Upstate and Downstate CLCPA Studies

Stakeholder Meeting – Draft Study Outputs

November 28, 2022

nationalgrid

Today’s Agenda

- **Review CLCPA Study schedule (5 min)**
- **Describe responses to stakeholder questions/feedback on modeling assumptions (20 min)**
  - Leak-prone pipe, RNG/Hydrogen; ASHP/GHSP; treatment of Inflation Reduction Act
- **Q&A and Break (15 min)**
- **Model Results (90 minutes)**
  - Statewide Results – GHG, Energy, Capital Investment, Customer Cost
  - Upstate Results for Niagara Mohawk territory
  - Downstate Results for KEDNY, KEDLI
- **Challenges, risks and regulatory and policy considerations (20 min)**
- **Q&A (30 min)**
- ***Note: today’s discussion is primarily focused on the findings and implications of the quantitative modeling analysis.***
  - ***Factors being addressed qualitatively such as reliability, health and environment, impact on/benefits to disadvantaged communities, and local economic impacts, will be addressed in the draft report that will be shared in December.***

Review of Stakeholder Engagement Schedule and Upcoming Dates

Key Activity	Date
Stakeholder Meeting #1 – Study Workplan	July 13
Stakeholder Meeting #2 – Study Assumptions	August 9
Draft Study Outputs to Stakeholders	November 21
Stakeholder Meeting #3 – Draft Study Outputs	November 28
• *Stakeholder Comments Due on Study Outputs*	*December 7*
Draft Report to Stakeholders	Mid December
Stakeholder Meeting #4 – Review Draft Report	Early January
• *Stakeholder Comments Due on Draft Report*	January TBD

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Agenda

- Introduction and Recap
- Response to Stakeholder Feedback on Assumptions
- Modeling Results and Cost Outcomes
- Stakeholder Feedback and Q&A

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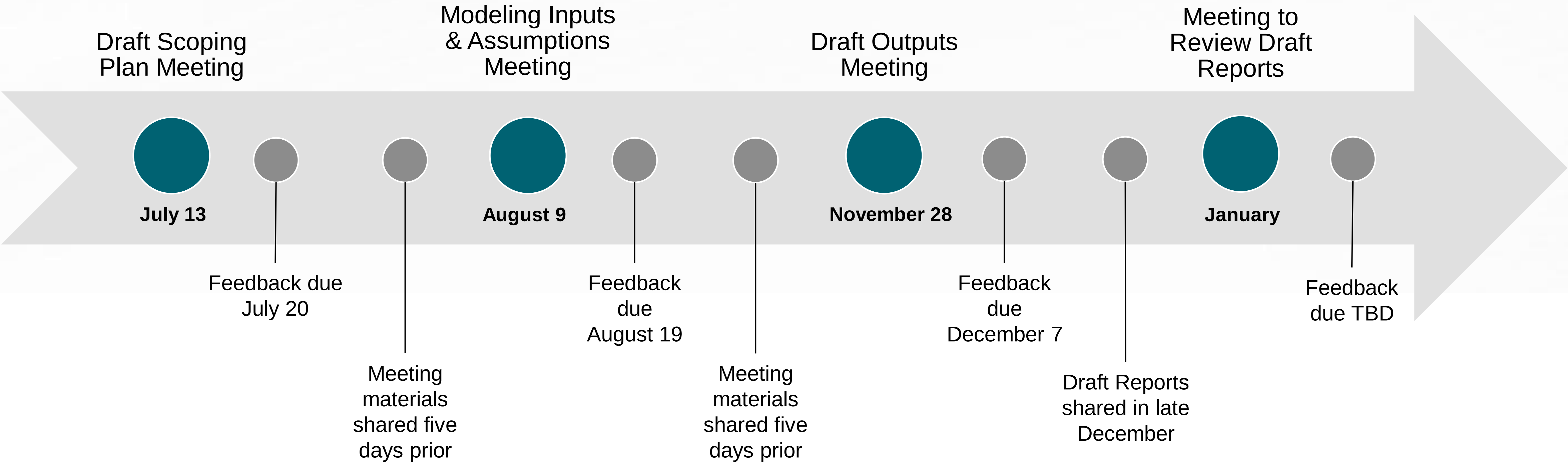
Objectives for Today's Session

