New York State Climate Action Council

October 1, 2021

Meeting 15

NEW YORK STATE OF OPPORTUNITY. | Climate Action Council

Meeting Procedures

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

> CAC Members should be on mute if not speaking.

> If using phone for audio, please tap the phone mute button.

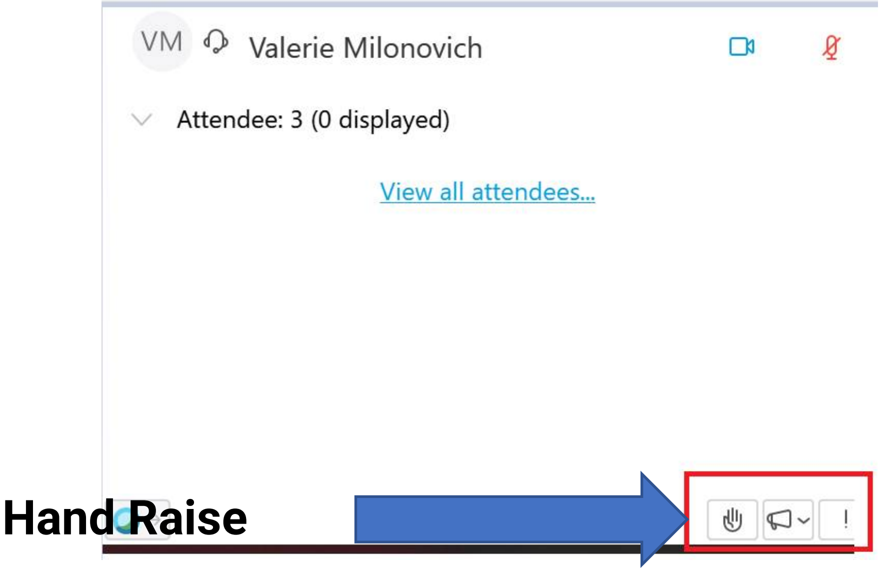
> If using computer for audio, please click the mute button on the computer screen (1st visual).

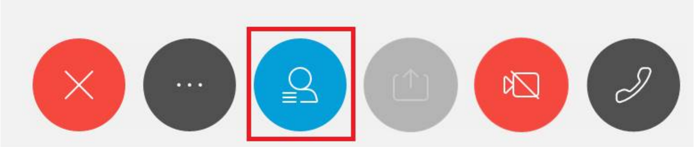
> Video is encouraged for CAC members, in particular when speaking.

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

> If technical problems arise, please contact NYS.CAC@cadmusgroup.com.

You'll see when your microphone is muted





Agenda

- Welcome and Roll Call
- Consideration of September 13, 2021 Minutes
- Co-Chair Remarks and Reflections
- Presentation and Discussion: Climate Justice Working Group
    - Waste and Energy-Intensive & Trade-Exposed Industries Advisory Panels and Just Transition Working Group Recommendations Feedback
- Presentation and Discussion: Updated Climate Assessment
- Presentation and Discussion: Integration Analysis Initial Scenario Results
- Next Steps

Consideration of September 13, 2021 Minutes

Co-chair Remarks and Reflections

Climate Week Announcements

> New Resilient NY Agenda
  - Major investments in water infrastructure for resiliency and flood protection
  - $4 billion Clean Water, Clean Air and Green Jobs Environmental Bond Act

> Community Air Monitoring Program
  - Hyperlocal Air Quality Assessments in Communities Historically Overburdened by Pollution
  - Informs Strategies to Reduce Air Pollution and Climate-Altering Greenhouse Gases in disadvantaged communities
  - Community Air Monitoring Capacity Building Grants to Environmental Justice Organizations

> Governor Hochul Announces 11 New Certified Climate Smart Communities

Climate Week Announcements (cont’d)

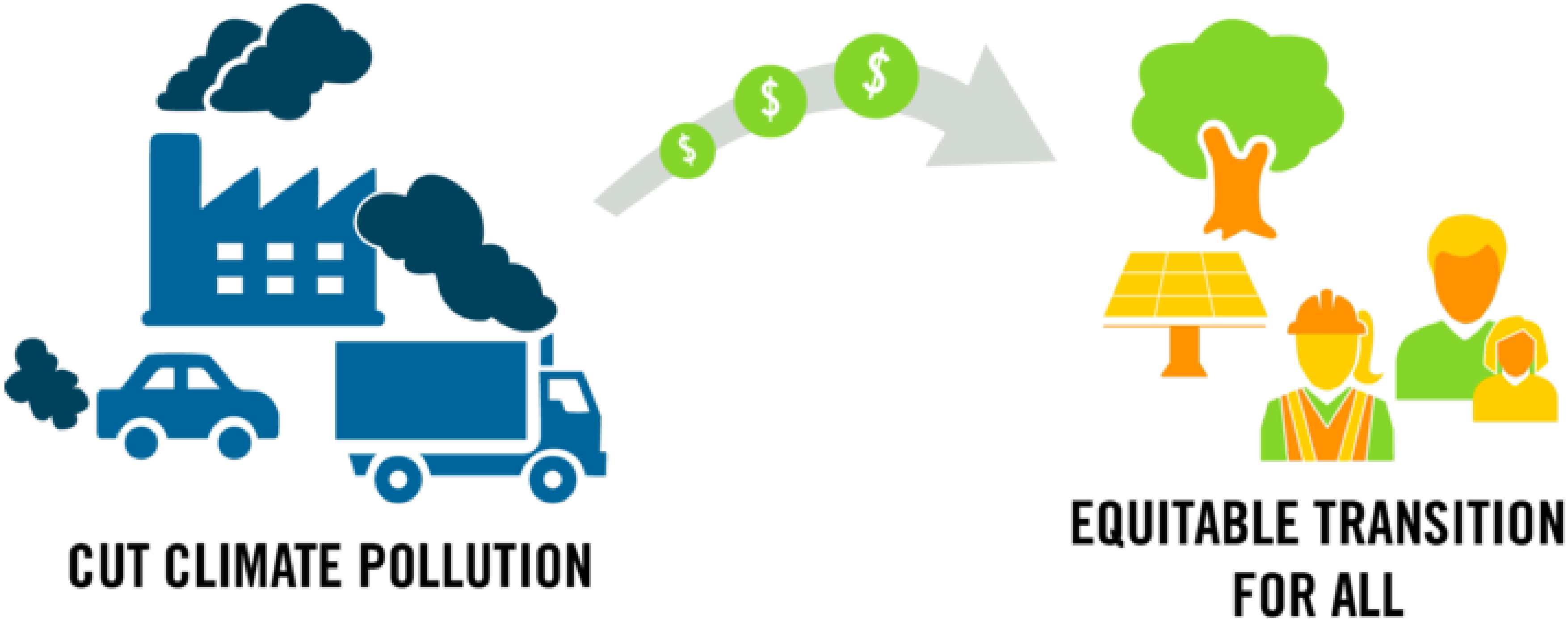
- **Distributed Solar (09/20/2021):** Governor Hochul Announces Expanded NY-Sun Program to Achieve at Least 10 Gigawatts of Solar Energy by 2030 | Expands Upon State's Successful Six Gigawatt by 2025 Distributed Solar NY-Sun Program Which Has Reached Every County in the State and is On Track to Achieve its Goal Earlier Than Anticipated, Supporting More Than 12,000 Solar Jobs to Date
- **Tier 4 Transmission (09/20/2021):** During Climate Week, Governor Hochul Announces Major Green Energy Infrastructure Projects to Power New York City With Wind, Solar and Hydropower From Upstate New York and Canada | New Transmission Lines Will Create Approximately 10,000 Family-Sustaining Jobs Statewide and Bring $8.2 Billion in Economic Development Investments, Including Developer-Committed Investments to Support Disadvantaged Communities
- **Clean Energy Hubs (09/23/2021):** Governor Hochul Announces $36 Million "Regional Clean Energy Hubs" Initiative To Help Provide Clean Energy Solutions And Opportunities At The Community Level Program Will Improve Community Engagement and Ensure Disadvantaged Communities Benefit from New York's Clean Energy Transition
- **Clean Green Schools (09/23/2021):** Governor Hochul Announces $59 Million "Clean Green Schools" Initiative To Improve Air Quality And Reduce Carbon Emissions In Pre-K-12 Schools Education Leaders to Convene in Fall to Discuss Clean Energy, Energy Efficiency and Healthy Solutions for More Than 500 Schools in Disadvantaged Communities

Climate Justice Working Group Feedback

Waste and Energy-Intensive & Trade-Exposed Industries Advisory Panels

Just Transition Working Group

CJWG perspectives on Just Transition, EITE, and Waste



October 1, 2021

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Just Transition

- Clarify definition of ‘low carbon energy’ manufacturing
  - Require a ‘best in class’ framework when public subsidies are allocated to manufacturers to encourage high road performers

- The Enabling Initiatives are generally strong and commendable
  - Add a Workforce Assessment Plan to ensure impacted workers can contribute to the process of protecting workers and include retirement planning, allowing aging fossil workers a dignified retirement

Just Transition

- Consider Community Benefits Agreements between manufacturers, union groups, and impacted communities
  - Make these legally binding

- Minimize disruptions in the transition of the existing workforce by including plans to reuse shuttered dirty power plants for clean energy and sustainable manufacturing

- Focus on eliminating implicit bias in searching/hiring for workers

EITE

We support the emphasis on:

- Green job creation for members of DACs
- Data collection and reporting requirements to paint an accurate picture of how industrial facilities impact DACs
- State procurement of low-carbon materials

***But**, we* suggest:

- Making climate and EJ the explicit objective, as opposed to business development
- Strongly emphasizing demand-side changes to reduce materials waste
- Prioritizing electrification for industrial heat whenever feasible
- Ensure the BIPOC are included in the process of creating workforce development programs, to ensure that their unique perspectives are represented

Justly reduce EITE industry footprints

- ➔ Carbon capture and storage is not a clean resource

- ➔ ‘Green H2’ can be a suitable alternative fuel in high heat industrial processes but DEC should be ready to use its power under Section 7 of the CLCPA to prohibit actions that add to pollution burdens in DACs, i.e. avoid harmful emission releases from combustion, such as NOx

- ➔ Offset projects should deliver meaningful local environmental benefits that negate the source impacts

Waste

- Industry flexed significant power over panel recommendations:
  - Ideas pertaining to rethinking and redesigning waste systems were omitted, like:
    - Barring incineration
    - Taxing overproduction of food
    - Mandating sustainable shipping/packaging and pet litter bags
    - Creating polluter funded union jobs for cleanup of waterways, oceans, sewage, soils, air
  - The overall lack of emphasis on waste reduction and local scale diversion practices was staggering

Waste

- DEC overemphasized incremental, underwhelming actions like creating landfill and biogas markets (despite their questionable air and climate benefits) and recycling as opposed to reducing/rethinking
- Industry influence perpetuated practices, like the lack of regulations on waste trucking and the overproduction of materials
- The process by which the panel recommendations were finalized lacked opaqueness
- As revealed by the integration analysis, greater ambition in reducing emissions from waste is necessary

Updated Climate Assessment

NYS Climate Impact Assessment

NEW YORK STATE CLIMATE IMPACT ASSESSMENT

Understanding and Preparing for Our Changing Climate

Climate Action Council
10/1/21

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IPCC 6th Assessment Report (AR6)

Working Group 1, The Physical Science Basis, released on 8/9/21

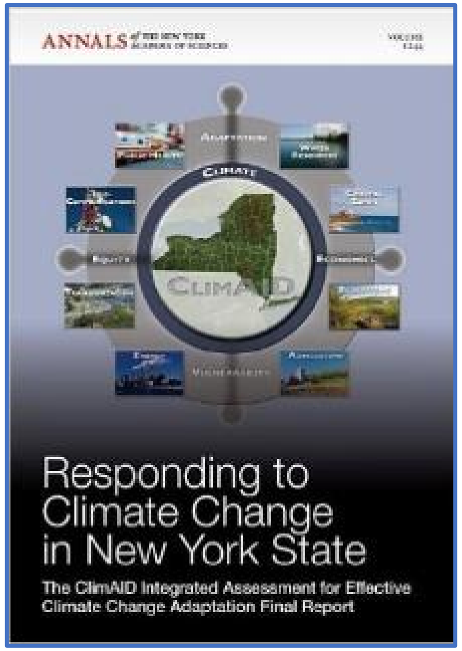
Key Findings:

- Human influence on the climate system is “unequivocal.”
- Extreme events are “unprecedented” and will continue.
- More CO_2 is emitted today than in any other period; 81-91% is from fossil fuels combustion.
- Methane growth also faster in past 6 years. In 2019, concentrations of methane were higher than anytime in the last 800,000 years, and have increased 156% since 1750.
- Potential for warming to exceed 1.5° by 2040 even in the low-emissions scenario.
- Warming increases linearly with emission levels. Emission levels must be reduced and stabilized at net zero CO2.

Link to Summary for Policymakers

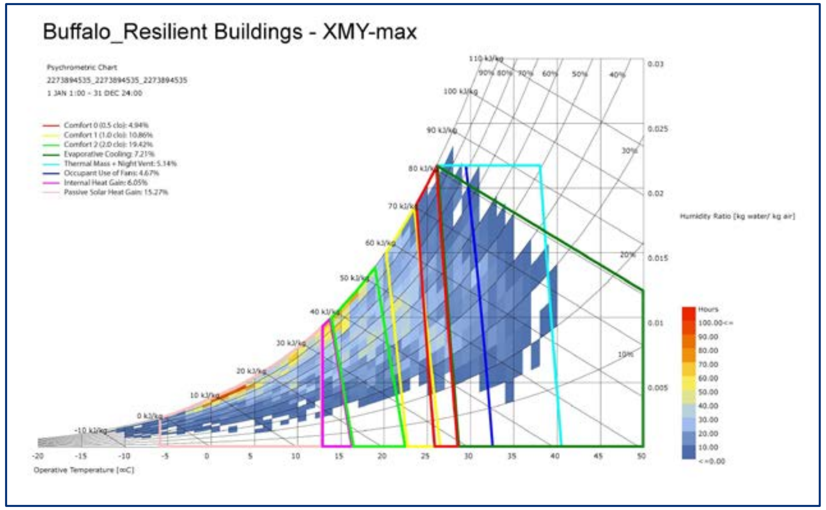
NYSERDA's Environmental Research Program

- Increase the understanding and awareness of the **environmental** and public **health** impacts of **energy** choices and emerging energy options
- Provide **scientific foundation** for creating effective and equitable energy-related environmental policies and resource management practices



Example Climate Research Projects

- Equitable cooling
- Building-energy modeling under climate change
- Climate impacts on renewable resources
- Climate migration modeling



Climate Assessment - Vision and Goals

What?

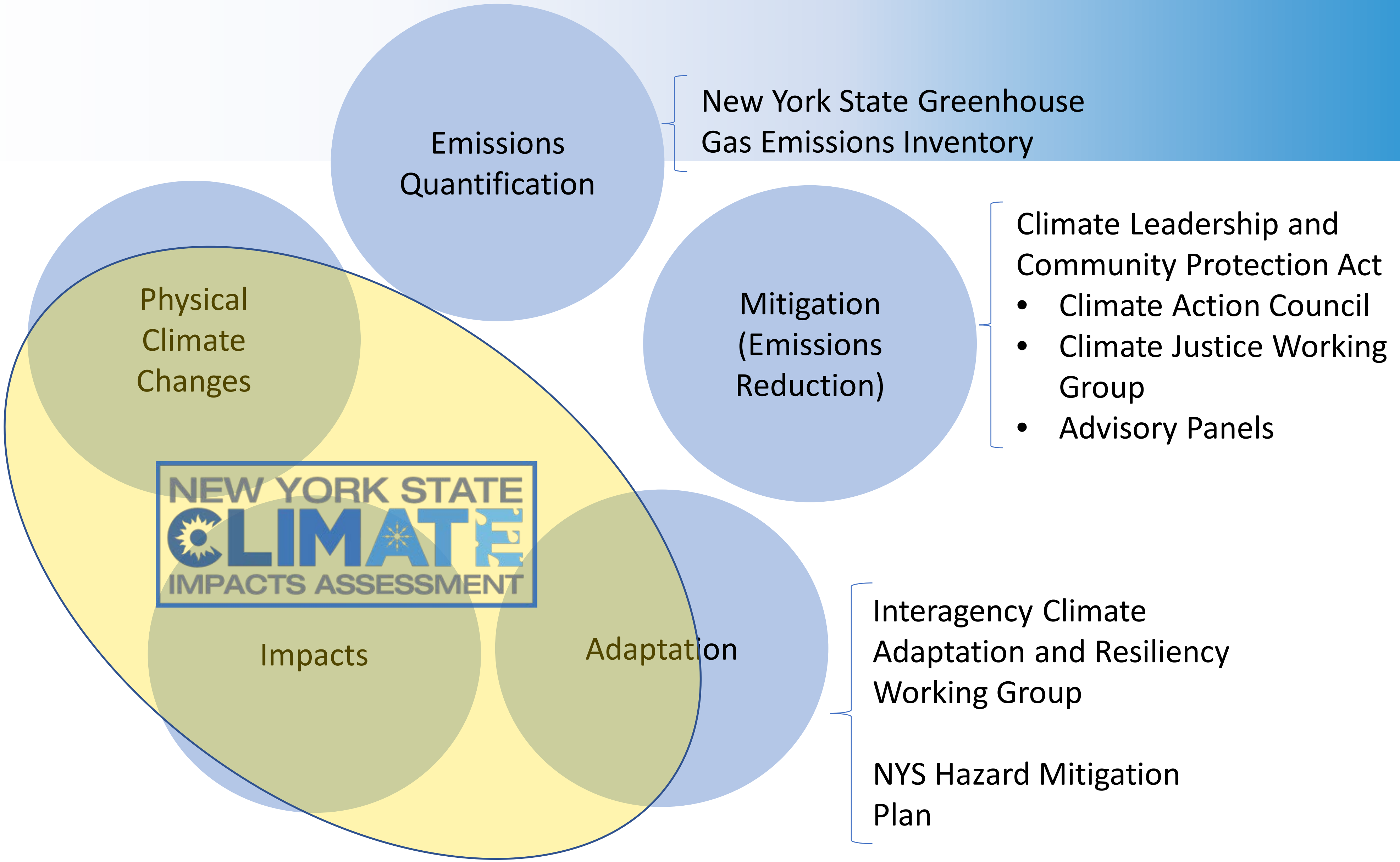
> Up-to-date science and information on projected impacts of climate change on New York State
> Actionable information on preparing for and adapting to these impacts

Why?

> Provide scientific foundation for climate policy and decisions

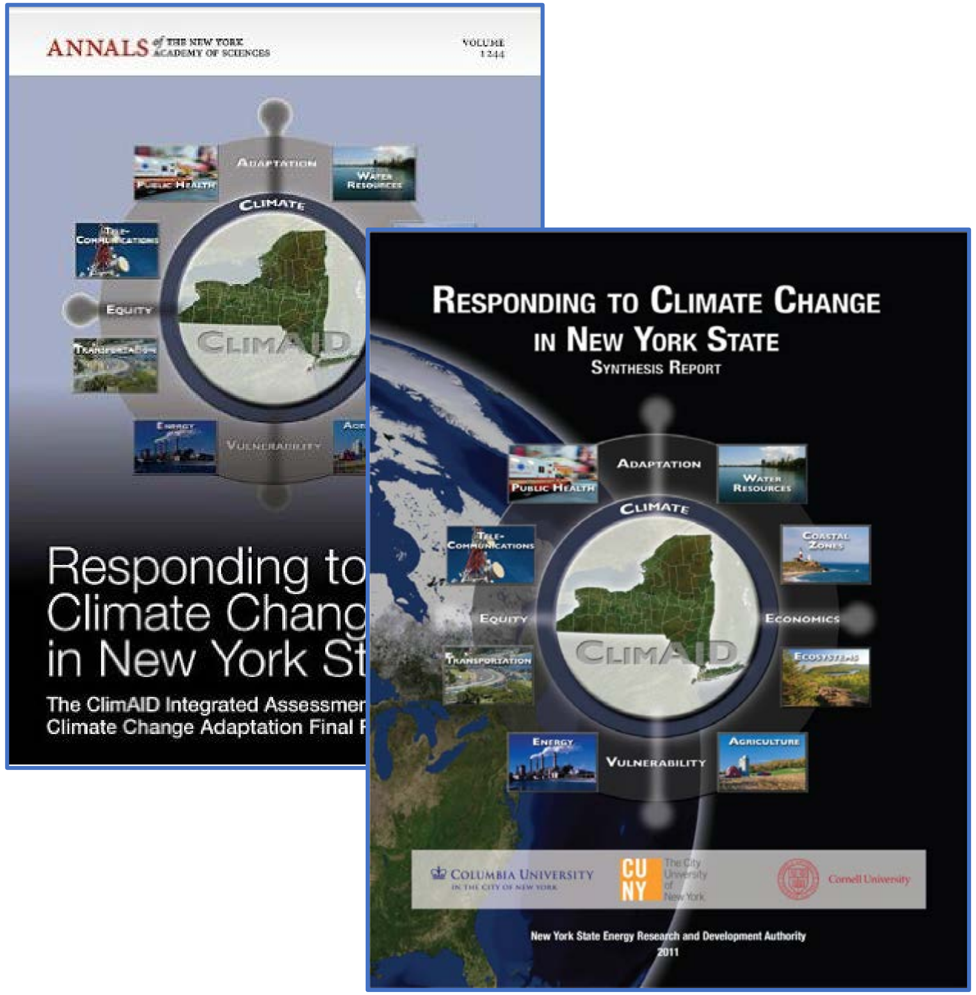
How?

> Incorporate diverse concerns and perspectives
> Provide information in more engaging and useful ways


Emissions Quantification
New York State Greenhouse Gas Emissions Inventory
Mitigation (Emissions Reduction)
Climate Leadership and Community Protection Act
• Climate Action Council
• Climate Justice Working Group
• Advisory Panels
Physical Climate Changes
NEW YORK STATE CLIMATE IMPACTS ASSESSMENT
Impacts
Adaptation
Interagency Climate Adaptation and Resiliency Working Group
NYS Hazard Mitigation Plan

What was ClimAID?

- The State's first comprehensive climate change impact assessment
  - 7 regions of the state
  - 8 sectors (e.g., agriculture, energy, transportation)
  - Projections, impacts, adaptation strategies
- Original report: 2011
- Projections update: 2014



How Does This Assessment Build on ClimAID?

> Updated projections and methodologies

> In-depth economic analysis

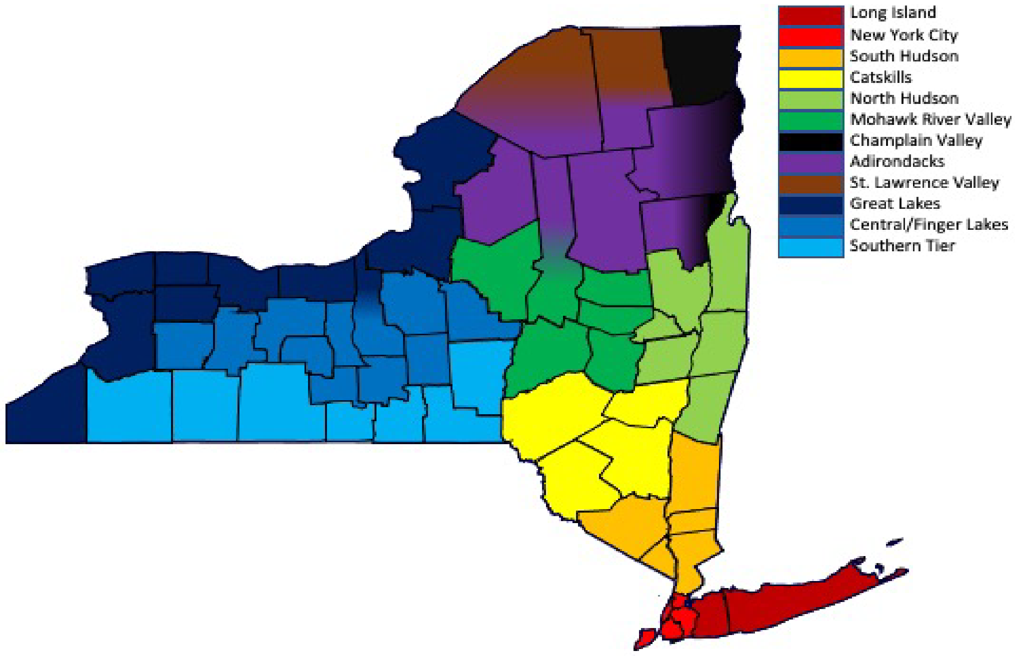
> More diverse perspectives and stakeholder engagement

> More products and outputs to drive wider usage

Climate Projections

> Draft core projections have been completed
- e.g., average and extreme temperature, precipitation
- Likely to be released later this year
- Additional projections may come later

> NYC/NPCC coordination
- Working closely with the NPCC co-chairs to ensure coordination and not duplication



Economic Impacts Analysis

> Modeling the economic impacts of climate change on different sectors
  - Economic damages for different aspects of each sector
  - Will model high and middle emissions scenarios,
    % difference between them

> As feasible, will include impacts of adaptation strategies

> Some preliminary results this year; final work 2022

IEc

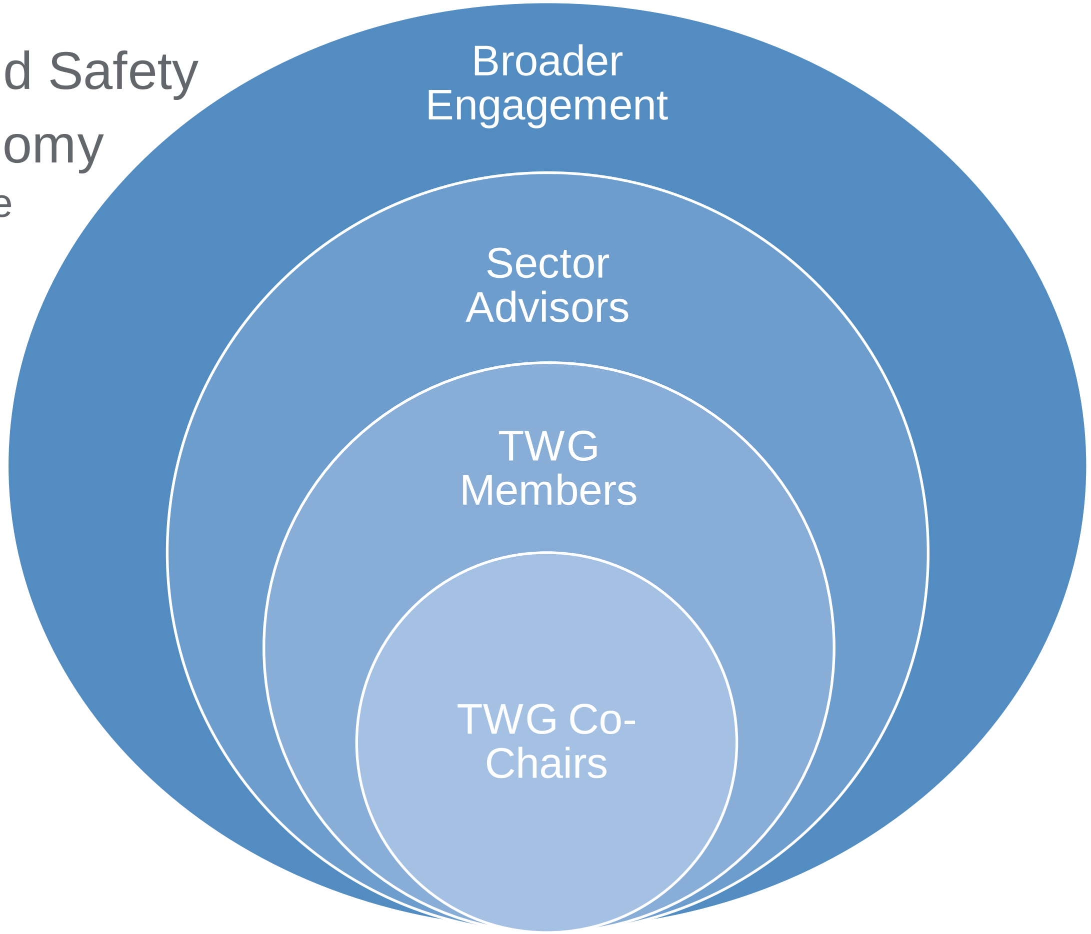
Technical Workgroups / Sectors

Eight sector workgroups

- Agriculture
- Buildings
- Ecosystems
- Energy
- Human Health and Safety
- Society and Economy
  - Finance & insurance
- Transportation
- Water Resources

Cross-cutting topics

- Disadvantaged communities
- Municipal perspectives
- Marine coastal zones
- Great Lakes coastal zones



Outputs and Products

> Technical content will be packaged into multiple products
  - Statewide summary
  - Multi-sector topical reports (e.g., equity, rural communities, Indigenous Communities)
  - Regional reports (e.g., Great Lakes, Adirondacks, ocean coast)

> Digital, including data

> Targeted for different audiences and needs

Timeline

2020

- Project scoping and planning
- Stakeholder interviews
- Convene steering committee

2021

- Assemble technical workgroups
- Workgroups start scoping and research (and continue regular meetings)
- Generate preliminary results from projections and economic analysis

2022

- Complete projections and economic analysis
- Complete technical products for review
- Conduct peer review
- Refine and finalize technical products
- Create and disseminate outreach products

Integration Analysis: Initial Scenario Results

New York State
Climate Action Council

Integration Analysis: Initial Results

October 1, 2021

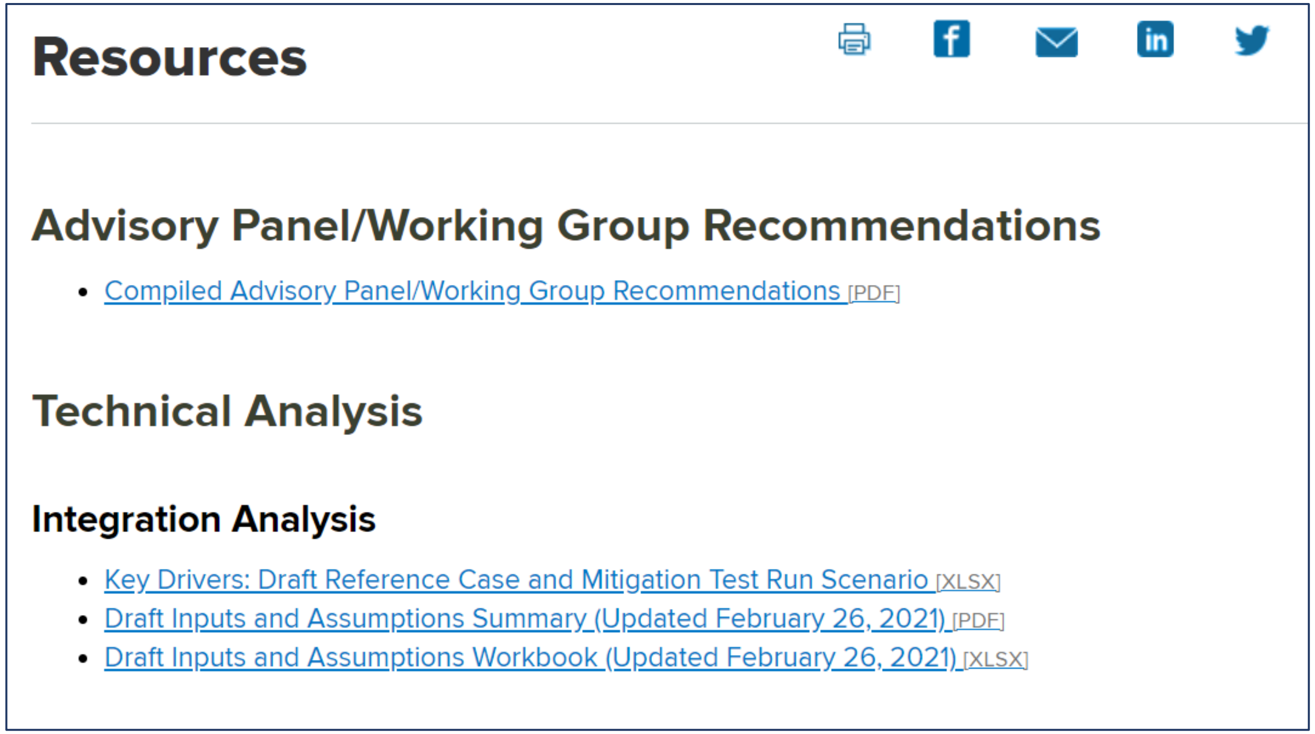
NEW YORK STATE OF OPPORTUNITY. | Climate Action Council

Contents

More Information

> For more information visit:

- https://climate.ny.gov/Climate-Resources
- https://climate.ny.gov/Climate-Action-Council/Meetings-and-Materials



Resources

Advisory Panel/Working Group Recommendations

- Compiled Advisory Panel/Working Group Recommendations [PDF]

Technical Analysis

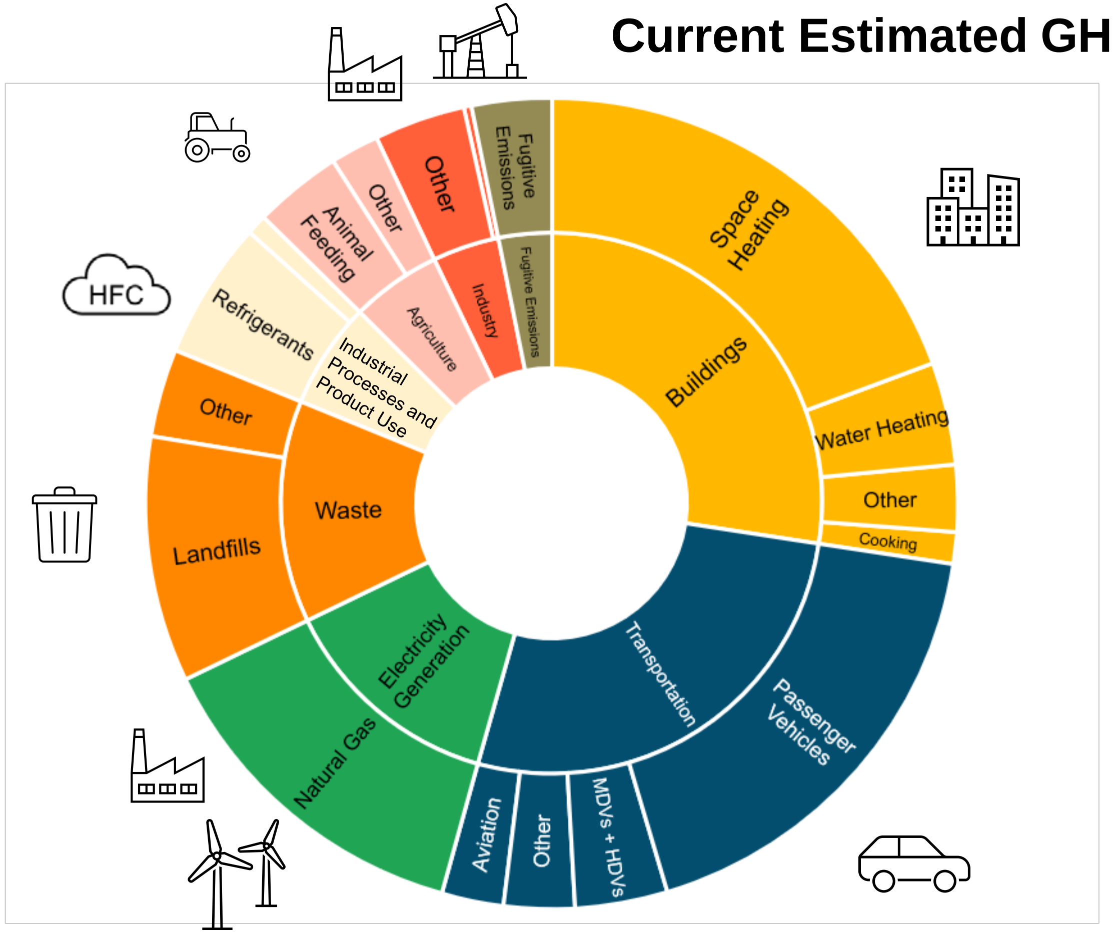
Integration Analysis

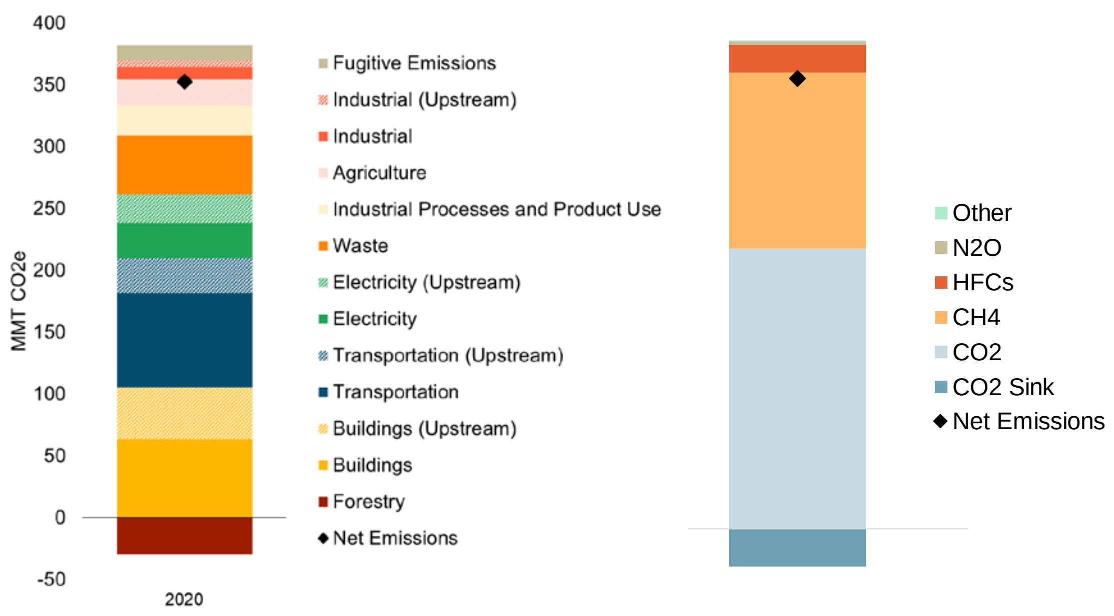
- Key Drivers: Draft Reference Case and Mitigation Test Run Scenario [XLSX]
- Draft Inputs and Assumptions Summary (Updated February 26, 2021) [PDF]
- Draft Inputs and Assumptions Workbook (Updated February 26, 2021) [XLSX]

Overview and Findings

Current Emissions in New York State

Current Estimated GHG Emissions by Sector*





*Draft 2020 results in line with DEC CLCPA accounting including upstream emission factors, 20-year GWP, and estimates from NY PATHWAYS

Scenario Overview

> Previous scenarios
- *Reference Case*
  - *Currently implemented policies*
- *Scenario 1: Advisory Panel Recommendations*
  - *Aggregate impacts of recommendations from Advisory Panels*

> Scenarios that meet or exceed GHG emission limits, achieve carbon neutrality by midcentury
- Foundational themes across **all** mitigation scenarios based on findings from Advisory Panels and supporting analysis
  - Zero emission power sector by 2040
  - Enhancement and expansion of transit & vehicle miles traveled reduction
  - More rapid and widespread end-use electrification & efficiency
  - Higher methane mitigation in agriculture and waste
  - End-use electric load flexibility reflective of high customer engagement and advanced techs
- **Scenario 2: Strategic Use of Low-Carbon Fuels**
  - Includes the use of bioenergy derived from biogenic waste, agriculture & forest residues, and limited purpose grown biomass, as well as green hydrogen, for difficult to electrify applications
- **Scenario 3: Accelerated Transition Away from Combustion**
  - Low-to-no bioenergy and hydrogen combustion; Accelerated electrification of buildings and transportation
- **Scenario 4: Beyond 85% Reduction**
  - Accelerated electrification + limited low-carbon fuels; Additional VMT reductions; Additional innovation in methane abatement; Avoids direct air capture of CO_2

Level of Transformation by Mitigation Scenario

	Scenario 2: Strategic Use of Low-Carbon Fuels	Scenario 3: Accelerated Transition Away from Combustion	Scenario 4: Beyond 85% Reduction
Efficiency and Electrification	*High*	*Very High*	*Very High*
Transit and Smart Growth	*High*	*High*	*Very High*
Zero-Emission Vehicles	*High*	*Very High*	*Very High*
Clean Electricity	*High*	*High*	*High*
Low-Carbon Fuels	*High*	*Low*	*Medium*
Emissions Mitigation in Agriculture & Waste	*High*	*High*	*High / Very High*
Carbon Sequestration in Lands and Forests	*High*	*Very High*	*Very High*
Negative Emissions Technologies	*High*	*Medium*	*Low / None*

New Findings

> Achievement of emissions reductions to meet state law requires action in all sectors, especially considering New York State's novel emissions accounting

- Every sector will see high levels of transformation over the next decade and beyond, requiring critical investments in New York's economy

> Energy efficiency and end-use electrification will be essential parts of any Pathway that hits NYS Emissions Limits

- In all scenarios modeled, zero emission vehicles and heat pumps become the majority of new purchases by the late 2020s, and fossil-emitting cars and appliances are no longer sold after 2035
- 1 - 2 million efficient homes electrified with heat pumps by 2030
- Approximately 3 million zero-emission vehicles (predominantly battery electric) by 2030
- Unprecedented rate of adoption of novel and potentially disruptive technologies and measures
- Consumer decision-making plays a large role, especially important for the purchase of new passenger vehicles and heating systems for homes and businesses through the next decade

> Substantially reduce vehicle miles traveled while increasing transportation access

- Expansion of transit service structured around community needs
- Smart growth inclusive of equitable transit-oriented development
- Transportation demand management

New Findings (cont’d)

- Wind, water, and sunlight power the majority of New York’s economy in 2050 in all Pathways
  - Even with aggressively managed load, electric consumption doubles and peak nearly doubles by 2050, and NYS becomes a winter peaking system by 2035.
  - Offshore wind on the order of 20 GW, solar on the order of 60 GW, and 4- and 8-hour battery storage on the order of 20 GW by 2050
  - Firm, zero-emission resources, such as green hydrogen or long-duration storage, will play an important role to ensure a reliable electricity system beyond 2040
- Low-carbon fuels such as bioenergy or hydrogen may play a critical role in helping to decarbonize sectors that are challenging to electrify
  - By 2030, initial market adoption of green hydrogen in the following applications: medium and heavy-duty vehicles, high-temperature industrial
  - Additional promising end-use applications include district heating and non-road transportation such as aviation and rail
- Required transition to low-GWP refrigerants and enhanced refrigerant management by 2050

New Findings (cont'd)

> Large-scale carbon sequestration opportunities include lands and forests and negative emissions technologies
- Protecting and growing New York's forests is required for carbon neutrality
- Negative emissions technologies (e.g. direct air capture of CO_2) may be required if the State cannot exceed 85% direct emissions reductions
- Strategic land-use planning will be essential to balance needs

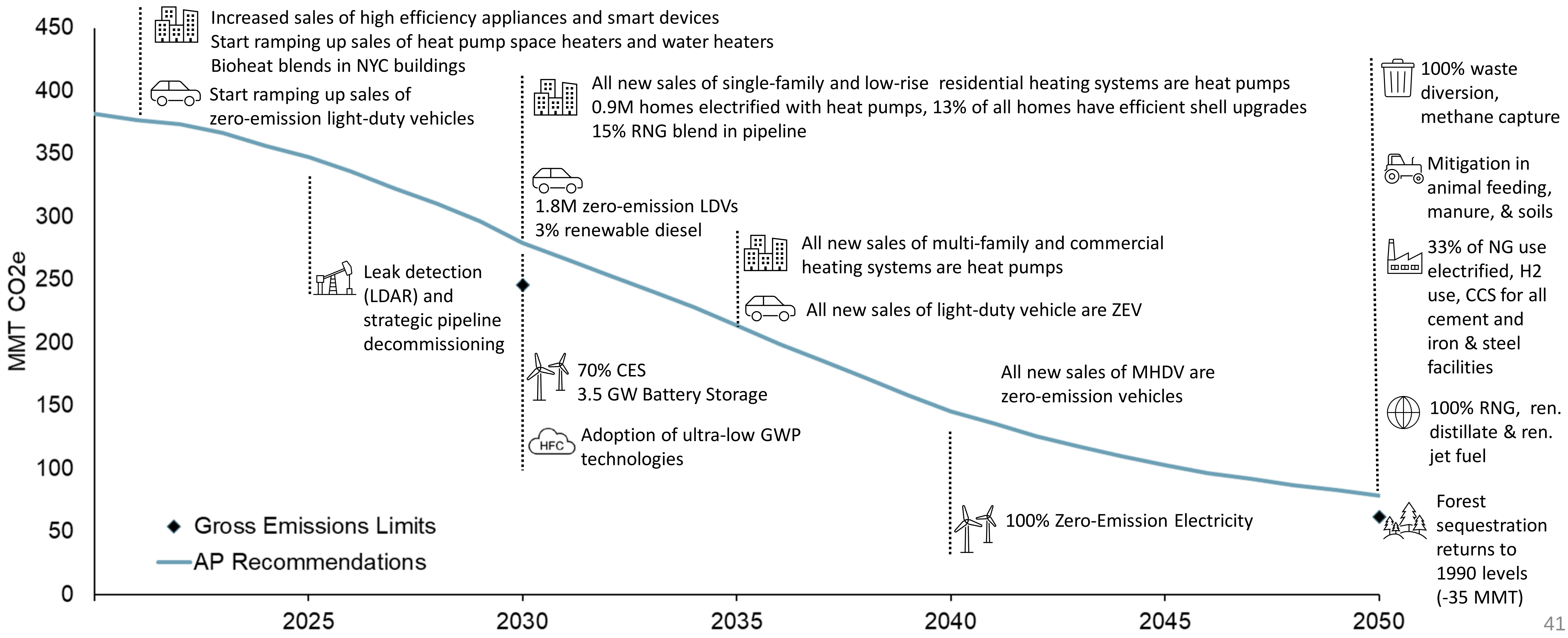
> Necessary methane emissions mitigation in waste and agriculture will require transformative solutions
- Diversion of organic waste, capture of fugitive methane emissions are key in waste sector
- Alternative manure management and animal feeding practices are key in agriculture

> Additional innovation will be required in areas such as carbon sequestration solutions, long-duration storage, flexible electric loads, low-GWP refrigerants, and animal feeding, in concert with Federal action (e.g. Earthshots)

> Largest three remaining sources of emissions in 2050: Landfills, aviation, and animal feeding

