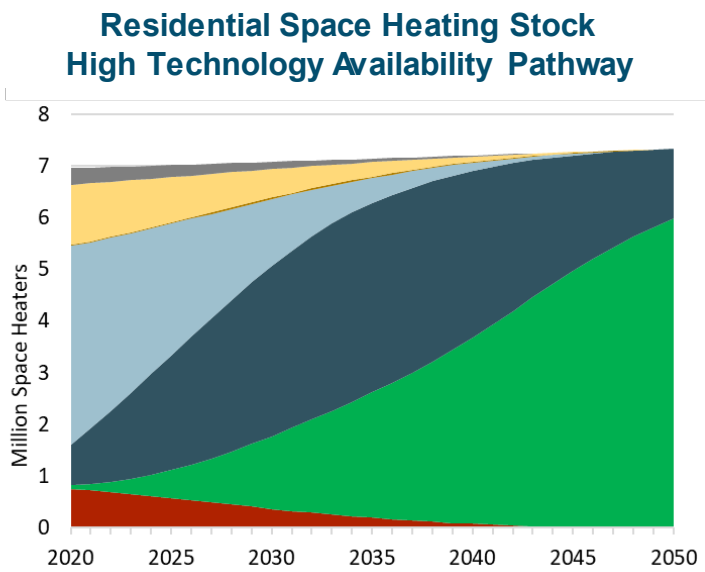
Metric	2030**	2050**
Percent GHG emissions reduction*	31%-39%	85%-93%
Percent reduction in final energy demand*	26%-31%	55%-59%