Update when agenda is final

- Provide responses to key stakeholder feedback
- Share draft modeling results and costs at the state and OpCo level
- Outline regulatory and business considerations
- Answer questions regarding draft results

Key Stakeholder Engagement Dates



The exact dates and timeframes shown are estimates. We will seek to give as much advance notice on exact dates as possible.

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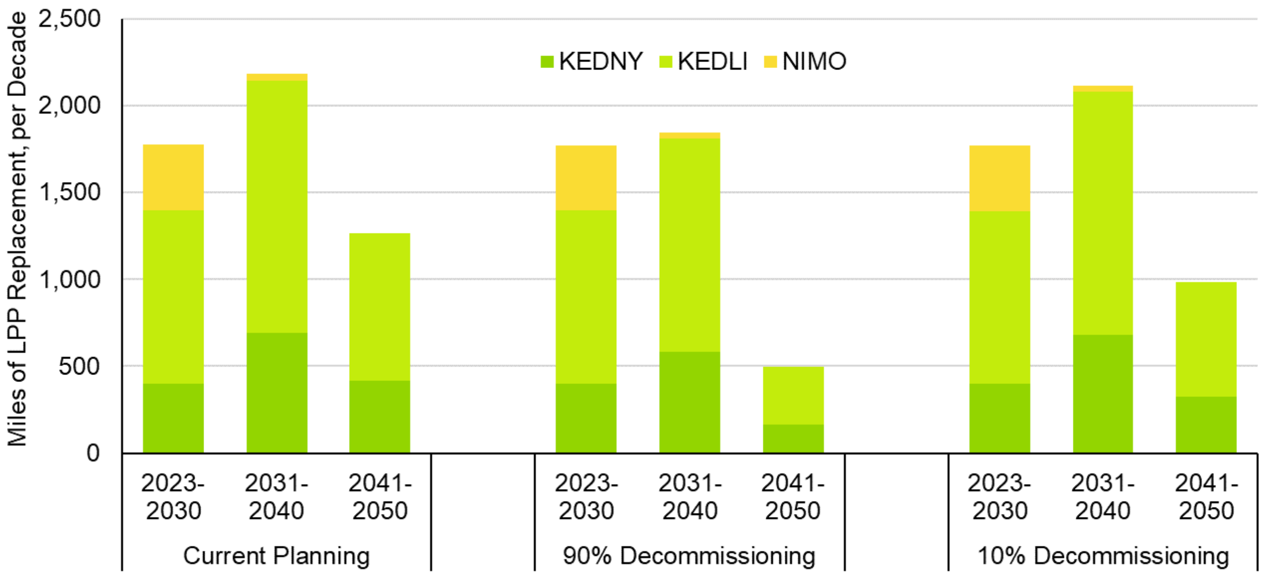
Leak Prone Pipe: Scenarios with high rates of gas network decommissioning have fewer miles of leak-prone pipe replacement and lower projected LPP replacement costs.

- Scenarios assume targeted electrification may be used to prune branches of the gas network.
- Length of LPP in service, LPP replacement costs, and timeline of cost avoidance measures vary by OpCo.