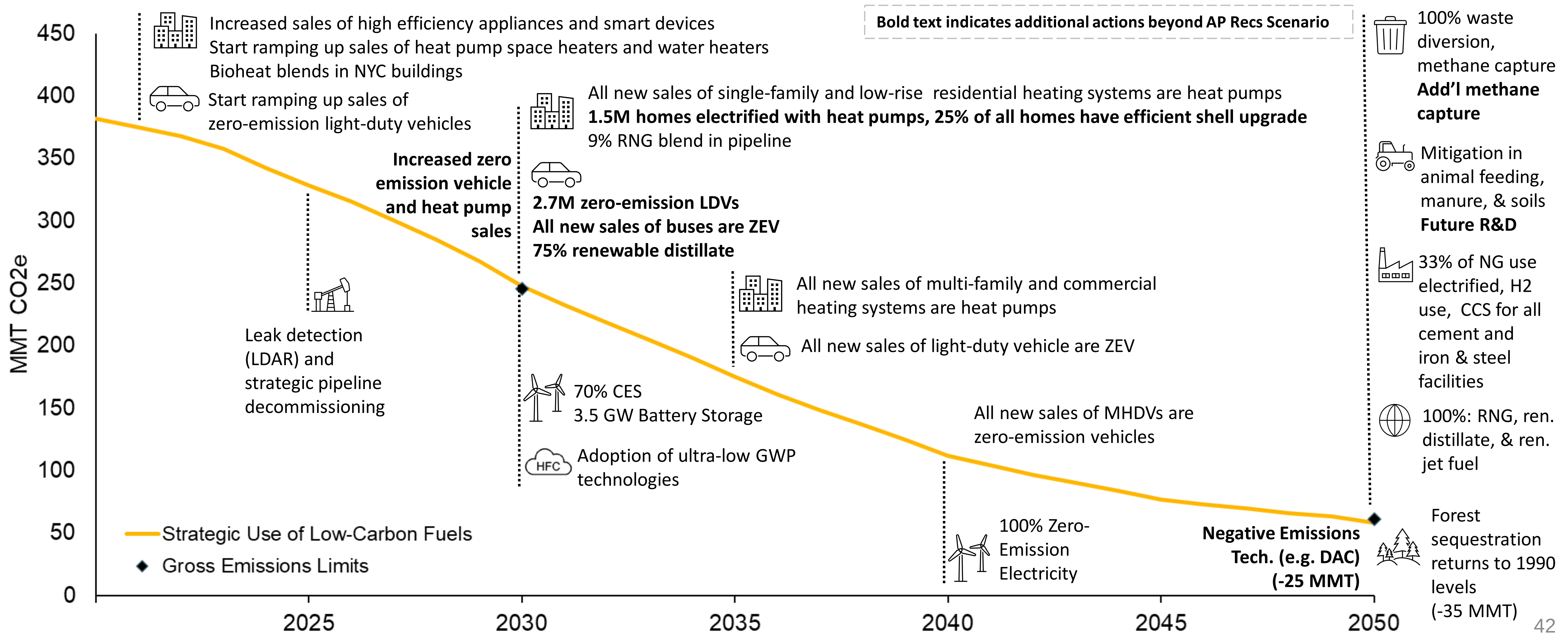
Scenario 1 at a Glance

AP Recommendations



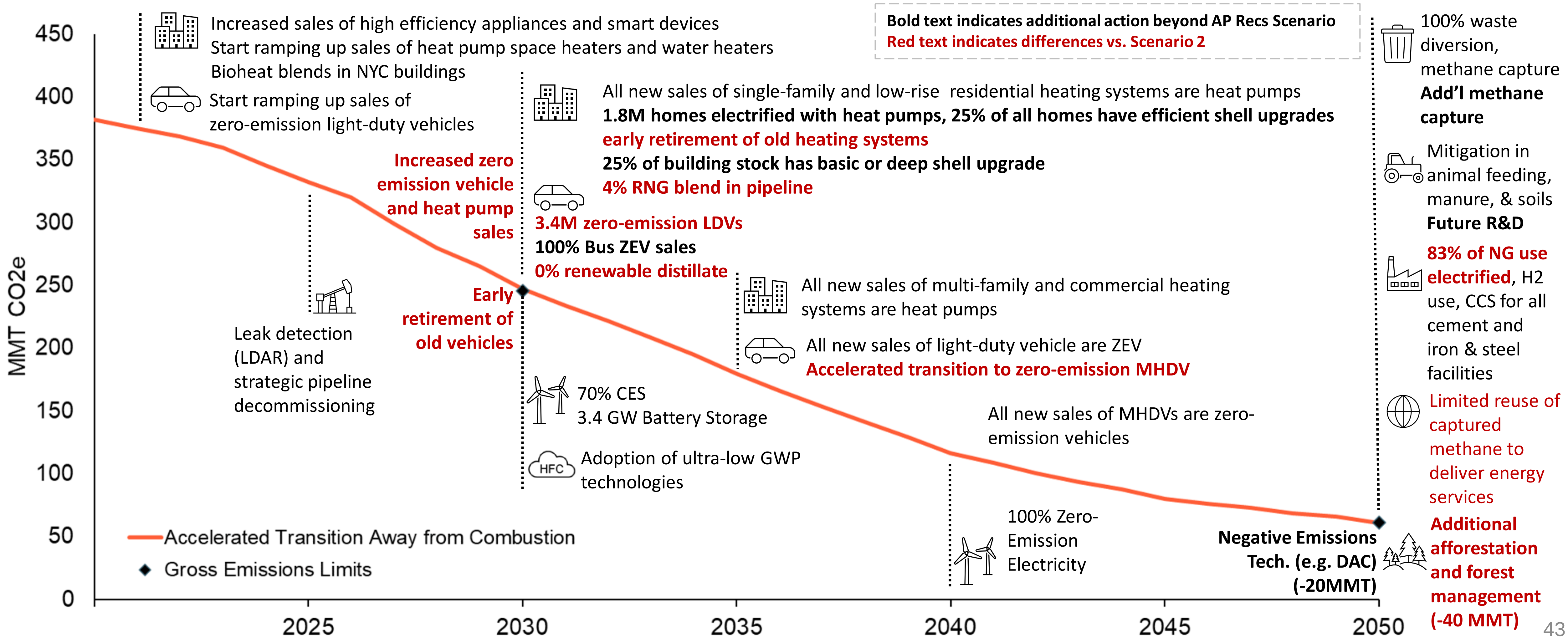
Scenario 2 at a Glance

Strategic Use of Low-Carbon Fuels



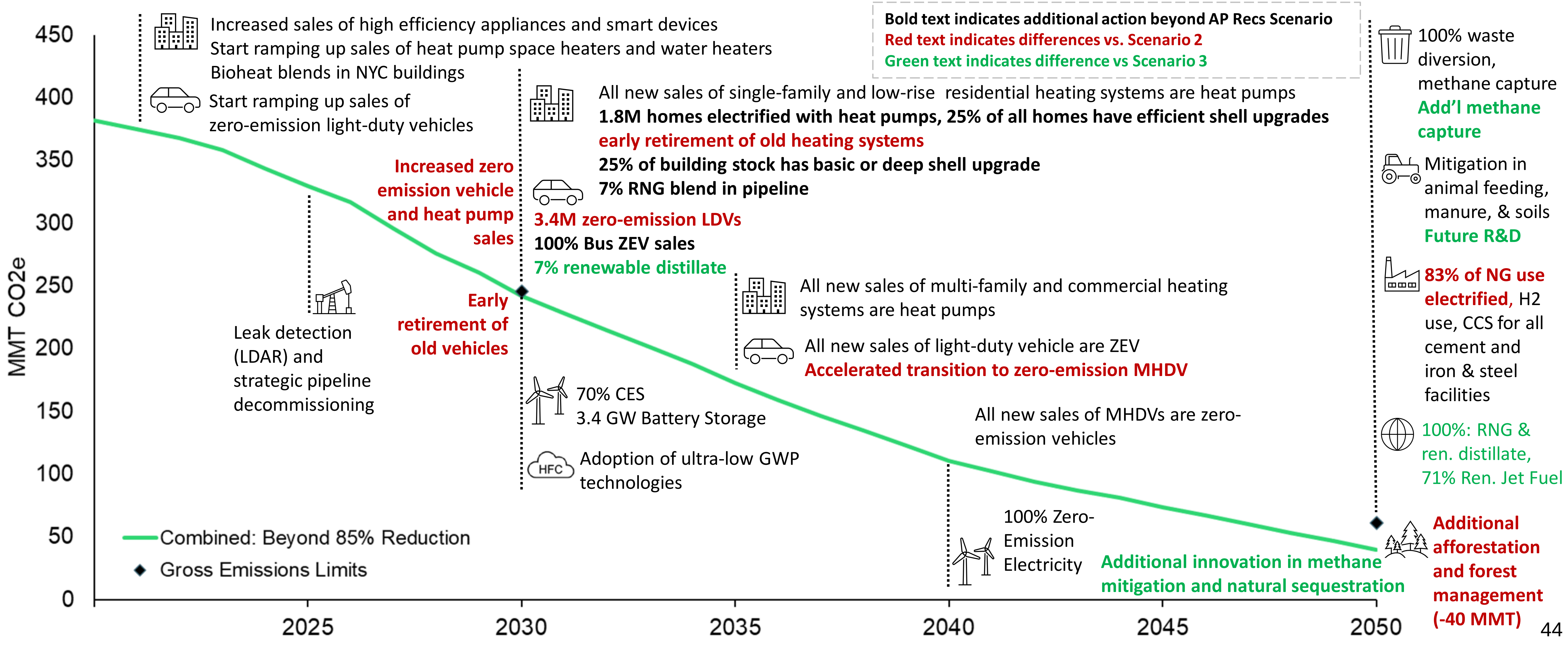
Scenario 3 at a Glance

Accelerated Transition Away from Combustion



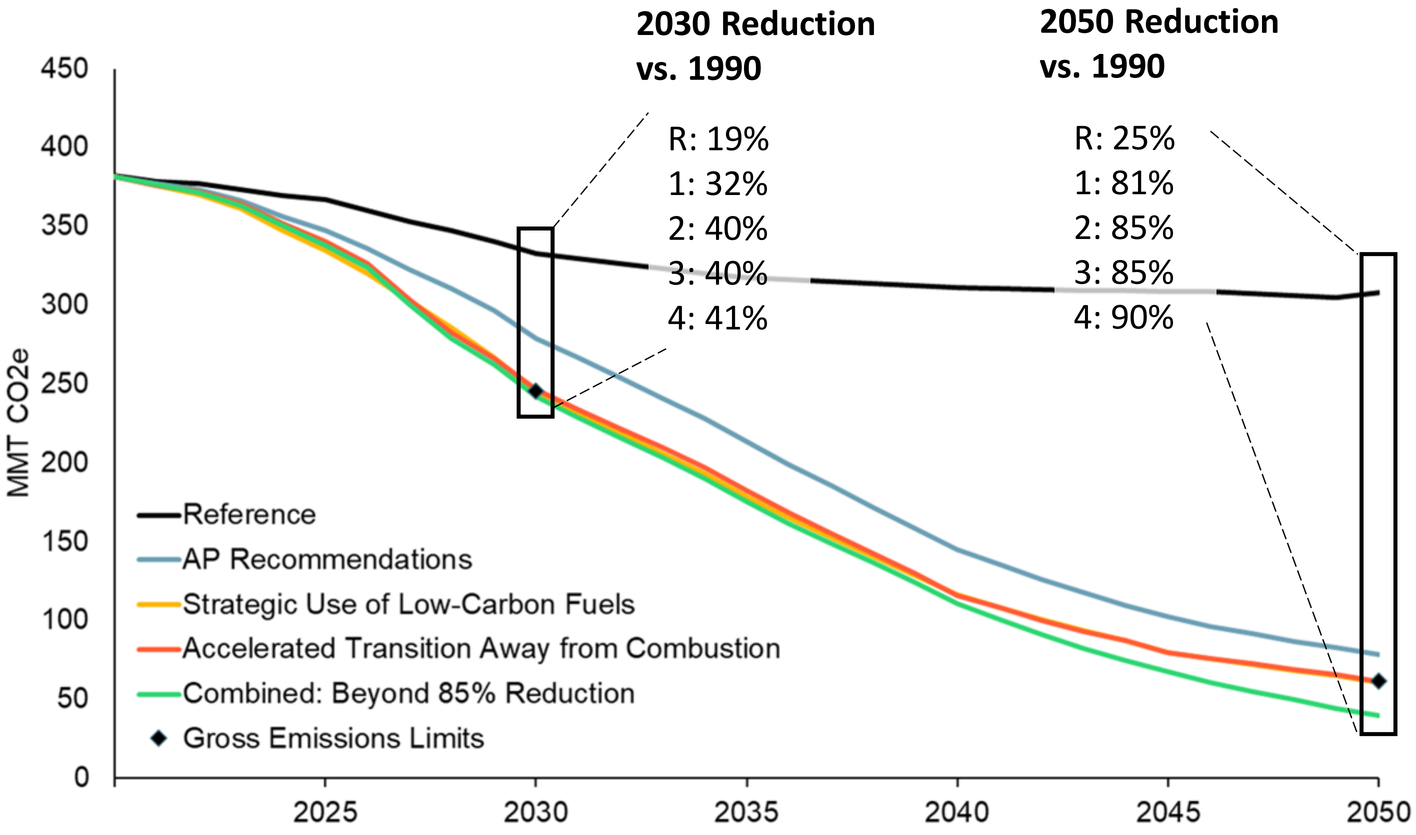
Scenario 4 at a Glance

Beyond 85% Reduction



Economy-wide Results

GHG Emissions by Mitigation Scenario

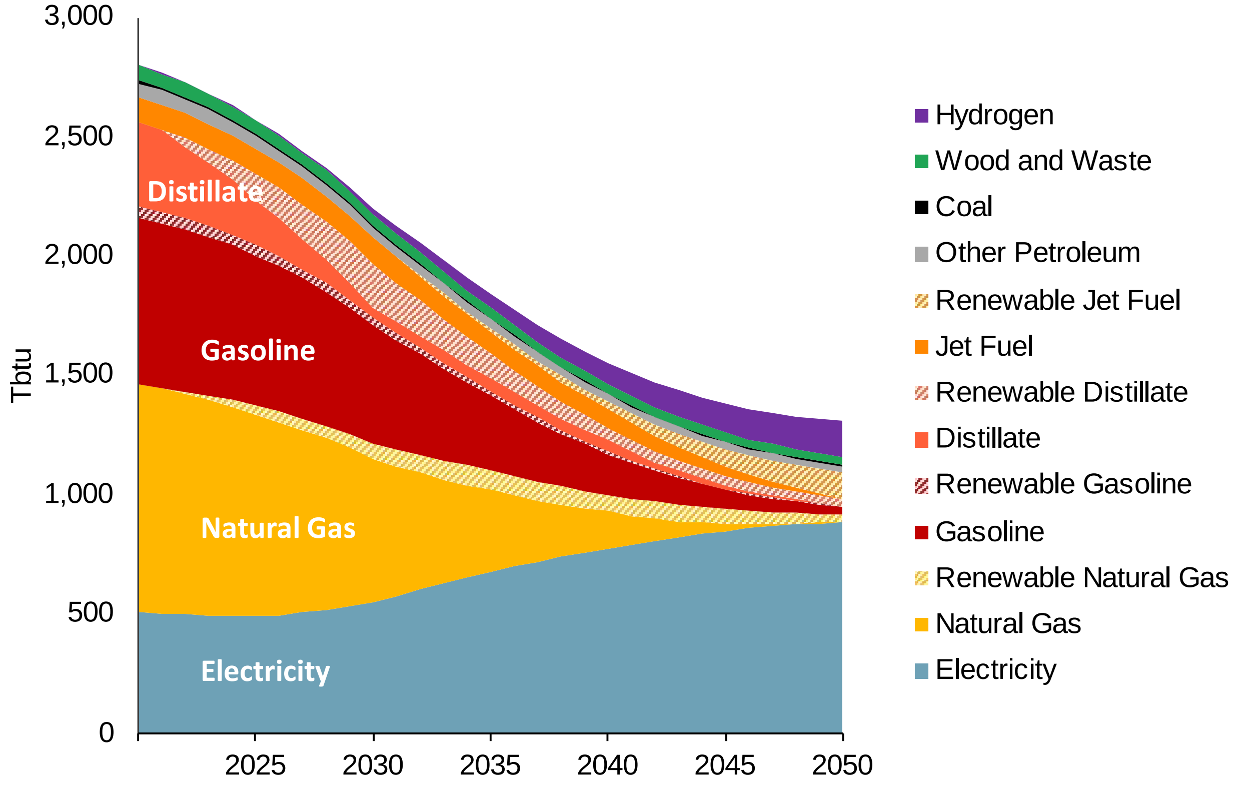


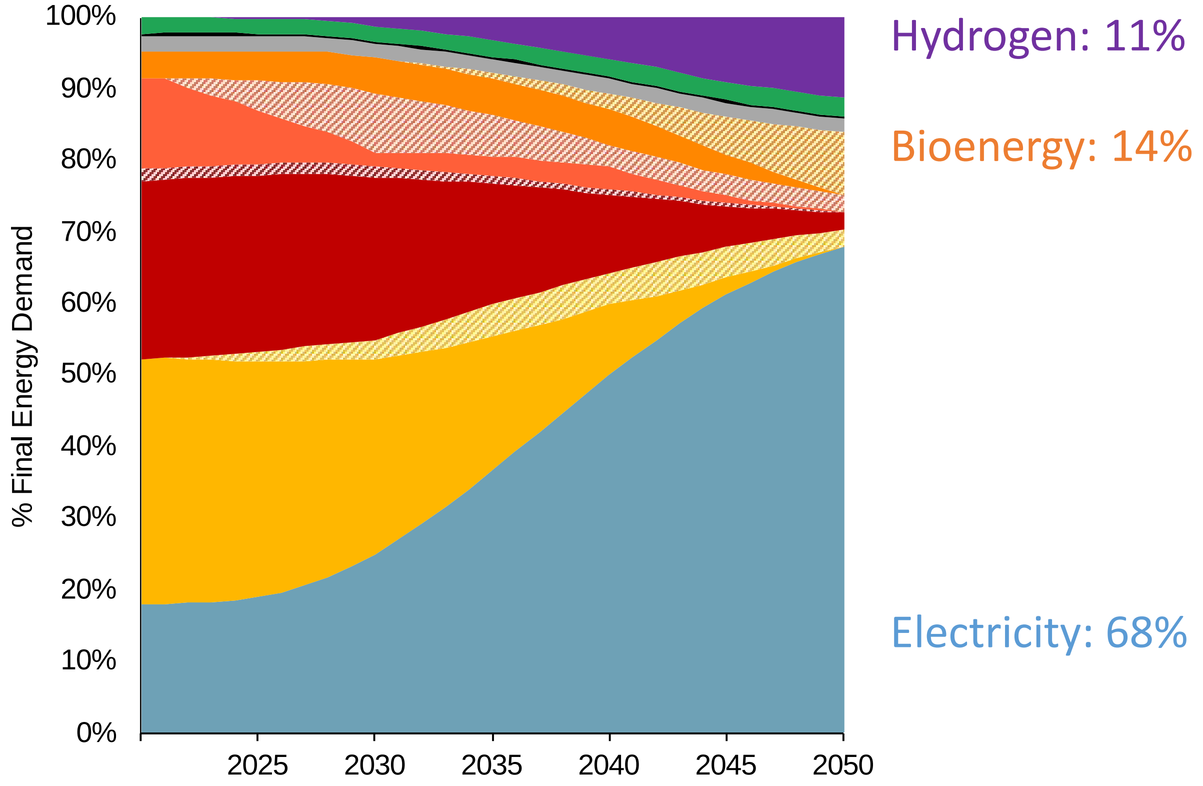
#	Remaining GHGs by Scenario [MMT CO2e]	2030	2050
R	Reference	332	311
1	AP Recommendations	276	72
2	Strategic Use of Low-Carbon Fuels	246	61
3	Accelerated Transition Away from Combustion	246	61
4	Beyond 85% Reduction	242	40
◆	Gross Emissions Limits	246	61

AR5, 20-yr GWP

2020 is a modelled year, reflecting historical trends

Total Energy by Fuel
Scenario 2: Strategic Use of Low-Carbon Fuels

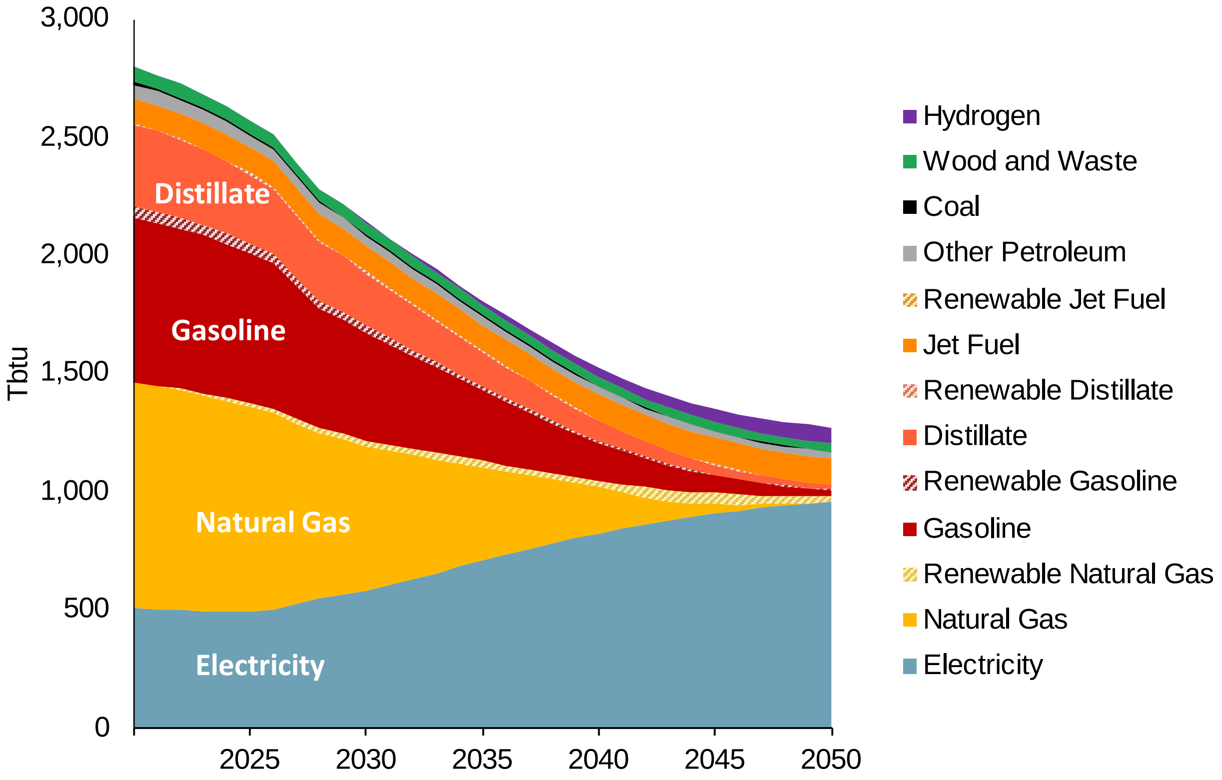


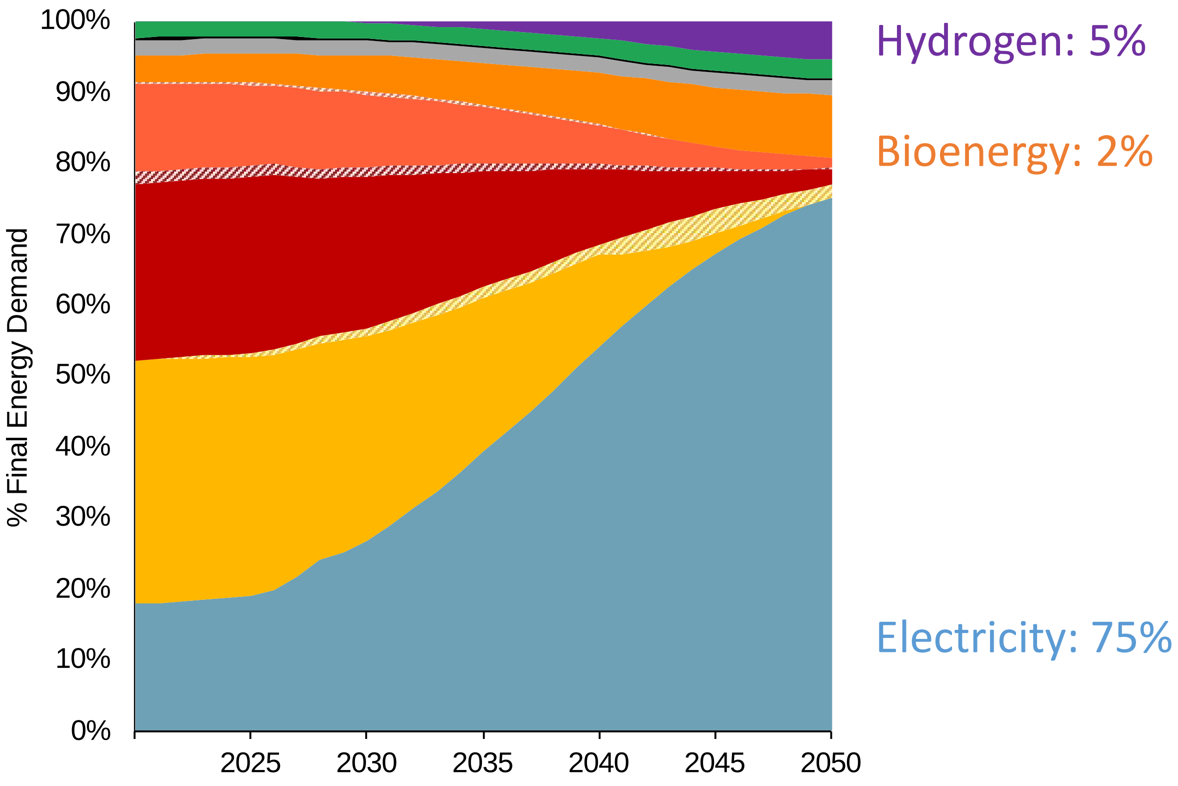


Includes energy use from transportation, industrial, commercial, and residential sectors.
2020 is a modelled year, reflecting historical trends

Total Energy by Fuel

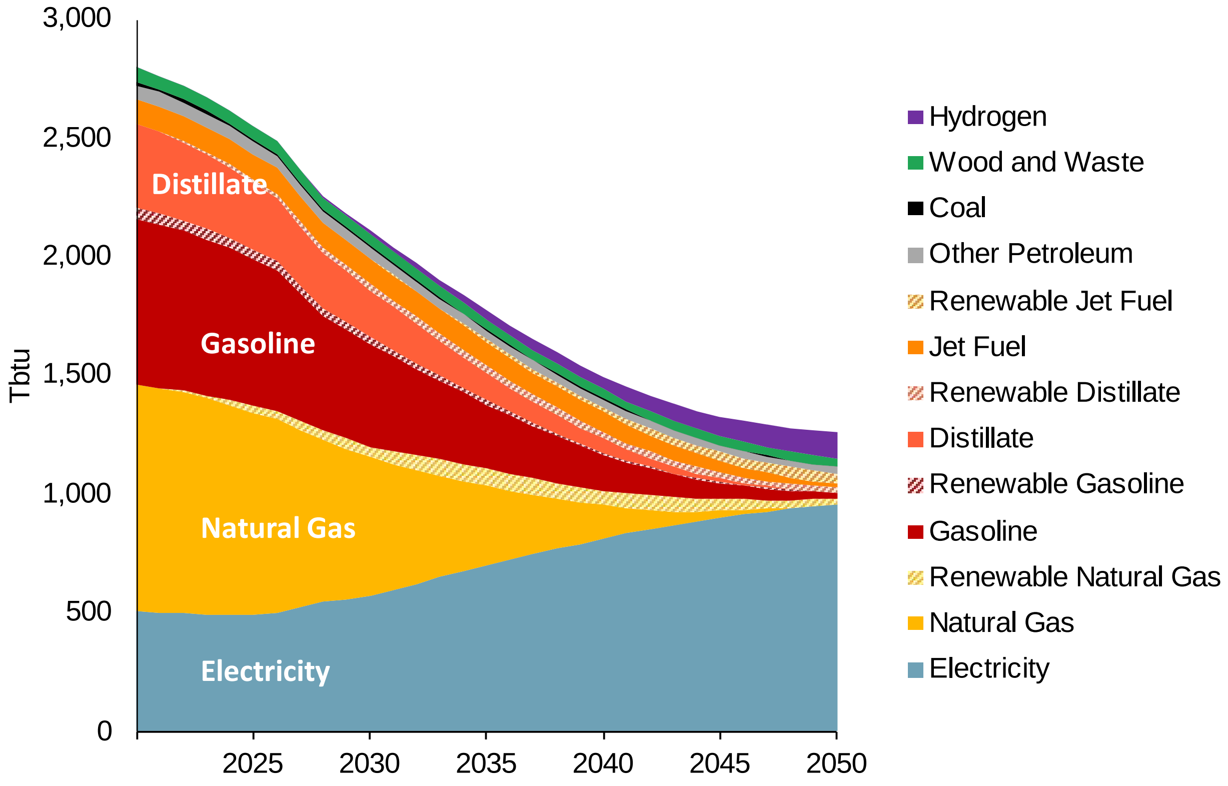
Scenario 3: Accelerated Transition Away from Combustion

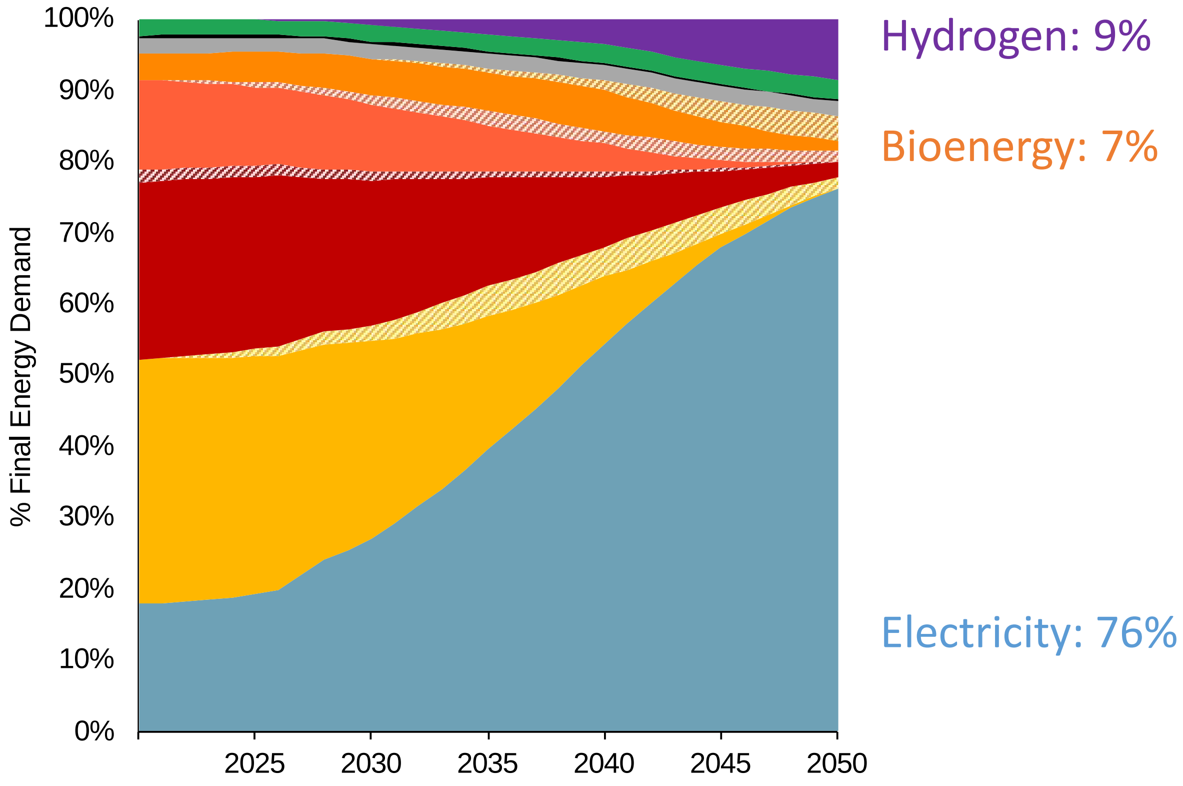




Includes energy use from transportation, industrial, commercial, and residential sectors.
2020 is a modelled year, reflecting historical trends

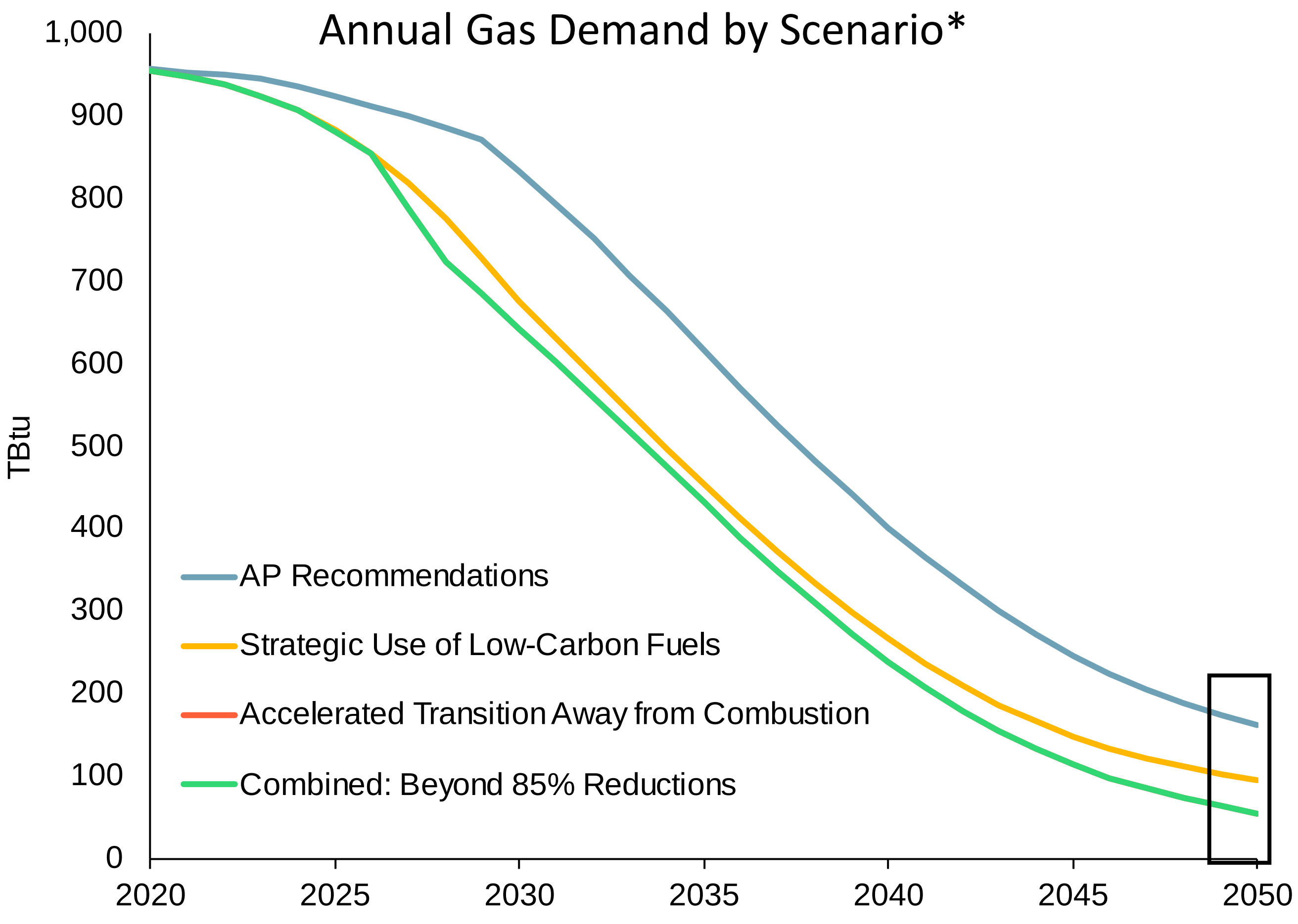
Total Energy by Fuel
Scenario 4: Beyond 85% Reduction

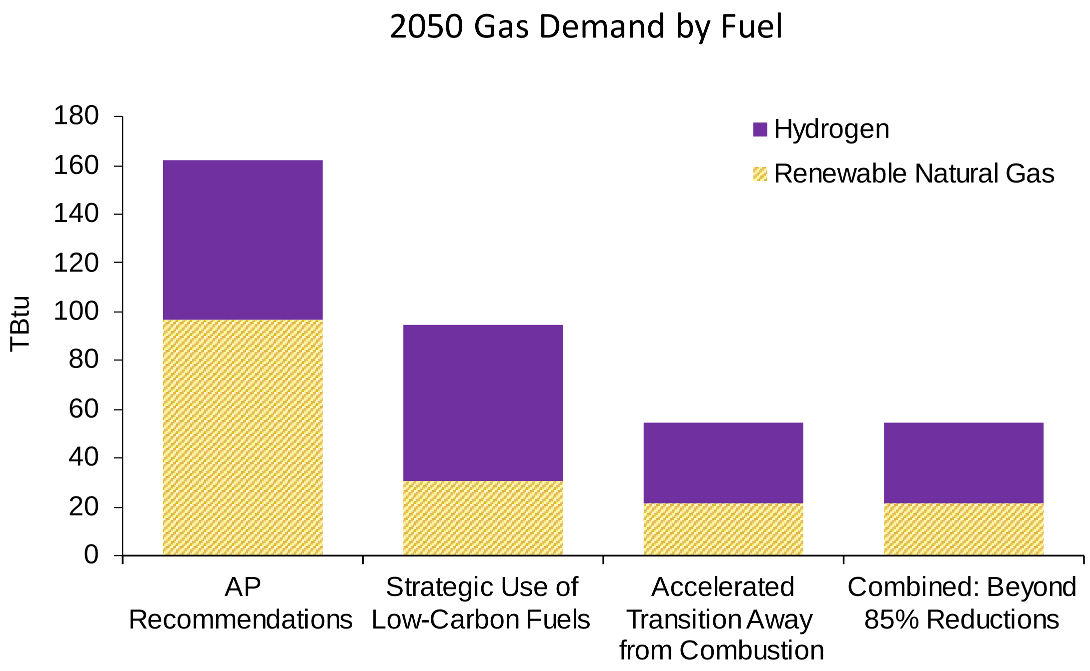




Includes energy use from transportation, industrial, commercial, and residential sectors.
2020 is a modelled year, reflecting historical trends

End-Use Gas Demand

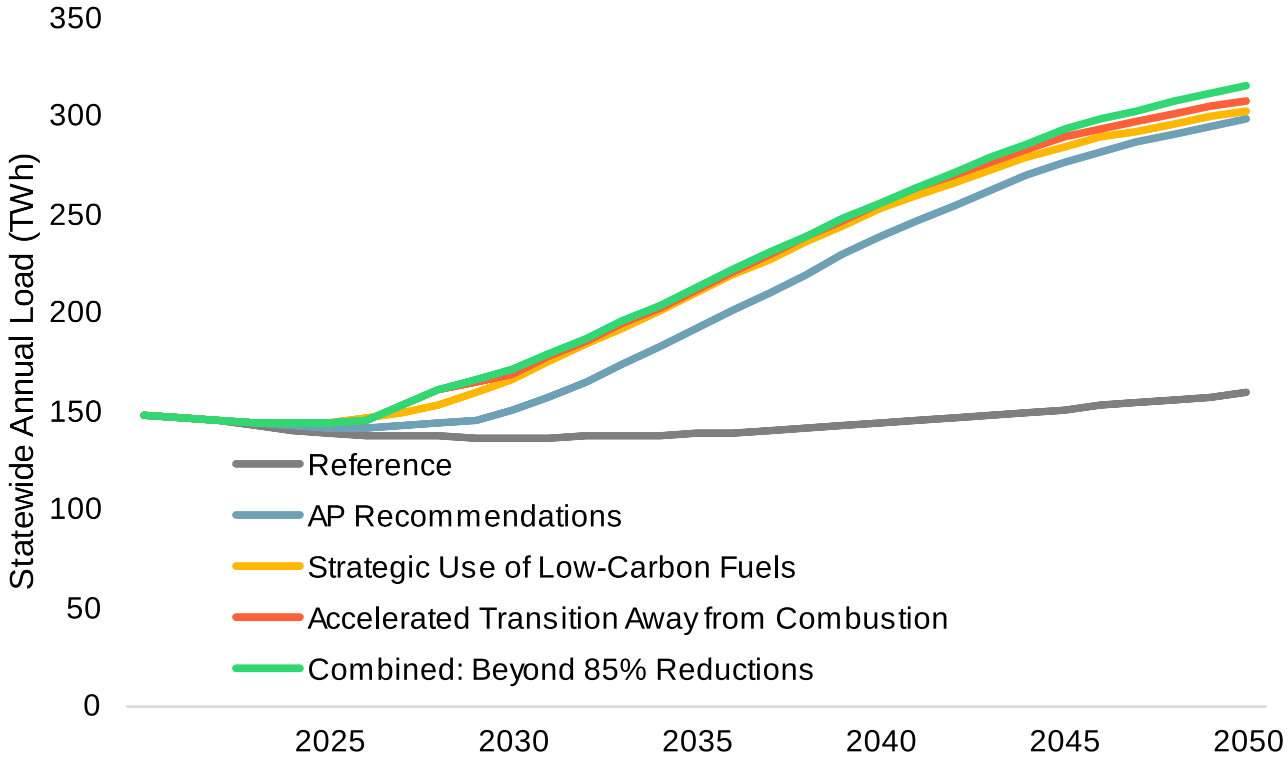




*Includes gas demand in buildings industry, and transportation. Excludes gas burned in electric generating units and hydrogen for fuel cell vehicles

Annual Load Forecast by Scenario

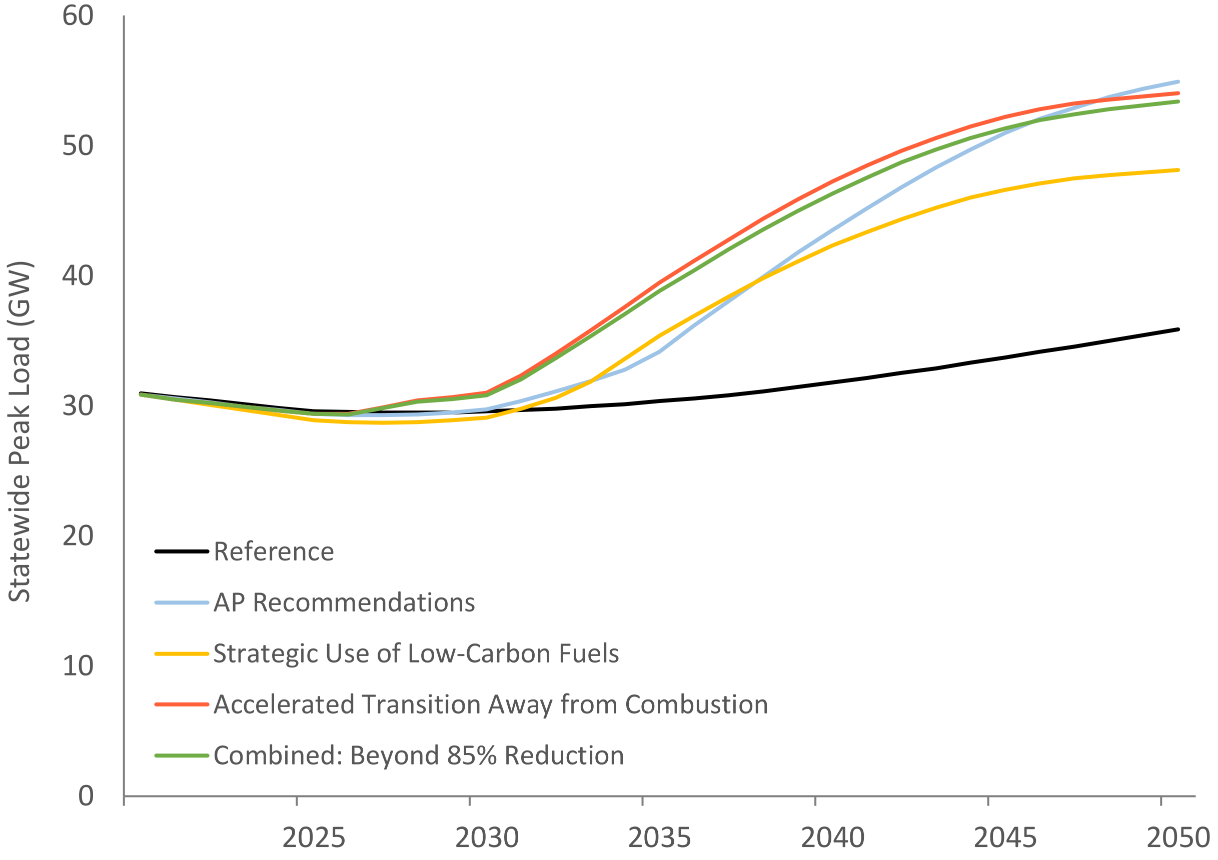
Buildings, Transportation, Industry, Hydrogen Electrolysis



Load is exclusive of T&D losses, potential DAC loads. 2020 is a modelled year, reflecting historical trends.