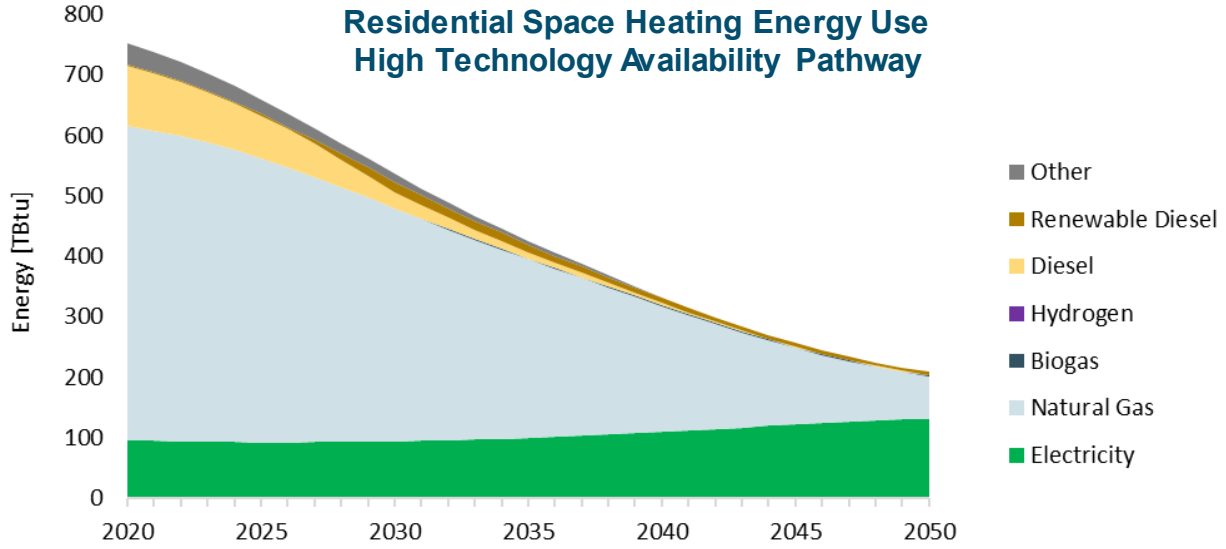
** Relative to 2016*

*** Range of values includes limited non-energy pathway*

Timing of Building Electrification

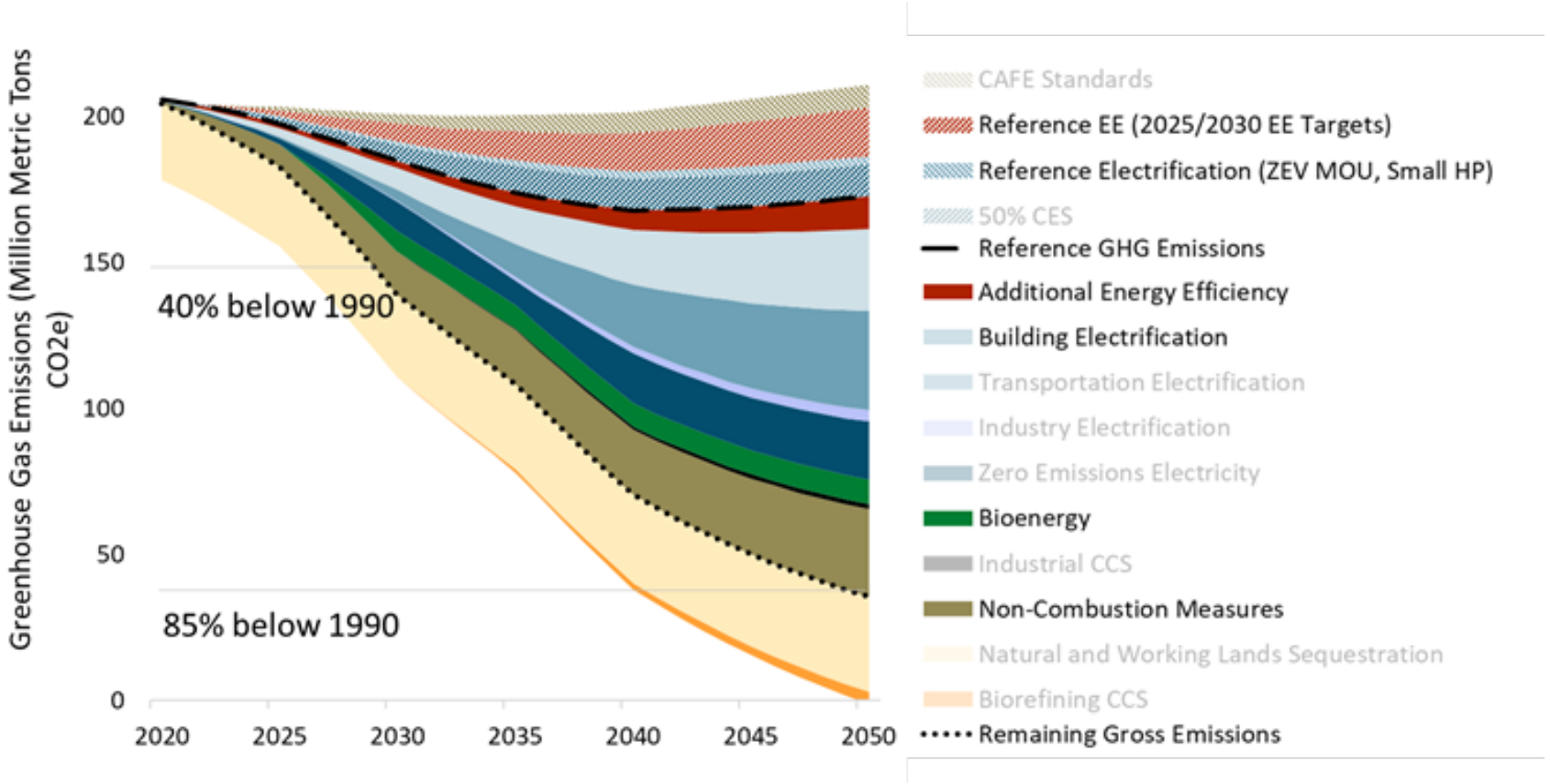






Emissions Reductions by Measure

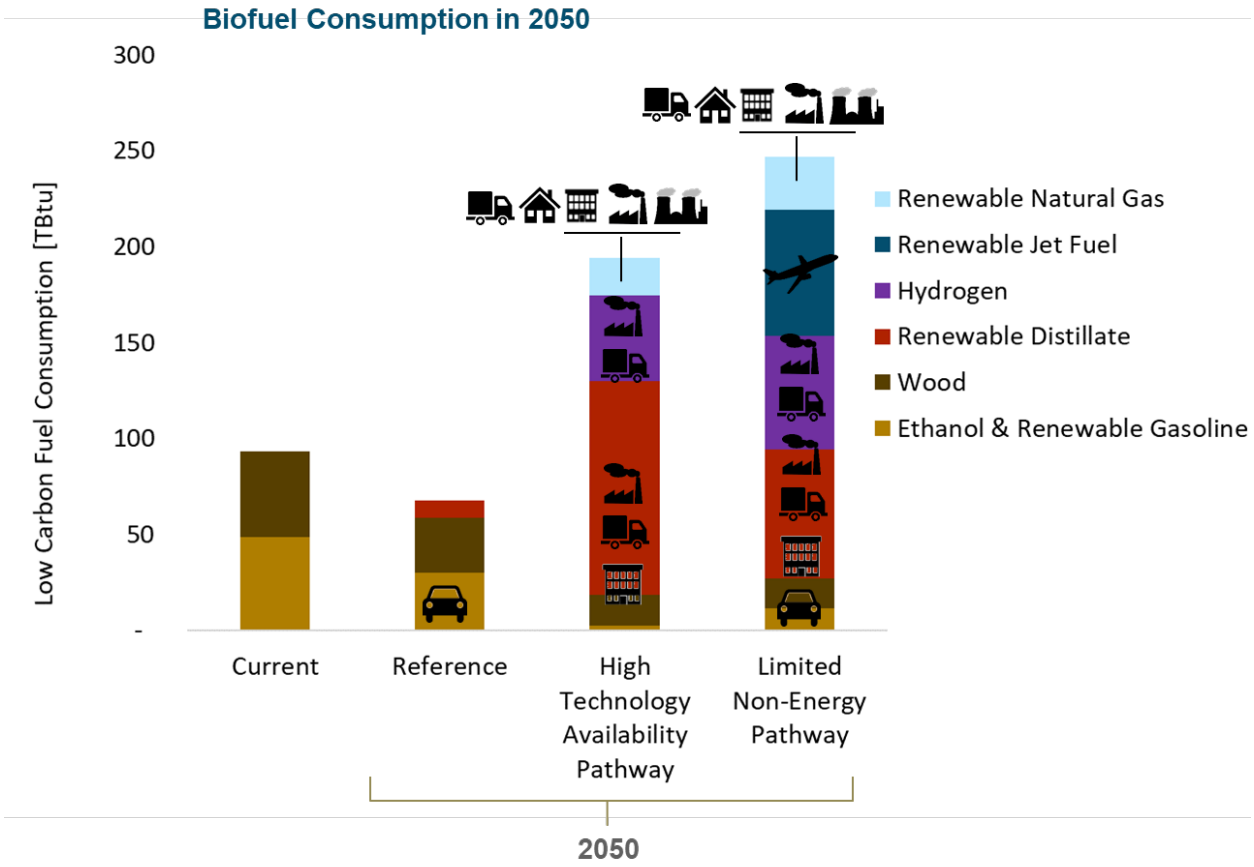
High Technology Availability Pathway



+ **Building efficiency and electrification measures make up significant portion of reductions to reach CLCPA goals**

Low-Carbon Fuels

+ Advanced low-carbon liquid and gaseous fuels are key to decarbonizing sectors where electrification is challenging, such as pipeline renewable natural gas for cold weather space heat backup or renewable distillate use in buildings



+ "Starting Point" pathways can achieve deep decarbonization using in-state feedstocks for advanced biofuels

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Next Steps

Next Steps

- ***Adding CLCPA GHG accounting viewpoint***
  - *Upstream emissions from imported fuels*
  - *20-year Global Warming Potential*
- ***Review of performance and cost assumptions***
- ***Incorporation of Panel input into integrated, economy-wide pathways analysis***