OpCo	Length of LPP in Service, 2021[1] (miles)	Cost of LPP Replacement[2] (2022$/foot)	Start Year of LPP Cost Avoidance
KEDNY	1,437	$1,653	2034
KEDLI	2,782	$450	2028
NMPC	404	$274	2025

Miles of LPP Replacement by decade, by OpCo, comparing current plans to scenarios with gas network decommissioning



[1] US DOT, PHMSA. https://www.phmsa.dot.gov/data-and-statistics/pipeline/pipeline-mileage-and-facilities

[2] Cases 19-G-0309 and 19-G-0310 for KEDNY and KEDLI, and Case 20-G-0381 for Niagara Mohawk

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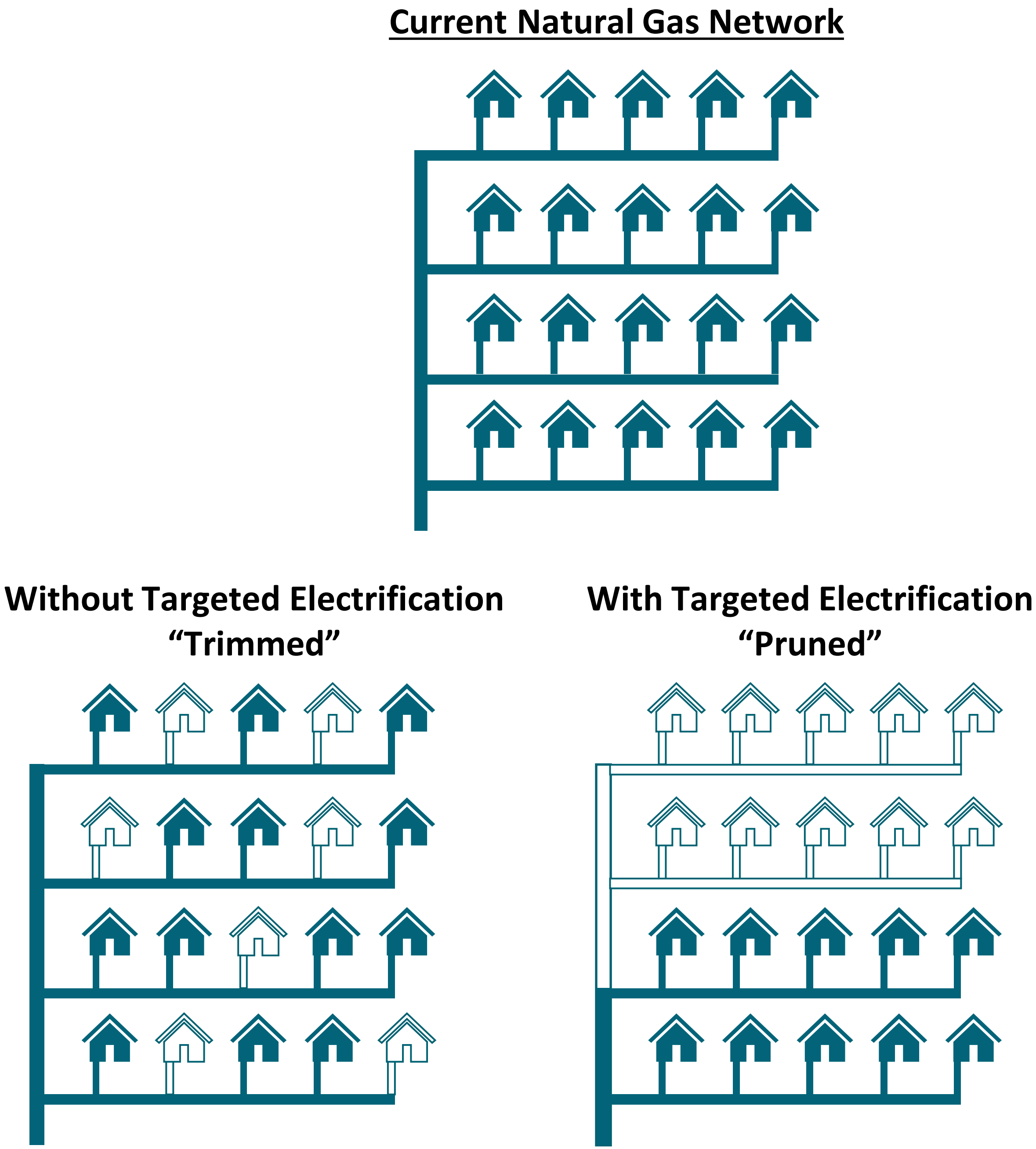
Targeted electrification may offer potential LPP cost savings