- The load increase in 2050 relative to today for each scenario is:
  - Reference: 7%
  - Scenario 1: AP Recommendations: 103%
  - Scenario 2: Strategic Low Carbon Fuels: 105%
  - Scenario 3: Accelerated Transition Away from Combustion: 108%
  - Scenario 4: Beyond 85% Reduction: 114%
- Electrolysis to produce hydrogen can be a significant share of load, reaching almost 44 TWh of load by 2050 in the Strategic Use of Low Carbon Fuels scenario

Peak Load Forecast



Note: peak forecast does not include the impacts of load flexibility. Flexible loads are accounted for when developing electric sector resource portfolios. 2020 is a modelled year, reflecting historical trends

- All Mitigation scenarios shift from summer to winter-peaking by 2035
- The peak load increase in 2050 relative to today for each scenario is:
  - Reference: 16%
  - Scenario 1: AP Recommendations: 77%
  - Scenario 2: Low Carbon Fuels: 56%
  - Scenario 3: Accelerated Transition: 75%
  - Scenario 4: Combined: 73%

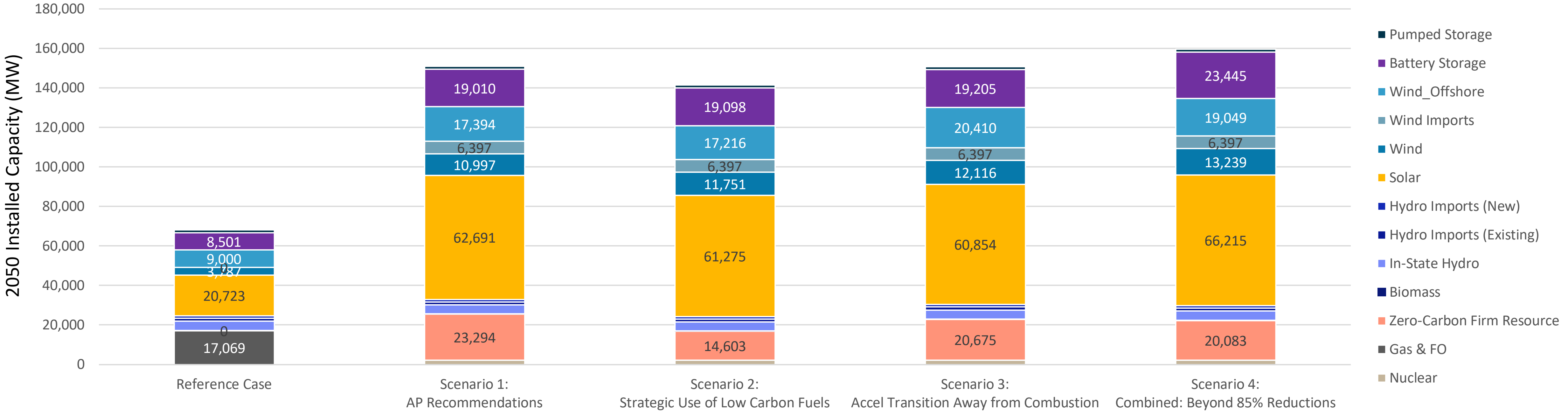
Electricity Generation

Comparison of 2050 Installed Capacity

> In these Scenarios, firm capacity is provided by hydrogen resources to meet multi-day reliability needs, ranging from 15-23 GW

> Significant expansion of foundational resources (wind, solar, and storage) is needed across scenarios

- Offshore wind: 17-20 GW
- Land based wind: 17-20 GW
- Solar: 61-66 GW
- Storage: 19-23 GW

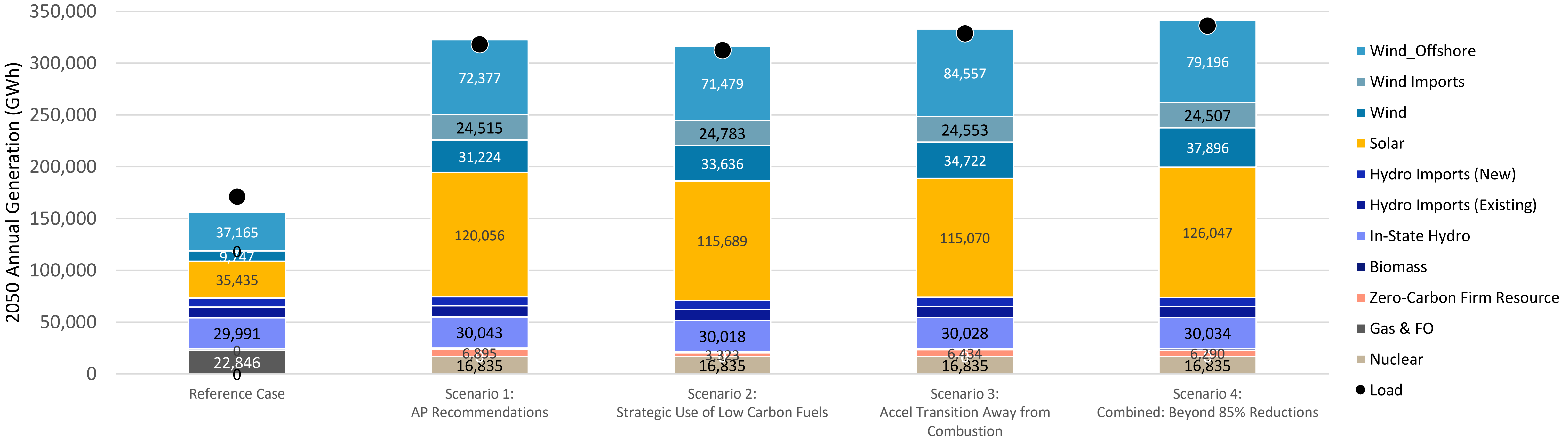


Electricity Generation

Comparison of 2050 Annual Generation

> Share of annual generation across mitigation scenarios:

- Solar: 35-38%
- Wind: 40-44%
- Zero-carbon firm resource: 1-2%



Bioenergy Analysis Framework

- Feedstocks supply sourced from the DOE Billion Ton Study, NYSERDA Potential Studies, and adjusted based on Advisory Panel deliberations with academic partners
- Feedstocks are allocated to final fuels based on production costs, fossil fuel prices, and emissions abatement potential
- Principles that guide biofuel allocation:
  - As each biofuel is a substitute for an existing fossil fuel, allocation is limited by the long-term demand for that fuel type in hard-to-electrify applications
  - Maximize emission reduction per MMBTU (RNG)
  - For liquid fuels, allocation based on relative fuel production cost (renewable diesel < renewable jet fuel)

Bioenergy Scenario Approach

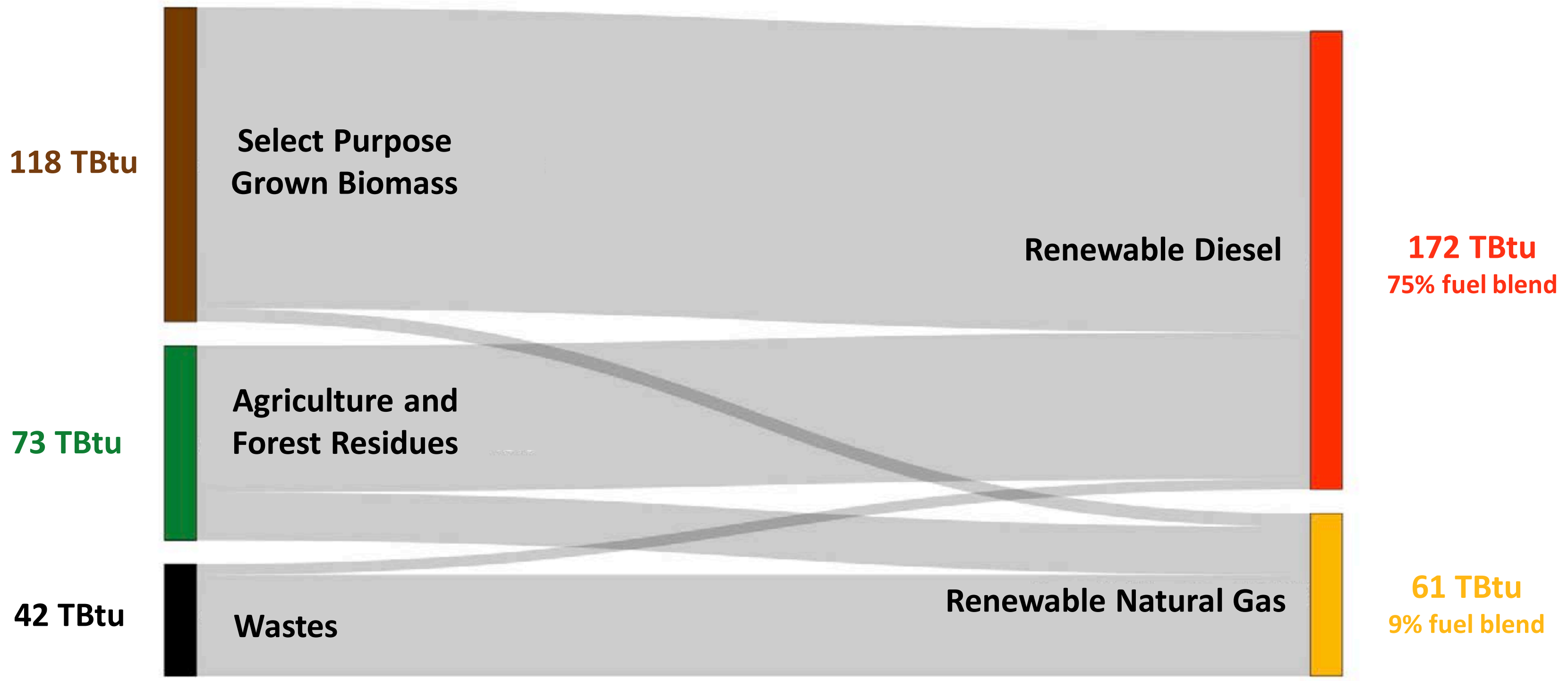
Scenario 2: Strategic Use of Low-Carbon Fuels
- Share of regional feedstocks
- Includes wastes, residues, and select purpose grown biomass

Scenario 3: Accelerated Transition Away from Combustion
- Targeted methane abatement from landfills and wastewater only

Scenario 4: Combined: Beyond 85x50
- In-state bioenergy feedstocks
- Focus on wastes and residues

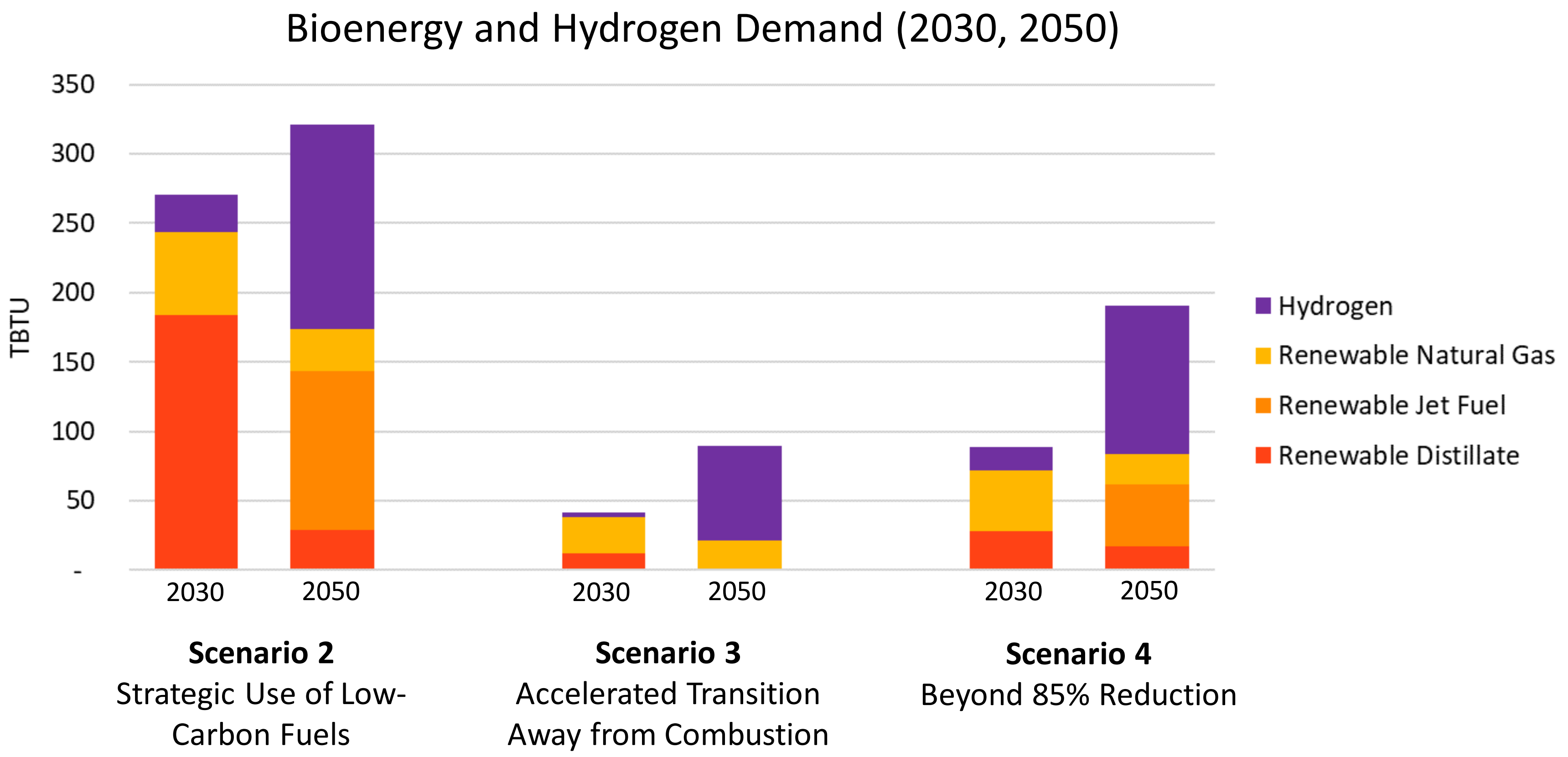
Biofuels Supply

Bioenergy by Feedstock and Final Fuel in 2030 for Scenario 2 (TBtu)



> Scenario 2 Feedstocks
- Includes in-state and population-weighted share of out-of-state feedstocks
- Includes purpose-grown biomass (e.g. miscanthus), residues (e.g. crop residues), and wastes (e.g. landfill gas, waste water treatment gas)
- Assume 2/3 of total supply is available in 2030 (100% in 2050)

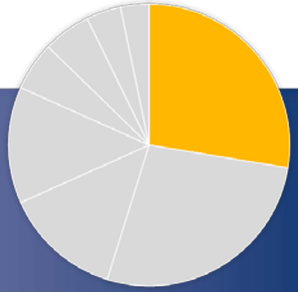
Low-Carbon Fuel Utilization



Includes hydrogen demands for transportation and industry but not electricity generation
Wood continues to be used across all scenarios (~30 TBtu in 2050)

Sectoral Results

Buildings Sector
Reference Case



Key Drivers

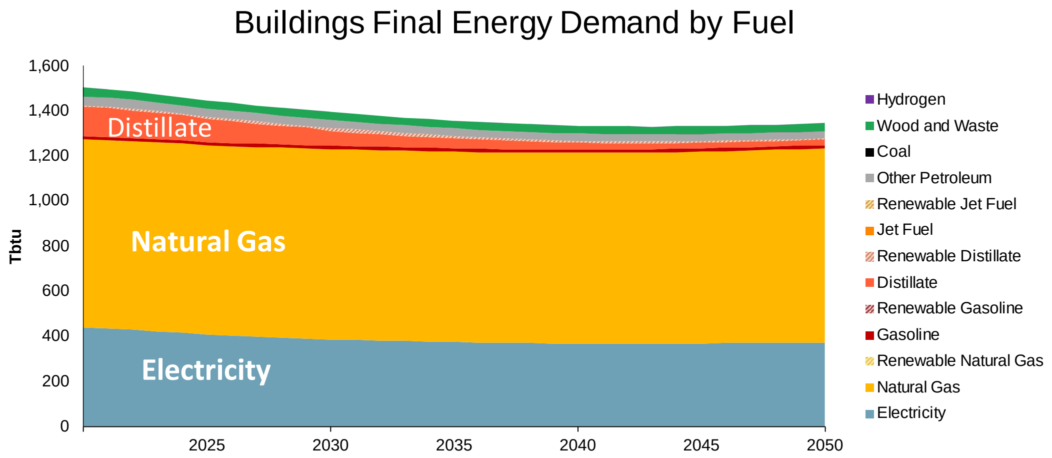
> Population, household, and commercial growth rates drive energy demand and GHG emissions

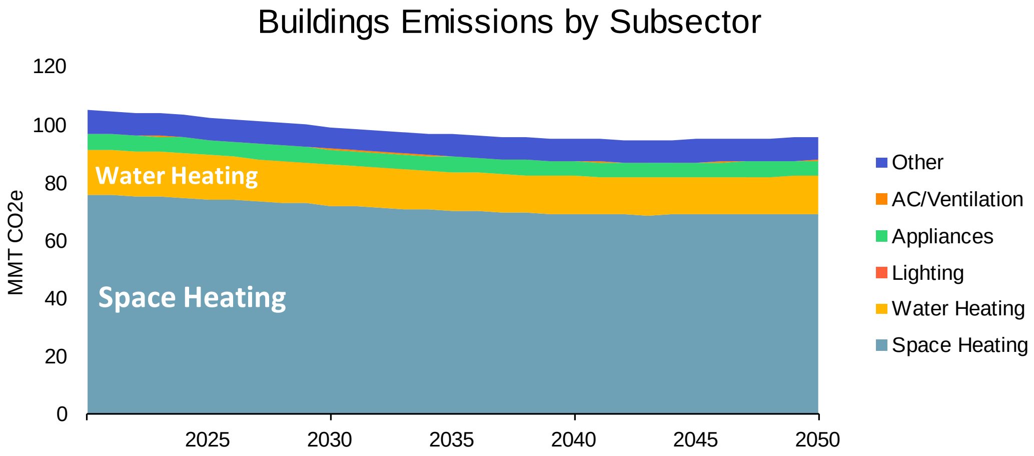
> Appliance efficiency improvements, behavioral conservation, and codes and standards, including:

- Reference Case includes estimates of funded energy efficiency and electrification programs, including HCR+NYPA, DPS (IOUs), LIPA, NYSERDA CEF (assumes market transformation maintains level of efficiency and electrification post-2025)
- Existing federal and state appliance codes and standards

> Reference case achieves significant emissions reductions relative to 1990:

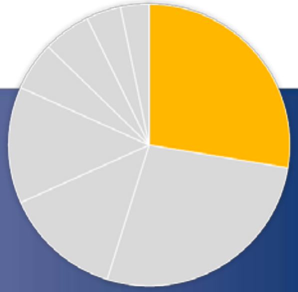
- 2030: 6%
- 2050: 9%





2020 is a modelled year, reflecting historical trends

Underlying characterization of key technologies informed by Building Electrification Roadmap analysis

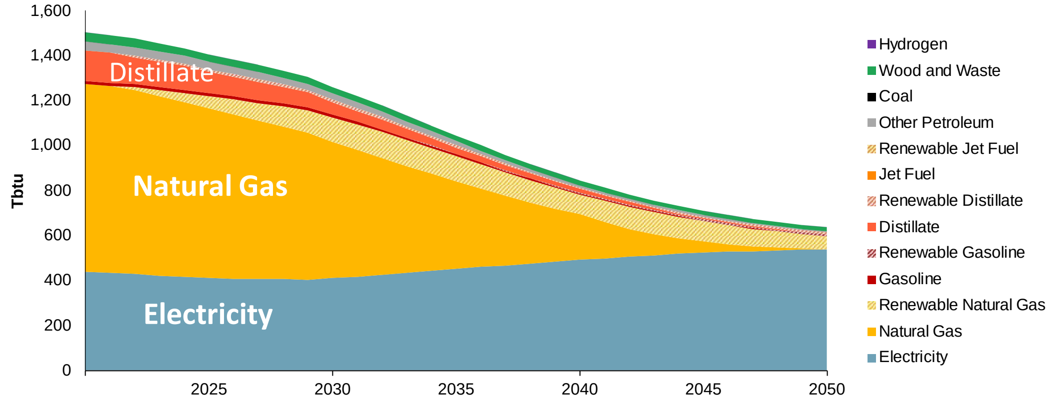


Buildings Sector

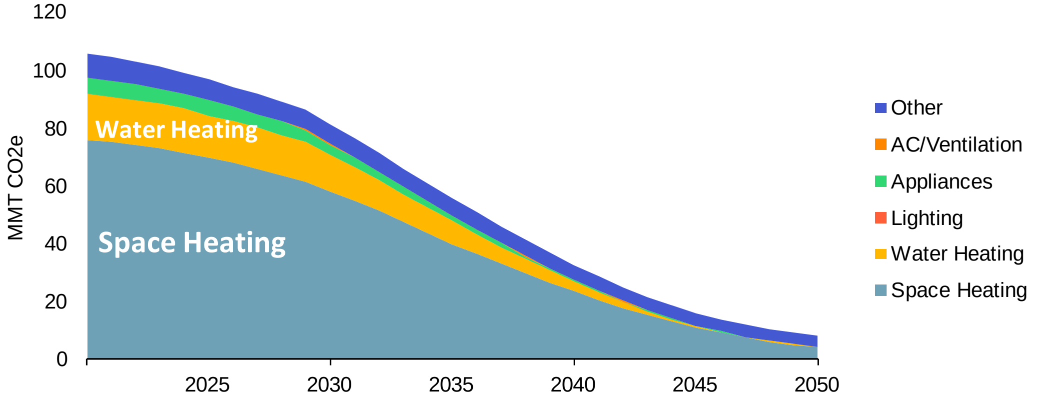
Scenario 1: AP Recommendations

- Building emissions reductions are driven by rapid electrification, increased energy efficiency, and improved building shells
- Rapid adoption of electrified technologies in line with ambitious interpretation of AP recommendations:
  - 100% sales of HPs for all buildings by 2035
  - 34% of residential SH stocks are HPs by 2035, 89% by 2050
  - 33% of commercial SH stocks are HPs by 2035, 93% by 2050
  - 100% sales of electrified end uses for cooking and clothes drying by 2035
  - Reduction in NYC district steam system fuel consumption in line with “Electrification Pathway” from NYC
- Adoption of improved building shells for most new sales by 2035
  - By 2035, 80% of new building shell installations (new and retrofits) implement a shell improvement or retrofit. By 2050, around 65% of buildings have some shell improvements
- Backup heat and GSHP to maintain reliability in critical buildings and mitigate electric sector peak impacts
  - Roughly 20% share of GSHP, 80% ASHP, with greater GSHP share upstate
- Scenario 1 achieves significant emissions reductions relative to 1990:
  - 2030: 23% reductions below 1990 levels
  - 2050: 92% reductions below 1990 levels

Buildings Final Energy Demand by Fuel

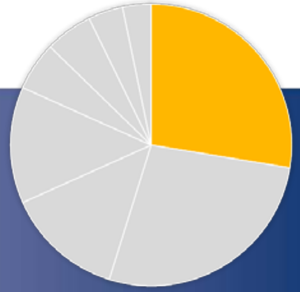


Buildings Emissions by Subsector



2020 is a modelled year, reflecting historical trends

Underlying characterization of key technologies informed by Building Electrification Roadmap analysis

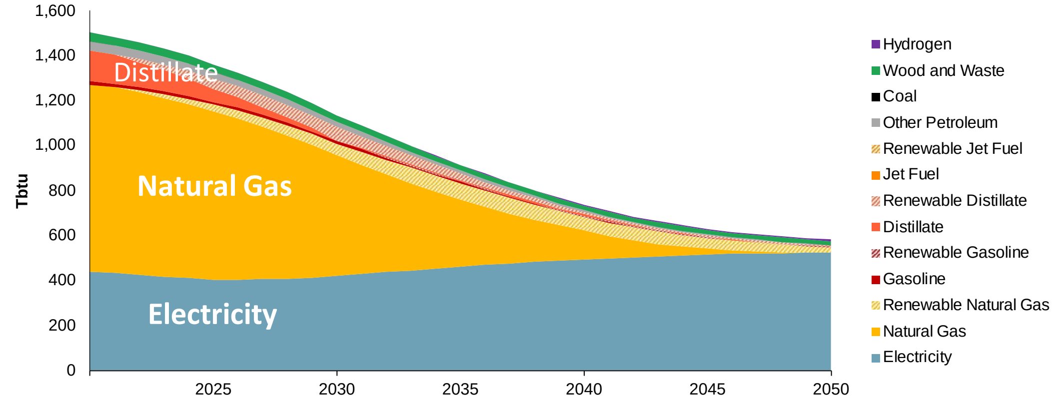


Buildings Sector

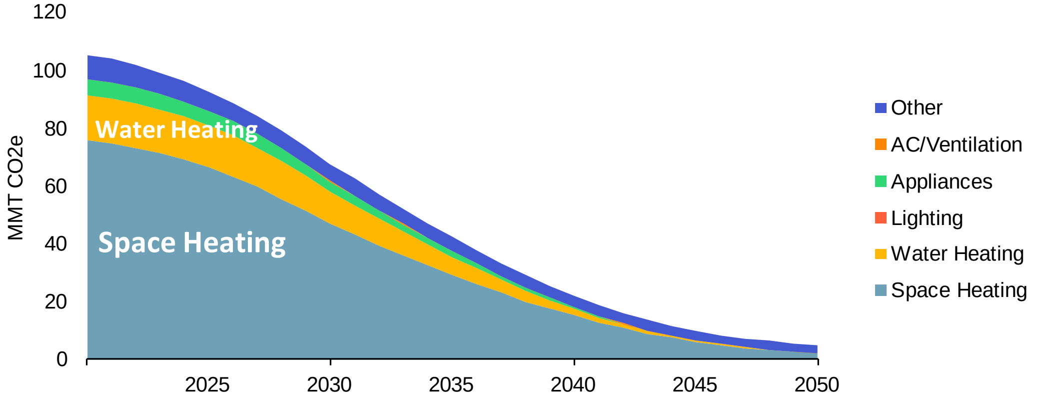
Scenario 2: Strategic Use of Low-Carbon Fuels

- > Building emissions reductions are driven by rapid electrification, increased energy efficiency, and improved building shells
- > Rapid adoption of electrified technologies in line with ambitious interpretation of AP recommendations:
  - 77% sales of HPs by 2029, 100% sales of HPs for all buildings by 2035
    - 41% of residential SH stocks are HPs by 2035, 92% by 2050
    - 47% of commercial SH stocks are HPs by 2035, 94% by 2050
    - 80% ASHP, 20% GSHP, with most ASHP using electric back-up
  - 100% sales of electrified end uses for cooking and clothes drying by 2035
  - NYC District Heat system converts 100% of natural gas use to hydrogen by 2050.
- > Adoption of improved building shells for most new sales by 2035
  - By 2035, 95% of new building shell installations (new and retrofits) implement a shell improvement or retrofit.
    - By 2050, around 92% of building stocks have improved shells
- > Scenario 2 achieves significant emissions reductions relative to 1990:
  - 2030: 36% reductions below 1990 levels
  - 2050: 95% reductions below 1990 levels

Buildings Final Energy Demand by Fuel



Buildings Emissions by Subsector

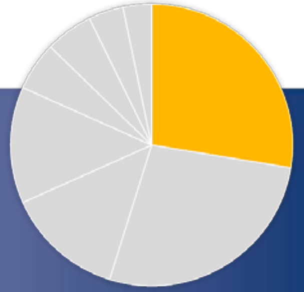


2020 is a modelled year, reflecting historical trends

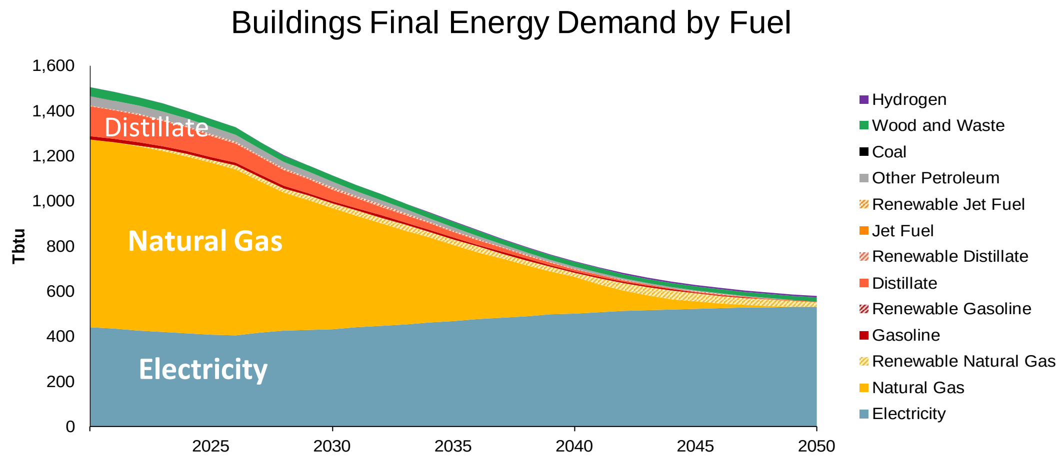
Underlying characterization of key technologies informed by Building Electrification Roadmap analysis

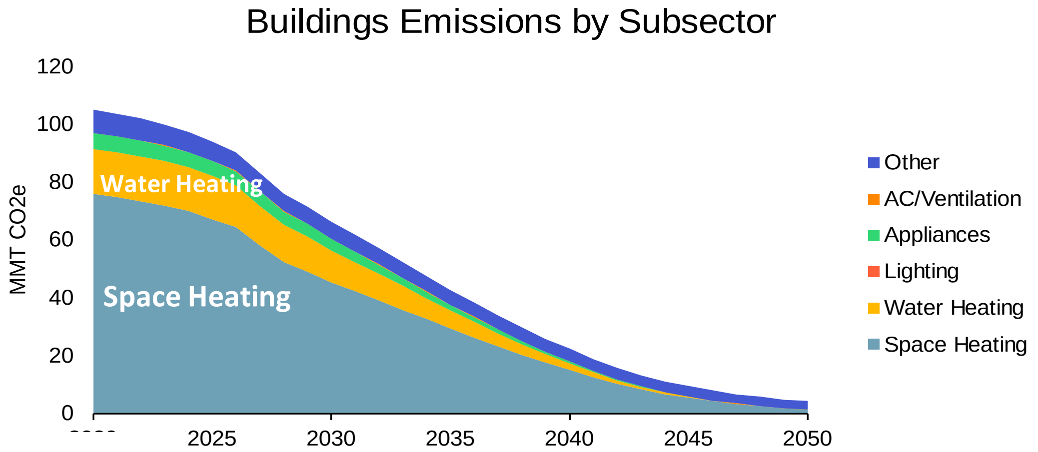
Buildings Sector

Scenario 3: Accelerated Transition Away from Combustion



- > Building emissions reductions are driven by rapid electrification, increased energy efficiency, and improved building shells
- > Rapid adoption of electrified technologies in line with ambitious interpretation of AP recommendations:
  - 80% sales of HPs by 2029, 100% sales of HPs for all buildings by 2035
    - Up to 10% early retirements of fossil stock for residential and commercial space heating by 2030
    - 41% of residential SH stocks are HPs by 2035, 92% by 2050
    - 51% of commercial SH stocks are HPs by 2035, 99% by 2050
    - All ASHP have electric backup, higher share of GSHP than scenario 2
  - 100% sales of electrified end uses for cooking and clothes drying by 2035
  - NYC District Heat system converts 100% of natural gas use to hydrogen by 2050.
- > Adoption of improved building shells for most new sales by 2035
  - By 2035, 95% of new building shell installations (new and retrofits) implement a shell improvement or retrofit.
    - By 2050, around 92% of buildings stocks have improved shells
- > Scenario 3 achieves significant emissions reductions relative to 1990:
  - 2030: 37% reductions below 1990 levels
  - 2050: 96% reductions below 1990 levels





2020 is a modelled year, reflecting historical trends

Underlying characterization of key technologies informed by Building Electrification Roadmap analysis

Buildings Sector

Scenario 4: Beyond 85% Reduction

> Building emissions reductions are driven by rapid electrification, increased energy efficiency, and improved building shells

> Rapid adoption of electrified technologies in line with ambitious interpretation of AP recommendations:

- 80% sales of HPs by 2029, 100% sales of HPs for all buildings by 2035
  - Up to 10% early retirements of fossil stock for residential and commercial space heating by 2030
  - 41% of residential SH stocks are HPs by 2035, 92% by 2050
  - 51% of commercial SH stocks are HPs by 2035, 99% by 2050
  - All ASHP have electric backup, higher share of GSHP than scenario 2
- 100% sales of electrified end uses for cooking and clothes drying by 2035
- NYC District Heat system converts 100% of natural gas use to hydrogen by 2050.

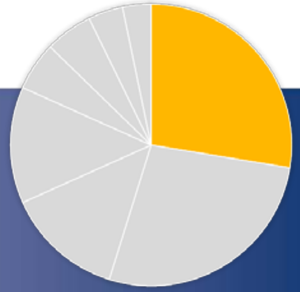
> Adoption of improved building shells for most new sales by 2035

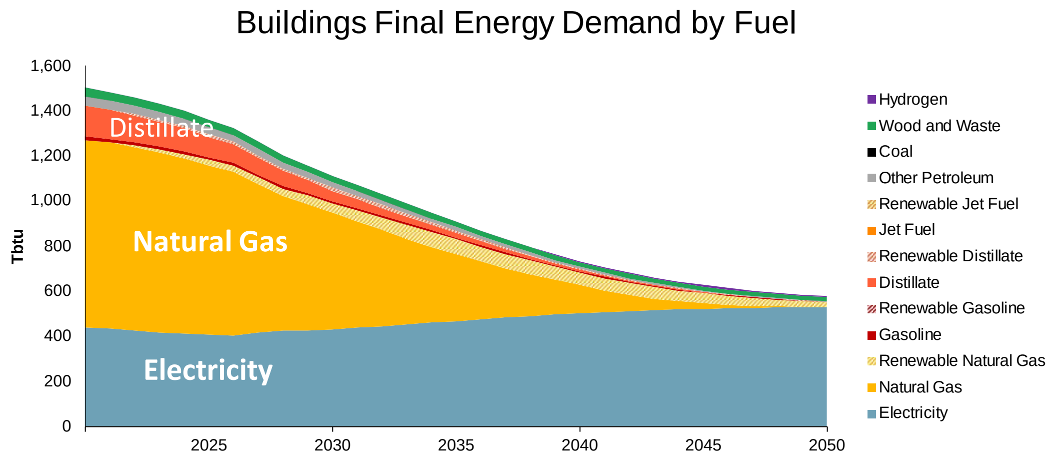
- By 2035, 95% of new building shell installations (new and retrofits) implement a shell improvement or retrofit.
  - By 2050, around 92% of building stocks have improved shells

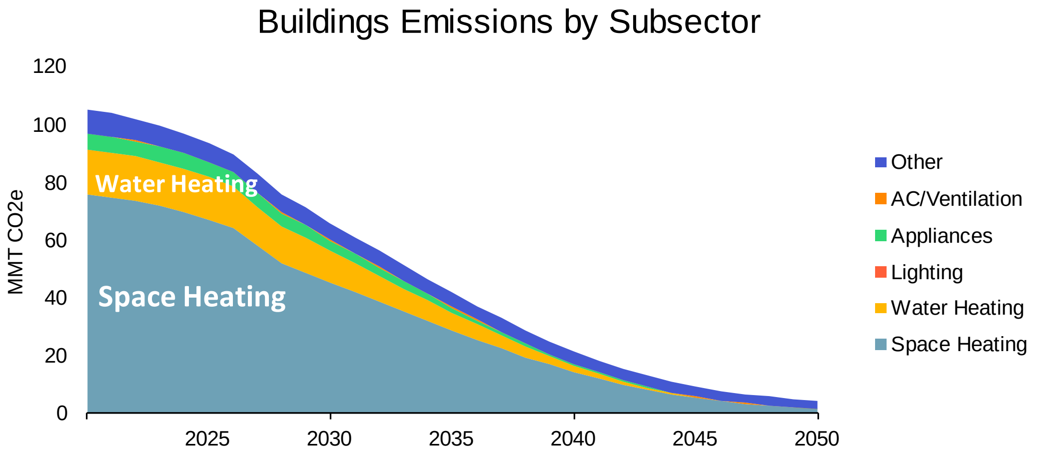
> Scenario 4 achieves significant emissions reductions relative to 1990:

- 2030: 38% reductions below 1990 levels
- 2050: 96% reductions below 1990 levels

Underlying characterization of key technologies informed by Building Electrification Roadmap analysis





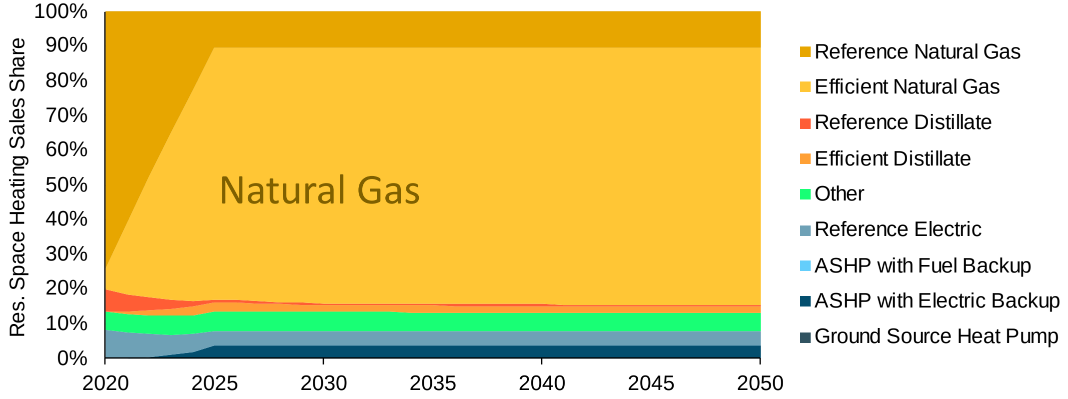


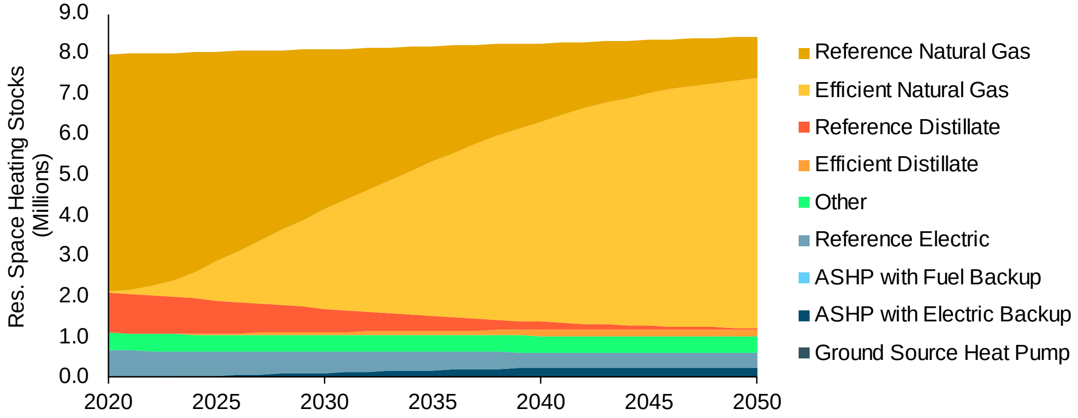
2020 is a modelled year, reflecting historical trends

Key Technology Adoption in Buildings

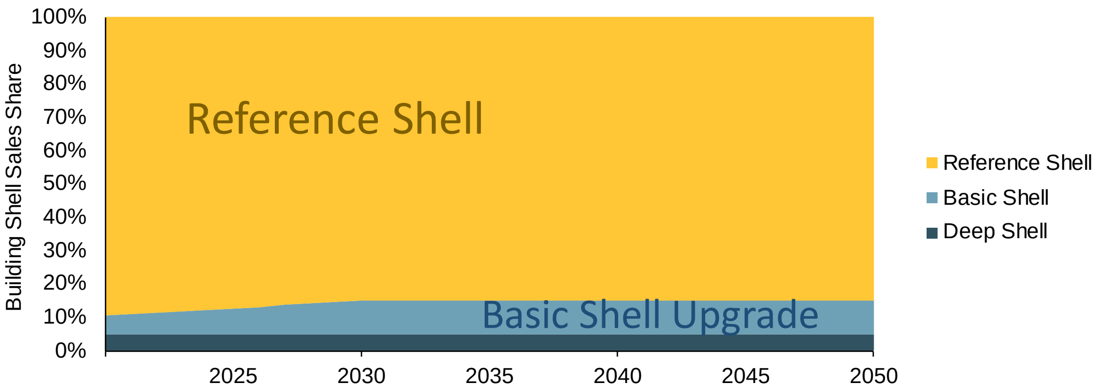
Reference Case

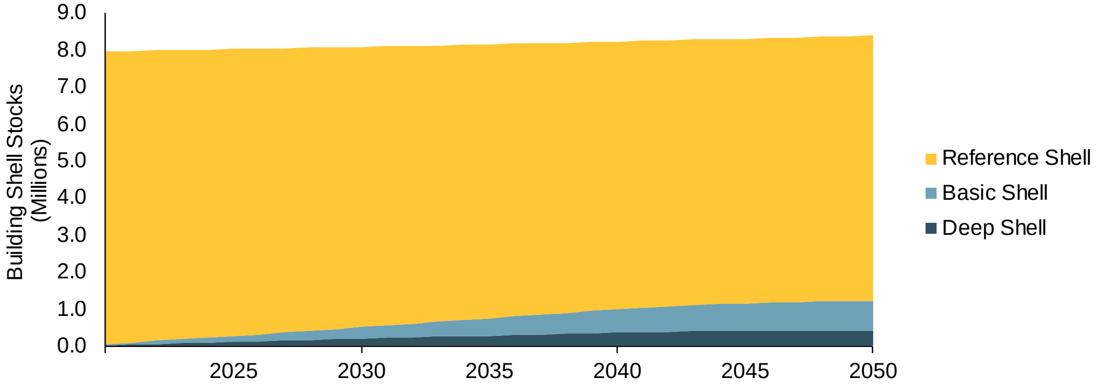
Residential Space Heating





Residential Building Shell



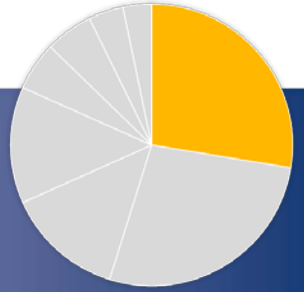


Basic Shell Definition: **27-44**% reduction in building space heating and **14-27%** AC demands
Deep Shell Definition: **57-90**% reduction in building space heating and **9-57%** AC demands

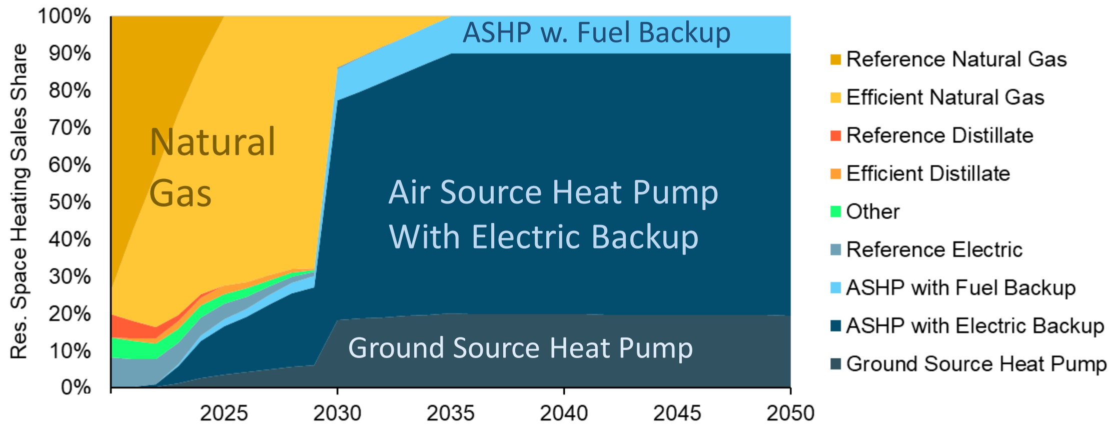
2020 is a modelled year, reflecting historical trends

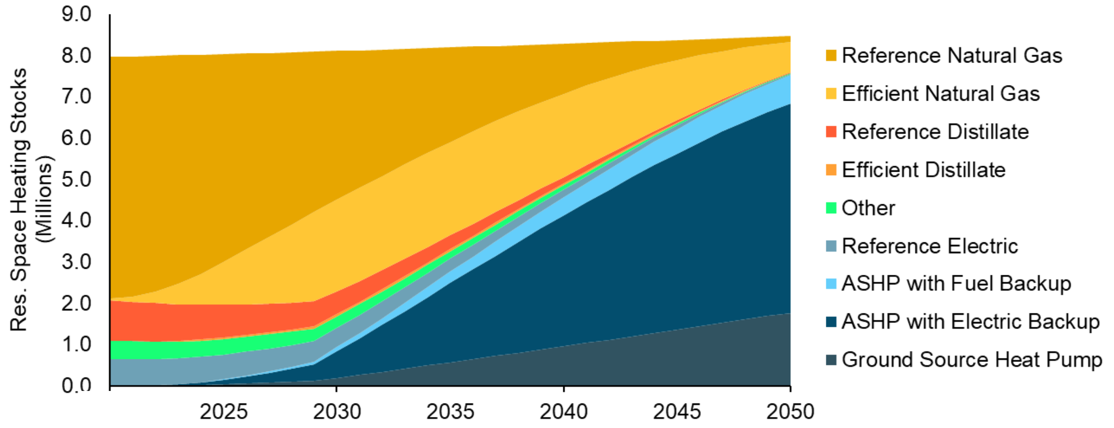
Key Technology Adoption in Buildings

Scenario 1: AP Recommendations

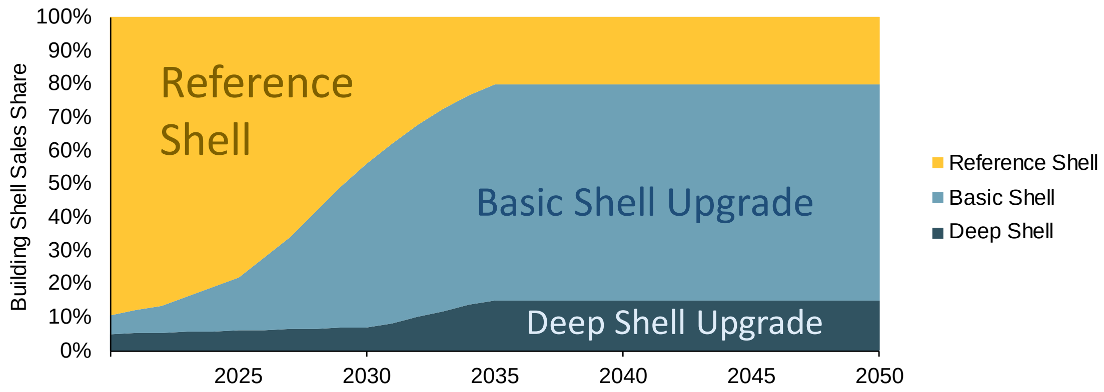


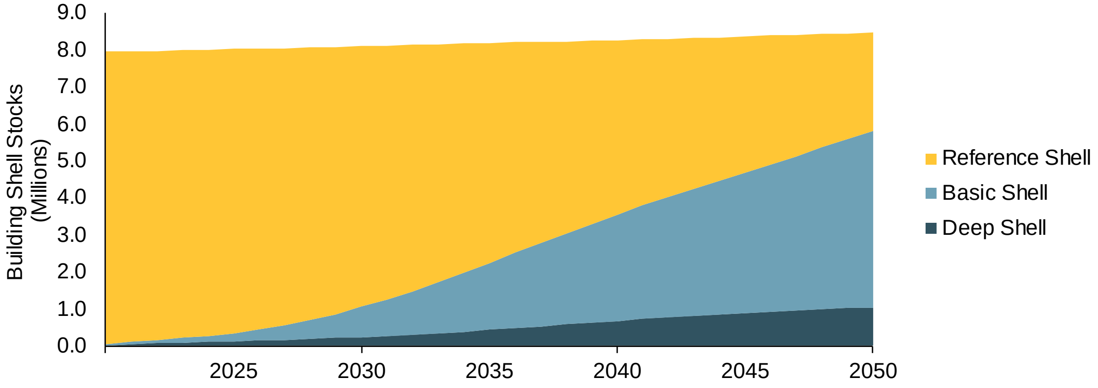
Residential Space Heating





Residential Building Shell





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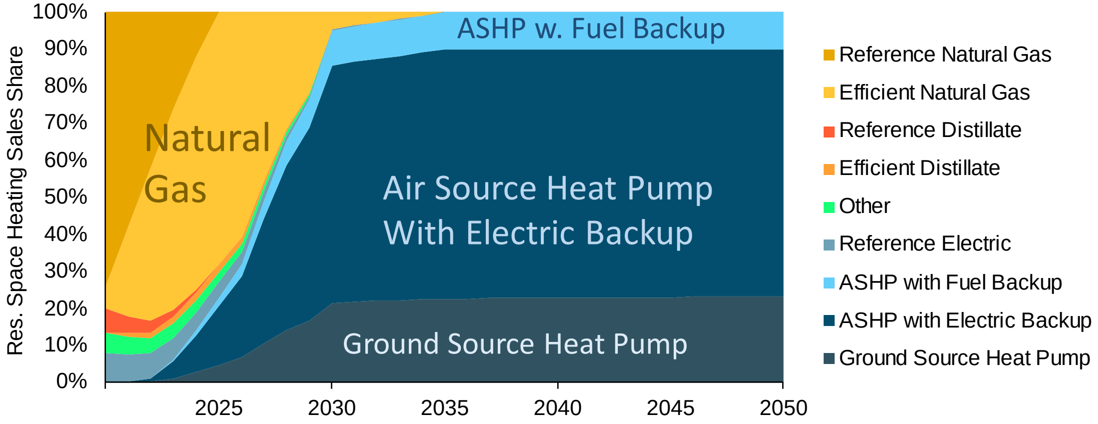
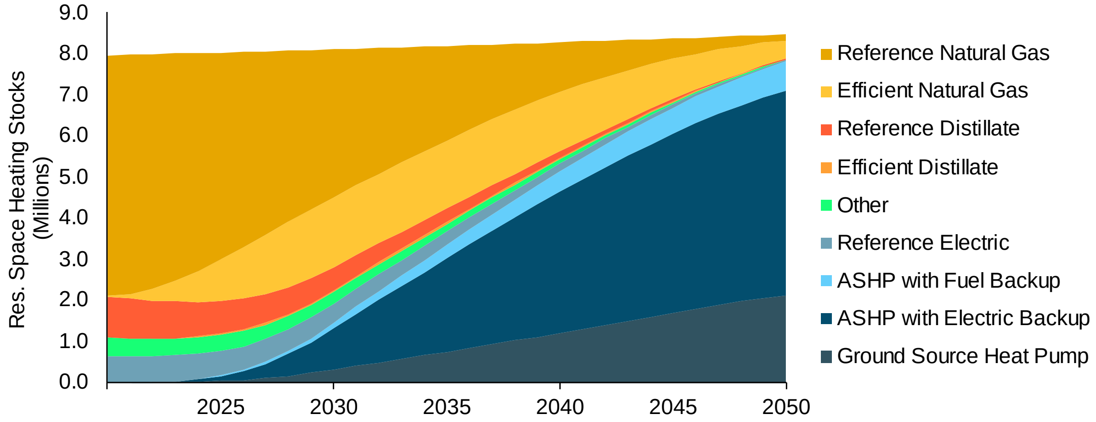
2020 is a modelled year, reflecting historical trends