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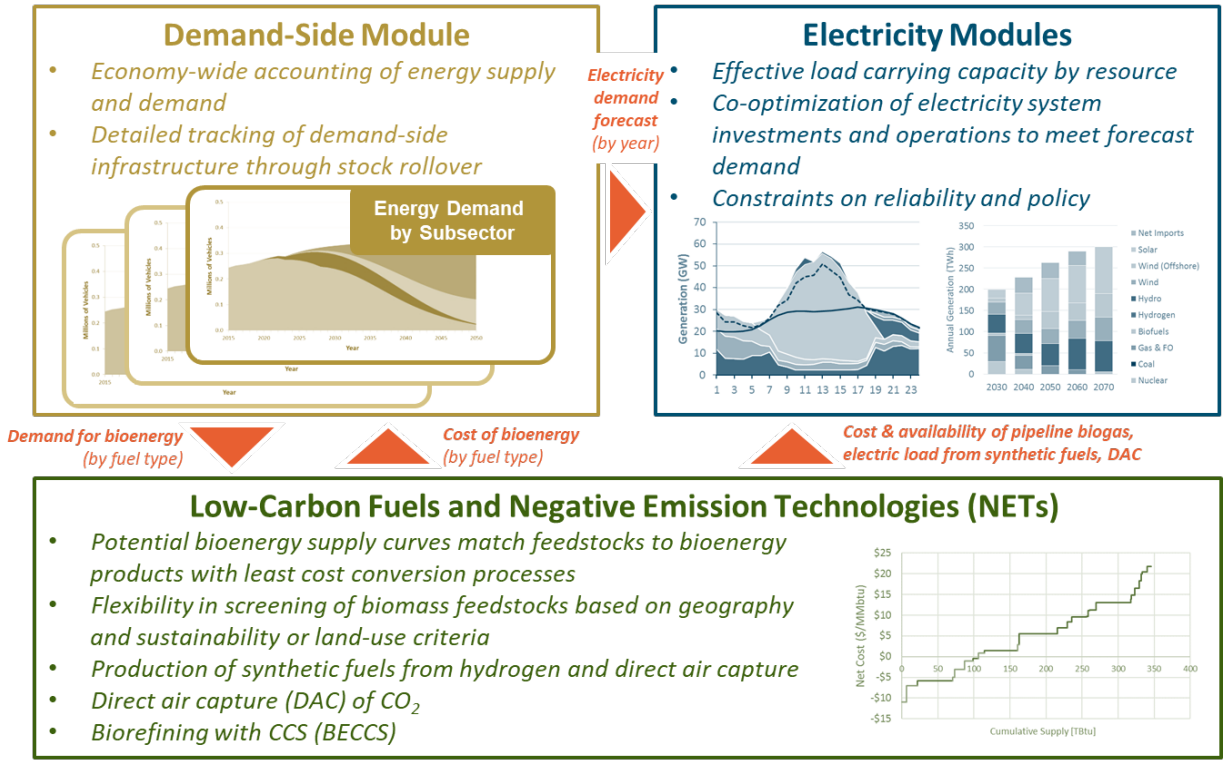
Questions?