- “Targeted electrification” describes the coordinated disconnection of gas network branches, rather than disconnecting individual customers and continuing branch service to remaining customers.
- This approach may enable cost savings from reduction in O&M costs and LPP investment.
- However, the feasibility of this approach and the potential for gas system cost avoidance is uncertain. Among other things, feasibility is influenced by:
  - The upfront equipment cost of whole-building electrification
  - Customer willingness to opt-in to electrification programs
  - Impacts to network safety and reliability



Hydrogen Assumptions

- All hydrogen used in study is assumed to be green hydrogen.
- Emissions associated with hydrogen use and combustion are consistent with DEC draft GHG accounting framework.
  - Hydrogen yields no GHG emissions from in-state combustion or from upstream out-of-state activities.
- CEV.NY scenario assumes H2 blending in pipeline gas at 7% of energy by 2050 (approx. 20% by volume)
  - Stakeholder concern over high percentage of volume assumed, citing UC Riverside's CPUC study.
  - The CPUC study recommends real-world demonstration of 5%-20% hydrogen volume projects to fill knowledge gaps and identify other factors that may contribute to leakage. Pilot projects are underway in the US and Europe.
  - CEV.NY scenario assumes that near-term blending (through mid-2030s) would be limited to 3.2% volume and that H2 blending concentrations of 20% volume would not be reached until late 2040s.
- The efficiency of hydrogen-fired equipment is assumed to be the same as natural gas fired equipment, in line with Integration Analysis assumptions.
- Costs of new hydrogen infrastructure are taken from Integration Analysis, Annex 1: Hydrogen Costs
  - Costs include a sum of "400-mile Pipeline Costs" and "Other Capital Costs" (for pipeline blending, interconnection, etc.)
- Assume that the cost of retrofitting existing pipeline to carry H2 is 18% of the cost of new pipeline construction.
  - Source: European Hydrogen Backbone (2020) Table 5 (link)
- Hydrogen import prices are based on MA DPU 20-80 Future of Gas Report (but our modeling projects that H2 demand will be met by in-state production).

[1]AGF (2019) Renewable Sources Of Natural Gas (Link)

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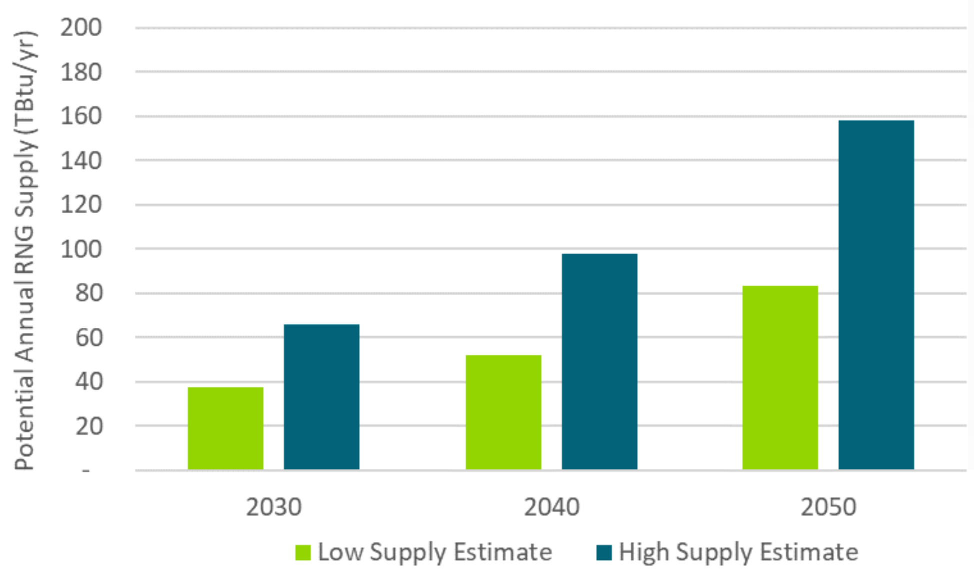
RNG Assumptions