Key Technology Adoption in Buildings

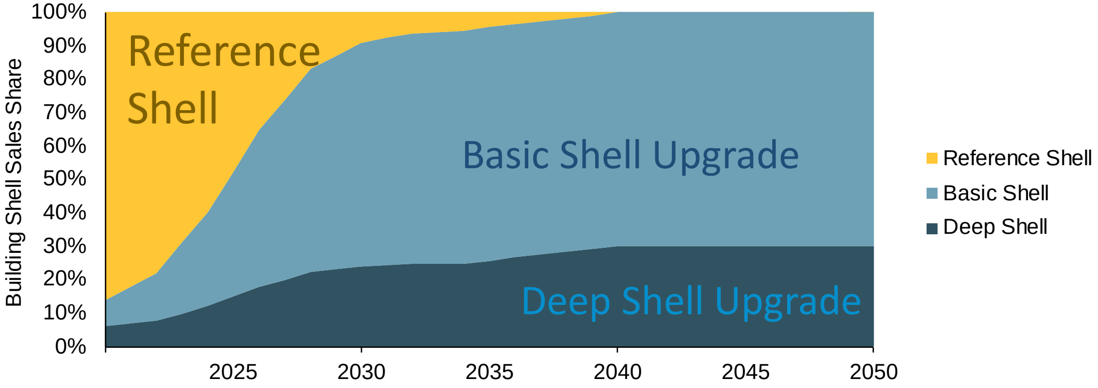
Scenario 2: Strategic Use of Low-Carbon Fuels

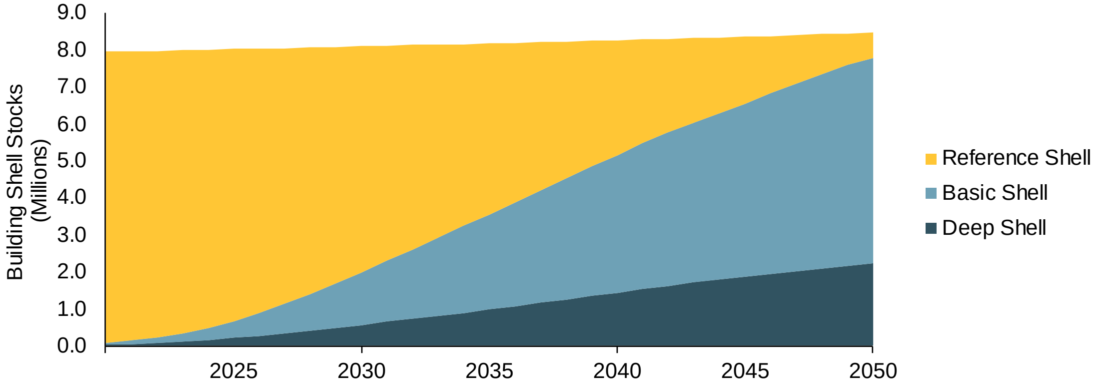
Residential Space Heating





Residential Building Shell





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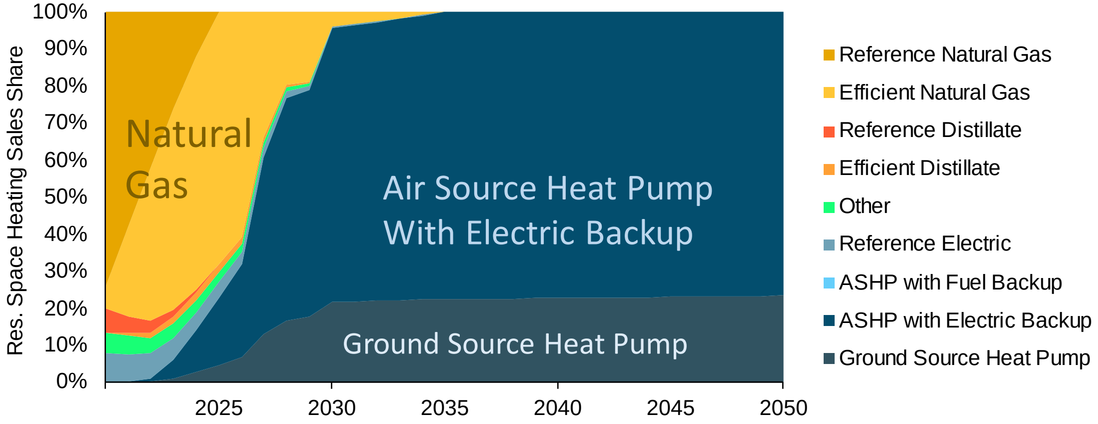
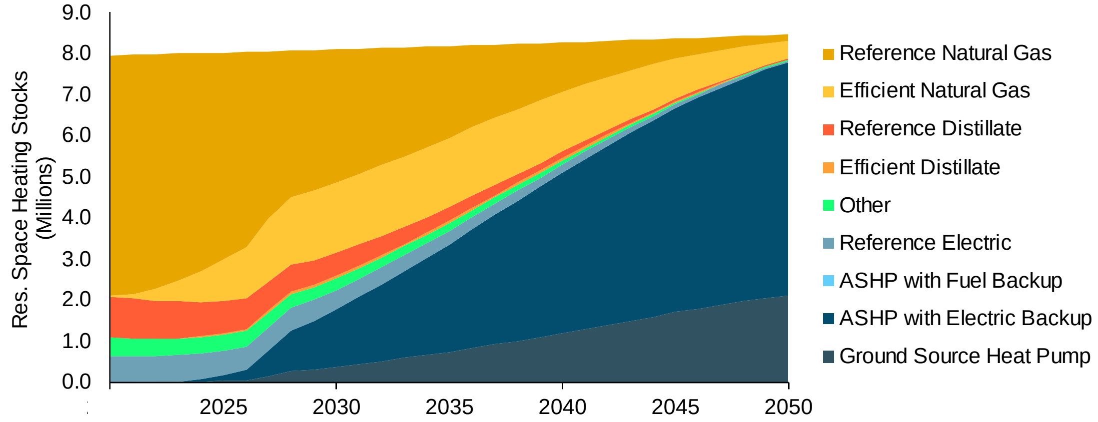
Key Technology Adoption in Buildings

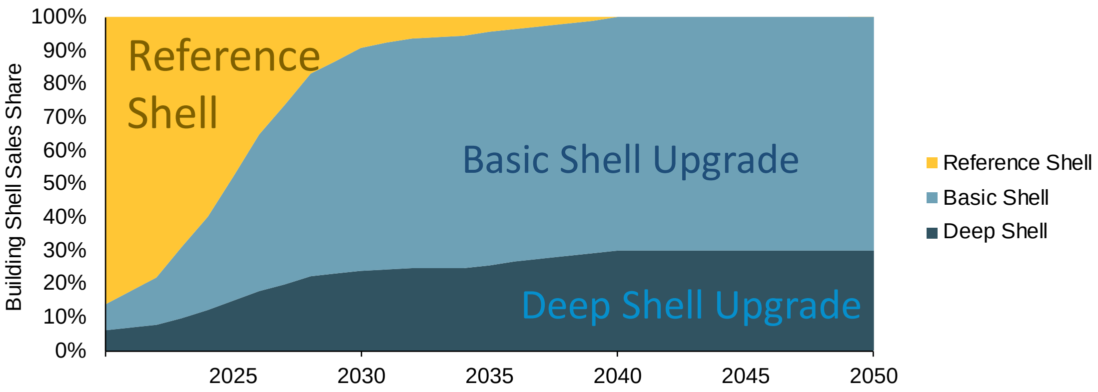
Scenario 3: Accelerated Transition Away from Combustion

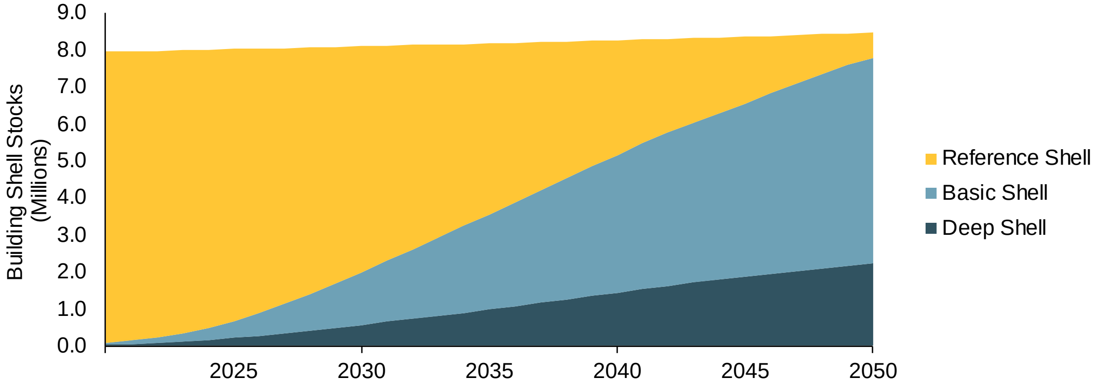
Residential Space Heating





Residential Building Shell





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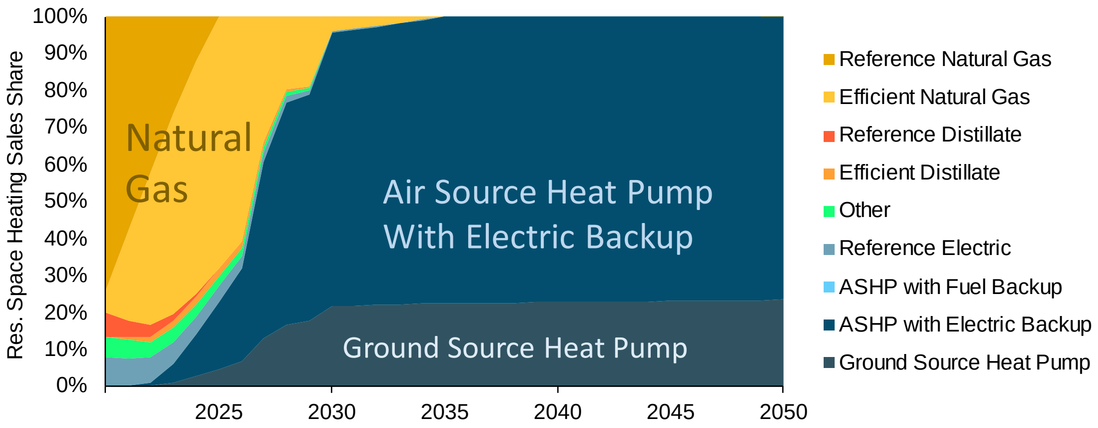
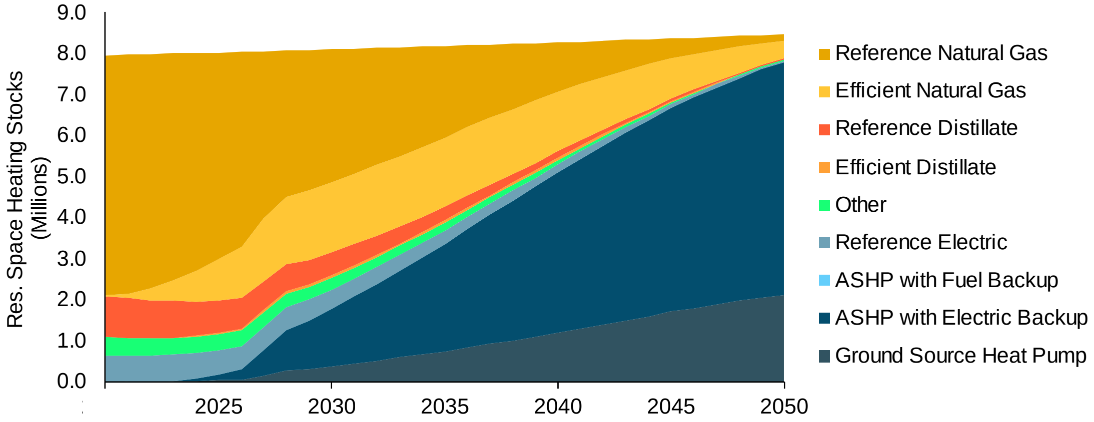
Key Technology Adoption in Buildings

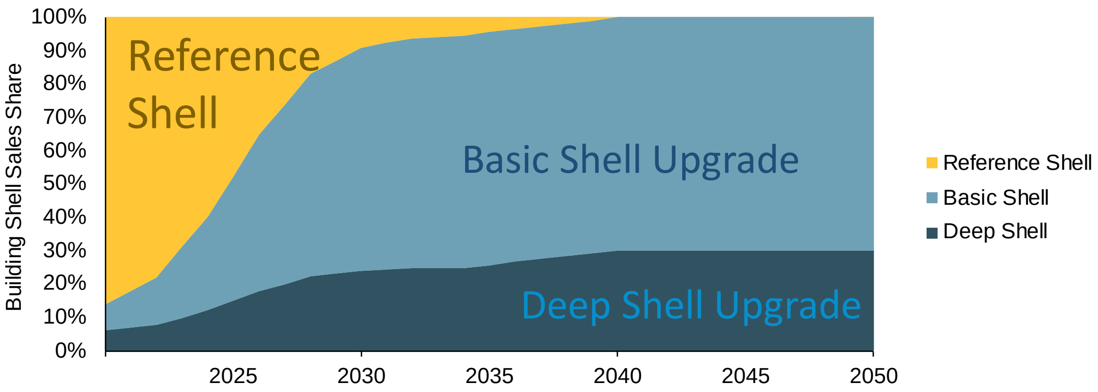
Scenario 4: Beyond 85% Reduction

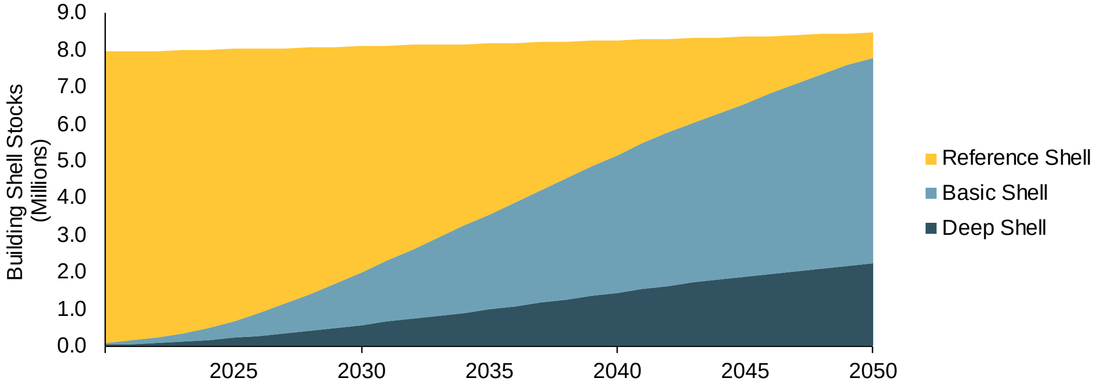
Residential Space Heating





Residential Building Shell





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Key Technology Adoption in Buildings

Reference Case

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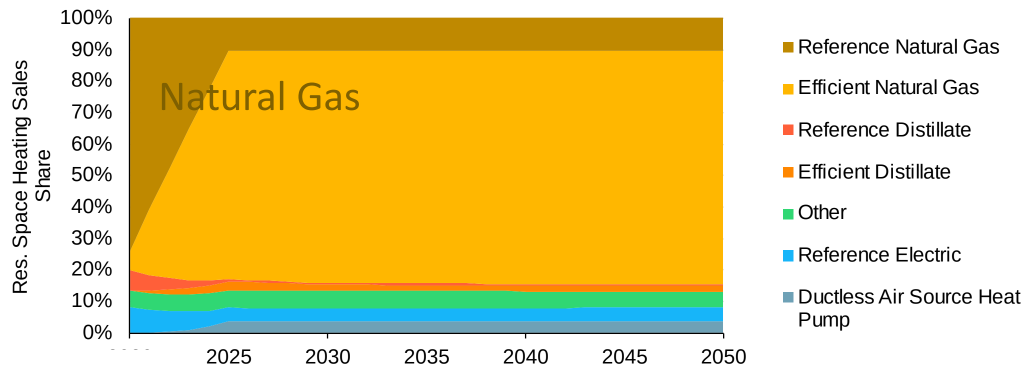
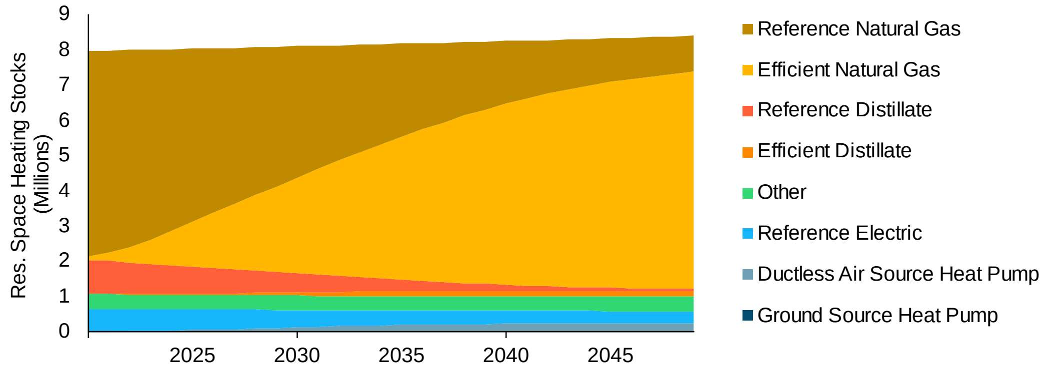
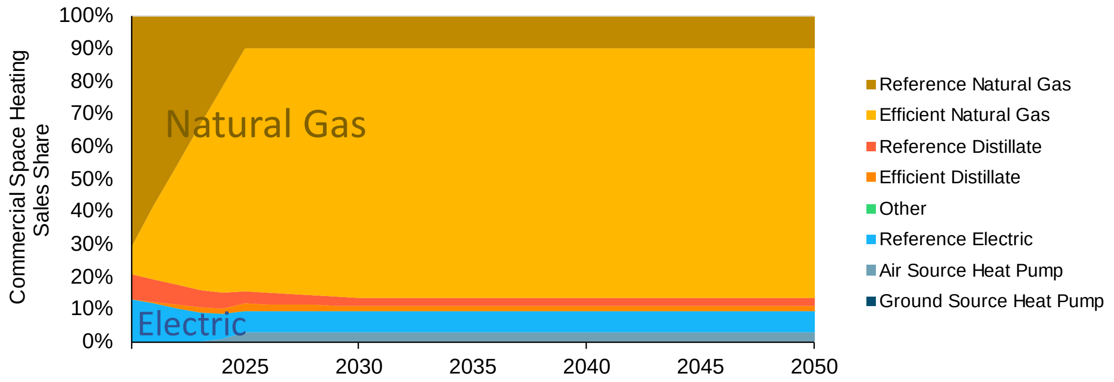
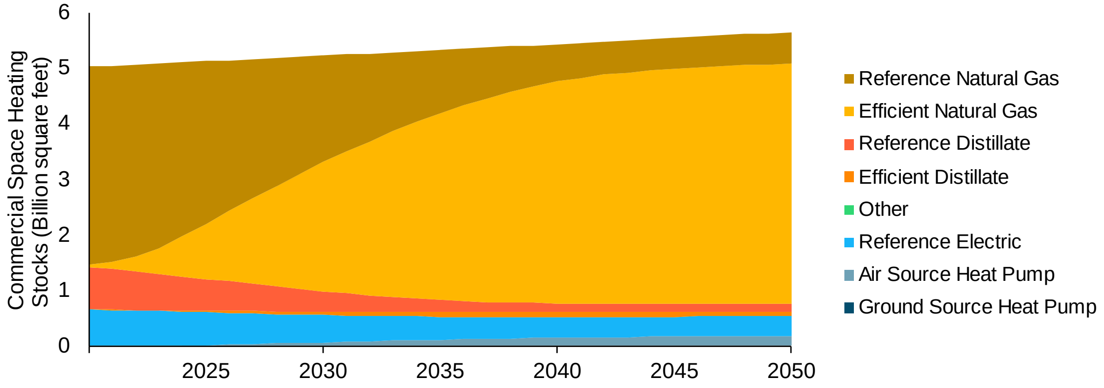




Commercial Space Heating





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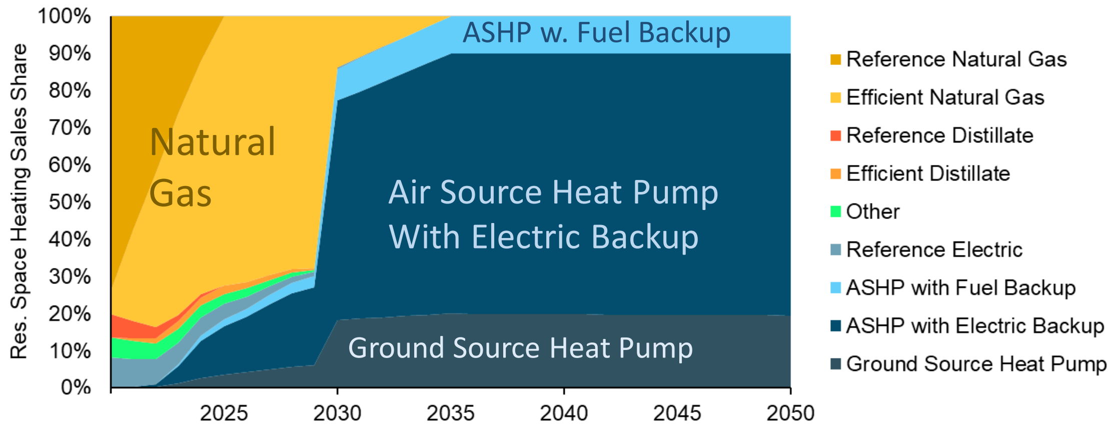
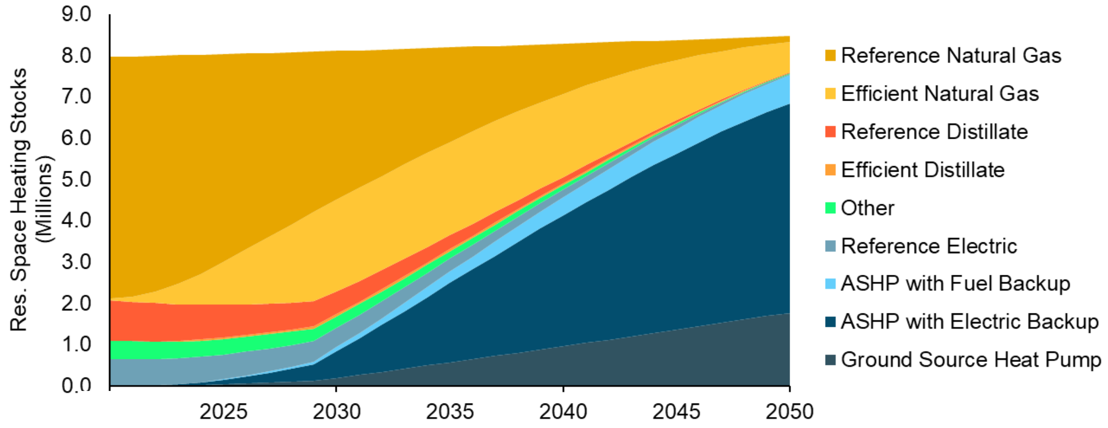
Key Technology Adoption in Buildings

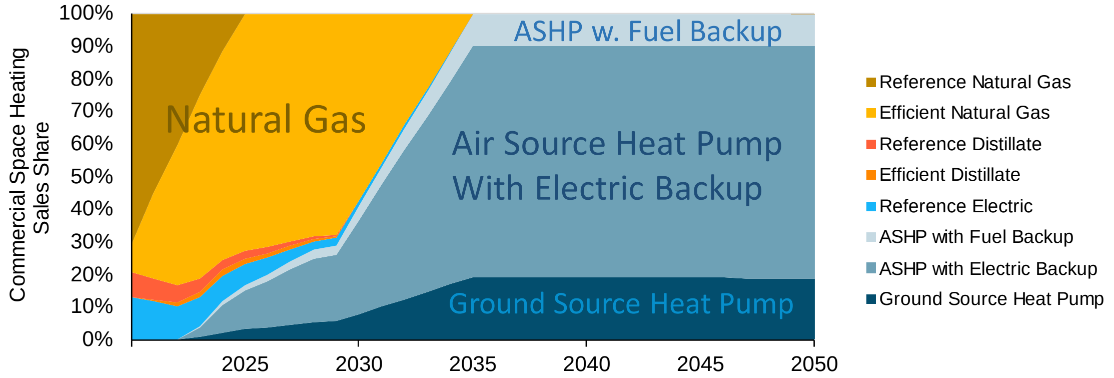
Scenario 1: AP Recommendations

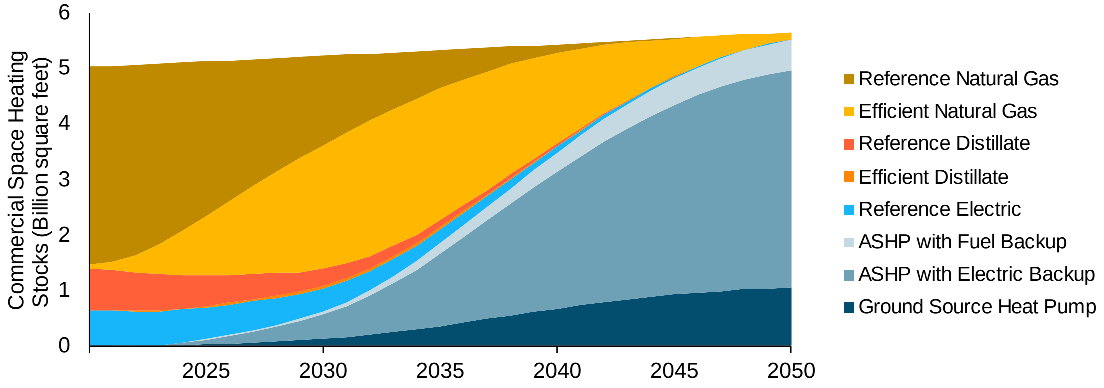
Residential Space Heating





Commercial Space Heating



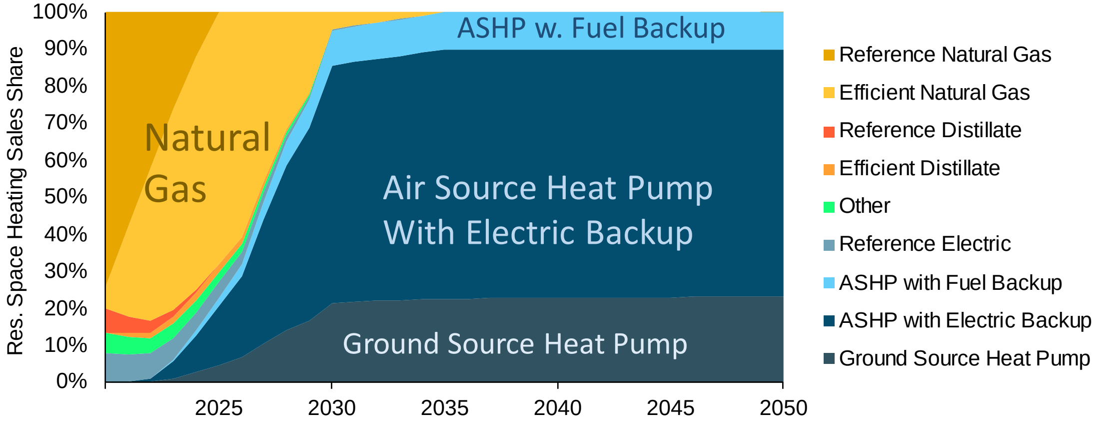


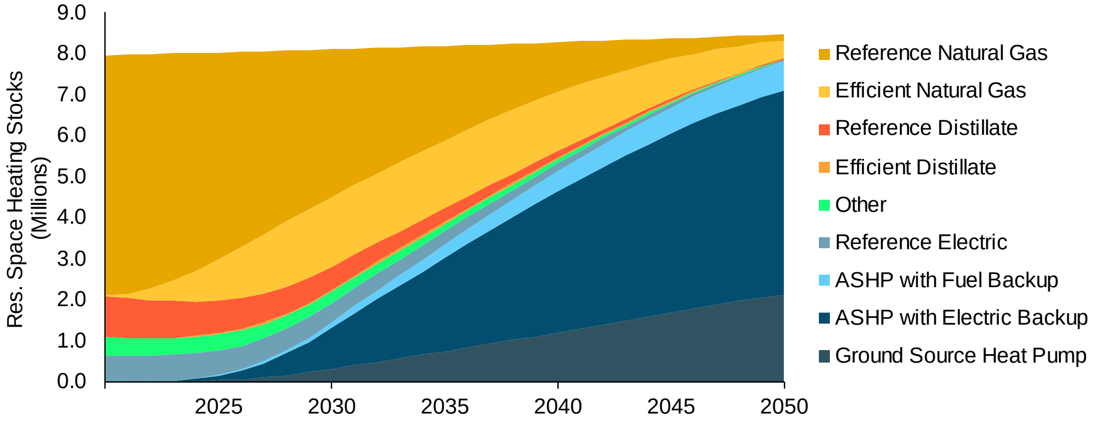
2020 is a modelled year, reflecting historical trends

Key Technology Adoption in Buildings

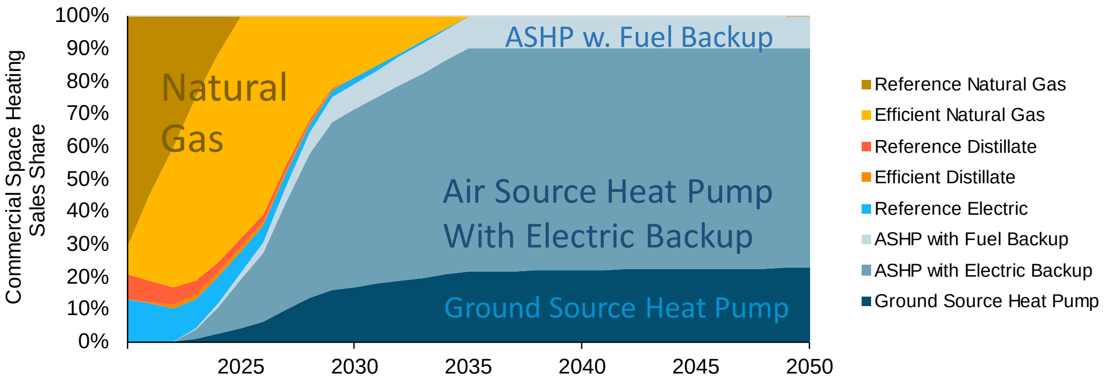
Scenario 2: Strategic Use of Low-Carbon Fuels

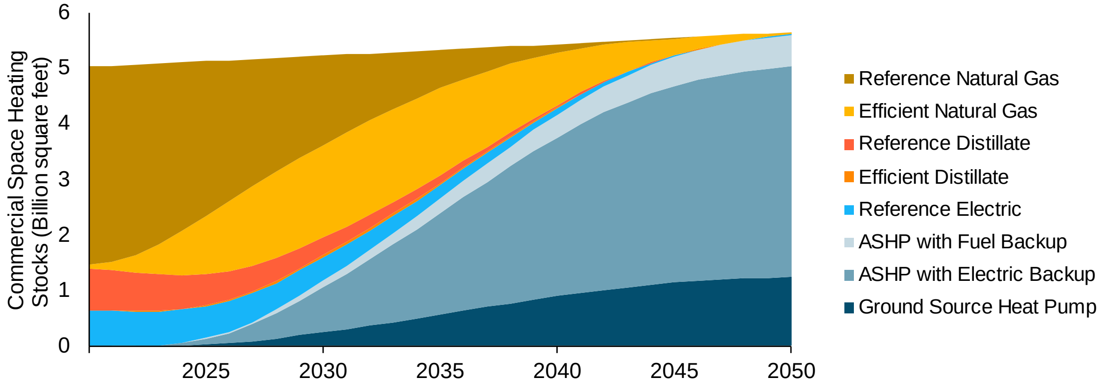
Residential Space Heating





Commercial Space Heating





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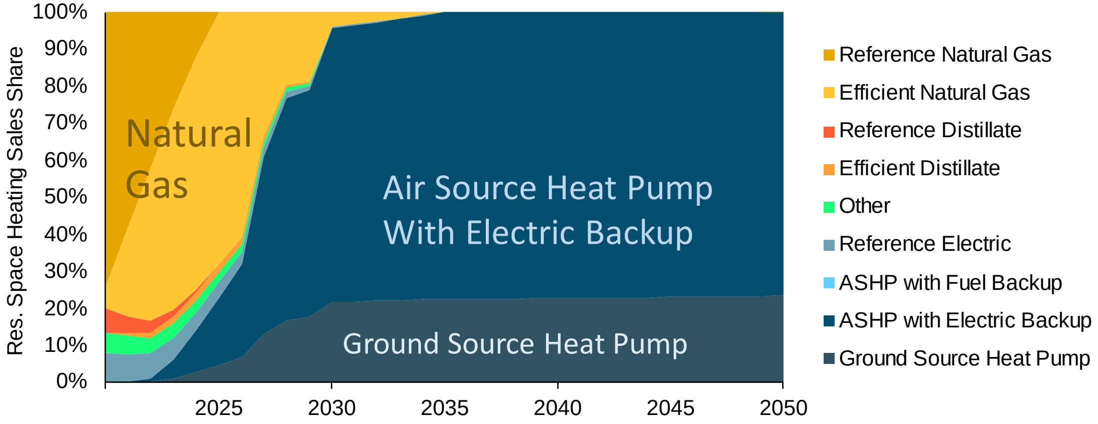
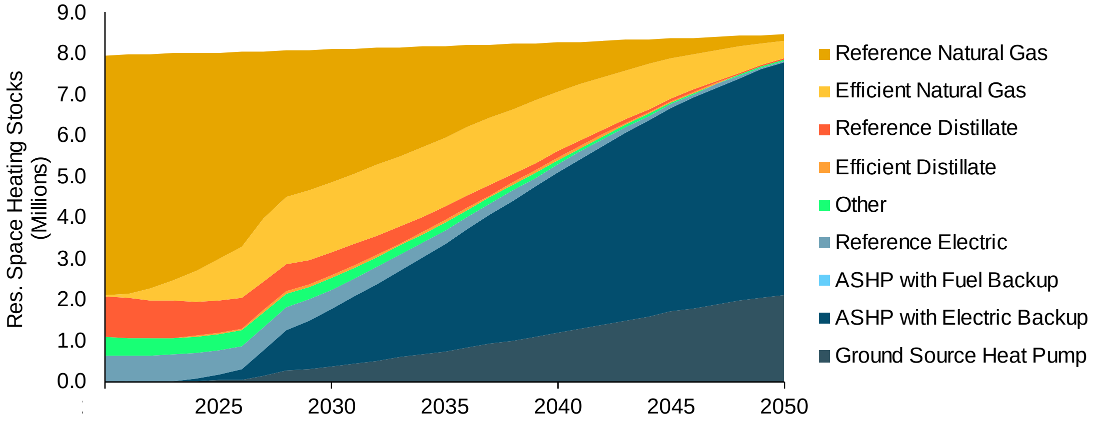
Key Technology Adoption in Buildings

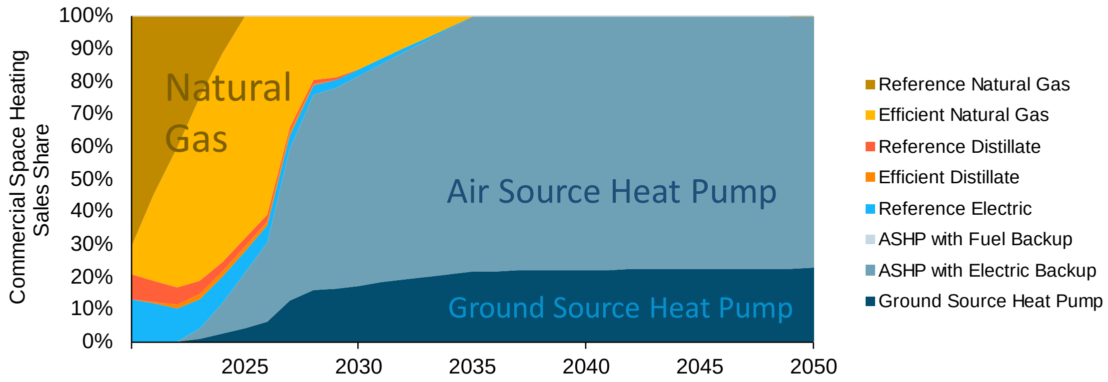
Scenario 3: Accelerated Transition Away from Combustion

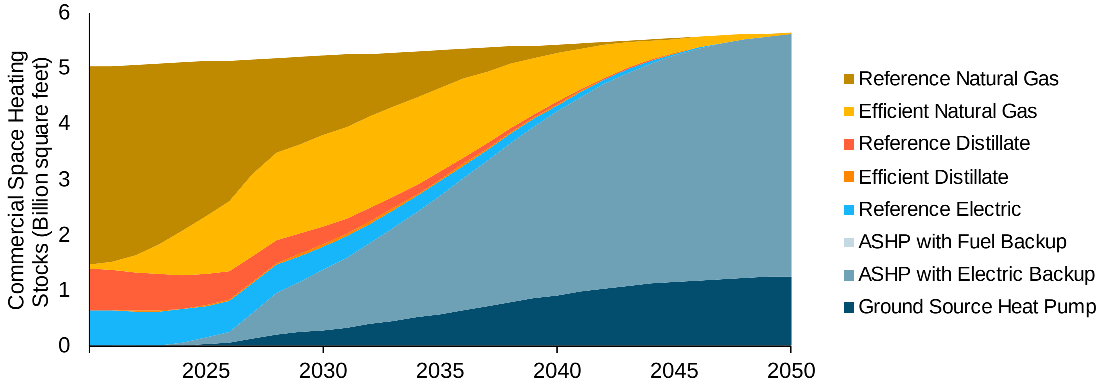
Residential Space Heating





Commercial Space Heating



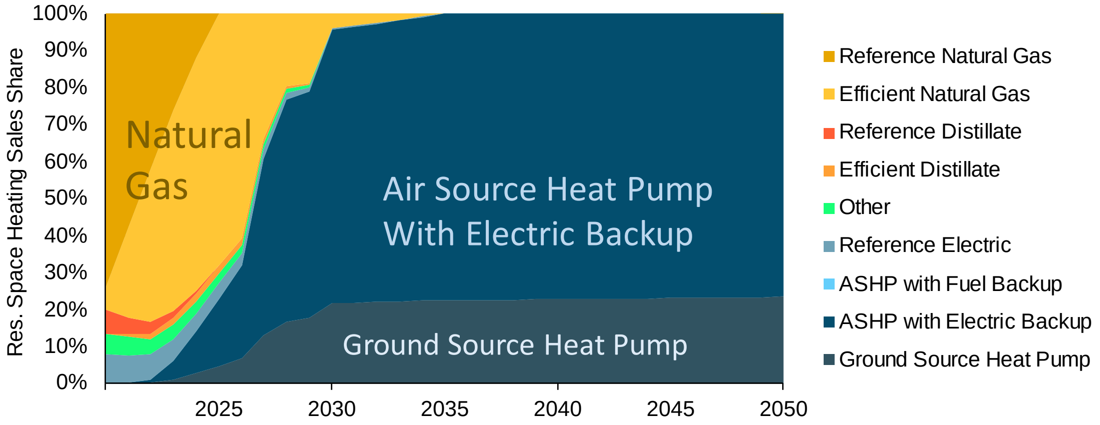


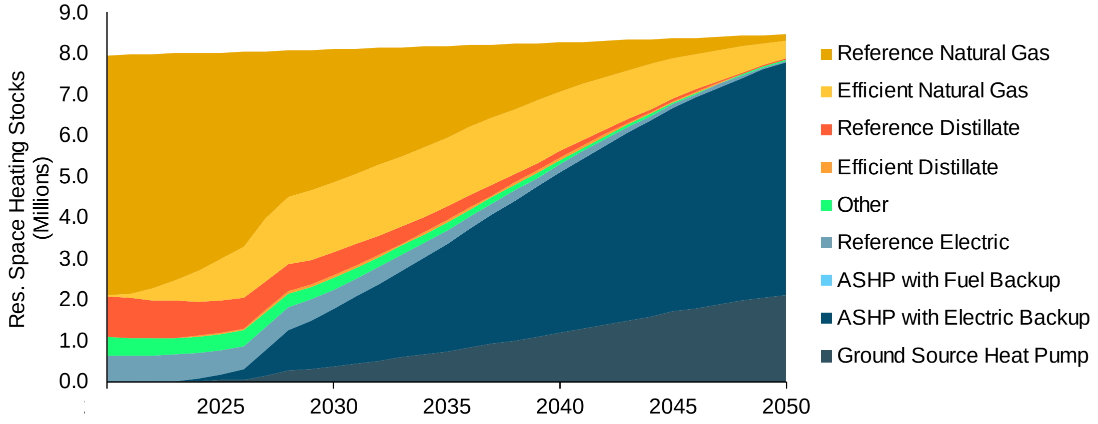
2020 is a modelled year, reflecting historical trends