Appendix

Model Framework

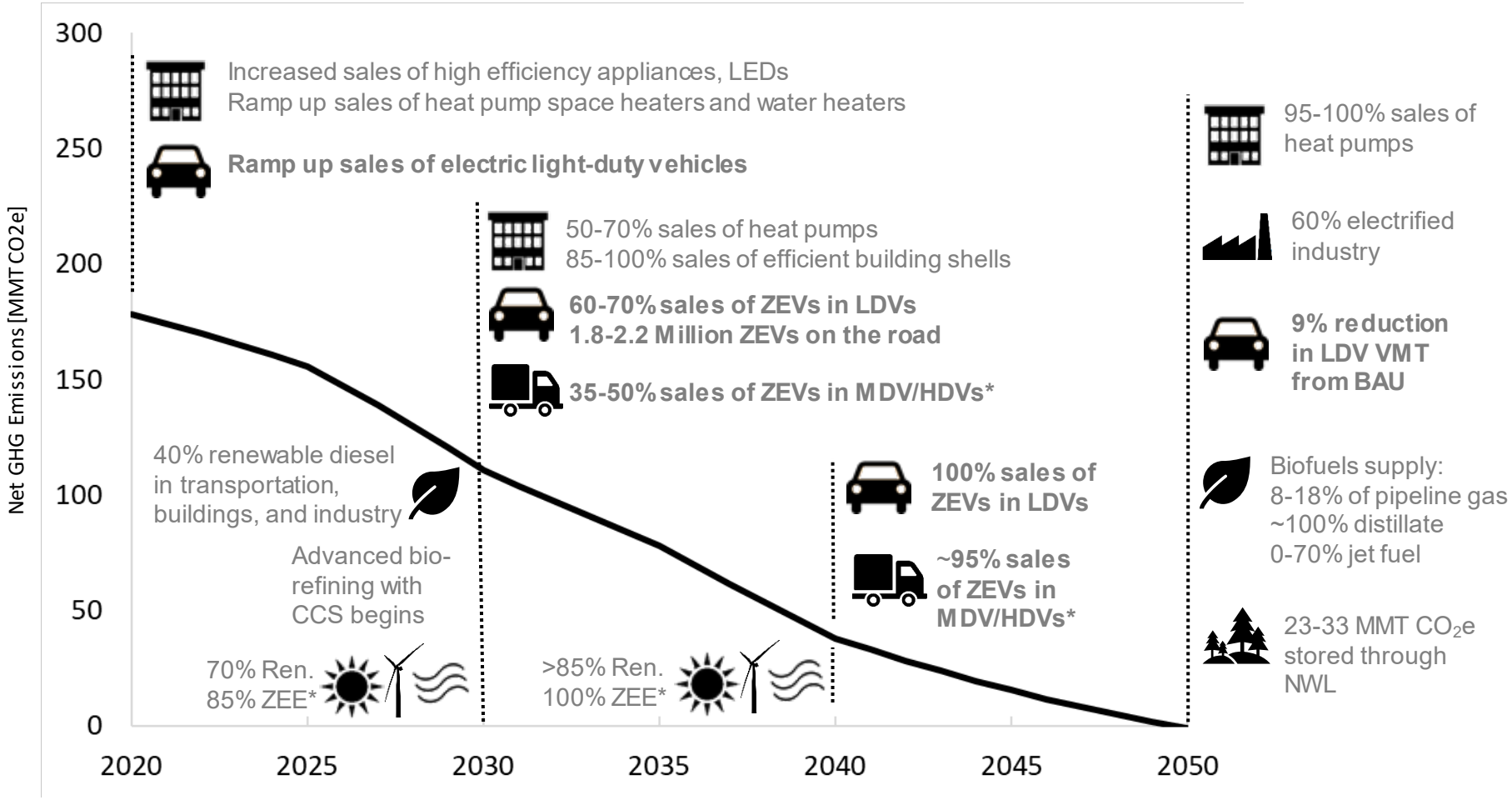
- Pathways analysis uses bottom-up, user-defined scenarios to test "what if" questions—or "**backcasting**"—to compare long-term decarbonization options and allows for development of realistic & concrete GHG reduction roadmaps.
- Bottom-up **stock rollover** modeling approach (based on EIA Nat'l Energy Modeling System and NYS-specific inputs) validated with top-down benchmarking (NYS actuals and forecasts)



- Model framework incorporates **interactions** between demand- and supply-side variables, with constraints and assumptions informed by existing analyses of resource availability, technology performance, and cost

Key Takeaways

+ **Achievement of emissions reductions to meet state law requires action in all sectors**
+ **A 30-year transition demands that action begin now**