- RNG will be available from in-state production and via imports from Eastern US states.
    - In-state RNG potential referenced from NYSERDA (2022).
    - RNG import potential is limited to 7.2% of high resource case potential in U.S. Eastern states, referenced from AGF(2019). This 7.2% share represents National Grid's share of Eastern US residential & commercial sales in 2020.
- Analysis for this study includes costs for production, connection to gas network, and environmental attributes.
    - In-state infrastructure cost source: NYSERDA (2022)
    - RNG import cost source: MA DPU 20-80 Future of Gas Report, Appendix 4
- Emissions from RNG combustion are consistent with DEC draft GHG accounting framework and Integration Analysis
    - Upstream (out-of-state) emissions avoided from RNG collection and upstream emissions from RNG leakage are not counted.

RNG Potential Available to KEDNY, KEDLI, and NMPC, based on utilities' portion of Eastern US RNG Supply Potential



Sources:
2040 potentials from: AGF (2019). *Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment*. Source: https://www.gasfoundation.org/wp-content/uploads/2019/12/AGF-2019-RNG-Study-Full-Report-FINAL-12-18-19.pdf

2030 and 2050 potentials scaled from: AGA (2022). *Net Zero Emissions Opportunities for Gas Utilities.* Source: https://www.aga.org/research/reports/net-zero-emissions-opportunities-for-gas-utilities/

NYSERDA (2022). "Potential of Renewable Natural Gas in New York State" https://www.nyserda.ny.gov/-/media/Project/Nyserda/files/EDPPP/Energy-Prices/Energy-Statistics/RNGPotentialStudyforCAC10421.pdf

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Other Assumptions Updates

- **Heat Pump Efficiencies:** Stakeholders asked why commercial ASHP efficiency values increase before 2030, while residential ASHP and GSHP efficiencies do not increase.
  - Efficiency values for ASHP and GSHP equipment were referenced from the CAC Integration Analysis.
  - Federal minimum efficiency standards for Commercial ASHPs will increase in 2023, as detailed in 10 CFR 431.97, Table 3.
- **Geothermal Heating:** Stakeholders questioned the relative prioritization of low carbon fuels versus geothermal heating technologies.
  - The CEV.NY scenario assumes significant adoption of geothermal technologies. By 2050, the CEV.NY scenario projects 18% of residential customers heating with either standalone GSHP or networked geothermal.

Input Assumptions Workbook 2.0

- Based on feedback after Stakeholder Meeting #2, Guidehouse updated the modeling inputs and assumptions workbook previously shared with stakeholders.
- A new tab notes the updates made to the workbook

Cover Page of Assumptions Appendix v2.0

CLCPA Study - Assumptions Appendix
Prepared for National Grid

November 18, 2022
guidehouse.com

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Excerpt of Change Log tab, Assumptions Appendix v2.0

Tab	Change	Rationale	New Source (if applicable)
Regionalization	Expanded Region/OpCo mapping	Improved regionalization	
Utility Finance	Added tab with key cost & accounting parameters	Used in cost calculations	
Emissions	Streamlined to include relevant quantities	Clarity	
End User Equipment	Combined efficiency and cost data	Clarity	
Supply Technology	Combined cost and existing quantity data	Clarity	
Infrastructure Technology	Combined cost and existing quantity data	Clarity	
Infrastructure Technology	Updated infrastructure costs to align with latest filings	Improved cost data	

Inflation Reduction Act

- Production tax credits (PTCs) and investment tax credits (ITCs) will shift some cost burden from New York investors and ratepayers to federal taxpayers.
- For many cost categories, the impact of IRA will be similar for CAC and CEV.NY scenarios.
- The National Grid CLCPA study will consider these impacts qualitatively, not quantitatively.