Key Technology Adoption in Buildings

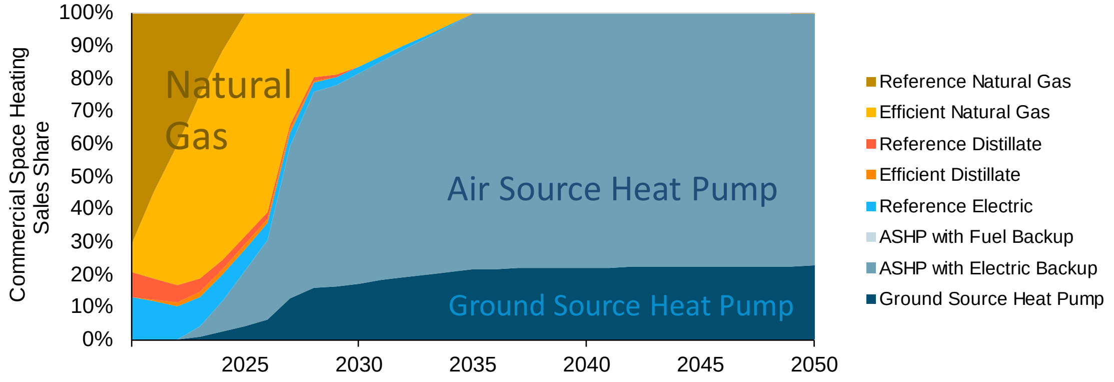
Scenario 4: Beyond 85% Reduction

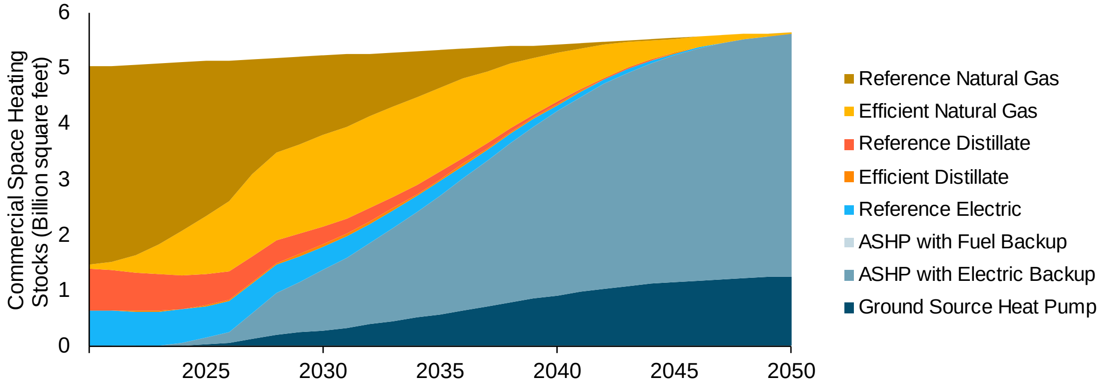
Residential Space Heating





Commercial Space Heating

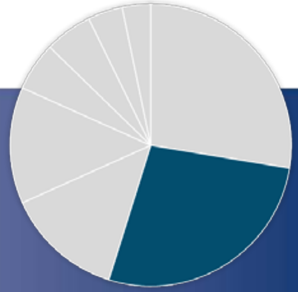




2020 is a modelled year, reflecting historical trends

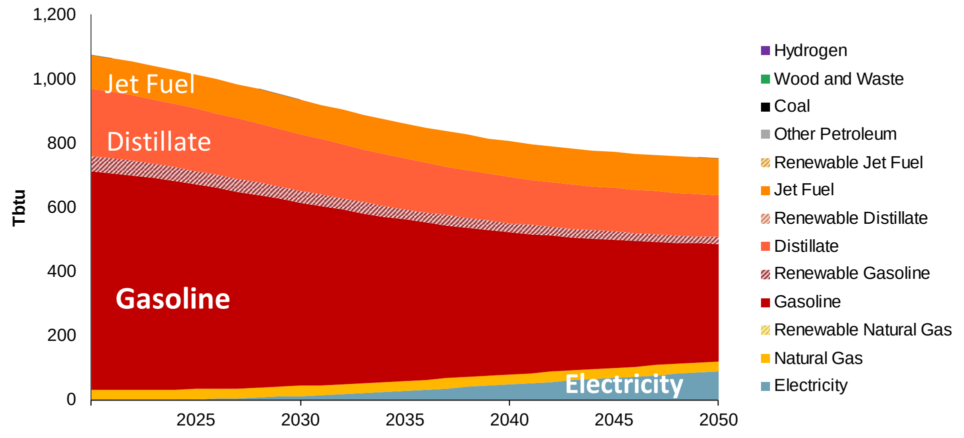
Transportation Sector

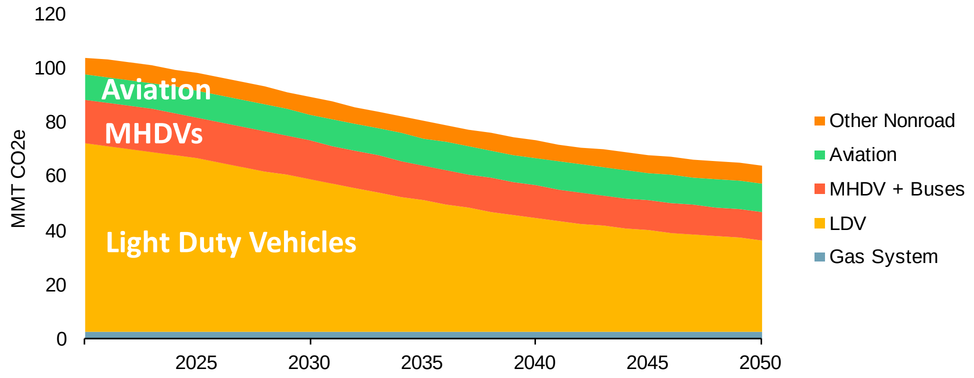
Reference Case



Key Drivers

- > Vehicle ownership and driving patterns drive energy use and emissions
  - The number of vehicles within the state is projected to grow with population (0.19%/year), but vehicle-miles traveled (VMT) is projected to grow more quickly (0.85%/year)
- > Fuel efficiency improvements from Federal CAFE standards reduce gasoline consumption
- > Light duty vehicles start to transition to battery electric technology in line with NY's ZEV mandate and subsequent market adoption
- > As the economy continues to grow, demand for aviation, shipping, rail, and port energy use is projected to increase
- > Reference case achieves emissions reductions relative to 1990:
  - 2030: 10% decrease relative to 1990
  - 2050: 36% decrease relative to 1990





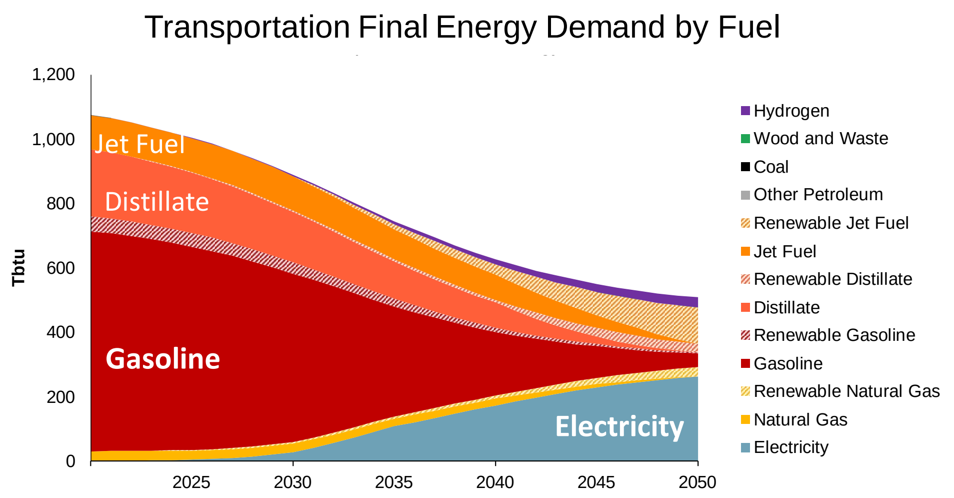
2020 is a modelled year, reflecting historical trends

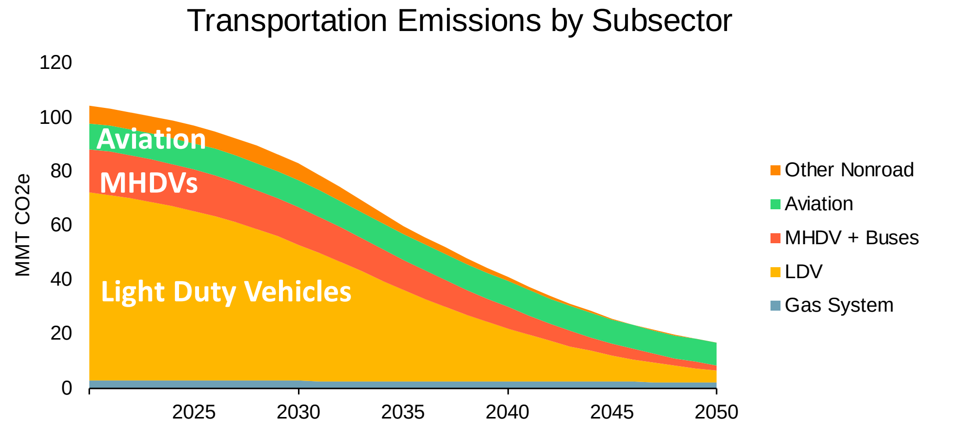
Key driver and underlying technology assumptions informed by Transportation Roadmap analysis

Transportation Sector

Scenario 1: AP Recommendations

- Light duty vehicles transition to battery electric technology
  - 70% of new sales are ZEVs by 2030, 100% by 2035
  - 14% of stocks are ZEVs by 2030, 93% by 2050
- Medium and heavy-duty vehicles are slower to transition, and rely on a combination of battery electric and hydrogen fuel cell technologies
  - 40% of new sales are ZEVs by 2030, 100% by 2045
  - 50/50 split BEV/FCEV for HDVs
  - 7% of stocks are ZEVs by 2030, 76% by 2050
- Reduction in vehicle miles travelled due to transit, transportation demand management, telework, mixed-use development, and complete streets policies drives emission reductions
  - 6% lower for LDV than the Reference in 2035 and 2050
- Scenario 1 achieves significant emissions reductions relative to 1990:
  - 2030: 17% reductions below 1990 levels
  - 2050: 83% reductions below 1990 levels





2020 is a modelled year, reflecting historical trends

Key driver and underlying technology assumptions informed by Transportation Roadmap analysis

Transportation Sector

Scenario 2: Strategic Use of Low-Carbon Fuels

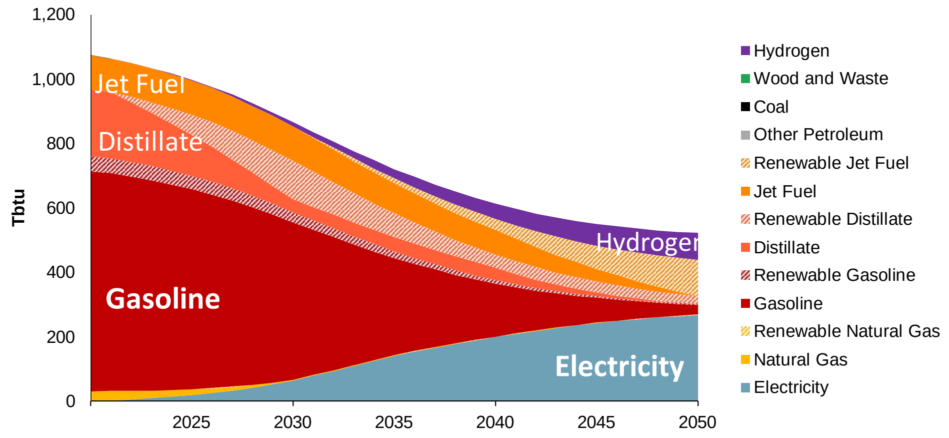
> Light duty vehicles transition to battery electric technology
  - 90% of new sales are ZEVs by 2030, 100% by 2035
  - 21% of stocks are ZEVs by 2030, 95% by 2050

> Medium and heavy-duty vehicles are slower to transition, and rely on a combination of battery electric and hydrogen fuel cell technologies
  - 40% of new sales are ZEVs by 2030, 100% by 2045
  - 50/50 split BEV/FCEV for MDVs, 25/75 for HDVs
  - 7% of stocks are ZEVs by 2030, 76% by 2050

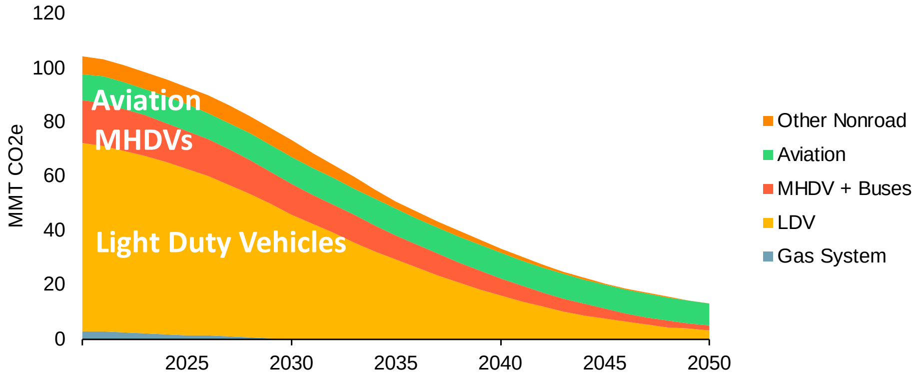
> Reduction in vehicle miles travelled due to transit, transportation demand management, telework, mixed-use development, and complete streets policies drives emission reductions
  - 6% lower for LDV than the Reference in 2035 and 2050

> Scenario 2 achieves significant emissions reductions relative to 1990:
  - 2030: 27% reductions below 1990 levels
  - 2050: 87% reductions below 1990 levels

Transportation Final Energy Demand by Fuel



Transportation Emissions by Subsector



2020 is a modelled year, reflecting historical trends

Key driver and underlying technology assumptions informed by Transportation Roadmap analysis

Transportation Sector

Scenario 3: Accelerated Transition Away from Combustion

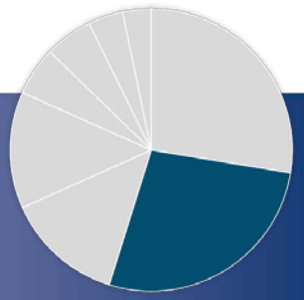
> Light duty vehicles transition to battery electric technology
- 98% of new sales are ZEVs by 2030, 100% by 2035
  - 10% early retirements of fossil stock by 2030
  - 26% of stocks are ZEVs by 2030, 95% by 2050

> Medium and heavy-duty vehicles are slower to transition, and rely on a combination of battery electric and hydrogen fuel cell technologies
- 50% of new MDV sales are ZEVs by 2030, 100% by 2045
  - 75/25 for MDVs
- 40% of new HDV sales are ZEVs by 2030, 100% by 2045
  - 50/50 split BEV/FCEV for HDVs
- 9% of MHDV stocks are ZEVs by 2030, 85% by 2050

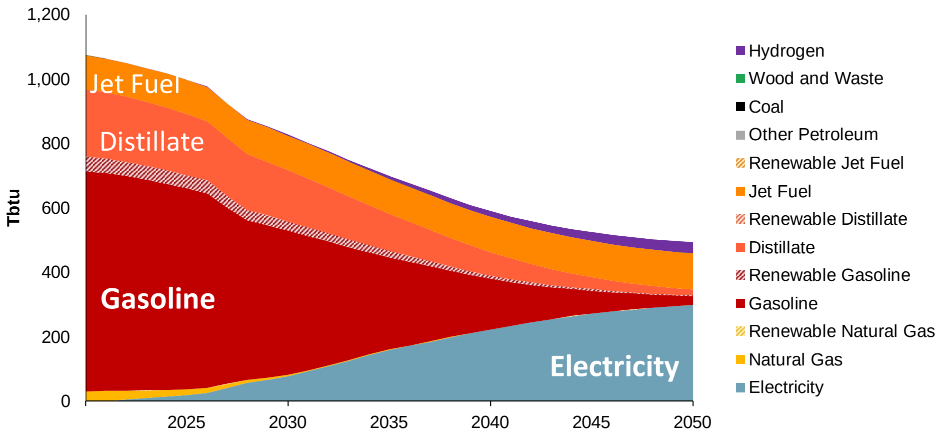
> Reduction in vehicle miles travelled due to transit, transportation demand management, telework, mixed-use development, and complete streets policies drives emission reductions
- 6% lower for LDV than the Reference in 2035 and 2050

> Scenario 3 achieves significant emissions reductions relative to 1990:
- 2030: 28% reductions below 1990 levels
- 2050: 85% reductions below 1990 levels

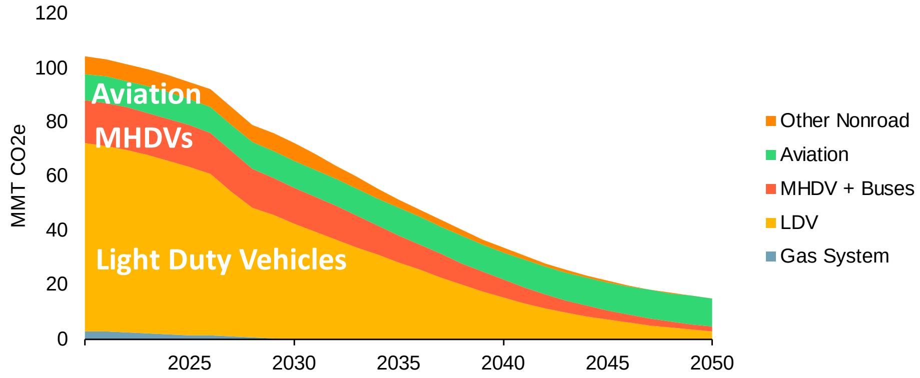
Key driver and underlying technology assumptions informed by Transportation Roadmap analysis



Transportation Final Energy Demand by Fuel



Transportation Emissions by Subsector



2020 is a modelled year, reflecting historical trends

Transportation Sector

Scenario 4: Beyond 85% Reduction

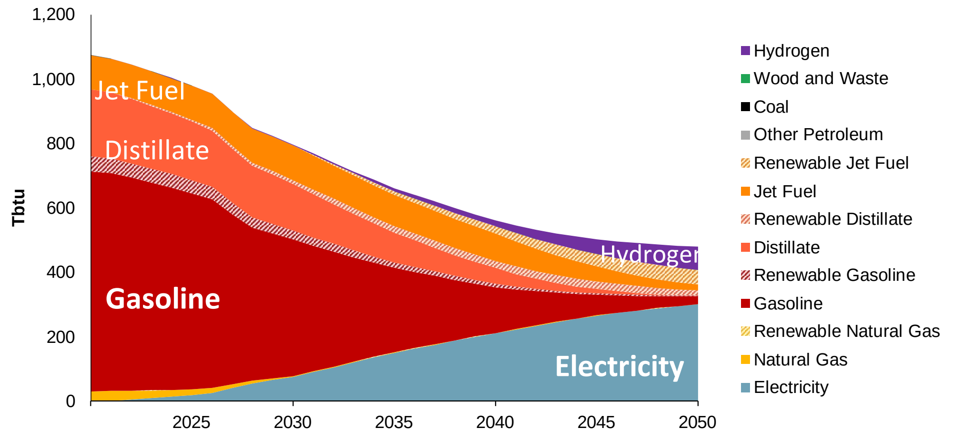
> Light duty vehicles transition to battery electric technology
- 98% of new sales are ZEVs by 2030, 100% by 2035
  - 10% early retirements of fossil stock by 2030
  - 26% of stocks are ZEVs by 2030, 95% by 2050

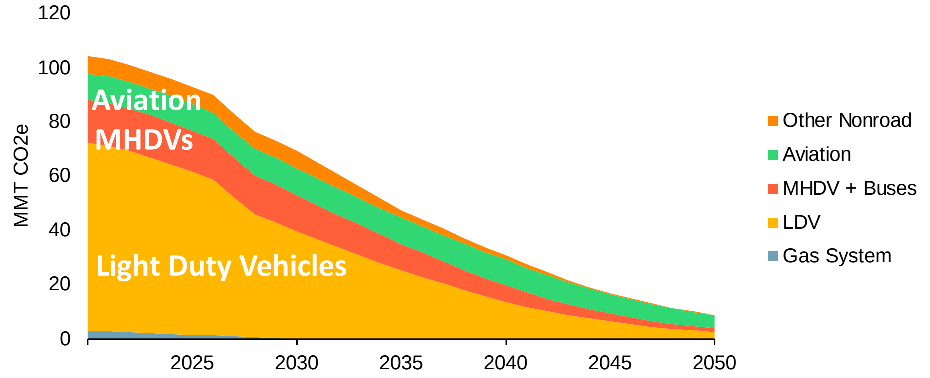
> Medium and heavy-duty vehicles are slower to transition, and rely on a combination of battery electric and hydrogen fuel cell technologies
- 50% of new MDV sales are ZEVs by 2030, 100% by 2045
  - 75/25 for MDVs
- 40% of new HDV sales are ZEVs by 2030, 100% by 2045
  - 50/50 split BEV/FCEV for HDVs
- 9% of MHDV stocks are ZEVs by 2030, 85% by 2050

> Reduction in vehicle miles travelled due to greater ambition in transit, transportation demand management, telework, mixed-use development, and complete streets policies drives emission reductions
- 15% lower for LDV than the Reference in 2035 and 2050

> Electric short-haul aviation (16% by 2050), 50% hydrogen aviation

> Scenario 4 achieves significant emissions reductions relative to 1990:
- 2030: 31% reductions below 1990 levels
- 2050: 91% reductions below 1990 levels





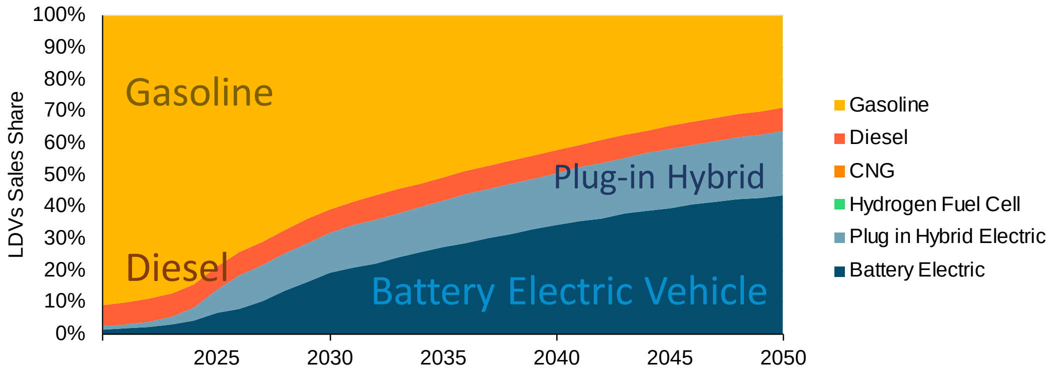
2020 is a modelled year, reflecting historical trends

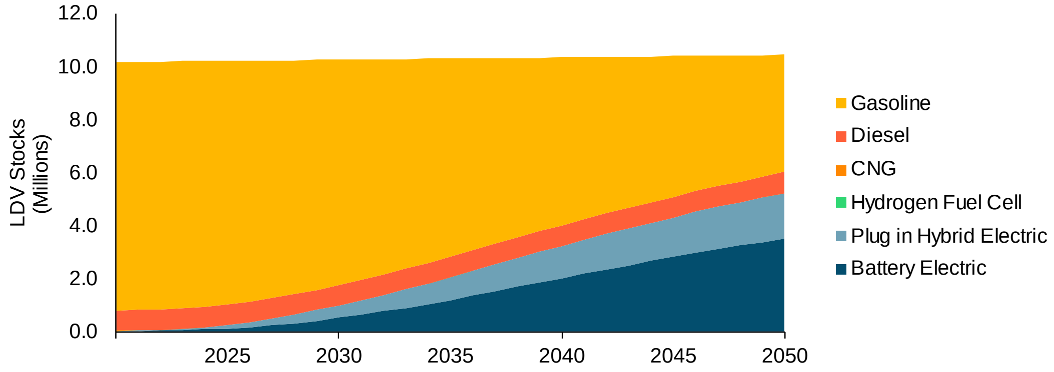
Key driver and underlying technology assumptions informed by Transportation Roadmap analysis

Transportation Stock Rollover

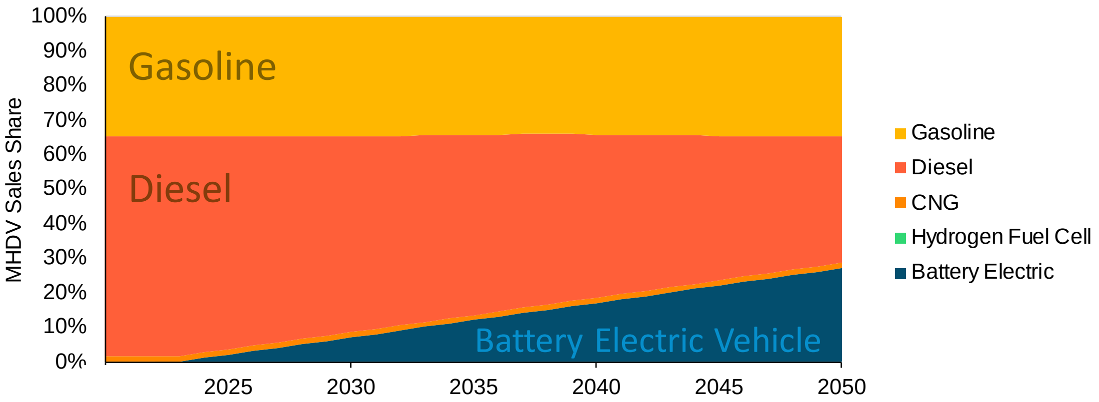
Reference Case

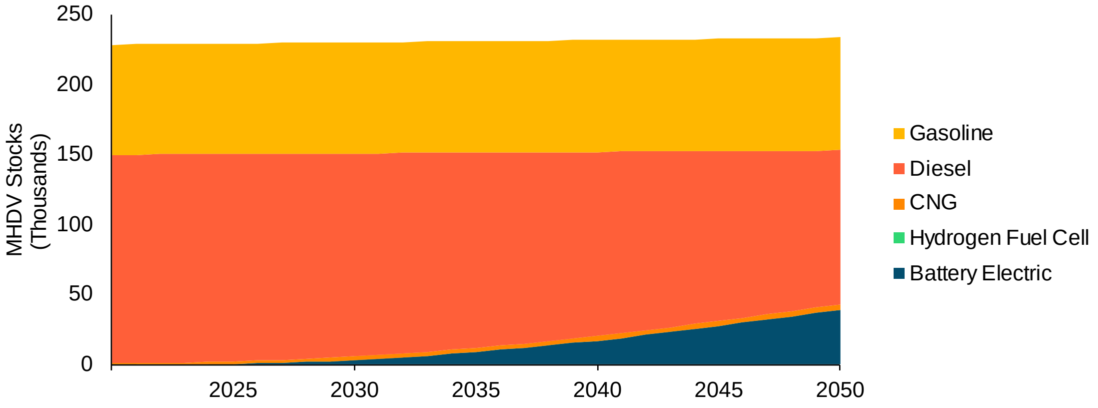
Light Duty Vehicles





Medium and Heavy Duty Vehicles



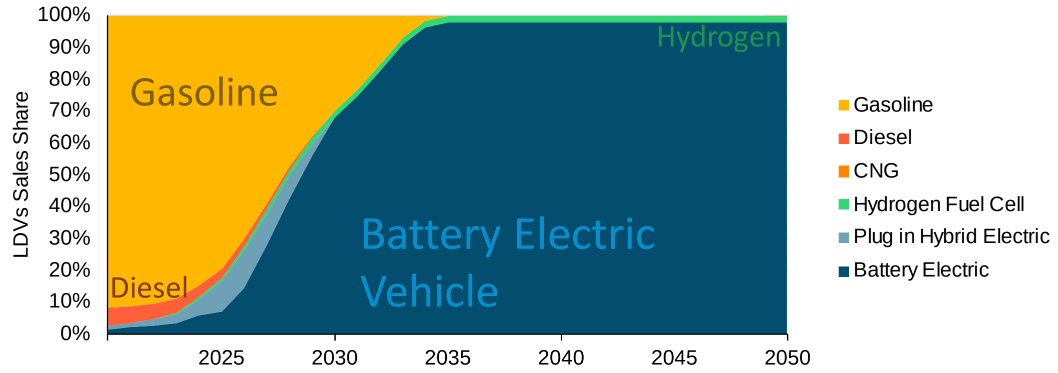


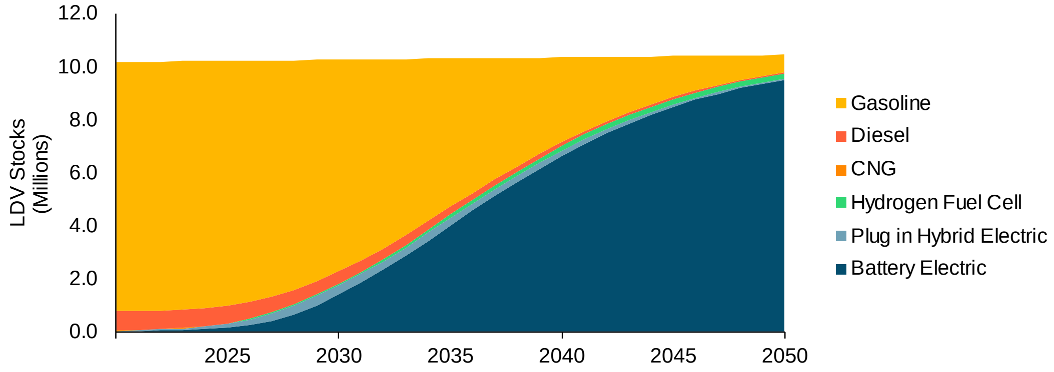
2020 is a modelled year, reflecting historical trends

Transportation Stock Rollover

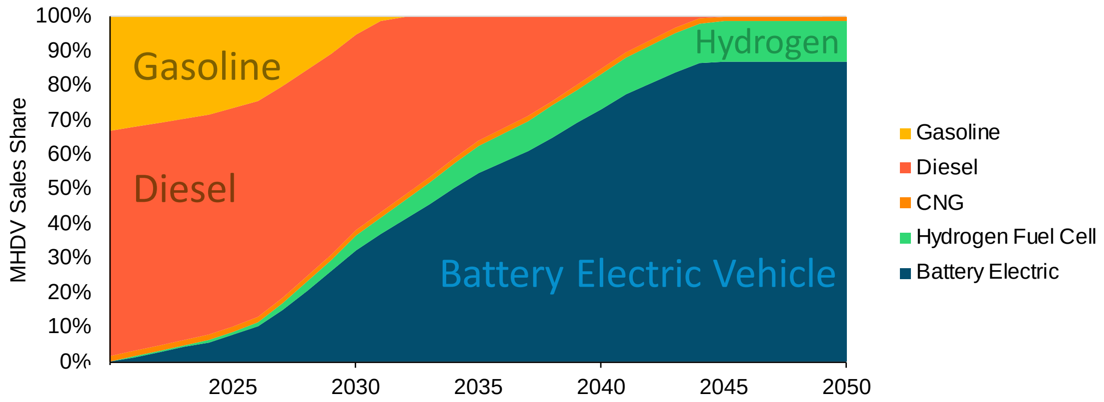
Scenario 1: AP Recommendations

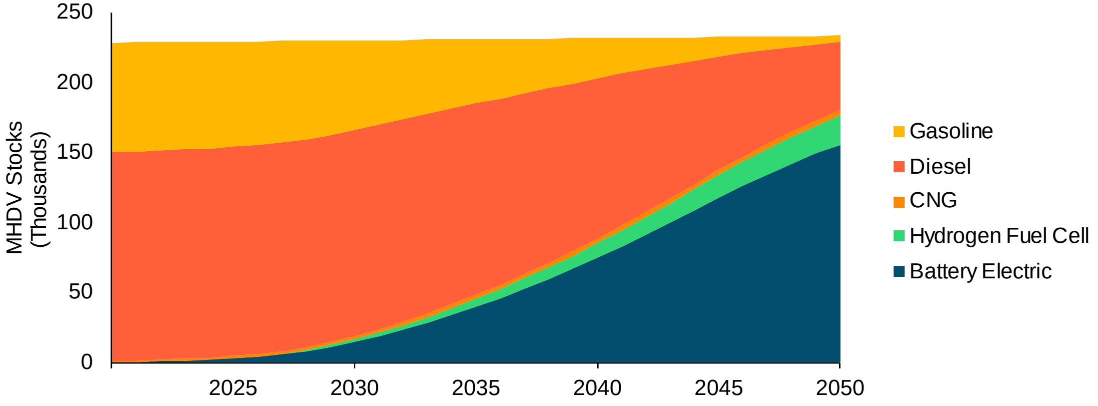
Light Duty Vehicles





Medium and Heavy Duty Vehicles



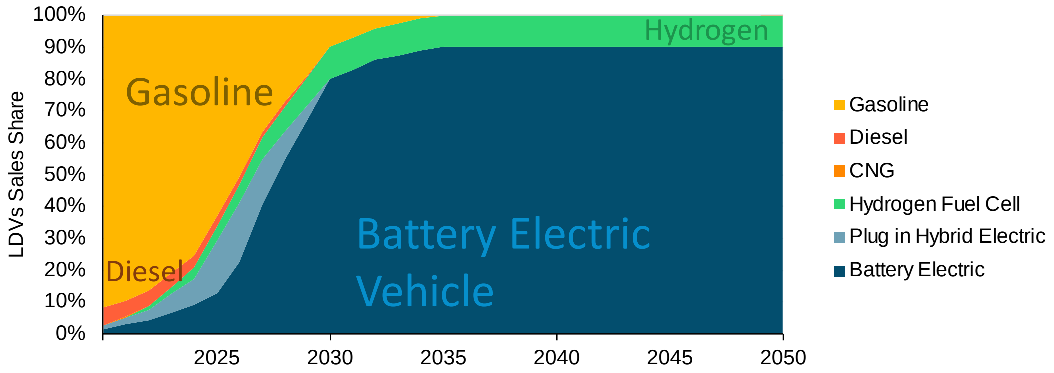


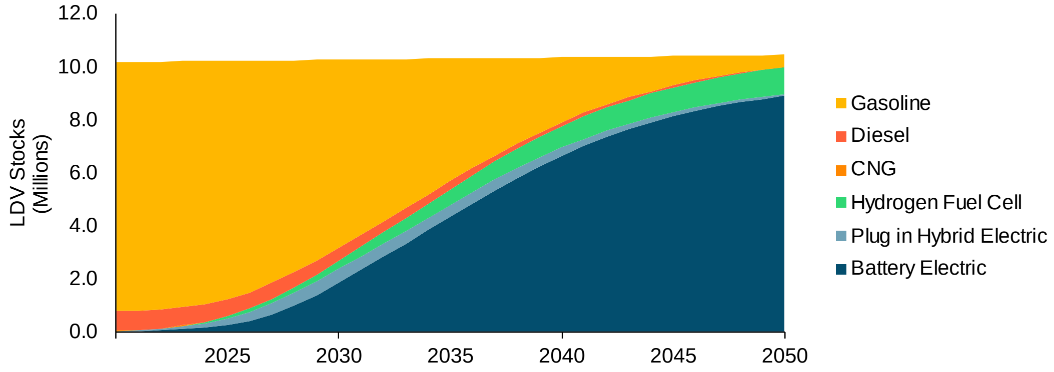
2020 is a modelled year, reflecting historical trends

Transportation Stock Rollover

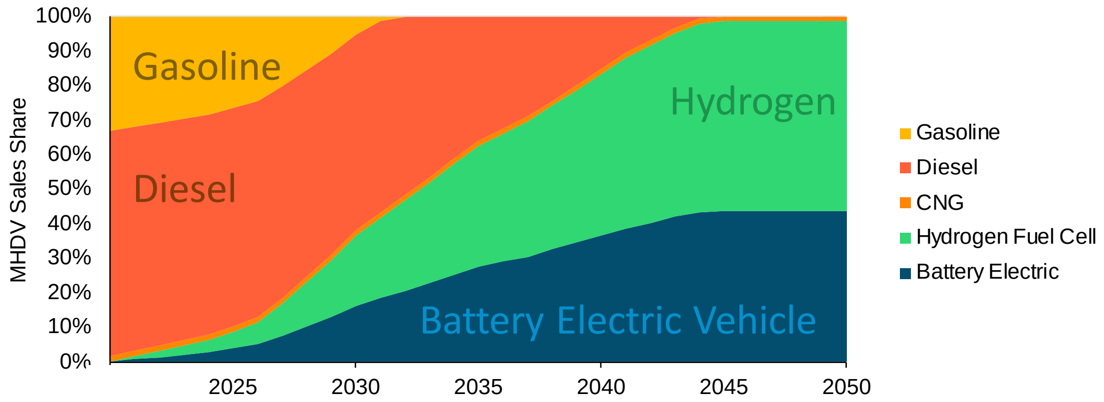
Scenario 2: Strategic use of Low-Carbon Fuels

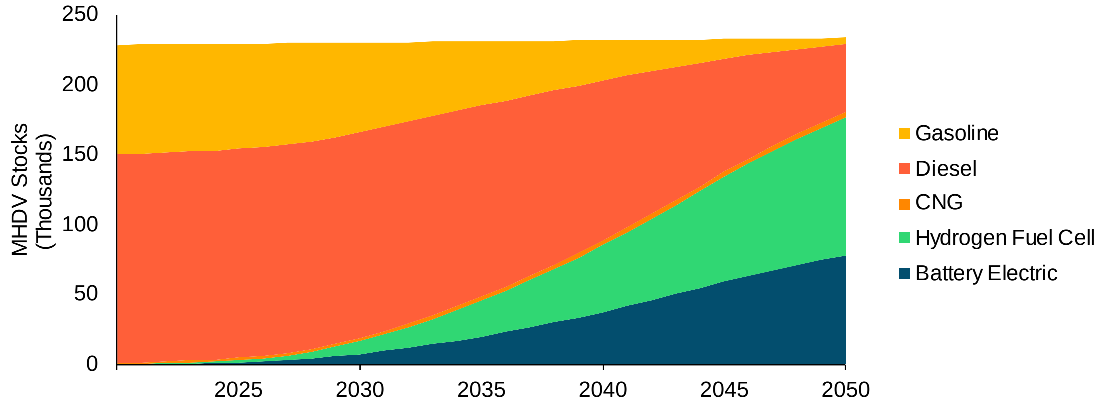
Light Duty Vehicles





Medium and Heavy Duty Vehicles



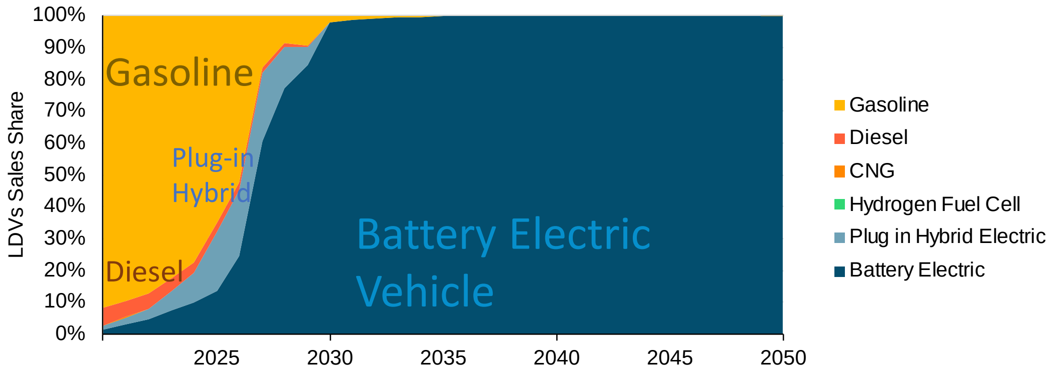


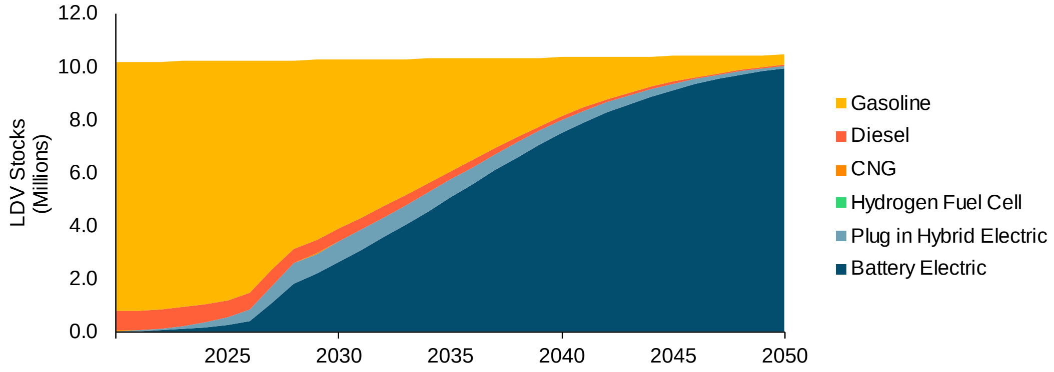
2020 is a modelled year, reflecting historical trends

Transportation Stock Rollover

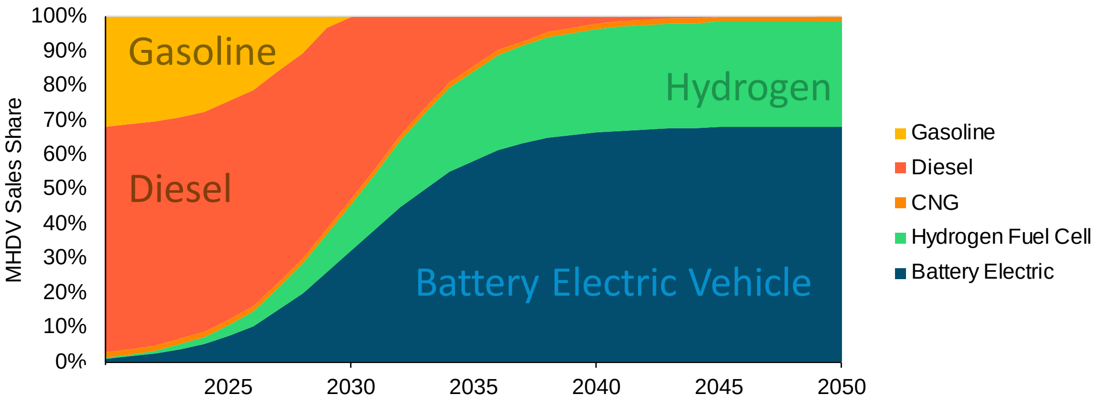
Scenario 3: Accelerated Transition Away from Combustion

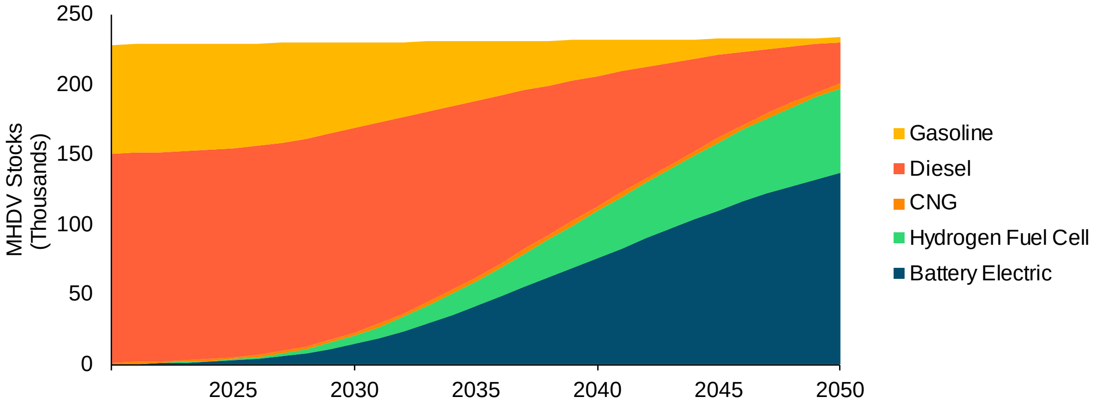
Light Duty Vehicles





Medium and Heavy Duty Vehicles



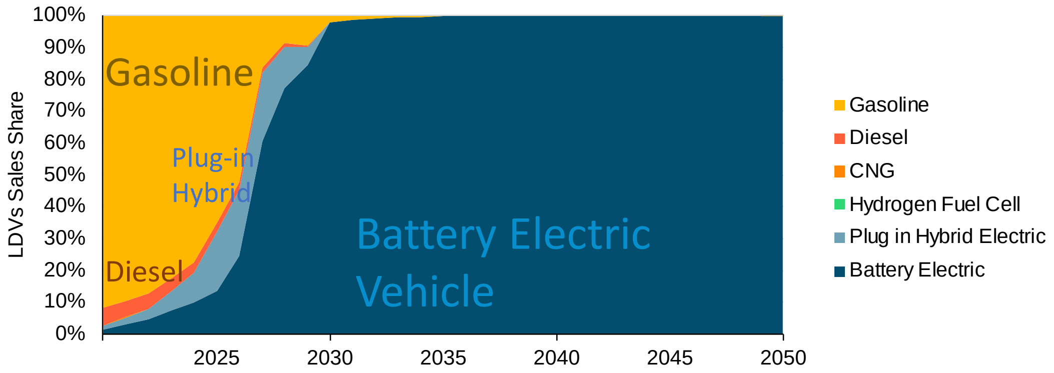


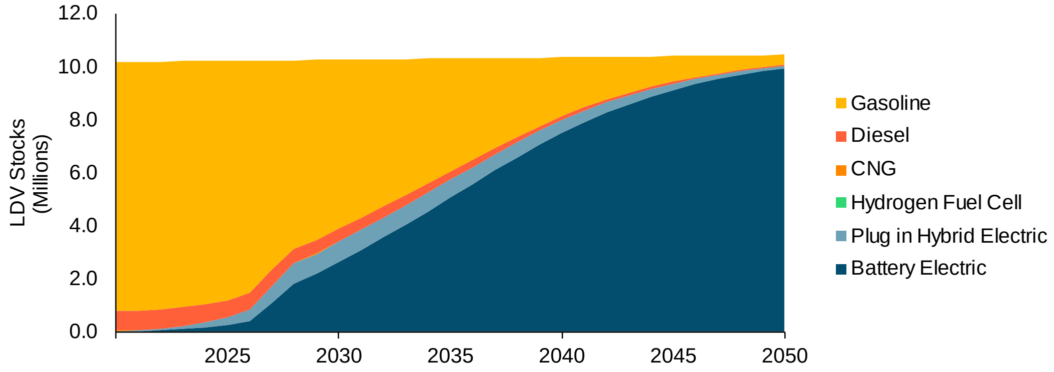
2020 is a modelled year, reflecting historical trends

Transportation Stock Rollover

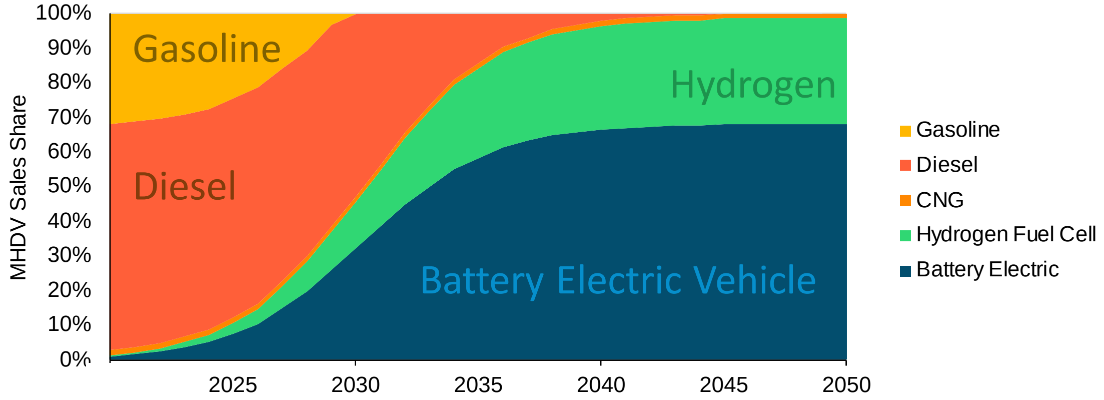
Scenario 4: Beyond 85% Reduction

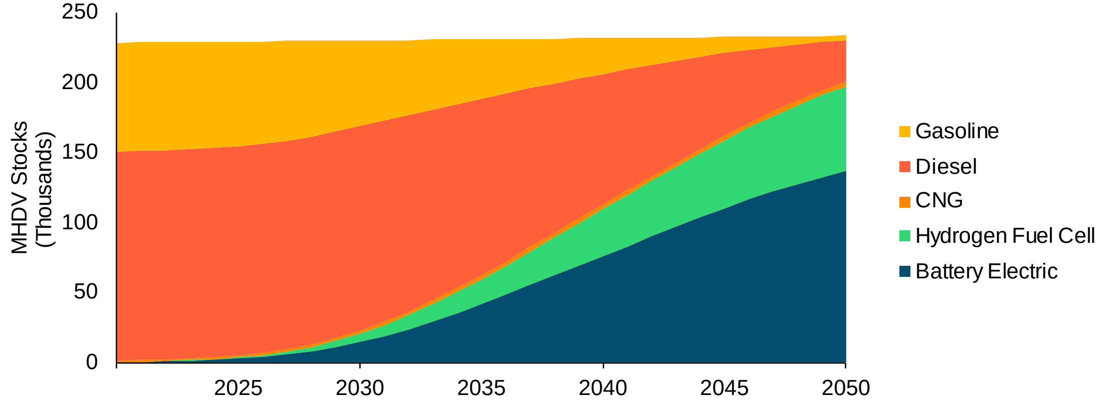
Light Duty Vehicles





Medium and Heavy Duty Vehicles

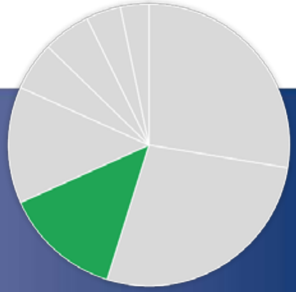




2020 is a modelled year, reflecting historical trends

Electricity Generation

Reference Case



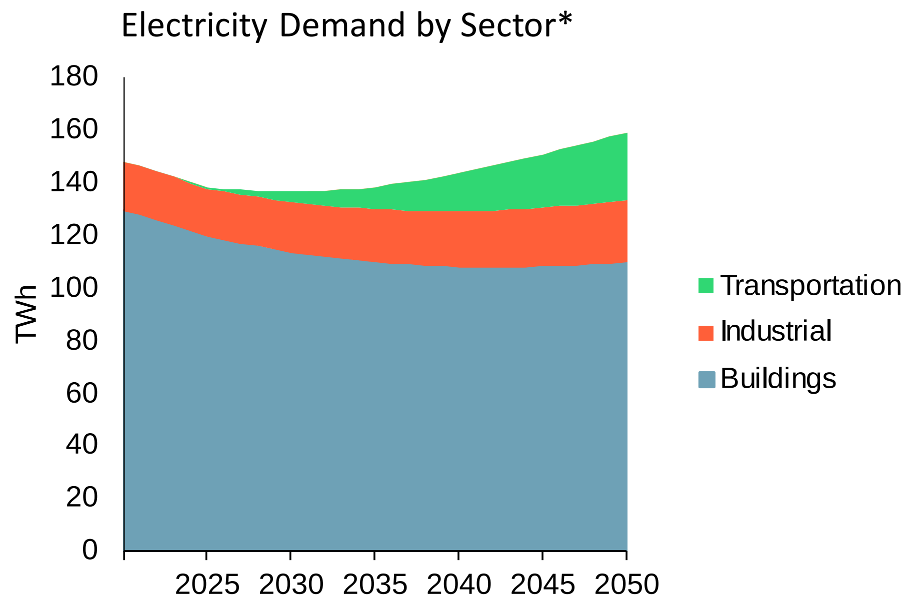
Key Drivers

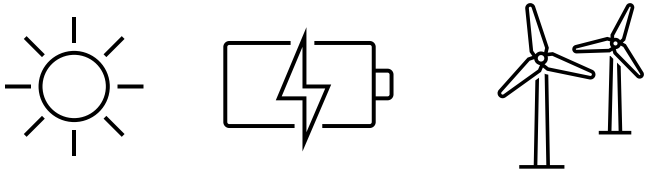
> Electric end use loads, built up from buildings, industry, and transportation sectors