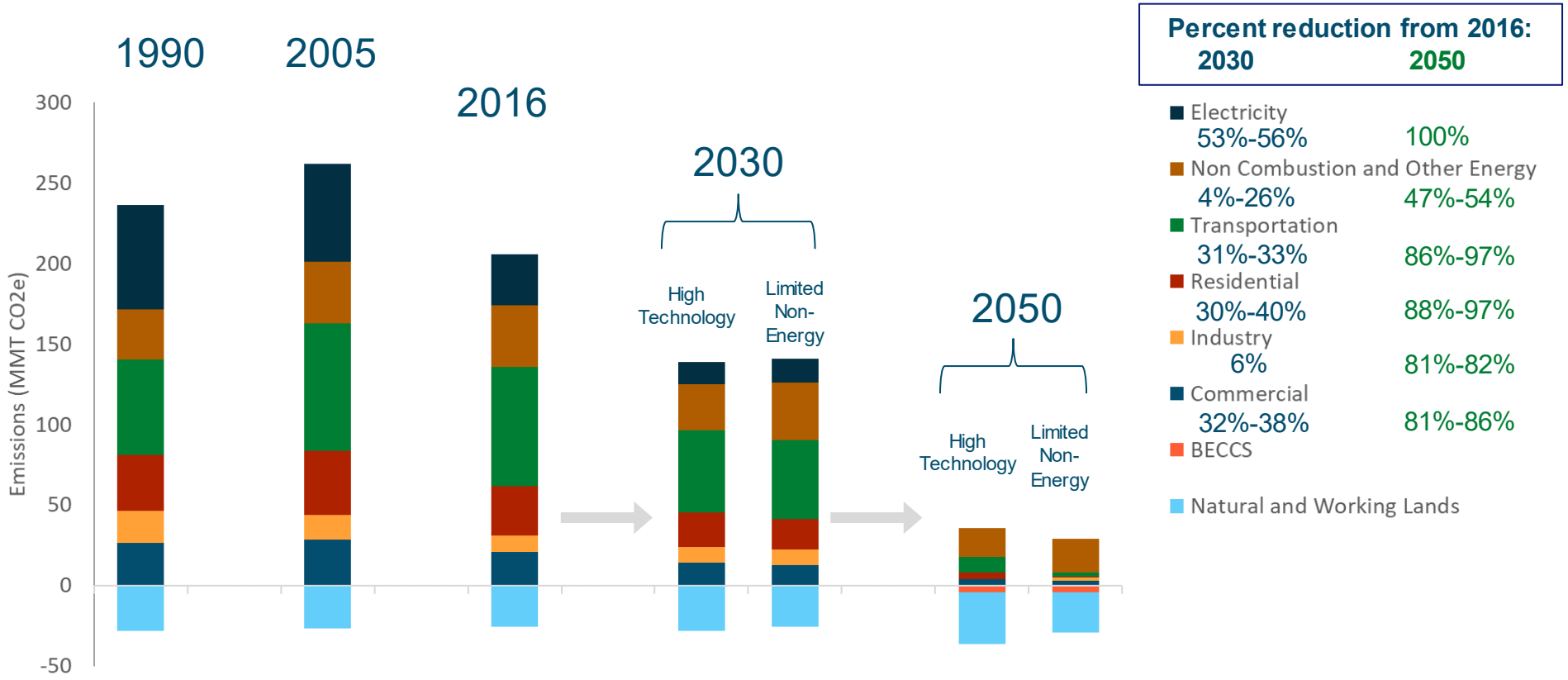


*Zero-Emissions Electricity (ZEE) includes wind, solar, large hydro, nuclear, CCS, and bioenergy; MDV includes buses