Topics (IRA Section)	Difference between scenarios	Rationale
Renewable Electric Generation (13101-13103)	Very Small	All scenarios project similar renewable development on a similar timeline (~45 GW by 2030, ~135 GW by 2050). Scenarios have slight difference in capacity mix.
Biogas Production (13102)	Small, favoring CEV.NY	CEV.NY scenario assumes greater deployment of incentive-eligible RNG. However, CEV.NY assumes most development of RNG happens after incentives sunset in 2025.
Clean Fuel Production (13704)	Small, favoring CEV.NY	Tax credit applies to heating fuels of "transportation quality" produced before 2028.
Carbon Capture (13104) Nuclear Power (13105) Vehicles (13401-04)	None	All scenarios have limited CCS deployment, have the same timeline for nuclear generation, and use similar assumptions re: vehicle fleet conversion.
Hydrogen Production (13204)	Large, favoring CEV.NY	CEV.NY deploys a much larger amount of in-state H2 generation than CAC scenarios, and deployment is all green H2, expected to qualify for high incentives.
Building Energy Efficiency (13301,13303)	None	Scenarios have identical assumptions re: building efficiency improvements.
Building Heating & Hot Water Equipment (13302)	Small, favoring CAC	Tax credits will reduce customer cost of equipment upgrades. CAC scenarios assume 10-15% higher adoption of heat pump equipment compared to CEV.NY scenario.
Residential Efficiency & Electrification Rebates (50121-23)	Small, favoring CAC	Rebates will reduce customer cost of building & equipment upgrades. Scenarios have similar assumptions re: efficiency & equipment, but CAC scenarios have slightly higher heat pump adoption. The impact of federal rebates will depend on state-level implementation approach.
Methane Emissions (60113)	Unclear – Likely small, favoring CAC	Could increase commodity cost of NG supply to account for methane emissions fees. All scenarios assume some continued gas use, and all scenarios cease fossil fuel use. CEV.NY scenario may be more impacted in interim years, prior to transition to RNG. Magnitude depends on upstream emissions and interventions to reduce them.

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Introduction and Recap

Response to Stakeholder Feedback on Assumptions

Modeling Results and Cost Outcomes

Stakeholder Feedback and Q&A

Modeling Approach – Low Carbon Pathway (LCP)

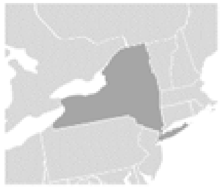
"What if?" modeling finds lowest-cost path to scenario outcomes

LCP Model Configuration to NY

The LCP model is an integrated capacity expansion and dispatch optimization model used to identify the lowest-cost pathway to a decarbonized energy system (electric and gas).

Different scenarios and sensitivities can be easily evaluated.