- In the Reference Case loads decline in near term as a result of funded energy efficiency and electrification programs before starting to rise again by 2050
- ZEV mandate and economic adoption of ZEVs drives increase in transportation loads

> The Reference Case includes:

- New York's 70% Clean Energy Standard (CES) by 2030, including technology carve outs:
  - 6 GW of behind-the-meter solar by 2025
  - 3 GW of battery storage by 2030
  - 9 GW of Offshore Wind deployment by 2035
- Regional Greenhouse Gas Initiative (RGGI)
- Least cost capacity-expansion and dispatch driven by a renewable resource supply curve and relevant cost assumptions (resource costs, fuel costs, and transmission costs)
- Indian Point nuclear facility retired in 2020/2021, upstate nuclear facilities retire after 60-year licenses expire

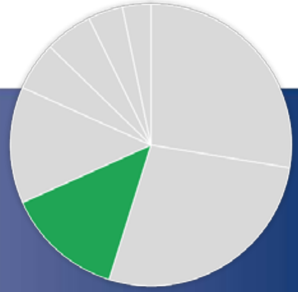




2020 is a modelled year, reflecting historical trends

Electricity Generation

Scenario 1: AP Recommendations



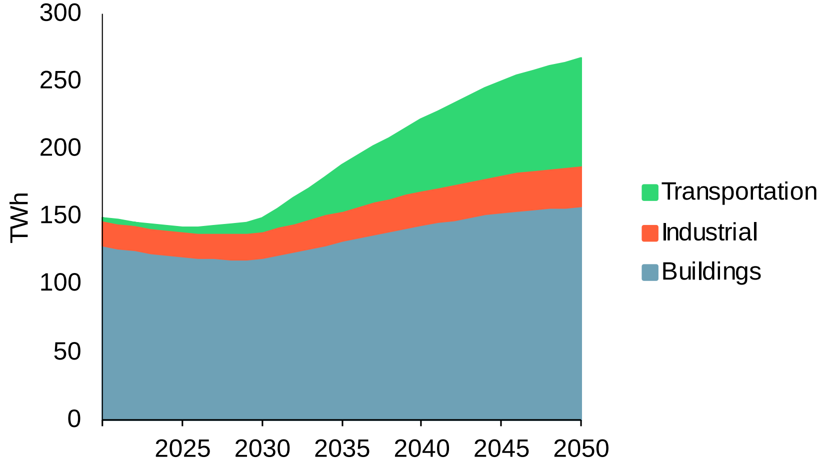
Key Drivers

> Electric end use loads, built up from buildings, industry, and transportation sectors

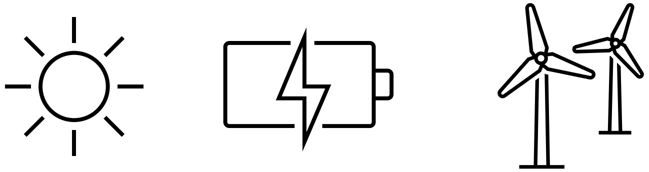
- In Scenario 1 loads decline in near term as a result of energy efficiency and electrification programs before starting to rise again by 2025
- Widespread vehicle and building electrification drive load growth

> Scenario 1 includes:

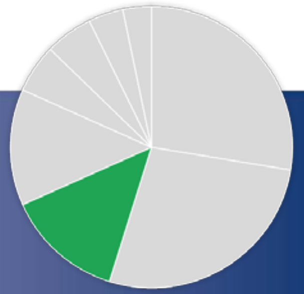
- New York's 70% Clean Energy Standard (CES) by 2030, including technology carve outs:
  - 6 GW of behind-the-meter solar by 2025 and 10 GW by 2030
  - 3 GW of battery storage by 2030
  - 9 GW of offshore wind by 2035
  - 2.5 GW of Tier 4 renewables by 2030
- 100% Zero Emissions Electricity by 2040, including renewables, battery storage, existing nuclear, and hydrogen as available resources.
- Regional Greenhouse Gas Initiative (RGGI)
- Least cost capacity-expansion and dispatch driven by a renewable resource supply curve and relevant cost assumptions (resource costs, fuel costs, and transmission costs)
- Indian Point nuclear facility retired in 2020/2021; upstate nuclear facilities receive 20-year license extensions



*Does not include electricity that may be required to produce hydrogen via electrolysis



2020 is a modelled year, reflecting historical trends



Electricity Generation

Scenario 2: Strategic Use of Low-Carbon Fuels

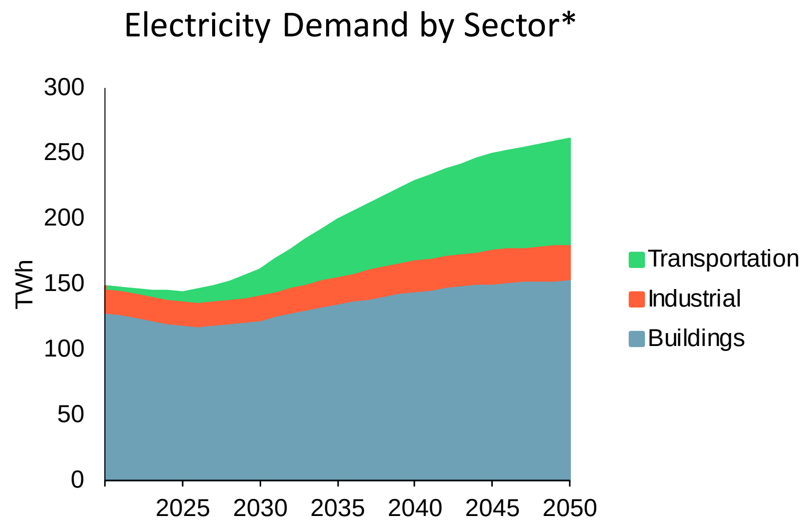
Key Drivers

> Electric end use loads, built up from buildings, industry, and transportation sectors

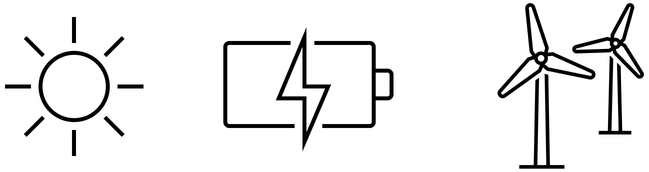
- In Scenario 1 loads decline in near term as a result of energy efficiency and electrification programs before starting to rise again by 2025
- Widespread vehicle and building electrification drive load growth

> Scenario 2 includes:

- New York's 70% Clean Energy Standard (CES) by 2030, including technology carve outs:
  - 6 GW of behind-the-meter solar by 2025 and 10 GW by 2030
  - 3 GW of battery storage by 2030
  - 9 GW of offshore wind by 2035
  - 2.5 GW of Tier 4 renewables by 2030
- 100% Zero Emissions Electricity by 2040, including renewables, battery storage, existing nuclear, and hydrogen as available resources.
- Regional Greenhouse Gas Initiative (RGGI)
- Least cost capacity-expansion and dispatch driven by a renewable resource supply curve and relevant cost assumptions (resource costs, fuel costs, and transmission costs)
- Indian Point nuclear facility retired in 2020/2021; upstate nuclear facilities receive 20-year license extensions



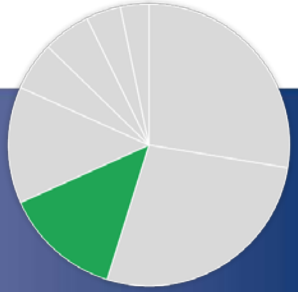
*Does not include electricity that may be required to produce hydrogen via electrolysis



2020 is a modelled year, reflecting historical trends

Electricity Generation

Scenario 3: Accelerated Transition Away from Combustion



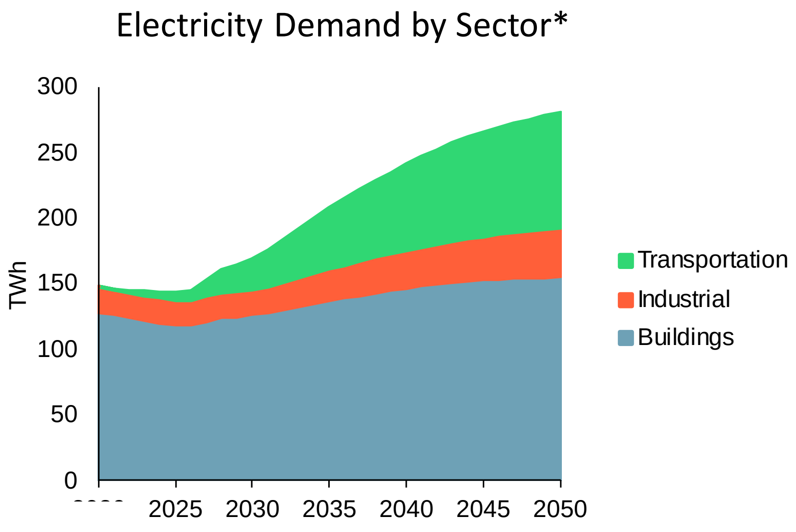
Key Drivers

> Electric end use loads, built up from buildings, industry, and transportation sectors

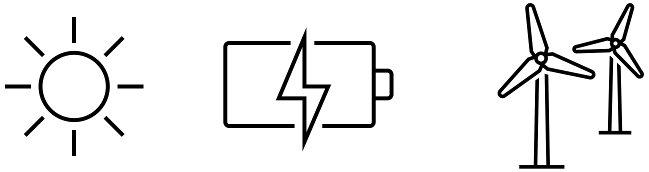
- In Scenario 1 loads decline in near term as a result of energy efficiency and electrification programs before starting to rise again by 2025
- Widespread vehicle and building electrification drive load growth

> Scenario 3 includes:

- New York's 70% Clean Energy Standard (CES) by 2030, including technology carve outs:
  - 6 GW of behind-the-meter solar by 2025 and 10 GW by 2030
  - 3 GW of battery storage by 2030
  - 9 GW of offshore wind by 2035
  - 2.5 GW of Tier 4 renewables by 2030
- 100% Zero Emissions Electricity by 2040, including renewables, battery storage, existing nuclear, and hydrogen as available resources.
- Regional Greenhouse Gas Initiative (RGGI)
- Least cost capacity-expansion and dispatch driven by a renewable resource supply curve and relevant cost assumptions (resource costs, fuel costs, and transmission costs)
- Indian Point nuclear facility retired in 2020/2021; upstate nuclear facilities receive 20-year license extensions
- **Existing fossil resources retire by 2040 and new fossil infrastructure is prohibited; new firm capacity must avoid local air pollution stemming from combustion**



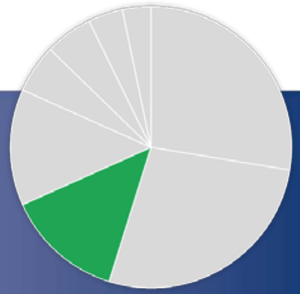
*Does not include electricity that may be required to produce hydrogen via electrolysis



2020 is a modelled year, reflecting historical trends

Electricity Generation

Scenario 4: Beyond 85% Reduction



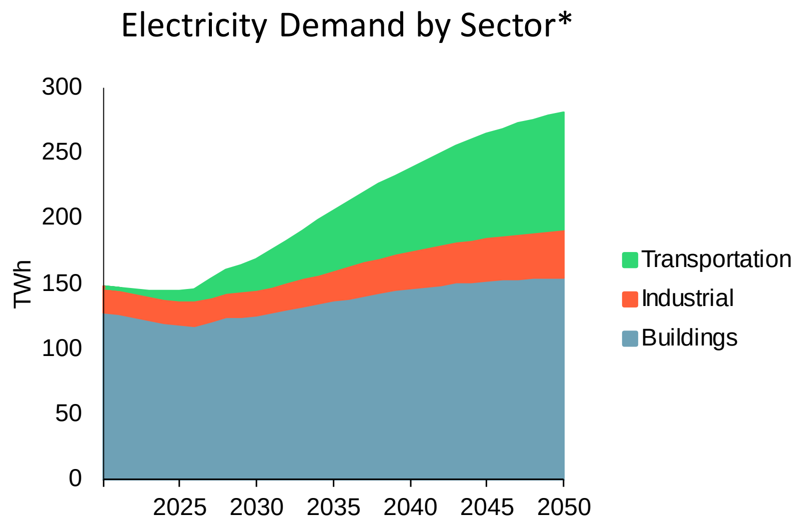
Key Drivers

> Electric end use loads, built up from buildings, industry, and transportation sectors

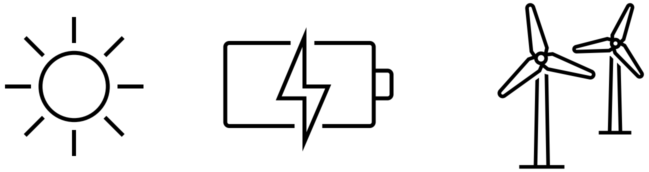
- In Scenario 1 loads decline in near term as a result of energy efficiency and electrification programs before starting to rise again by 2025
- Widespread vehicle and building electrification drive load growth

> Scenario 2 includes:

- New York's 70% Clean Energy Standard (CES) by 2030, including technology carve outs:
  - 6 GW of behind-the-meter solar by 2025 and 10 GW by 2030
  - 3 GW of battery storage by 2030
  - 9 GW of offshore wind by 2035
  - 2.5 GW of Tier 4 renewables by 2030
- 100% Zero Emissions Electricity by 2040, including renewables, battery storage, existing nuclear, and hydrogen as available resources.
- Regional Greenhouse Gas Initiative (RGGI)
- Least cost capacity-expansion and dispatch driven by a renewable resource supply curve and relevant cost assumptions (resource costs, fuel costs, and transmission costs)
- Indian Point nuclear facility retired in 2020/2021; upstate nuclear facilities receive 20-year license extensions



*Does not include electricity that may be required to produce hydrogen via electrolysis



2020 is a modelled year, reflecting historical trends

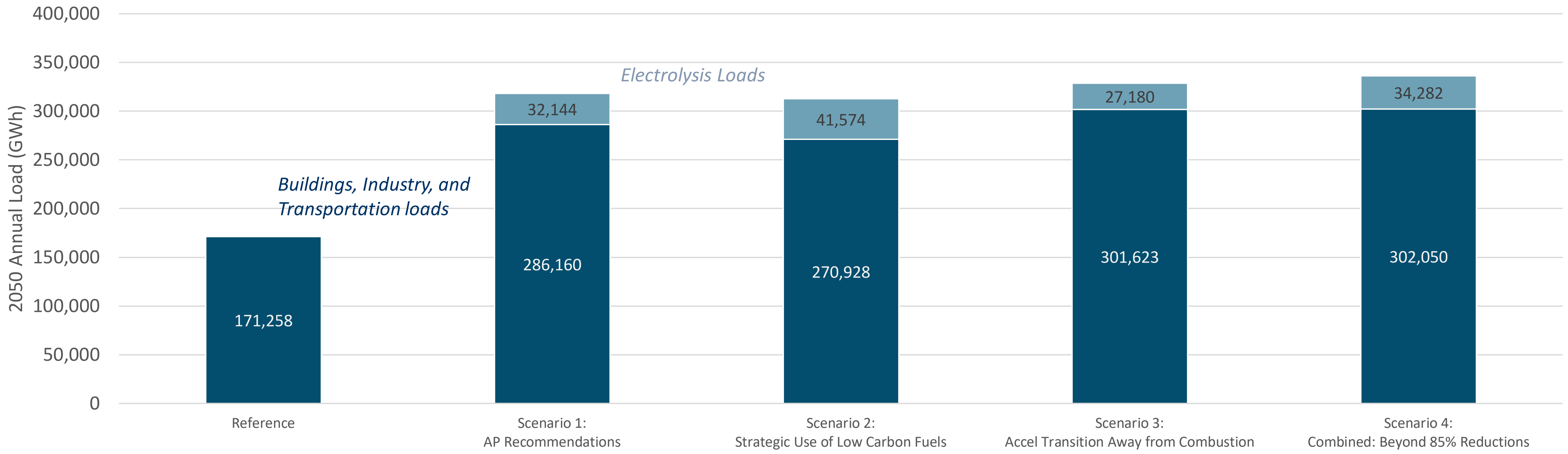
Annual Loads

Impacts of Electrolysis Loads by 2050

> Analysis assumes that 50% of New York's hydrogen demand must be supplied with in-state electrolysis loads

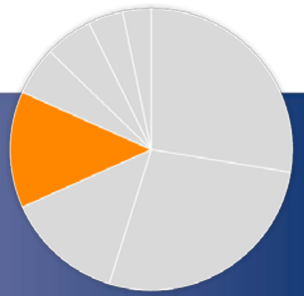
> Electrolysis loads are significant contributor to total loads by 2050 across all Mitigation scenarios (27-42 TWh)

> Electrolysis is modeled as a highly flexible end use that does not contribute to peak loads



Waste Sector

Reference Case



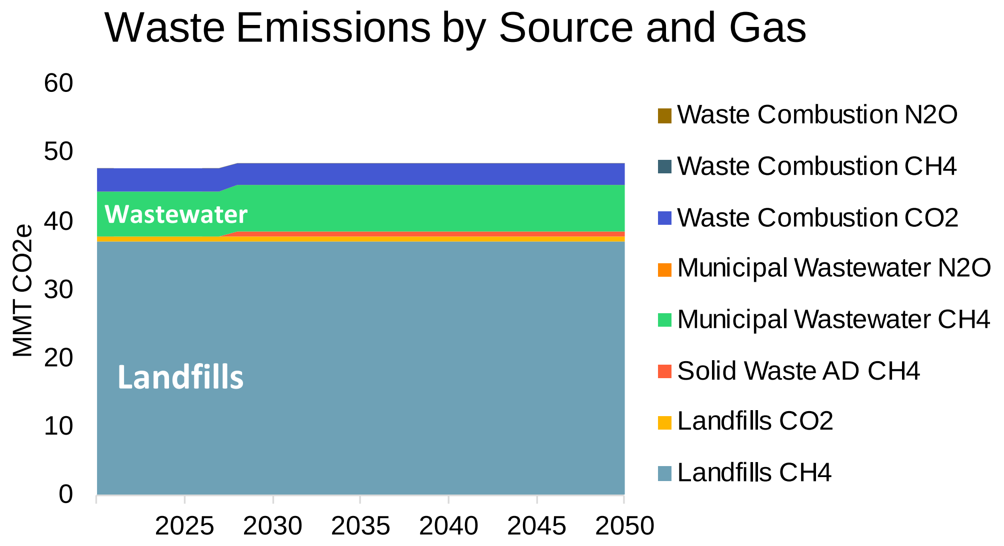
Key Drivers

> Historical trends and population growth rates drive landfill and wastewater emissions

- EPA SIT Projection Tool utilized, with 0.02% EPA recommended annual reduction of MSW.
- Continuation of trends to expand anaerobic digesters, but with no additional leakage control and no additional food waste management
- Waste combustion held constant

> Reference case achieves moderate emissions reductions relative to 1990:

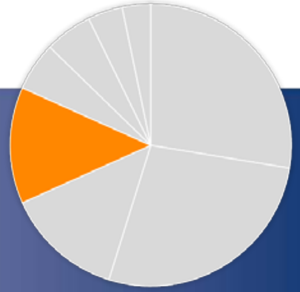
- 2030: 8%
- 2050: 8%



2020 is a modelled year, reflecting historical trends

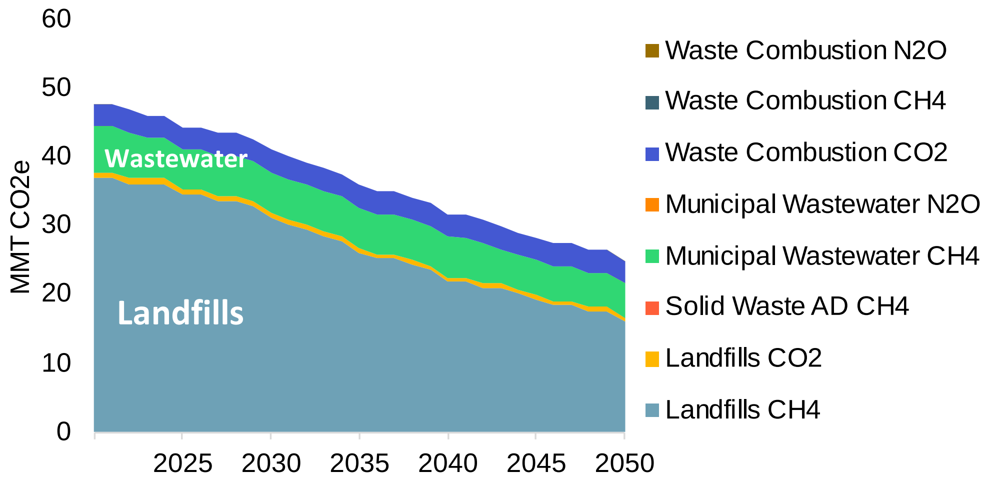
Waste Sector

Scenario 1: AP Recommendations



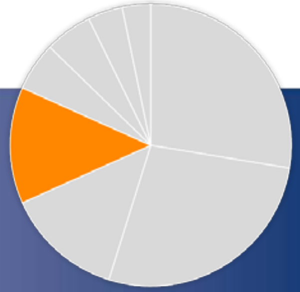
> Key Measures:
- Seeks to divert 100% of waste from landfills and reduce methane leakage 5% every 5 years from existing landfills
- Anaerobic digesters in solid waste running at capacity in 2030 with 75% methane leak reduction by 2050
- Methane leakage reduction from wastewater treatment facility anaerobic digesters
- Waste combustion held constant

> Scenario 1 achieves significant emissions reductions relative to 1990:
- 2030: 22%
- 2050: 53%



2020 is a modelled year, reflecting historical trends

Waste Sector



Scenario 2: Strategic Use of Low-Carbon Fuels
Scenario 3: Accelerated Transition Away from Combustion

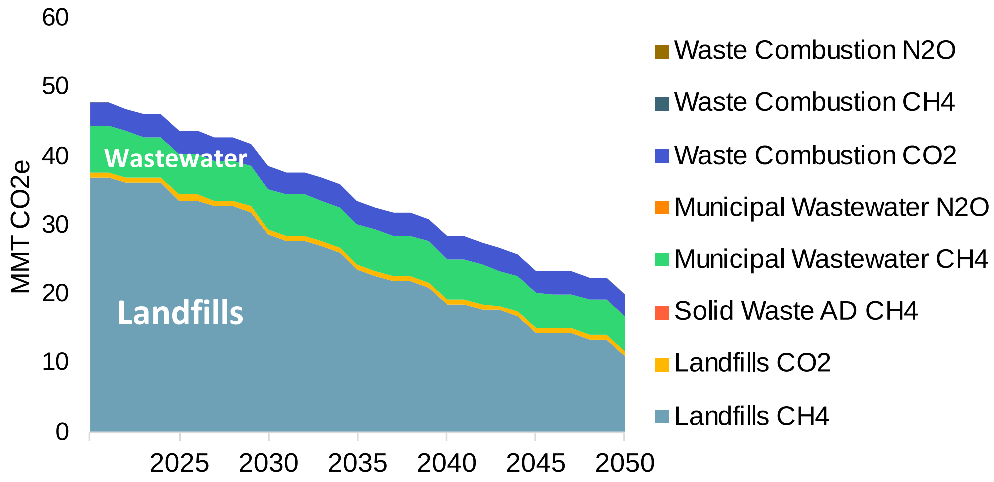
> Key Measures:

- Seeks to divert 100% of waste from landfills and reduce methane leakage 10% every 5 years from existing landfills
- Anaerobic digesters in solid waste running at capacity in 2030 with 75% methane leak reduction by 2050
- Methane leakage reduction from wastewater treatment facility anaerobic digesters
- Waste combustion held constant

> Scenarios 2 and 3 achieves significant emissions reductions relative to 1990:

- 2030: 27%
- 2050: 62%

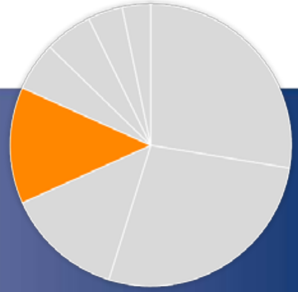
Waste Emissions by Source and Gas



2020 is a modelled year, reflecting historical trends

Waste Sector

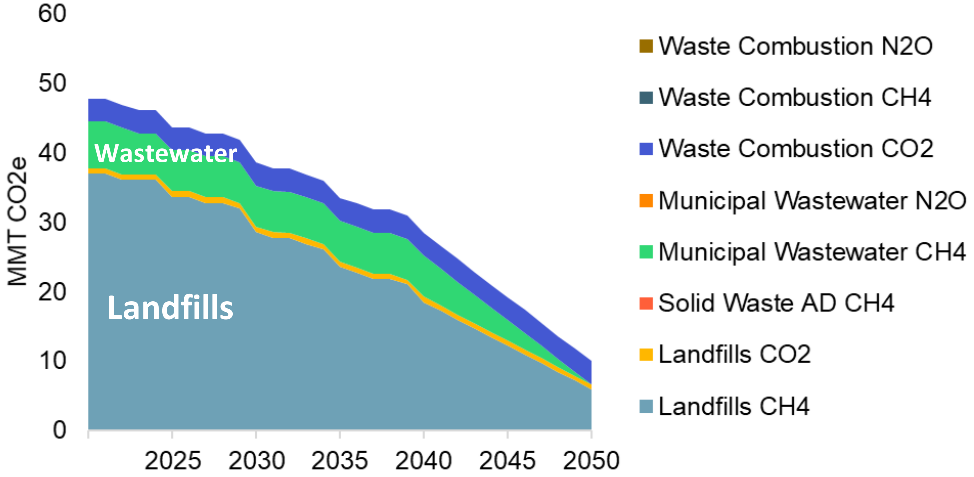
Scenario 4: Beyond 85% Reduction



> Key Measures:
- Same measures as Scenario 3, plus characterization of uncertainty in potential for additional innovation in methane management & capture for use in “no negative emission technologies” sensitivity analysis

> Scenario 4 achieves significant emissions reductions relative to 1990:
- 2030: 27%
- 2050: 81%

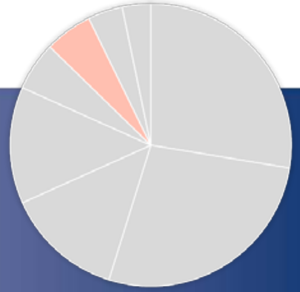
Waste Emissions by Source and Gas



2020 is a modelled year, reflecting historical trends

Agriculture, Forestry, and Other Land Use (AFOLU)

Reference Case



Pie chart shows positive AFOLU emissions only

AFOLU includes emissions sources from Agriculture and emissions sinks from Forestry

Key Drivers

> Declining forest carbon sequestration following historical trends

> Maintenance of current agriculture practices in animal feeding, manure management, and soil management

> Agriculture emissions increase relative to 1990:

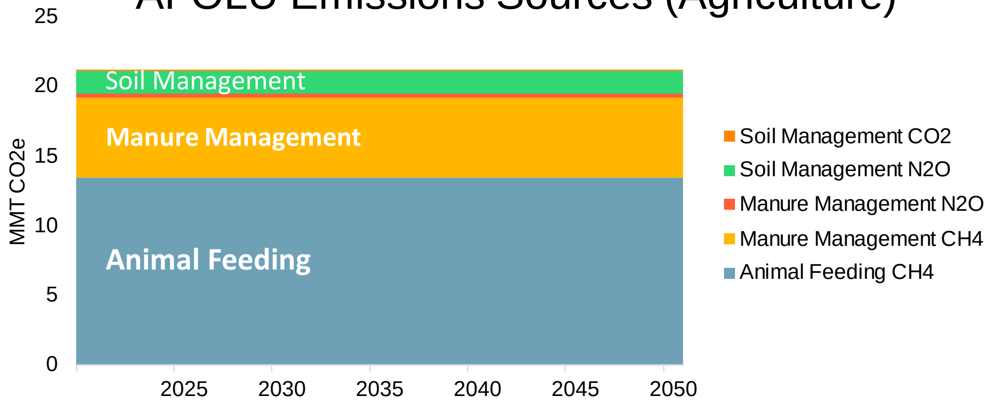
- 2030: 24%
- 2050: 24%

> Net sequestration from lands and forests decreases relative to 1990

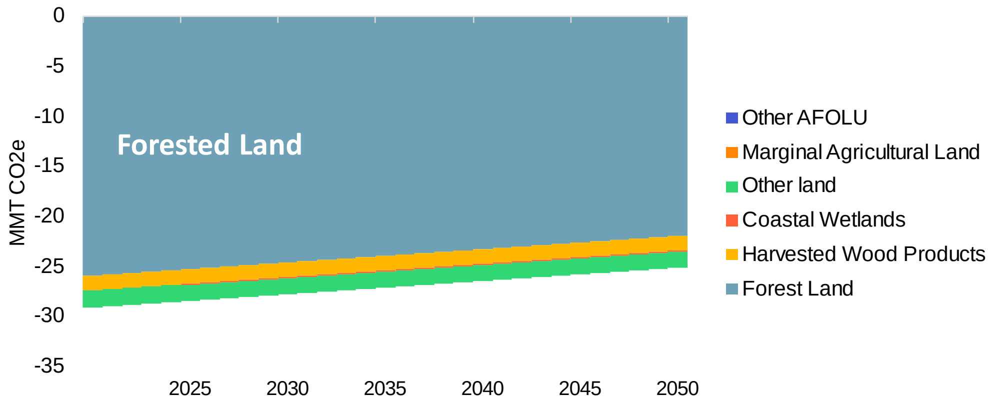
- 2030: 8%
- 2050: 17%

Note that forestry and other land sinks do not contribute to 40% or 85% direct emissions reduction limits

AFOLU Emissions Sources (Agriculture)



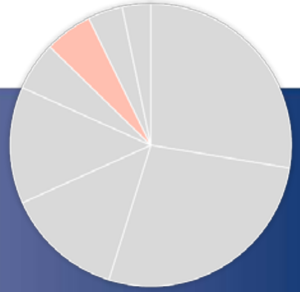
AFOLU Emissions Sinks (Forestry)



2020 is a modelled year, reflecting historical trends

Agriculture, Forestry, and Other Land Use (AFOLU)

Scenario 1: AP Recommendations



Pie chart shows positive AFOLU emissions only

> Key Measures:

- Agricultural emissions reductions in line with Wightman and Woodbury (2020)
- Forest land sequestration returns to 1990 levels, with additional afforestation on marginal agricultural lands (400k acres by 2050)
- Total AFOLU sequestration reaches -35 MMT by 2050

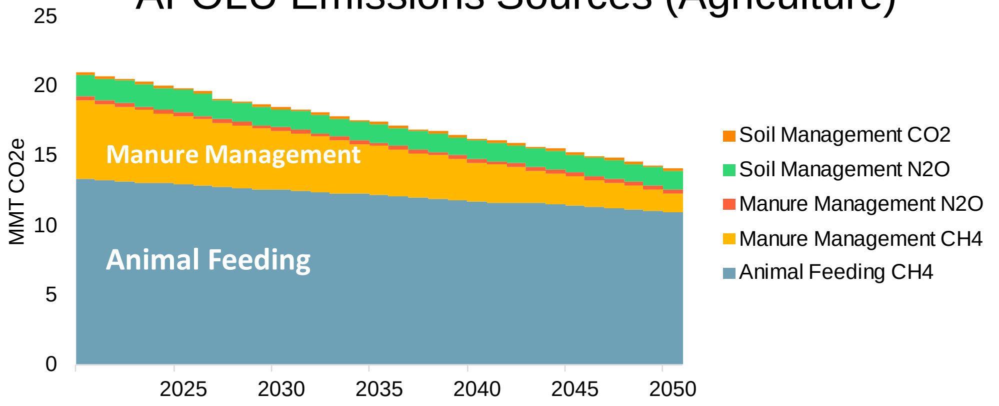
> Agriculture emissions change relative to 1990:

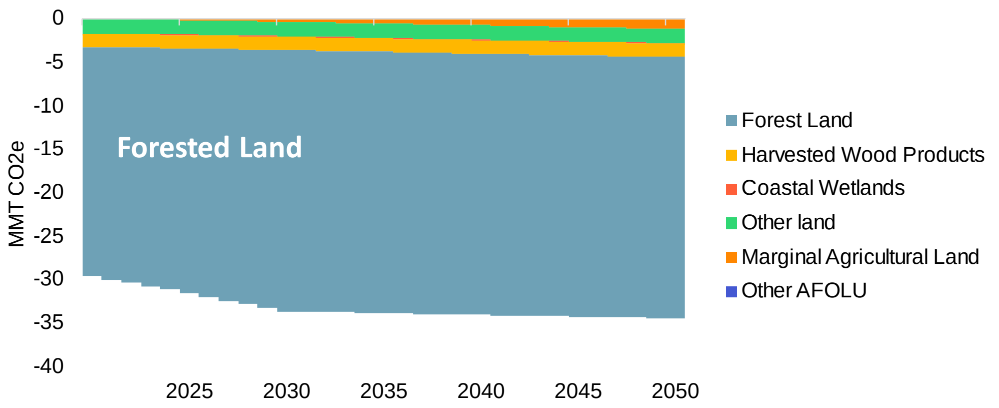
- 2030: 8% **increase**
- 2050: 18% **decrease**

> Net sequestration from lands and forests change relative to 1990:

- 2030: 12% **increase**
- 2050: 14% **increase**

Note that forestry and other land sinks do not contribute to 40% or 85% direct emissions reduction limits

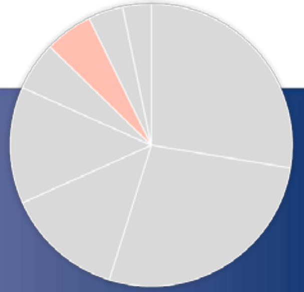




2020 is a modelled year, reflecting historical trends

Agriculture, Forestry, and Other Land Use (AFOLU)

Scenario 2: Strategic Use of Low-Carbon Fuels



Pie chart shows positive AFOLU emissions only

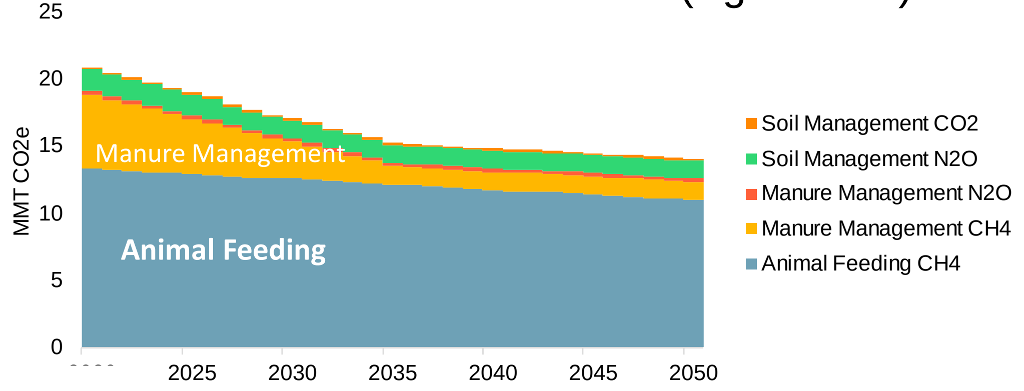
> Key Measures:
- Agricultural emissions reductions in line with Wightman and Woodbury (2020)
- Forest land sequestration returns to 1990 levels, with additional afforestation on marginal agricultural lands (400k acres by 2050)
- Total AFOLU sequestration reaches -35 MMT by 2050

> Agriculture emissions change relative to 1990:
- 2030: 0% change
- 2050: 24% **decrease**

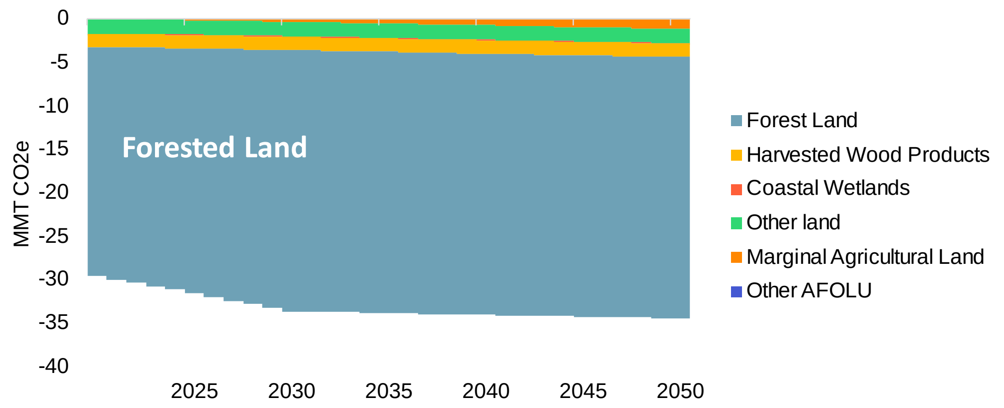
> Net sequestration from lands and forests change relative to 1990:
- 2030: 12% **increase**
- 2050: 14% **increase**

Note that forestry and other land sinks do not contribute to 40% or 85% direct emissions reduction limits

AFOLU Emissions Sources (Agriculture)



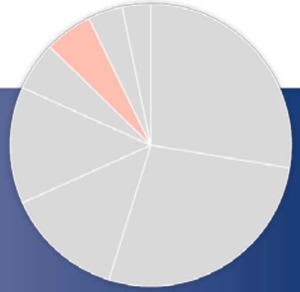
AFOLU Emissions Sinks (Forestry)



2020 is a modelled year, reflecting historical trends

Agriculture, Forestry, and Other Land Use (AFOLU)

Scenario 3: Accelerated Transition Away from Combustion



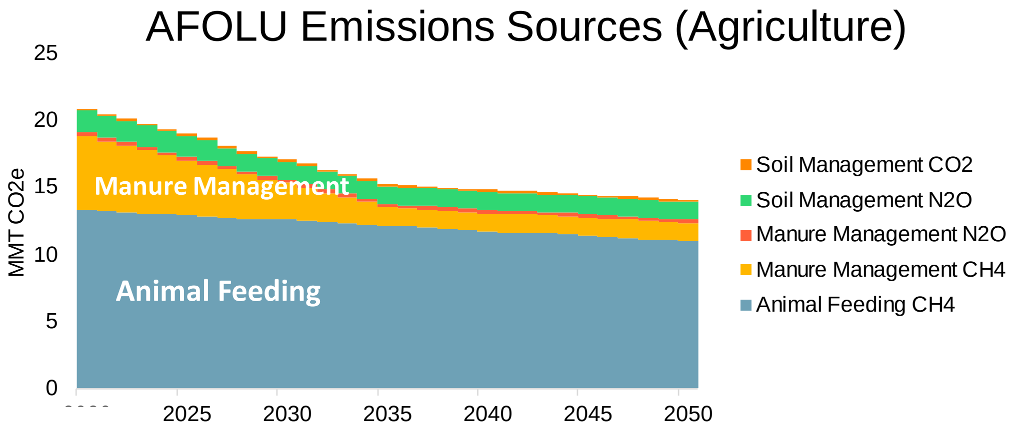
Pie chart shows positive AFOLU emissions only

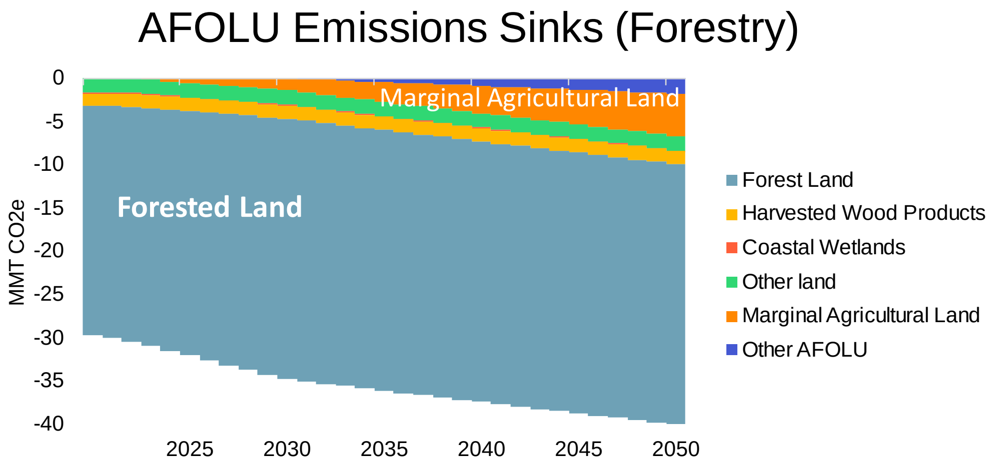
> Key Measures:
  - Agricultural emissions reductions in line with Wightman and Woodbury (2020)
  - Forest land sequestration returns to 1990 levels, with additional afforestation on marginal agricultural lands (1.7 million acres by 2050)
  - Total AFOLU sequestration reaches -40 MMT by 2050

> Agriculture emissions change relative to 1990:
  - 2030: 0% change
  - 2050: 24% **decrease**

> Net sequestration from lands and forests change relative to 1990:
  - 2030: 15% **increase**
  - 2050: 32% **increase**

Note that forestry and other land sinks do not contribute to 40% or 85% direct emissions reduction limits

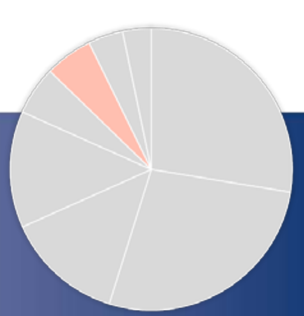




2020 is a modelled year, reflecting historical trends

Agriculture, Forestry, and Other Land Use (AFOLU)

Scenario 4: Beyond 85% Reduction

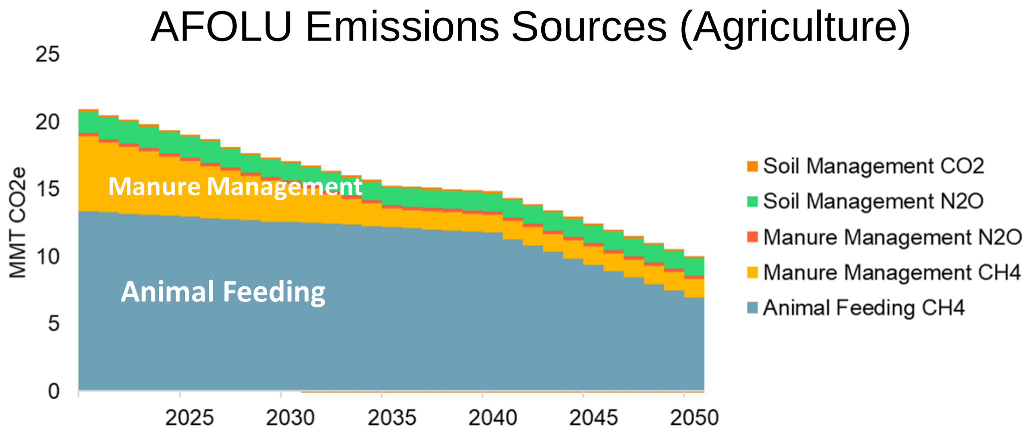


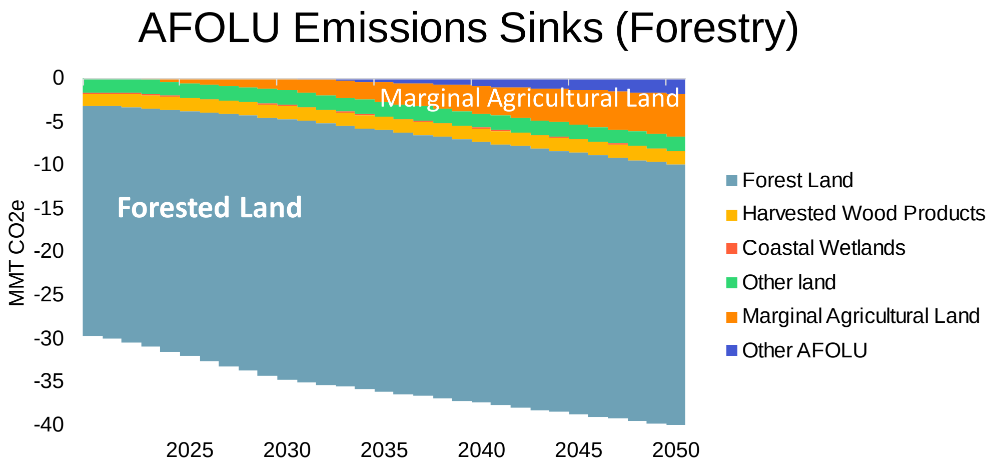
> Key Measures:
- Characterization of uncertainty in potential for additional innovation in agricultural practices for use in “no negative emission technologies” sensitivity analysis
- Forest land sequestration returns to 1990 levels, with additional afforestation on marginal agricultural lands (1.7 million acres by 2050)
- Total AFOLU sequestration reaches -40 MMT by 2050