Greenhouse Gas Emissions

New York Net Greenhouse Gas Emissions for Selected Years by Scenario

Note: CO2e calculations do not fully reflect methodology required by CLCPA



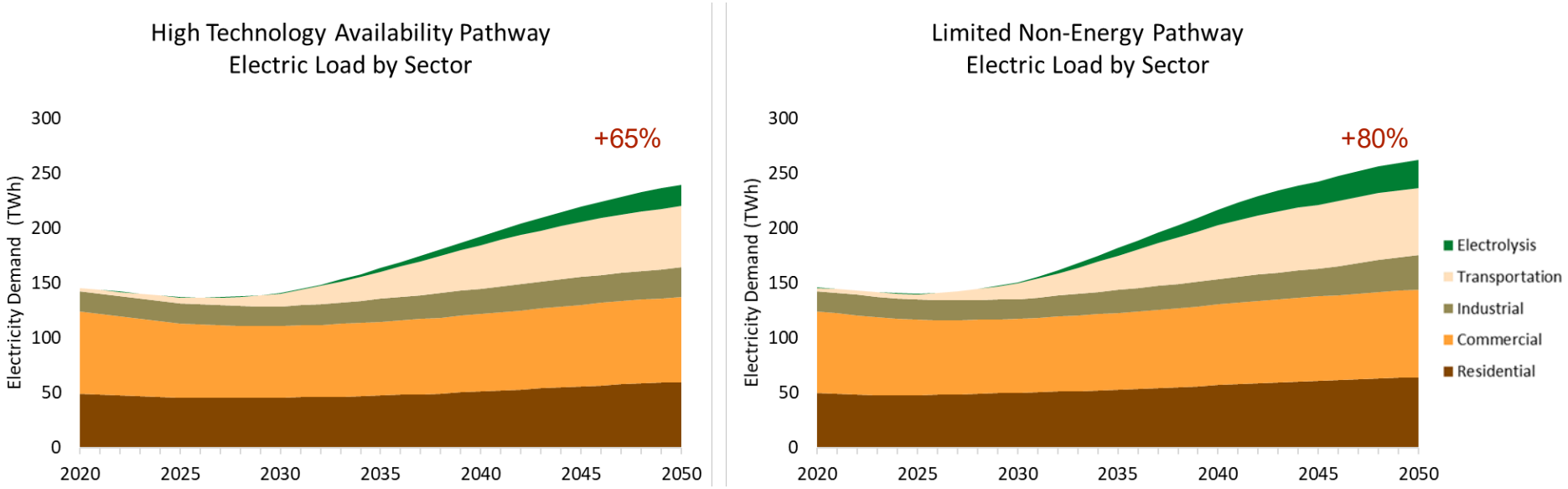
Key Assumptions

Sector	Strategy	Expressed as	Reference	High Technology Availability	Limited Non-Energy
Buildings	Building Shell Efficiency	Efficient shell sales share	75% by 2030	85% by 2030, 100% by 2045	*Same as HTA*
	Building Electrification	Electric heat pump sales share	6% by 2025	50% by 2030, 95% by 2050,	70% by 2030, 100% by 2045*
	Appliance Efficiency (non-HVAC)	Efficient appliance sales share	100% by 2025	90% by 2023, 100% by 2025	*Same as HTA*

* Annually retire up to 5% of existing stock early, beginning in 2040 and continuing through 2050 as needed

Annual Electricity Demand

- Further decarbonization of the power sector only gets us a fraction of the way toward the economy-wide goal
- However, end-use electrification to eliminate GHG emissions drives increase in electric load
  - Analysis within range found in the literature, which project annual load increases ranging 20%-100% by midcentury
  - Range primarily reflects extent and timing of end-use electrification, with some studies assuming lower electrification and larger role for renewable gas and/or renewable transportation fuels



Flexible Building Loads

- **We assume that by 2050, 40% of space heating load is able to shift within a 3-hour window**
  - Building load flexibility is based on electric system conditions
  - This charging flexibility can reduce electric system costs by reducing peak load impacts
- **Another source of peak mitigation is relying on other sources of heat demand during peak hours**
  - Fuel backup
  - Thermal storage
  - Home battery storage

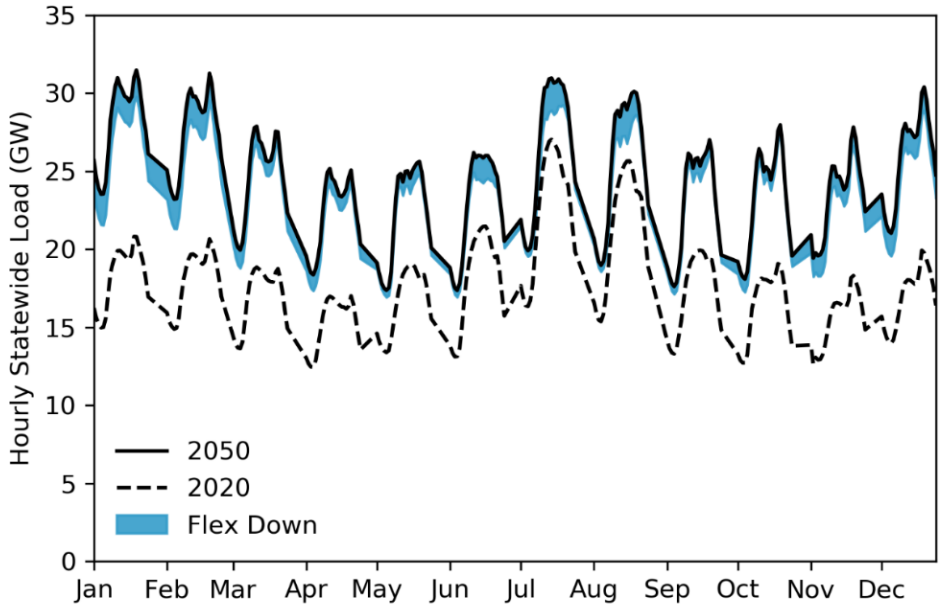
Sector	End use category	2030 - downstate (% flexible)	2030 – upstate (% flexible)	2050 - downstate (% flexible)	2050 – upstate (% flexible)	Hours Shiftable Daily
Residential	Space Cooling	10%	10%	60%	60%	3
	Space Heating	10%	10%	40%	40%	3
	Water Heating	10%	10%	40%	40%	3
	Refrigerators	20%	20%	60%	60%	2
Commercial	Space Cooling	20%	20%	60%	60%	3
	Space Heating	10%	10%	60%	40%	3
	Water Heating	10%	10%	60%	40%	3
	Refrigeration	20%	20%	60%	60%	2
Transportation	LDV EVs	25%	25%	50%	50%	12*
Other	Industry	0%	0%	0%	0%	0
	Electrolysis	100%	100%	100%	100%	12*
	Direct Air Capture	100%	100%	100%	100%	12*

Note:

*This is a simplification for vehicle charging, electrolysis, and direct air capture. More details on the flexibility parameters and constraints of transportation, electrolysis, and direct air capture are provided in sections 7.6.3 and 7.6.4.