Geographic Scope: NY & neighboring regions



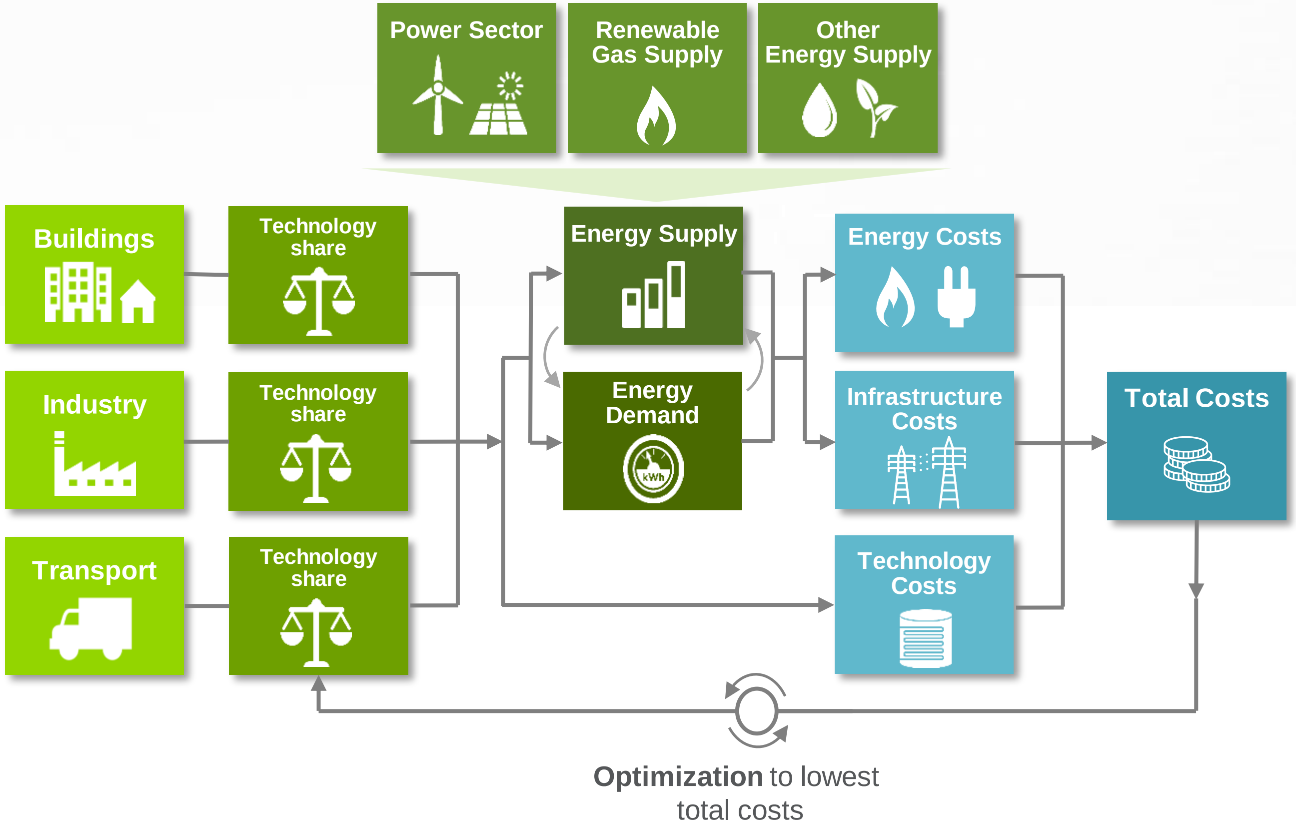
Energy Carriers:
- Electricity
- Hydrogen
- Methane

Investment Types:
- Infrastructure & supply capacity
- Elec/Gas Storage
- Conversion techs (e.g., electrolyzers)