> Agriculture emissions change relative to 1990:
- 2030: 0% change
- 2050: 53% **decrease**

> Net sequestration from lands and forests change relative to 1990:
- 2030: 15% **increase**
- 2050: 32% **increase**

Note that forestry and other land sinks do not contribute to 40% or 85% direct emissions reduction limits





2020 is a modelled year, reflecting historical trends

Industry: Energy

Reference Case

Key Drivers

> Industrial growth rates per subsector match those from EIA Annual Energy Outlook

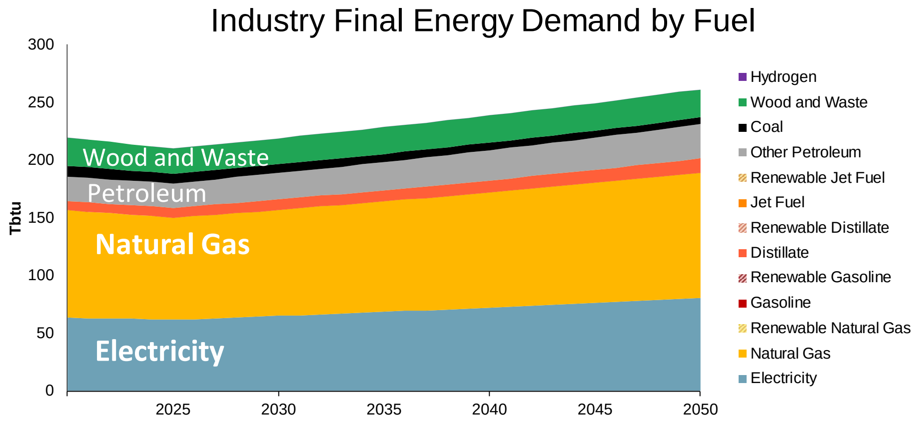
- For example, the chemicals manufacturing subsector (the largest industrial subsector in New York) has an energy demand growth rate of 1.2%

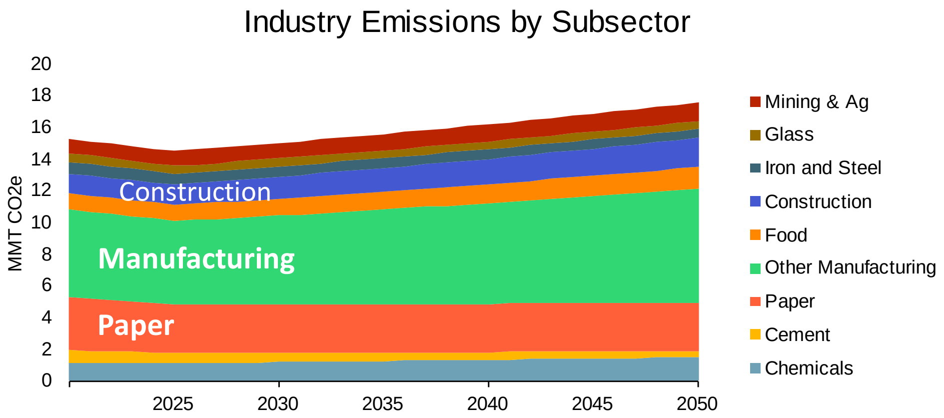
> Efficiency improvements, codes and standards

- Includes estimate of economic energy efficiency achieved by 2025 in Reference case, and held persistent through 2050

> Reference case achieves significant emissions reductions relative to 1990:

- 2030: 51%
- 2050: 43%



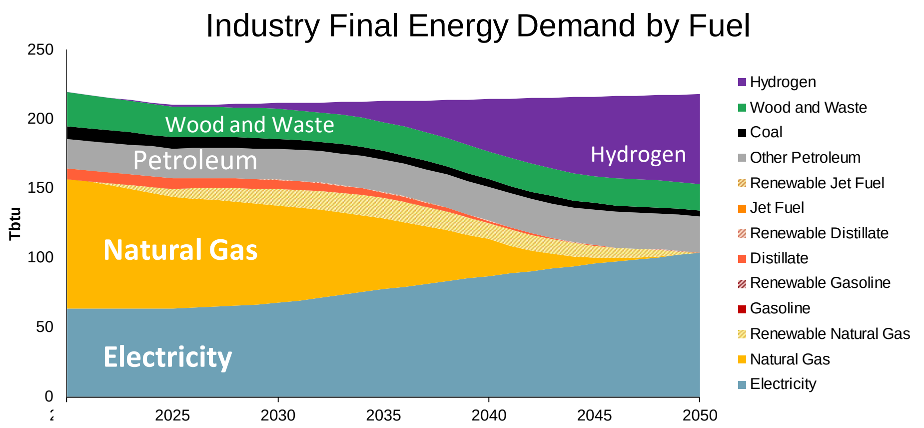


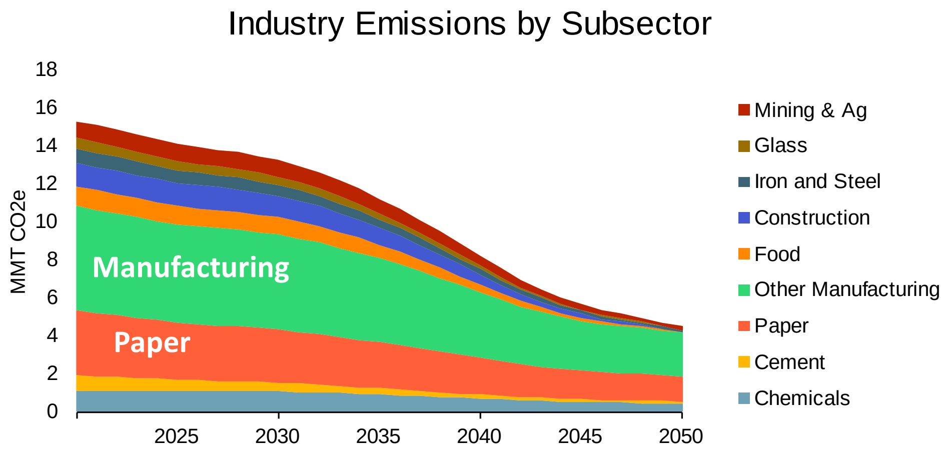
2020 is a modelled year, reflecting historical trends

Industry: Energy

Scenario 1: AP Recommendations

- > Key Measures
  - 10% increase in manufacturing energy efficiency by 2025 based on NYSERDA EE potential study, 30% by 2050
  - 4% of natural gas use is electrified by 2030, 33% by 2050
    - Remaining natural gas use assumed to be converted to hydrogen by 2050
    - A small amount of natural gas remains for non-fuel use as feedstocks
  - CCS for all cement and iron & steel facilities with 90% capture rate
- > Scenario 1 achieves significant emissions reductions relative to 1990:
  - 2030: 57%
  - 2050: 84%





2020 is a modelled year, reflecting historical trends

Industry: Energy

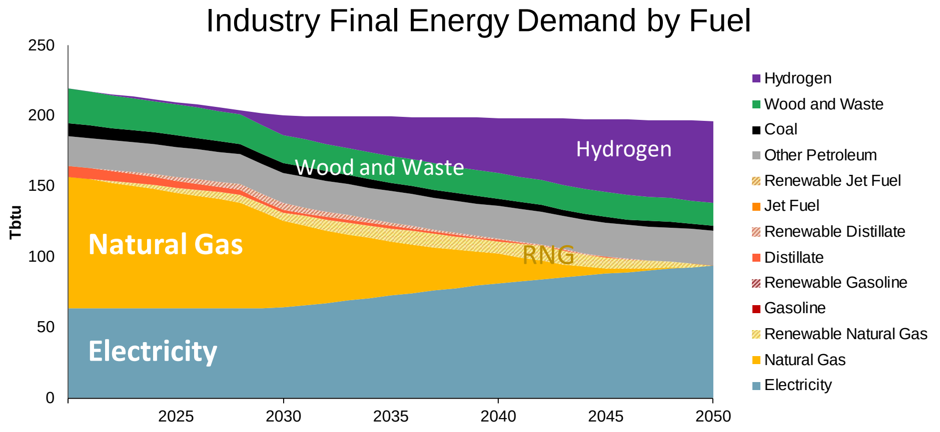
Scenario 2: Strategic Use of Low-Carbon Fuels

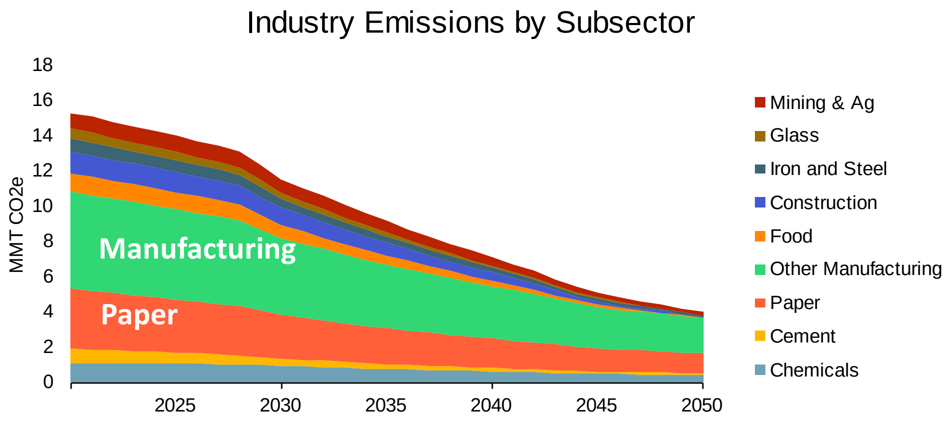
> Key Measures

- 20% increase in manufacturing energy efficiency by 2025 based on NYSERDA EE potential study, 40% by 2050
- 4% of natural gas use is electrified by 2030, 33% by 2050
  - 17% of remaining natural gas assumed to be converted to hydrogen by 2030, 100% by 2050
  - A small amount of natural gas remains for non-fuel use as feedstocks
- CCS for all cement and iron & steel facilities with 90% capture rate

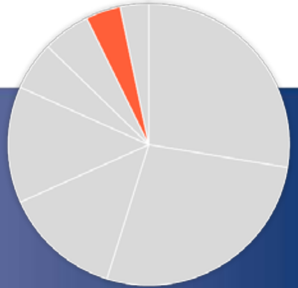
> Scenario 2 achieves significant emissions reductions relative to 1990:

- 2030: 64%
- 2050: 87%





2020 is a modelled year, reflecting historical trends



Industry: Energy

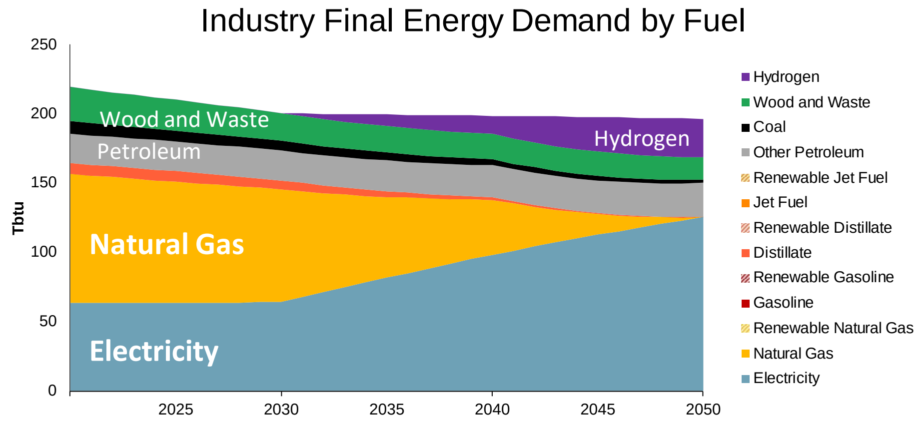
Scenario 3: Accelerated Transition Away from Combustion

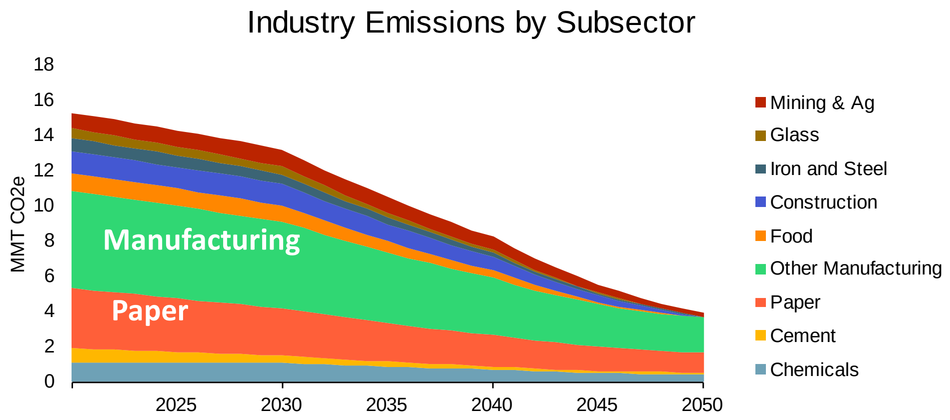
> Key Measures

- 20% increase in manufacturing energy efficiency by 2025 based on NYSERDA EE potential study, 40% by 2050
- 4% of natural gas use is electrified by 2030, 83% by 2050
  - 17% of remaining natural gas assumed to be converted to hydrogen by 2030, 100% by 2050
  - A small amount of natural gas remains for non-fuel use as feedstocks
- CCS for all cement and iron & steel facilities with 90% capture rate

> Scenario 3 achieves significant emissions reductions relative to 1990:

- 2030: 57%
- 2050: 87%





2020 is a modelled year, reflecting historical trends

Industry: Energy

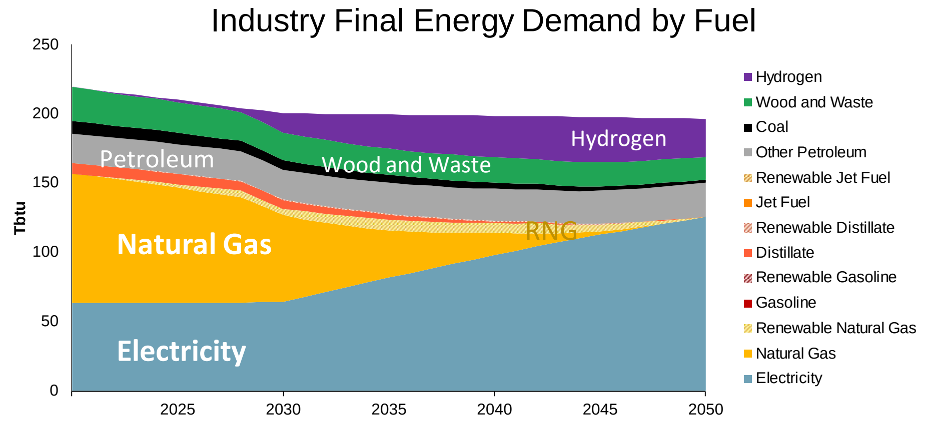
Scenario 4: Beyond 85% Reduction

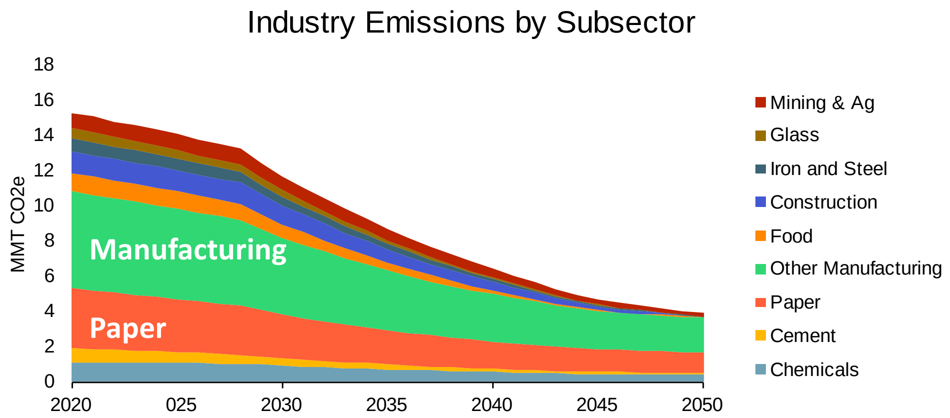
> Key Measures

- 20% increase in manufacturing energy efficiency by 2025 based on NYSERDA EE potential study, 40% by 2050
- 4% of natural gas use is electrified by 2030, 83% by 2050
  - Remaining natural gas use assumed to be converted to hydrogen by 2050
  - A small amount of natural gas remains for non-fuel use as feedstocks
- CCS for all cement and iron & steel facilities with 90% capture rate

> Scenario 4 achieves significant emissions reductions relative to 1990:

- 2030: 62%
- 2050: 87%

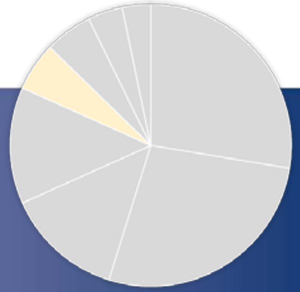




2020 is a modelled year, reflecting historical trends

Industry: Processes

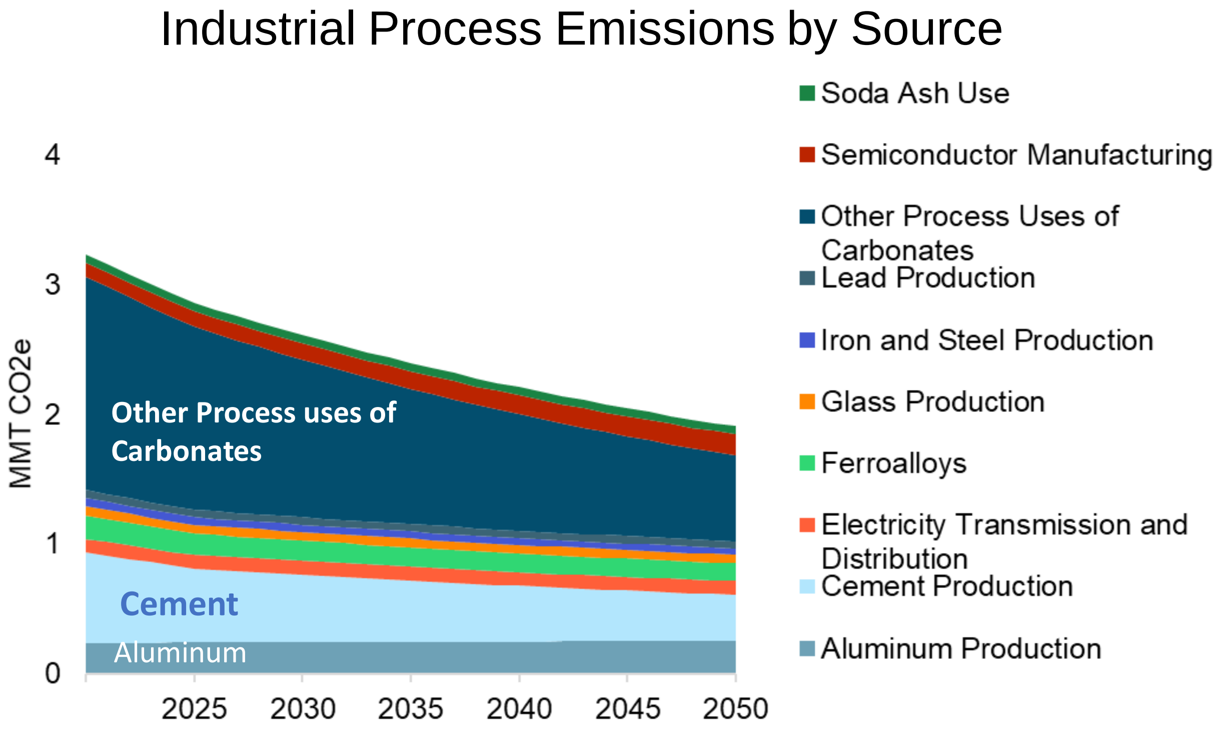
Reference Case



Pie chart shows total IPPU emissions, including HFCs and Industry Processes

Key Drivers

- > Industrial process emissions are expected to decline over time, for example in production of cement, ferroalloys, glass, iron, and steel
- > Reference case reductions relative to 1990:
  - 2030: 3%
  - 2050: 29%

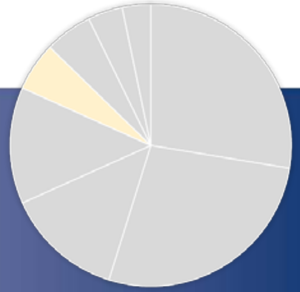


"Other Process Uses of Carbonates" includes flux stone use, flue gas desulfurization, magnesium production, acid neutralization, and sugar refining.

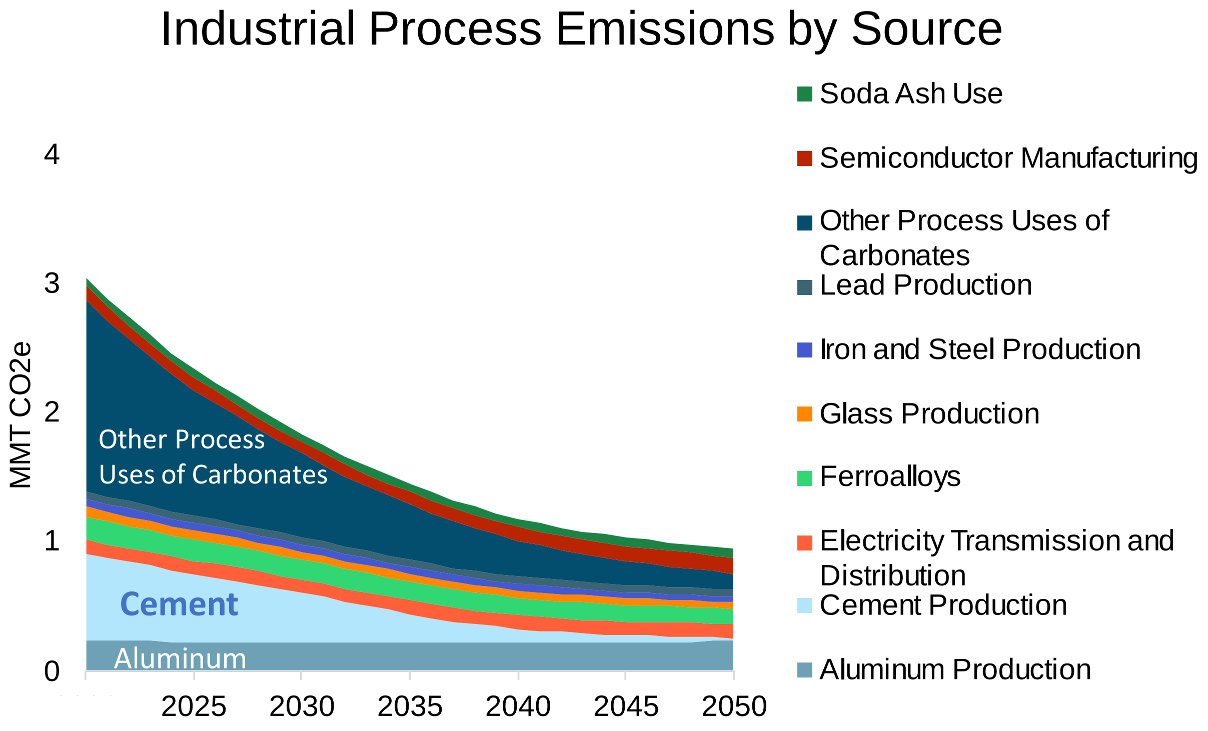
2020 is a modelled year, reflecting historical trends

Industry: Processes

Scenarios 1, 2, 3, 4



- Key Measures
  - Largest reductions come from other process uses of carbonates, which are assumed to decline based on continuation of historical trend national EPA GHG inventory
  - Process emissions from cement are captured with CCS
    - 100% of cement facilities have CCS by 2050
  - Other non-CO2 Industrial Process emissions are reduced based on incorporation of mitigation potential from EPA non-CO2 report [1]
- Scenarios 1, 2, 3, and 4 have significant reductions relative to 1990:
  - 2030: 31%
  - 2050: 65%



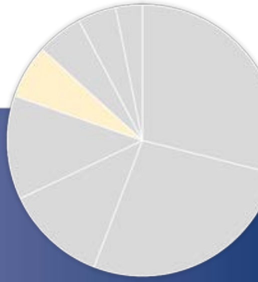
"Other Process Uses of Carbonates" includes flux stone use, flue gas desulfurization, magnesium production, acid neutralization, and sugar refining.

[1] https://www.epa.gov/global-mitigation-non-co2-greenhouse-gases/global-non-co2-greenhouse-gas-emission-projections

2020 is a modelled year, reflecting historical trends

Industrial Product Use (HFCs/Refrigerants)

Reference Case



Pie chart shows total IPPU emissions, including HFCs and Industrial Processes

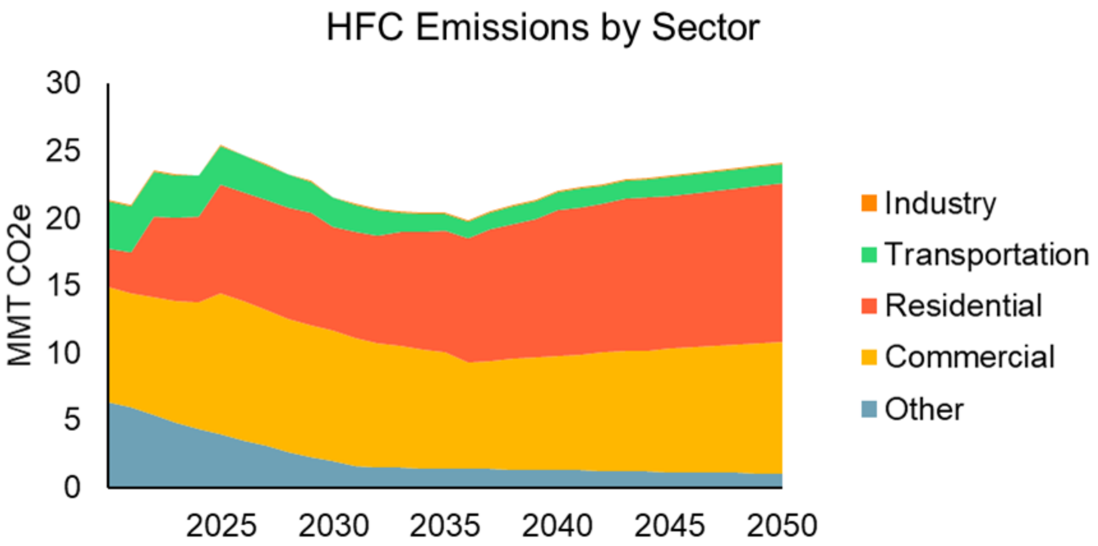
> HFC emissions have grown from near zero in 1990 to over 20 MMT in 2020, driven by the replacement of CFCs/HCFCs with HFCs

> Key Measures in HFCs:

- Maximum adoption of ultra-low-GWP technologies for all AC/HP and other commercial systems
- Maximum possible service reclaim at end of life (90% recover rates)
- Near term increase in the early 2020s comes from building electrification in residential and commercial sectors, although this impact declines as lower-GWP technologies are adopted

> Reference Case has an increase relative to 1990:

- 2030: 59,651% increase (20% increase from 2020)
- 2050: 65,544% increase (31% increase from 2020)



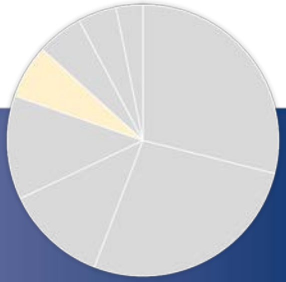
"Other" includes emissions from foams, aerosol propellants, solvents, and fire suppressants.

Incorporates assumptions from HFC Mitigation Potential Study

2020 is a modelled year, reflecting historical trends

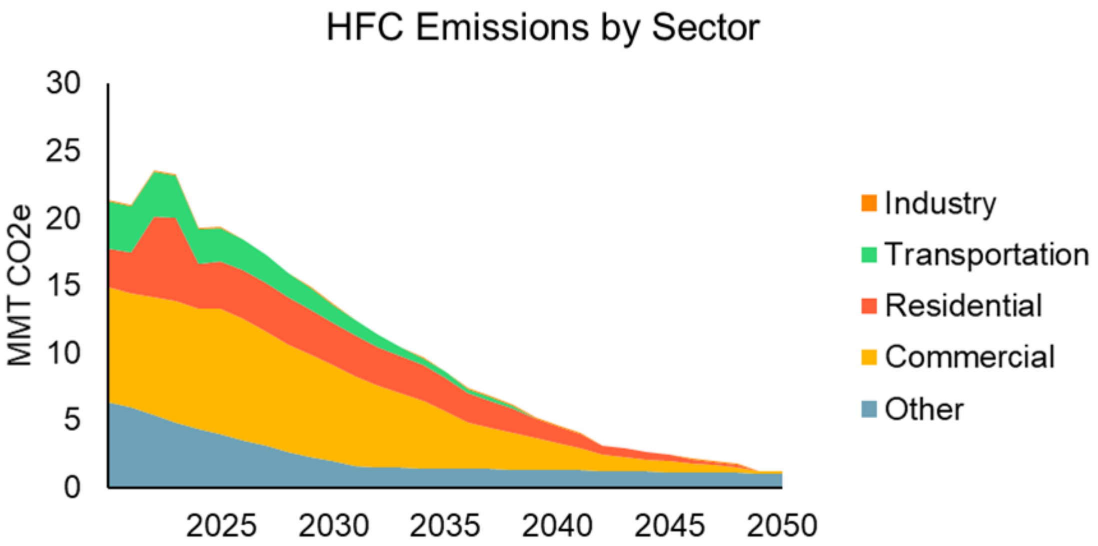
Industrial Product Use (HFCs/Refrigerants)

Scenarios 1, 2, 3, and 4



Pie chart shows total IPPU emissions, including HFCs and Industrial Processes

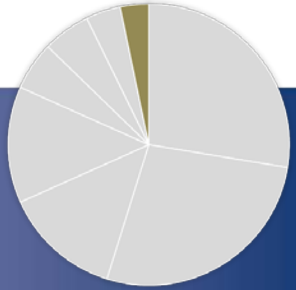
- HFC emissions have grown from near zero in 1990 to over 20 MMT in 2020, driven by the replacement of CFCs/HCFCs with HFCs
- Key Measures in HFCs:
  - Maximum adoption of ultra-low-GWP technologies for all building, transportation, industrial HVAC&R systems
  - Maximum possible service reclaim at end of life (90% recover rates)
  - Near term increase in the early 2020s comes from building electrification in residential and commercial sectors, although this impact declines as lower-GWP technologies are adopted
- Scenarios 1-4 have significant reductions relative to today, but an increase relative to 1990 in all years:
  - 2030: 31,867% increase (36% decrease from 2020)
  - 2050: 2,729% increase (94% decrease from 2020)



"Other" includes emissions from foams, aerosol propellants, solvents, and fire suppressants.

2020 is a modelled year, reflecting historical trends

Incorporates assumptions from HFC Mitigation Potential Study



In-State Oil & Gas Fugitive Emissions

Reference Case

Key Drivers

> Fugitive emissions are driven by existing oil and gas infrastructure in the state

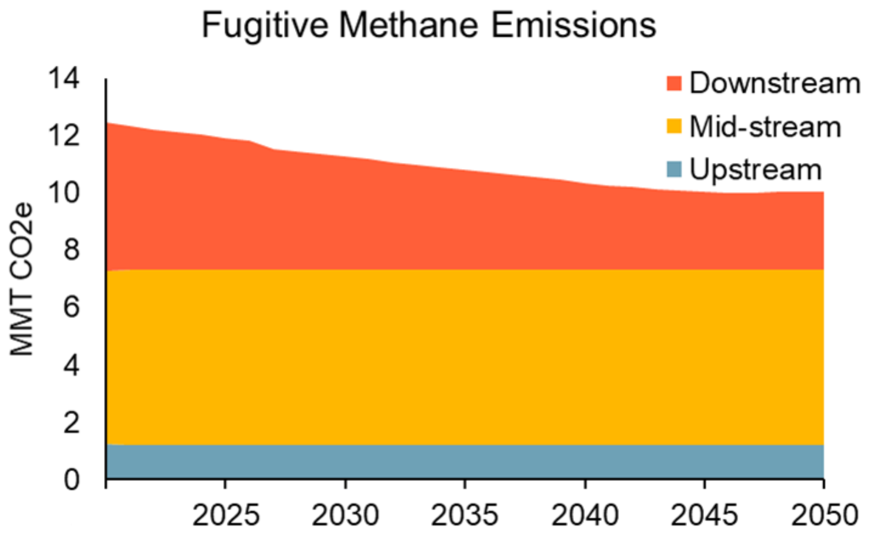
> Majority of emissions are from low-producing natural gas wells, transmission and storage compressor stations, steel and cast-iron pipes in the distribution system, and buildings (meters and beyond-the-meter)

> Leaks from the oil and gas distribution system are aligned with modeled natural gas service provision in buildings and industry

> Change over time in fugitive emissions reflect decreasing natural gas production and replacement of steel and cast-iron distribution pipes with plastic pipes

> Reference Case achieves reductions relative to 1990

- 2030: 27% decrease
- 2050: 35% decrease



Downstream includes distribution pipelines and building meters
Mid-stream includes gas transmission, compression, and storage
Upstream includes gas production and abandoned oil and gas wells

2020 is a modelled year, reflecting historical trends

Incorporates assumptions from Oil and Gas Systems Mitigation Potential Study

In-State Oil & Gas Fugitive Emissions

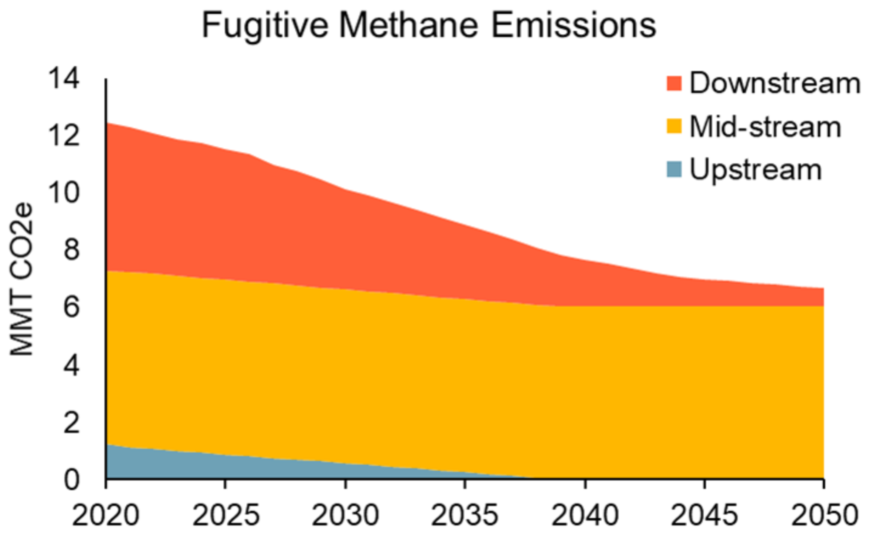
Scenario 1: AP Recommendations

> Key Measures

- Largest reductions from abatement at upstream sources, distribution pipeline decommissioning and LDAR, and residential building disconnection and decommissioning

> Scenario 1 achieves significant reductions relative to 1990

- 2030: 34% decrease
- 2050: 57% decrease



Downstream includes distribution pipelines and building meters
Mid-stream includes gas transmission, compression, and storage
Upstream includes gas production and abandoned oil and gas wells

2020 is a modelled year, reflecting historical trends

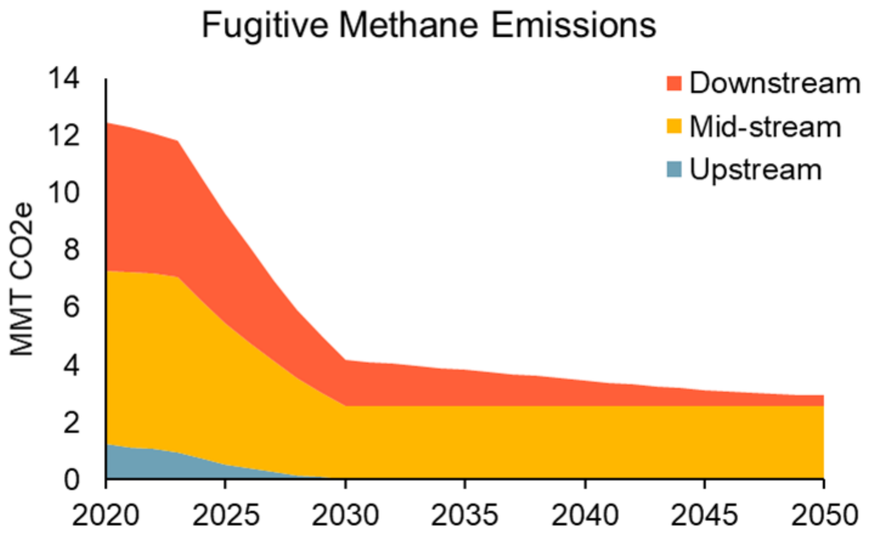
Incorporates assumptions from Oil and Gas Systems Mitigation Potential Study

In-State Oil & Gas Fugitive Emissions

Scenario 2: Strategic Use of Low-Carbon Fuels

> Key Measures
- Largest reductions from equipment replacement and LDAR at compressor stations, abatement at upstream sources, distribution pipeline decommissioning, and residential building disconnection and decommissioning

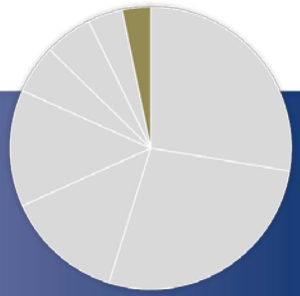
> Scenario 2 achieves significant reductions relative to 1990
- 2030: 73% decrease
- 2050: 81% decrease



Downstream *includes distribution pipelines and building meters*
Mid-stream *includes gas transmission, compression, and storage*
Upstream *includes gas production and abandoned oil and gas wells*

Incorporates assumptions from Oil and Gas Systems Mitigation Potential Study

2020 is a modelled year, reflecting historical trends



In-State Oil & Gas Fugitive Emissions

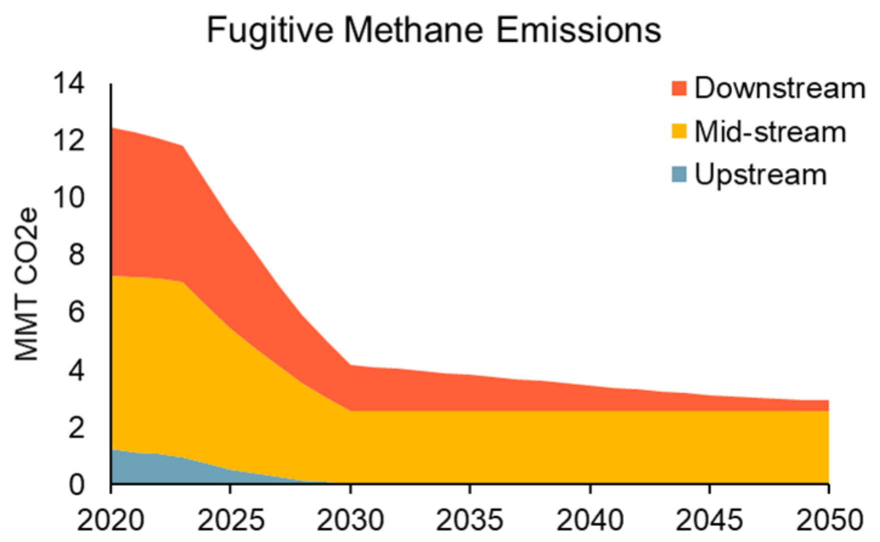
Scenarios 3 & 4

> Key Measures

- Largest reductions from equipment replacement and LDAR at compressor stations, abatement at upstream sources, distribution pipeline decommissioning, and residential building disconnection and decommissioning
- Scenarios 3 and 4 achieve slightly larger reductions than Scenario 2 with similar measures due to lower gas throughput

> Scenarios 3 and 4 achieve significant reductions relative to 1990

- 2030: 74% decrease
- 2050: 82% decrease



Downstream includes distribution pipelines and building meters
Mid-stream includes gas transmission, compression, and storage
Upstream includes gas production and abandoned oil and gas wells

2020 is a modelled year, reflecting historical trends

Incorporates assumptions from Oil and Gas Systems Mitigation Potential Study

Appendix A:
Scenario Assumptions by Sector and Level of Transformation

Level of Transformation by Scenario: **Buildings**

	Scenario 1: AP Recommendations	Scenario 2: Strategic Use of Low-Carbon Fuels	Scenario 3: Accelerated Transition Away from Combustion	Scenario 4: Combined: Beyond 85% Reduction
Efficiency and Electrification	*High*	*High*	*Very High*	*Very High*
New Sales of Heat Pumps	30% by 2029, 100% by 2030/2035 (SF/MF+Com)	77% by 2029, 100% by 2030/2035 (SF/MF+Com)	80% by 2029, 100% by 2030/2035 (SF/MF+Com), 10% early retirement by 2030	80% by 2029, 100% by 2030/2035 (SF/MF+Com), 10% early retirement by 2030
Mix of Heat Pump Technologies	70% ASHP, 10% ASHP + fuel backup, 20% GSHP	70% ASHP, 10% ASHP + fuel backup, 20% GSHP	77% ASHP, 23% GSHP	77% ASHP, 23% GSHP
Share of Electrified Buildings*	11% by 2030, 89% by 2050 0.9 Mil. Households by 2030, 7.5 Mil. by 2050 0.6 Bil. Com sqft by 2030, 5.3 Bil. By 2050	18% by 2030, 92% by 2050 1.5 Mil. Households by 2030, 7.8 Mil. by 2050 1.1 Bil. Com sqft by 2030, 5.3 Bil. By 2050	22% by 2030, 92% by 2050 1.8 Mil. Households by 2030, 7.8 Mil. by 2050 1.4 Bil. Com sqft by 2030, 5.6 Bil. By 2050	22% by 2030, 92% by 2050 1.8 Mil. Households by 2030, 7.8 Mil. by 2050 1.4 Bil. Com sqft by 2030, 5.6 Bil. By 2050
Share of Buildings with Efficient Shell	3% Deep Shell, 10% Basic Shell by 2030 12% Deep Shell, 56% Basic Shell by 2050	7% Deep Shell, 18% Basic Shell by 2030 26% Deep Shell, 66% Basic Shell by 2050	7% Deep Shell, 18% Basic Shell by 2030 26% Deep Shell, 66% Basic Shell by 2050	7% Deep Shell, 18% Basic Shell by 2030 26% Deep Shell, 66% Basic Shell by 2050
Air Conditioning Saturation	100% saturation by 2050 reflecting climate trends and HP adoption	100% saturation by 2050 reflecting climate trends and HP adoption	100% saturation by 2050 reflecting climate trends and HP adoption	100% saturation by 2050 reflecting climate trends and HP adoption
NYC District Heat System	3% annual efficiency improvement	3% annual efficiency improvement, 100% hydrogen conversion by 2050	3% annual efficiency improvement, 100% hydrogen conversion by 2050	3% annual efficiency improvement, 100% hydrogen conversion by 2050
Smart Devices and Conservation (AC, Space Heating)	5% reduction in 2030, 10% by 2050	10% reduction by 2030, 15% by 2050	10% reduction by 2030, 15% by 2050	10% reduction by 2030, 15% by 2050

**Electrified buildings include all homes with a heat pump (ASHP, ASHP with fuel backup, GSHP) but do not include homes with electric resistance heat, which are appx. 470,000 in 2030)*

Basic Shell Definition: **27-44**% reduction in building space heating and **14-27%** AC demands
Deep Shell Definition: **57-90**% reduction in building space heating and **9-57%** AC demands

Level of Transformation by Scenario: **Buildings Continued**

		Scenario 2: Strategic Use of Low-Carbon Fuels	Scenario 3: Accelerated Transition Away from Combustion	Scenario 4: Combined: Beyond 85% Reduction
	Low-Carbon Fuels	*High*	*Low*	*Medium*
	Hydrogen (via electrolysis)	NYC district heat converted to hydrogen	NYC district heat converted to hydrogen	NYC district heat converted to hydrogen
	Biomass feedstock availability	In-state + regional feedstocks incl. energy crops	None	In-state wastes and residues only
	Bioenergy utilization	9% RNG, 75% renewable distillate by 2030 100% RNG and renewable distillate by 2050	4% RNG by 2030, 100% by 2050 (Limited volume from targeted methane abatement from landfills and wastewater only)	7% RNG, 7% renewable distillate by 2030 100% RNG and renewable distillate by 2050
HFC	**Climate-Friendly Refrigerants**	*High*	*High*	*High*
	Transition to ultra-low-GWP and natural refrigerant technologies	Max adoption for building, transportation, and industrial HVAC + refrigeration sectors	Max adoption for building, transportation, and industrial HVAC + refrigeration sectors	Max adoption for building, transportation, and industrial HVAC + refrigeration sectors
	Service reclaim at end of life	90% recover rate	90% recover rate	90% recover rate

Level of Transformation by Scenario: **Transportation**

	Scenario 2: Strategic Use of Low-Carbon Fuels	Scenario 3: Accelerated Transition Away from Combustion	Scenario 4: Combined: Beyond 85% Reduction
Transit and Smart Growth	*High*	*High*	*Very High*
Bus Transit Service	Enhancement and expansion of bus transit, where service more than doubles in many areas of the state	Enhancement and expansion of bus transit, where service more than doubles in many areas of the state	Enhancement and expansion of bus transit, where service more than doubles in many areas of the state
Telework + TDM, Walking/Biking, Smart Growth, Rail	Expansion of telework + TDM programs, urban infrastructure, and smart growth	Expansion of telework + TDM programs, urban infrastructure, and smart growth	Further expansion of telework + TDM programs, urban infrastructure, and smart growth, Strategic investments in rail
Zero-Emission Vehicles	*High*	*Very High*	*Very High*
New Sales of LDV ZEVs	90% by 2030, 100% by 2035, 90/10 BEV/FCEV	98% by 2030, 100% by 2035, 100% BEV 10% early retirement before 2030	98% by 2030, 100% by 2035, 100% BEV 10% early retirement before 2030
New Sales of MDV ZEVs	40% by 2030, 100% by 2045, 50/50 BEV/FCEV	50% by 2030, 100% by 2045, 75/25 BEV/FCEV	50% by 2030, 100% by 2045, 75/25 BEV/FCEV
New Sales of HDV ZEVs	40% by 2030, 100% by 2045, 25/75 BEV/FCEV	40% by 2030, 100% by 2045, 50/50 BEV, FCEV	40% by 2030, 100% by 2045, 50/50 BEV, FCEV
New Sales of Bus ZEVs	100% by 2030	100% by 2030	100% by 2030
LDV ZEVs on the Road	2.7 Million by 2030, 10 Million by 2050 26% of fleet by 2030, 95% of fleet by 2050	3.4 Million by 2030, 10.1 Million by 2050 33% of fleet by 2030, 96% of fleet by 2050	3.4 Million by 2030, 10.1 Million by 2050 33% of fleet by 2030, 96% of fleet by 2050
LDV BEV Charging Flexibility	25% of vehicles charge flexibly in 2030, 50% in 2050	25% of vehicles charge flexibly in 2030, 50% in 2050	25% of vehicles charge flexibly in 2030, 50% in 2050
MHDV ZEVs on the Road	19,000 by 2030, 180,000 by 2050 8% of fleet by 2030, 77% of fleet by 2050	23,000 by 2030, 200,000 by 2050 10% of fleet by 2030, 86% of fleet by 2050	23,000 by 2030, 200,000 by 2050 10% of fleet by 2030, 86% of fleet by 2050
Bus ZEVs on the Road	10,000 by 2030, 55,000 by 2050	10,000 by 2030, 55,000 by 2050	10,000 by 2030, 55,000 by 2050