Peak Electricity Demand

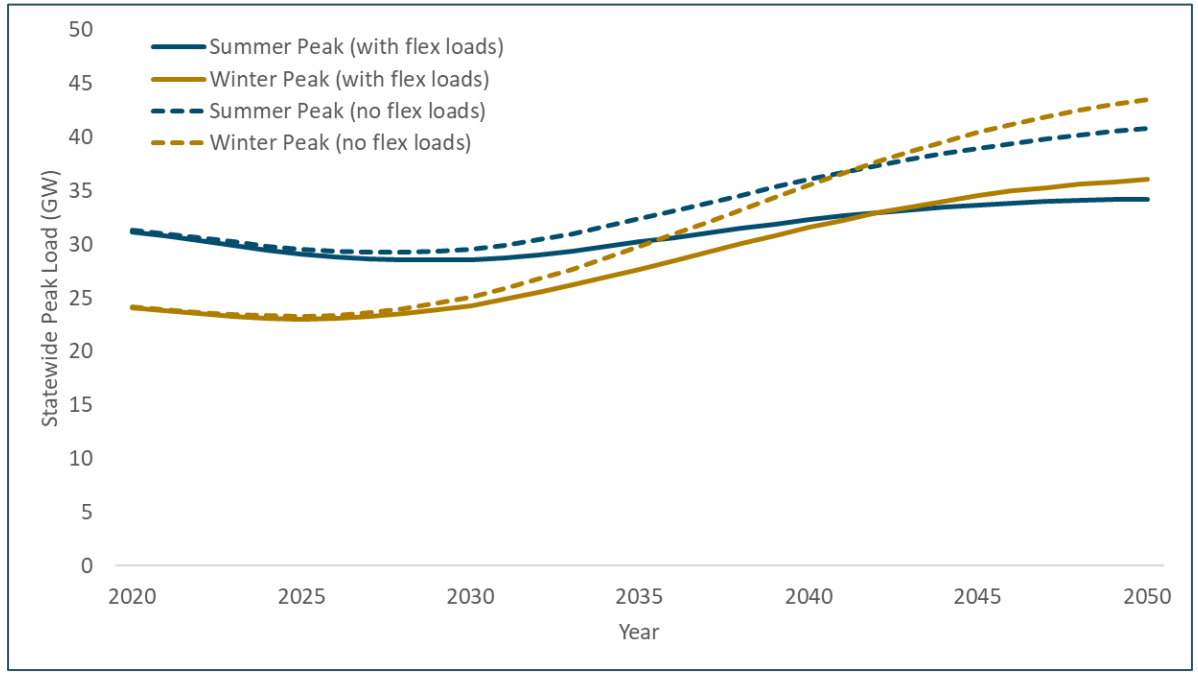
- NYS shifts from summer peak to winter peak around 2040, driven primarily by electrification of heating in buildings and EV battery use
- Flexibility in electric vehicles and building loads can significantly reduce peak demands and the need for new generation capacity
- Flexible loads can also serve a similar role to battery storage, shifting demand to times of high renewables output



Note: the chart above contains a 24-hour set of hourly loads for each month, representing an approximate monthly average hourly load; as a result, the chart above will not capture seasonal peaks. The "flex down" area represents the portion of load that can be reduced in that hour and shifted to other times of day.

Peak Electricity Demand

- NYS shifts from summer peak to winter peak around 2040, driven primarily by electrification of heating in buildings and EV battery use
- Flexibility in electric vehicles and building loads can significantly reduce peak demands and the need for new generation capacity



Non-Combustion Sources

- Non-combustion emissions are projected to increase over time. To bend the curve, significant reductions are needed across non-combustion emissions sources, which include landfills, farms, industrial facilities, and natural gas infrastructure.
- Mitigation of short-lived climate pollutants is key, with a focus on methane mitigation and climate-friendly refrigerants (ODS Substitutes). Further analysis needed to identify full range of mitigation options and strategies in these areas.