Level of Transformation by Scenario: **Transportation Continued**

	Scenario 2: Strategic Use of Low-Carbon Fuels	Scenario 3: Accelerated Transition Away from Combustion	Scenario 4: Combined: Beyond 85% Reduction
Low-Carbon Fuels	*High*	*Low*	*Medium*
Hydrogen (via electrolysis)	Used for MHDVs and freight rail	Used for MHDVs and freight rail	Used for MHDVs, freight rail, and 50% of aviation by 2050
Biomass feedstock availability	In-state + regional feedstocks incl. energy crops	None	In-state wastes and residues only
Bioenergy utilization	75% renewable diesel by 2030, 100% by 2050 100% renewable jet kerosene by 2050	None	7% renewable diesel by 2030, 100% by 2050 71% renewable jet kerosene by 2050
Non-Road Transportation	*Medium*	*Medium*	*Very High*
Aviation	Efficiency for new airplanes	Efficiency for new airplanes	Efficiency for new airplanes, 16% electrification by 2050 (short haul flights), 50% hydrogen aviation by 2050
Marine and Ports	75% renewable diesel in 2030, 100% electrification in 2050	100% electrification in 2050	7% renewable diesel in 2030, 100% electrification in 2050
Rail	90% electrification, 10% hydrogen use in 2050	90% electrification, 10% hydrogen use in 2050	90% electrification, 10% hydrogen use in 2050

Level of Transformation by Scenario:
Waste and Agriculture

	Scenario 2: Strategic Use of Low-Carbon Fuels	Scenario 3: Accelerated Transition Away from Combustion	Scenario 4: Combined: Beyond 85% Reduction
Emissions Mitigation in Waste	*High*	*High*	*Very High*
Waste diversion	100% waste diversion	100% waste diversion	Characterization of uncertainty in potential for additional innovation in methane management & capture for use in "no negative emission technologies" sensitivity analysis
Reduced methane leakage from existing landfills	10% reduction every 5 years	10% reduction every 5 years	
Anaerobic digesters in solid waste	Digesters running at capacity in 2030 with 75% methane leak reduction by 2050	Digesters running at capacity in 2030 with 75% methane leak reduction by 2050	
Emissions Mitigation in Agriculture	*High*	*High*	*Very High*
Abatement in manure emissions	50% reduction in 2030, 76% reduction in 2050	50% reduction in 2030, 76% reduction in 2050	Characterization of uncertainty in potential for additional innovation in agricultural practices for use in "no negative emission technologies" sensitivity analysis
Abatement in animal feeding emissions	6% reduction in 2030, 18% reduction in 2050	6% reduction in 2030, 18% reduction in 2050	
Abatement in soil management	17% reduction in 2030	17% reduction in 2030	
Additional abatement from future R&D	1 MMT CO2e	1 MMT CO2e	2 MMT CO2e
Low-Carbon Fuels	*High*	*Low*	*Medium*
Methane capture and re-use	Optimistic growth in RNG capture from landfills, wastewater treatment, and manure 32 Tbtu RNG	Targeted RNG capture from landfills, wastewater treatment, and manure 25 Tbtu RNG	Targeted RNG capture from landfills, wastewater treatment, and manure 25 Tbtu RNG

Level of Transformation by Scenario:
Forestry and Land Sinks, NETs

	Scenario 2: Strategic Use of Low-Carbon Fuels	Scenario 3: Accelerated Transition Away from Combustion	Scenario 4: Combined: Beyond 85% Reduction
Carbon Sequestration in Lands and Forests	*High*	*Very High*	*Very High*
Existing forest land management	Forest sequestration returns to 1990 levels	Forest sequestration returns to 1990 levels	Forest sequestration returns to 1990 levels
Additional afforestation on marginal agricultural lands	400,000 acres by 2050	1,700,000 acres by 2050	1,700,000 acres by 2050
Total Natural Sequestration	-35 MMT CO2 in 2050	-40 MMT CO2 in 2050	-40 MMT CO2e in 2050
Negative Emissions Technologies (NETs)	*High*	*Medium*	*None*
Total abatement from direct air capture of CO2 (DAC) or other NETs	-26 MMT CO2 in 2050	-21 MMT CO2 in 2050	0 MMT CO2e in 2050

Level of Transformation by Scenario:
Industrial Processes and Product Use, Fugitive Emissions

	Scenario 2: Strategic Use of Low-Carbon Fuels	Scenario 3: Accelerated Transition Away from Combustion	Scenario 4: Combined: Beyond 85% Reduction
Climate-Friendly Refrigerants	High	High	High
Transition to ultra-low-GWP and natural refrigerant technologies	Max adoption for building, transportation, and industrial HVAC + refrigeration sectors	Max adoption for building, transportation, and industrial HVAC + refrigeration sectors	Max adoption for building, transportation, and industrial HVAC + refrigeration sectors
Service reclaim at end of life	90% recover rate	90% recover rate	90% recover rate
Industrial Processes	High	High	High
Process emissions from cement and iron & steel emissions	100% CCS operations (at 90% CO2 capture rates)	100% CCS operations (at 90% CO2 capture rates)	100% CCS operations (at 90% CO2 capture rates)
Other processes	Maximum abatement from EPA non-CO2 report	Maximum abatement from EPA non-CO2 report	Maximum abatement from EPA non-CO2 report
In-State Oil and Gas Fugitive Emissions	High	High	High
Leak Detection (LDAR) at Compressor Stations	LDAR at 100% of stations phased in between 2023 and 2030	LDAR at 100% of stations phased in between 2023 and 2030	LDAR at 100% of stations phased in between 2023 and 2030
Pipeline Decommissioning and Building Disconnection	91% commercial and 84% residential decommissioning and building disconnection	99% commercial and 90% residential decommissioning and building disconnection	99% commercial and 90% residential decommissioning and building disconnection

Level of Transformation by Scenario:
Industry: Energy

	Scenario 2: Strategic Use of Low-Carbon Fuels	Scenario 3: Accelerated Transition Away from Combustion	Scenario 4: Combined: Beyond 85% Reduction
Industry Electrification and Hydrogen	*High*	*High*	*High*
Industry Efficiency	20% increase in efficiency by 2030, 40% by 2050 for manufacturing	20% increase in efficiency by 2030, 40% by 2050 for manufacturing	20% increase in efficiency by 2030, 40% by 2050 for manufacturing
Industry Electrification	4% of natural gas use electrified by 2030, 33% by 2050	4% of natural gas use electrified by 2030, 83% by 2050	4% of natural gas use electrified by 2030, 83% by 2050
Hydrogen Fuel Switching	17% of non-electrified natural gas use converted to hydrogen by 2030, 100% by 2050	0% of non-electrified natural gas use converted to hydrogen by 2030, 100% by 2050	17% of non-electrified natural gas use converted to hydrogen by 2030, 100% by 2050
Low-Carbon Fuels	*High*	*Low*	*Medium*
Hydrogen (via electrolysis)	High-temperature industries that are challenging to electrify	High-temperature industries that are challenging to electrify	High-temperature industries that are challenging to electrify
Biomass feedstock availability	In-state + regional feedstocks incl. energy crops	None	In-state wastes and residues only
Bioenergy utilization	9% RNG, 75% renewable distillate by 2030 100% RNG and renewable distillate by 2050	4% RNG by 2030, 100% by 2050 (Volumes limited to targeted methane abatement from landfills and wastewater only)	7% RNG, 7% renewable distillate by 2030 100% RNG and renewable distillate by 2050

Appendix B: Additional Material

Climate Impacts and Extreme Weather

- > The energy demand modeling assumes increased air conditioning demands consistent with growth in cooling degree days, sourced from AEO 2020 forecast for Mid-Atlantic region
  - To be conservative, we do not decrease heating demand even though AEO forecast for Mid-Atlantic also includes decrease in heating degree days from 2020-2050
  - In addition to growth in cooling degree days acting as an increase in per-unit air conditioning demand, we assume increased heating will spur increased AC saturation, resulting in 100% saturation of AC across households by 2050
- > Electric sector analysis examines reliability needs over wide range of weather conditions, layering increased demand on top of 40 years of daily temperature data [1979-2018]
  - Uses 1-in-2 planning standard to develop peak load projection
  - Resource portfolios are then selected to meet New York clean energy goals while maintaining reliability
- > Future research needed to assess the impacts of climate change on average energy demands and extreme weather conditions such as storms and heat waves

Negative Emissions Technologies

The Climate Act requires at least 85% direct emissions reductions by 2050, with a goal of carbon neutrality on a net emissions basis

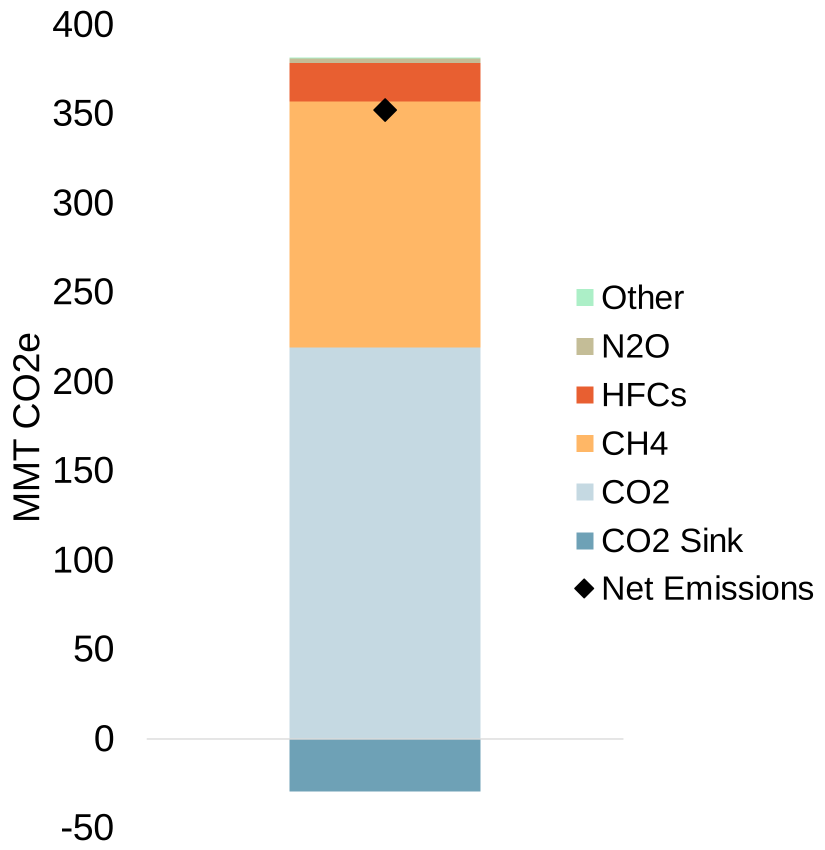
> There is significant uncertainty on the potential size of naturally occurring carbon sinks, and additional measures, such as Negative Emissions Technologies (NETs), may be needed.

- An example of a NET is Direct Air Capture (DAC) of CO_2, which requires a combination of high temperature heat and energy to capture CO_2 from ambient air
- DAC technologies are available today at a small commercial scale in North America and Europe, and will require additional technological progress to achieve 20-30 MMT capture modeled in Scenarios 2 and 3 by 2050

Current Emissions in New York State

By GHG

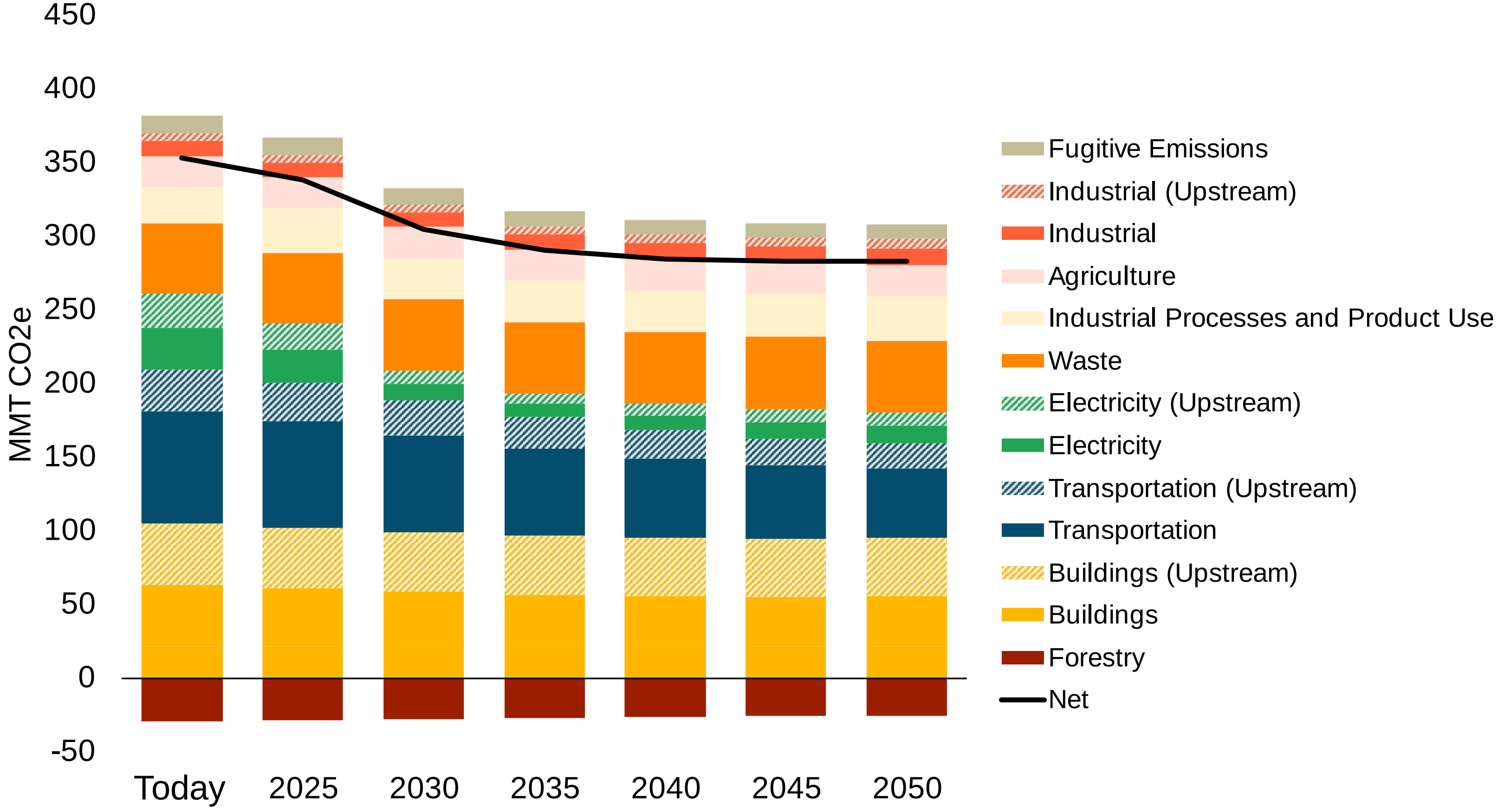
Current Estimated GHG Emissions by Sector*



*Draft 2020 results in line with DEC CLCPA accounting including upstream emission factors, 20-year GWP, and estimates from NY PATHWAYS

Emissions by Sector over Time

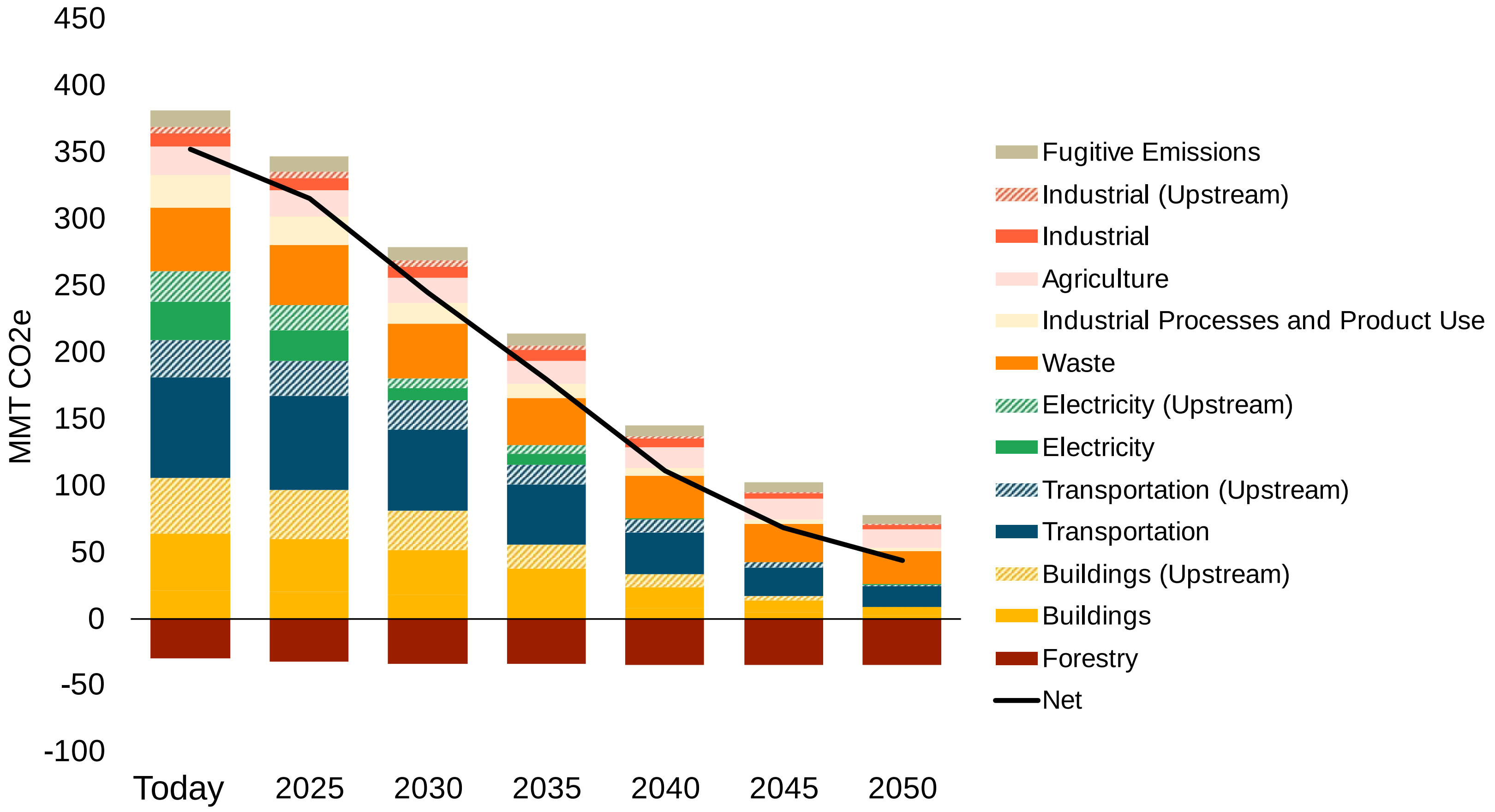
Reference Case



2020 is a modelled year, reflecting historical trends

Emissions by Sector over Time

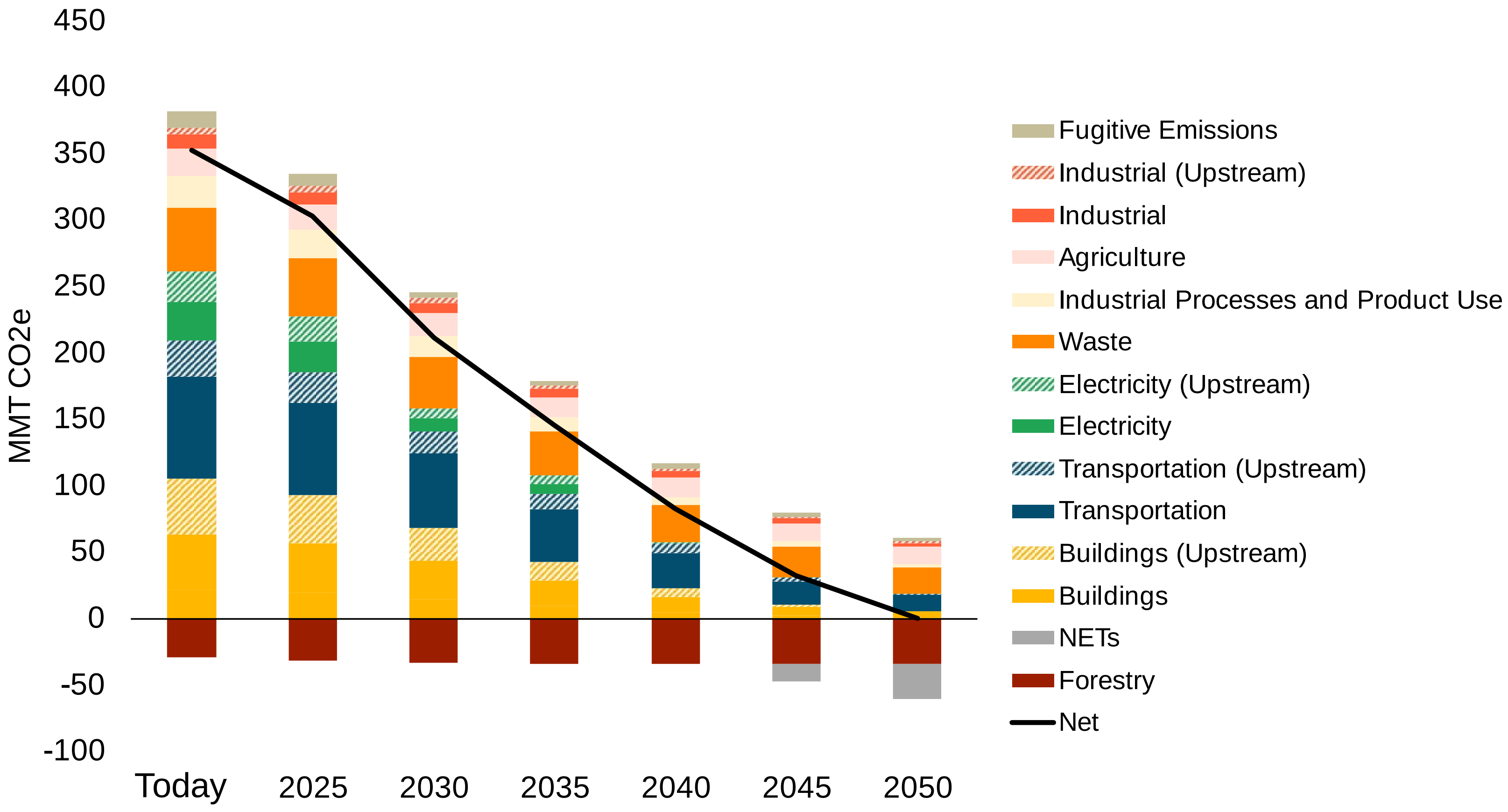
Scenario 1: AP Recommendations



2020 is a modelled year, reflecting historical trends

Emissions by Sector over Time

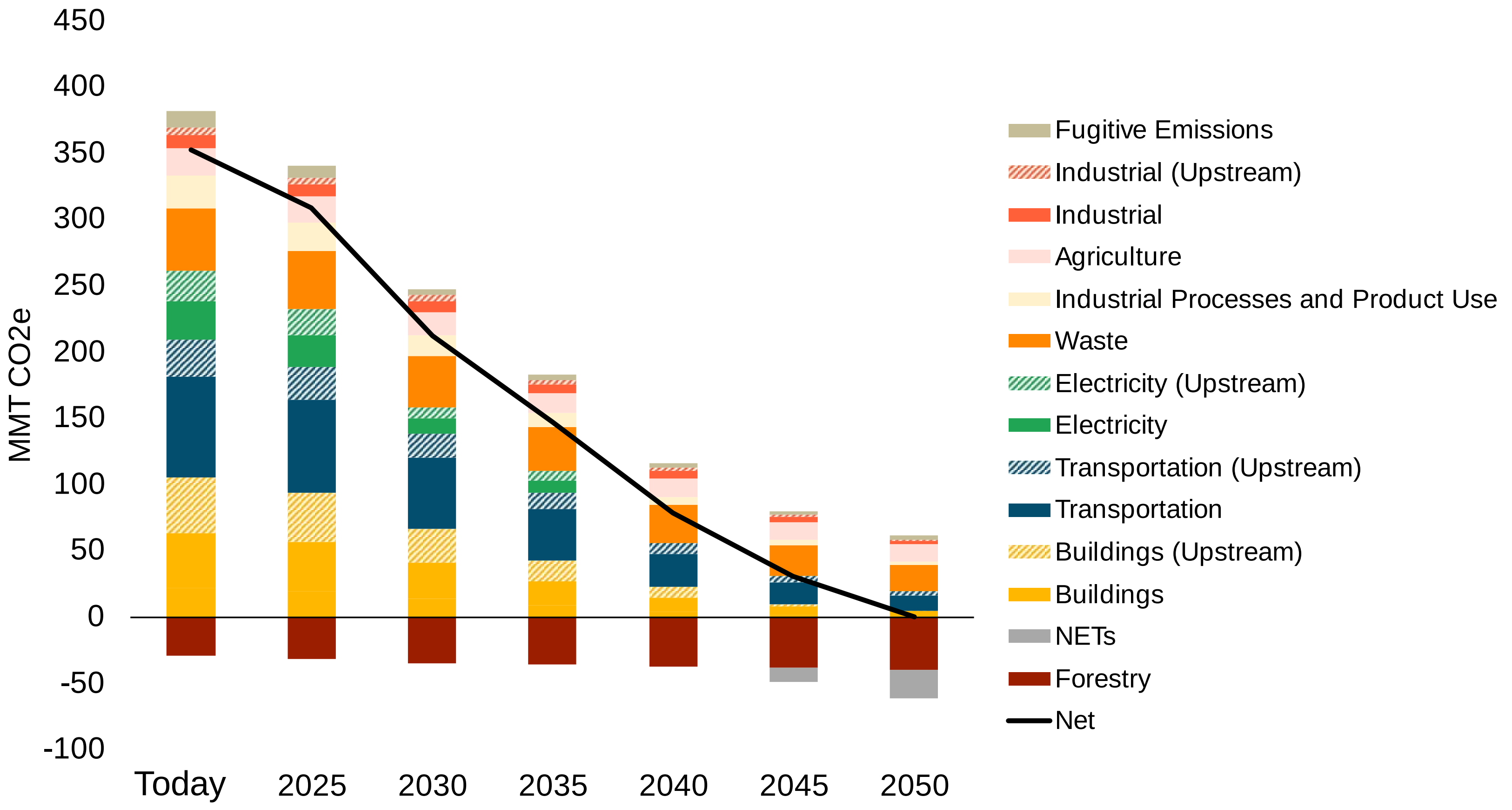
Scenario 2: Strategic Use of Low-Carbon Fuels



2020 is a modelled year, reflecting historical trends

Emissions by Sector over Time

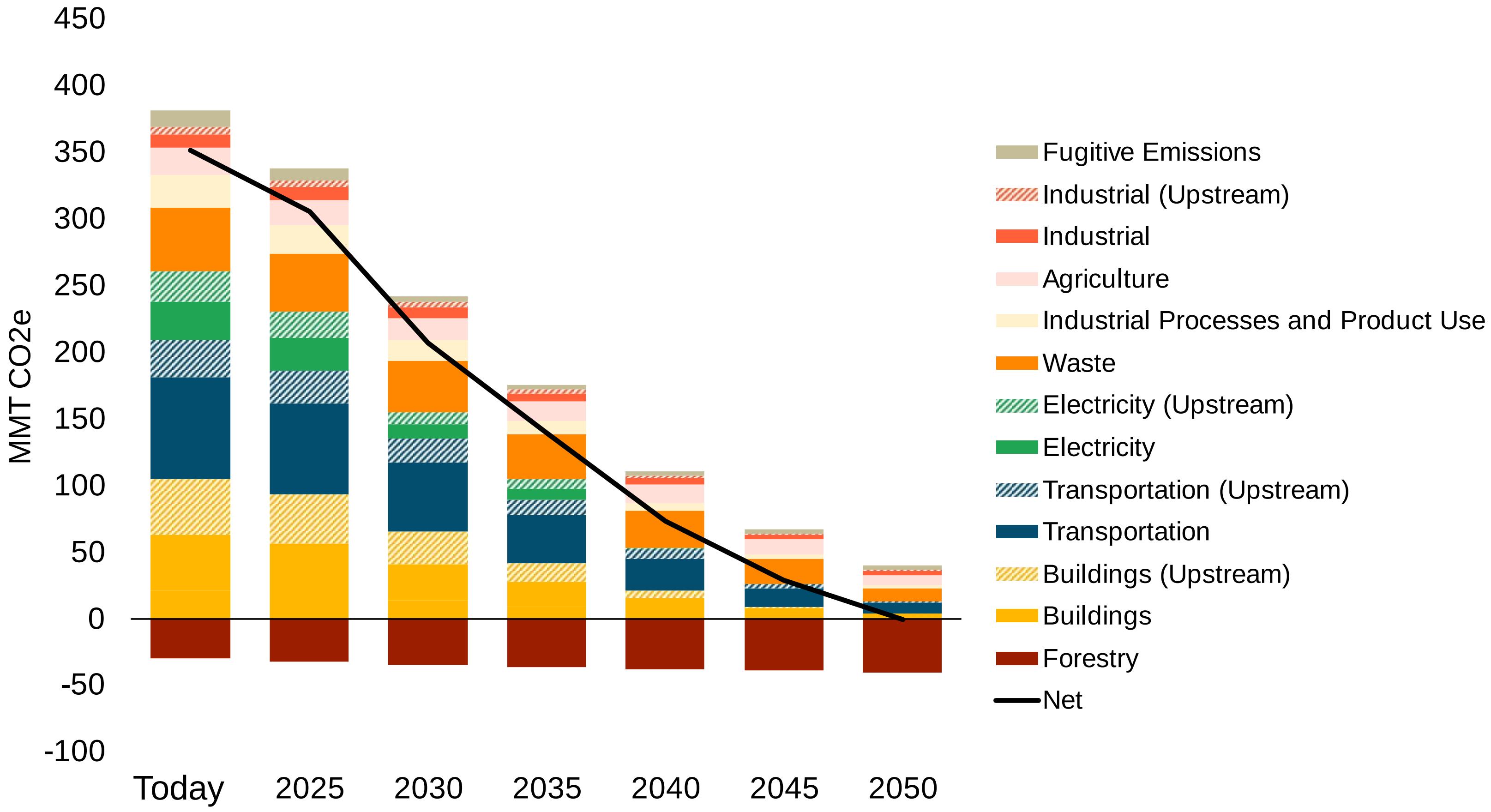
Scenario 3: Accelerated Transition Away from Combustion



2020 is a modelled year, reflecting historical trends

Emissions by Sector over Time

Scenario 4: Beyond 85% Reduction

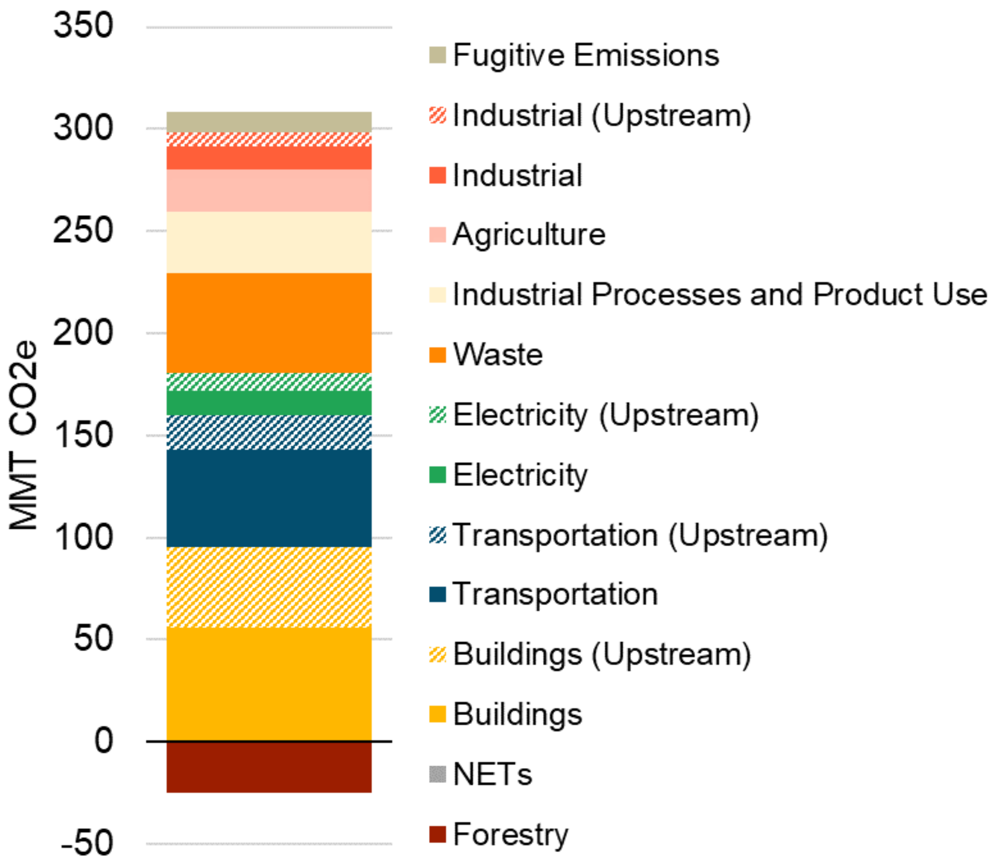


Includes illustrative assumptions for additional innovation in methane mitigation and natural sequestration

2020 is a modelled year, reflecting historical trends

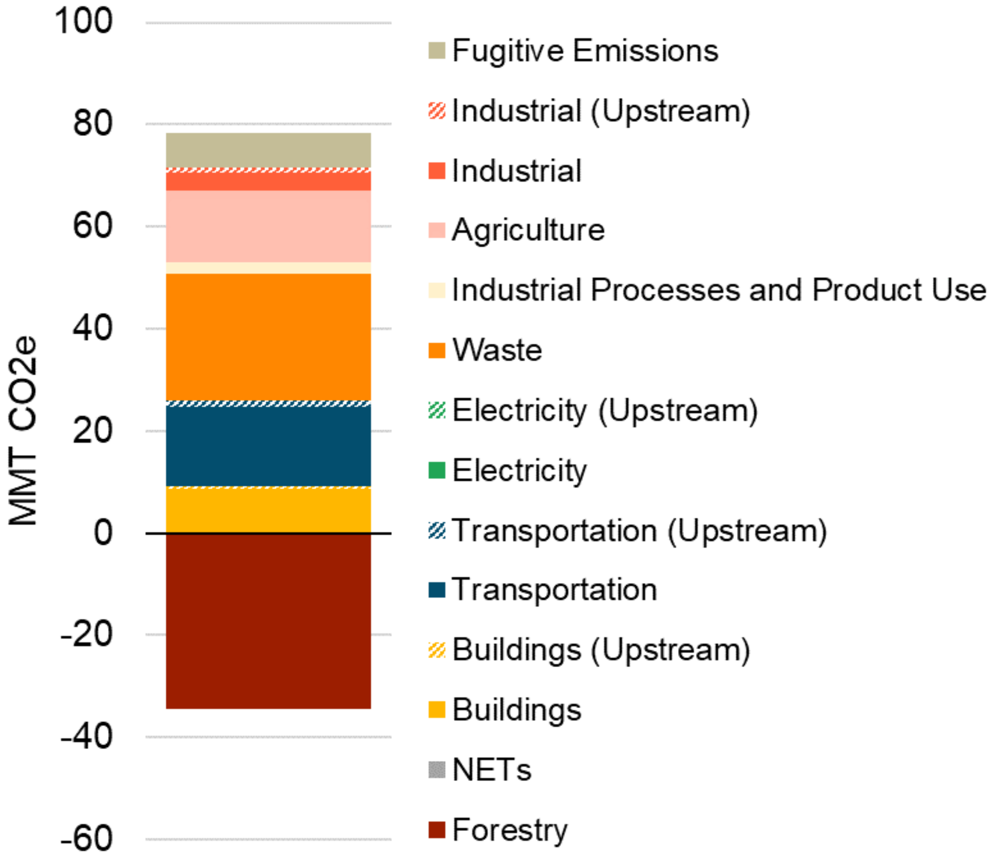
2050 Scenario Snapshot

Reference Case



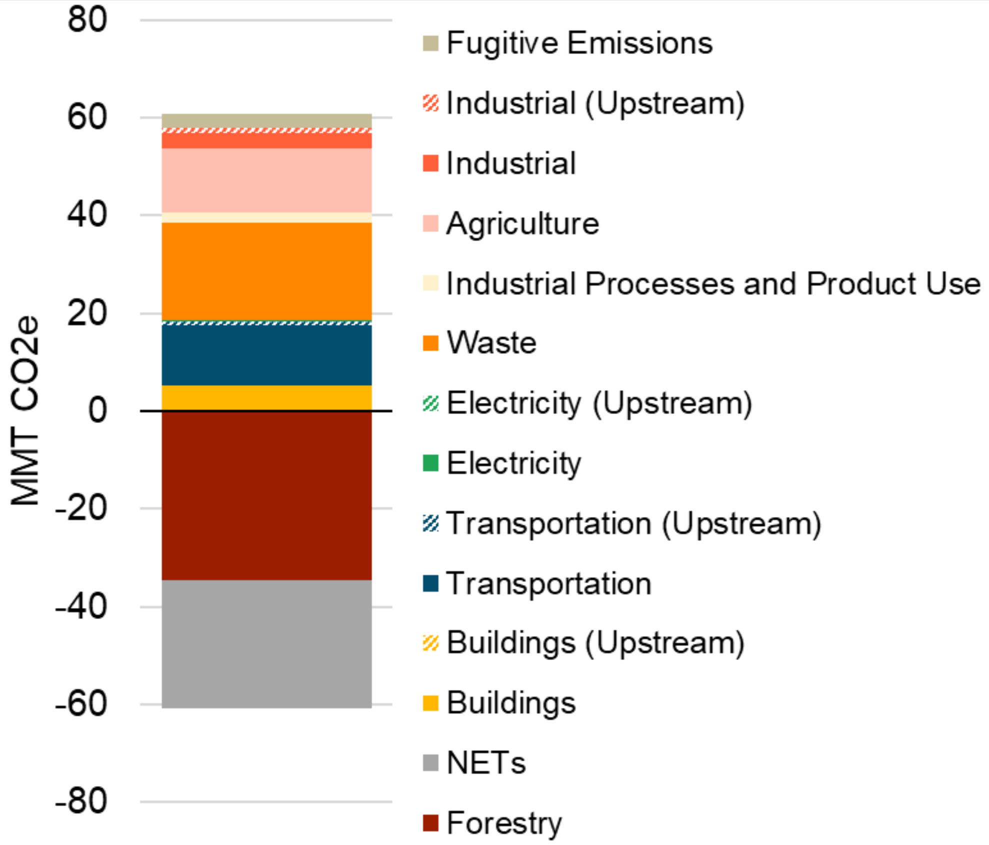
2050 Scenario Snapshot

Scenario 1: AP Recommendations



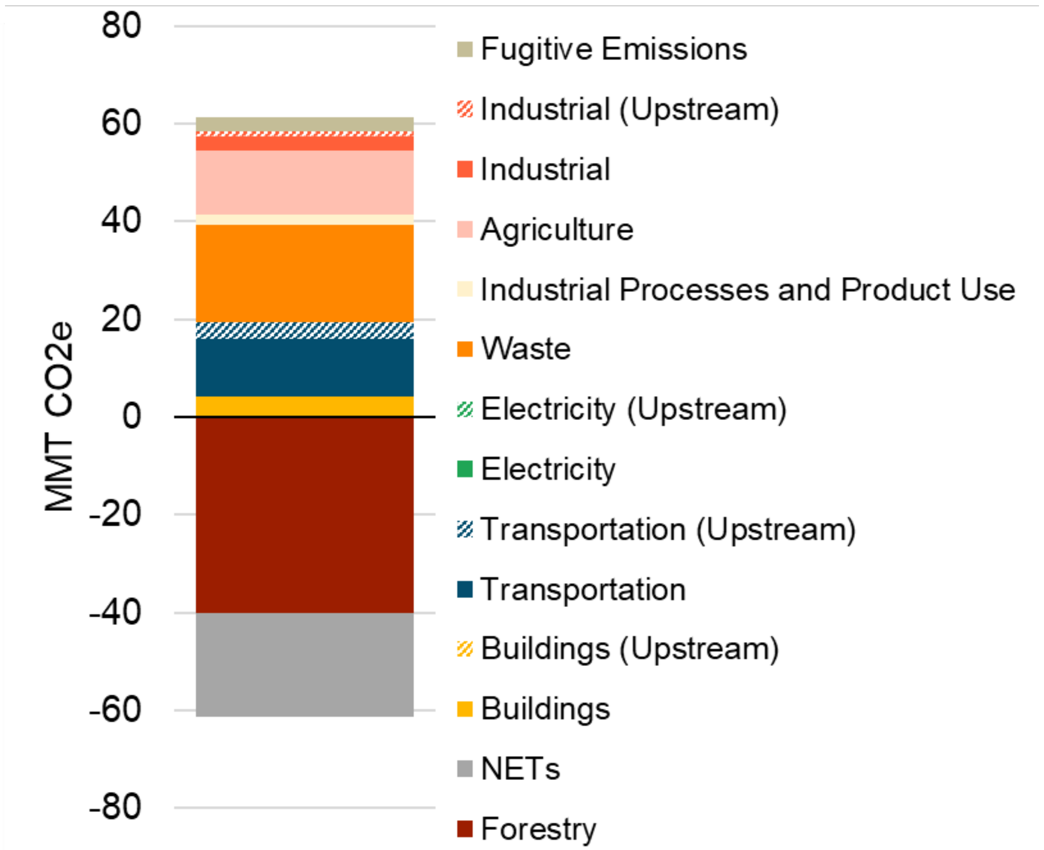
2050 Scenario Snapshot

Scenario 2: Strategic Use of Low-Carbon Fuels



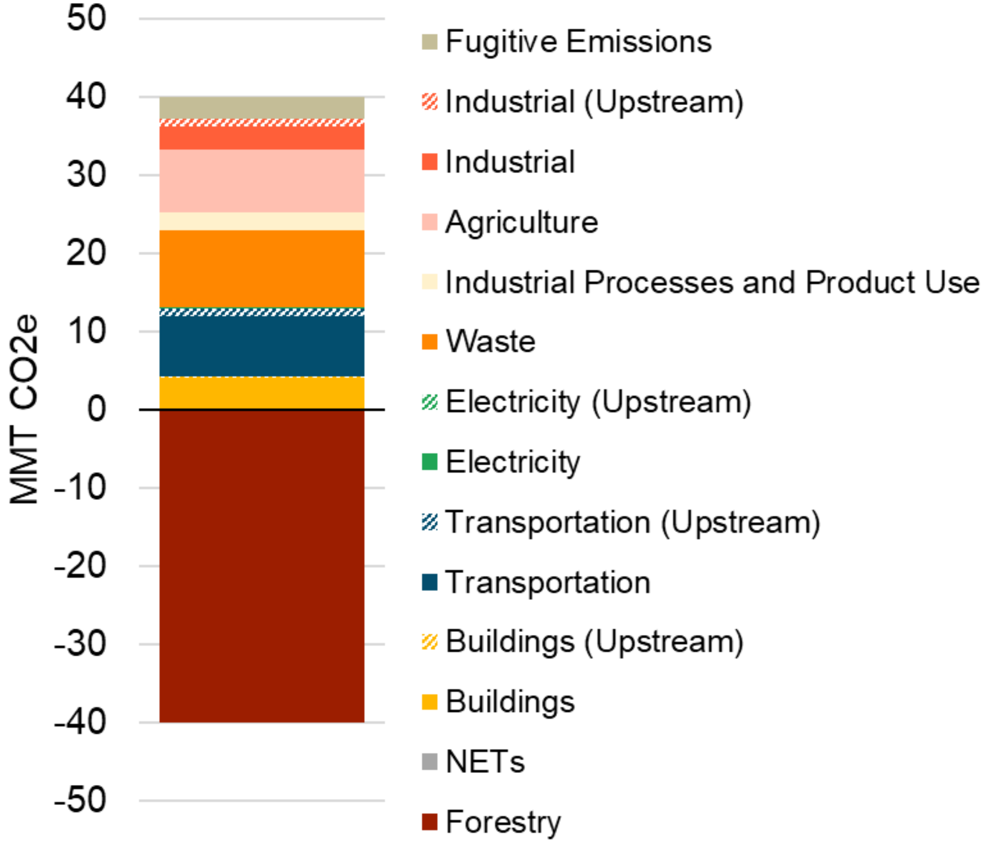
2050 Scenario Snapshot

Scenario 3: Accelerated Transition Away from Combustion



2050 Scenario Snapshot

Scenario 4: Beyond 85% Reduction



Includes illustrative assumptions for additional innovation in methane mitigation and natural sequestration

Next Steps

Next Steps

> Draft Scoping Plan approach
  - Will include multiple scenarios (along with the full costs and benefits) to achieve the emission limits
  - Scenarios build on recommendations from Panels and Working Groups
  - Scenarios informed by feedback from Climate Action Council and the Climate Justice Working Group

October 2021	CAC meeting: October 14, 1-5 PM • Integration Analysis presentation and discussion o Final scenarios results, including full benefits and costs • Draft Scoping Plan walk-through Scoping Plan • Initial draft Scoping Plan provided to CAC (late-Oct.)
November 2021	Scoping Plan • CAC feedback on initial draft Scoping Plan (first 1/2 of Nov.) o Planned as small group sessions by topic area CAC meeting: November 16, 2-5 PM • Report out on Jobs Study • Review/discuss CAC feedback and plan for resolution
December 2021	Scoping Plan • Revised draft Scoping Plan to CAC members (early-Dec.) CAC meeting: December 13, 2-5 PM • Discussion of changes made to draft Scoping Plan • Action on draft Scoping Plan