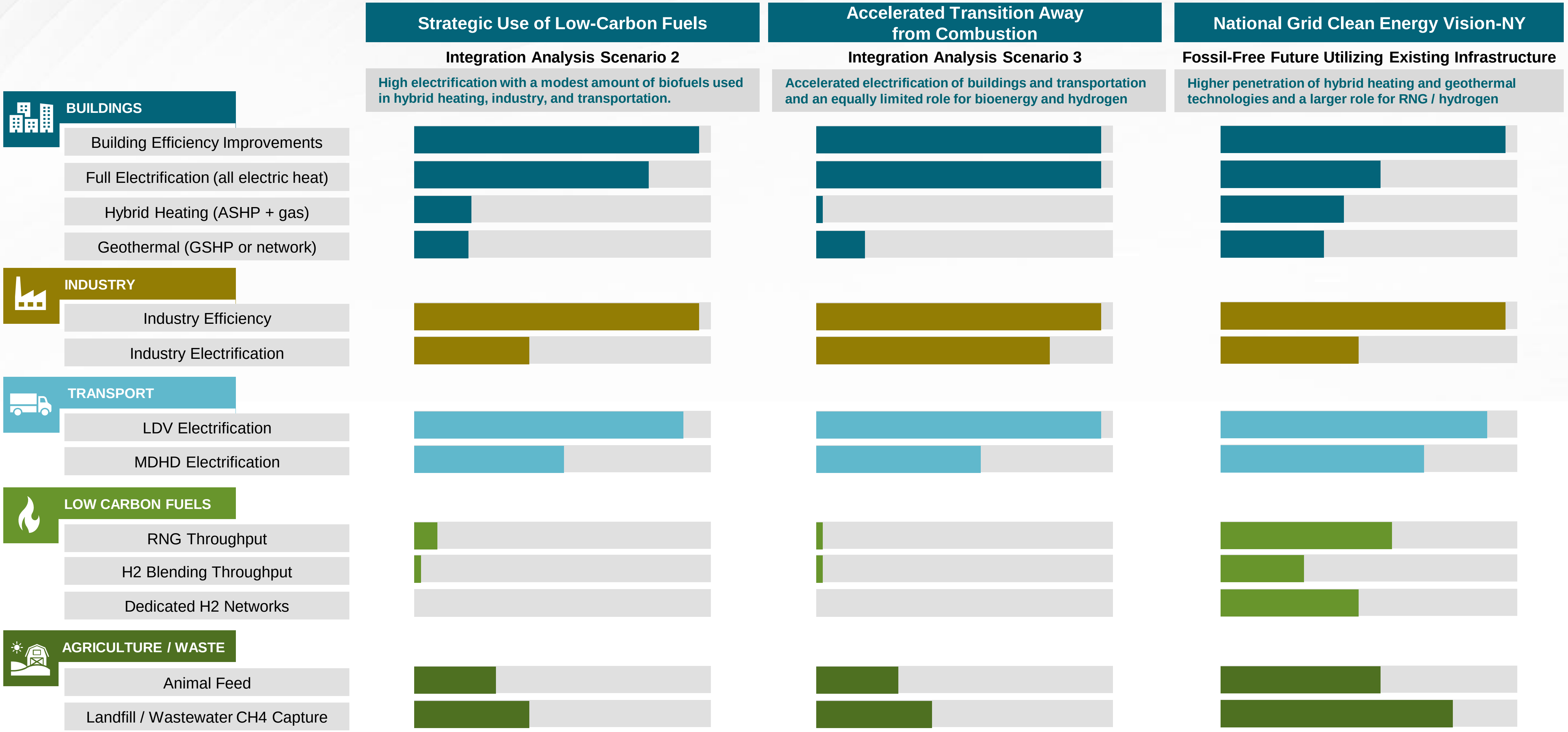
LCP Model Key Outputs

- Low-carbon and renewable gas quantities over time
- Energy system costs including gas and electric network investments:
- Supply capacity (onshore/offshore wind, electrolyzers, SMR, etc.)
- Transmission Interconnections (transmission lines, new/retrofit pipelines, etc.)
- Storage assets (hydrogen storage, battery storage, etc.)
- Timeline of investments (2025, 2030, 2035, 2040, 2045, 2050)

Model Design



CAC Integration Analysis scenarios focus on electrification; National Grid Clean Energy Vision scenario uses hybrid heating, RNG/H2 deployment



Each scenario will be CLCPA compliant under Draft DEC Emission Guidelines.

For emissions sources not illustrated above (Oil & Gas, IPPU, HFCs, and Sequestration), modeling will use consistent assumptions across scenarios, aligned with Integration Analysis Scenario 2.

The scenarios reflect the unique attributes of National Grid gas territories in Upstate and Downstate New York.

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Observation
Full electrification and H2 conversion are more challenging in dense urban settings
Hybrid heating is easier to deploy than full electrification in dense urban settings
NYC Local Law 97 will drive near-term electrification of larger buildings in NYC.
Downstate gas networks have greater lengths of leak-prone pipe (LPP) material
Replacing LPP is more costly in dense urban areas

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*Based on lengths and costs in Annual Leak Prone Pipe (LPP) Prioritization, Type 3 Leak, and Capital Report, Case 19-G-0309

The mix of building heating systems evolves over time as buildings are partially and fully electrified.

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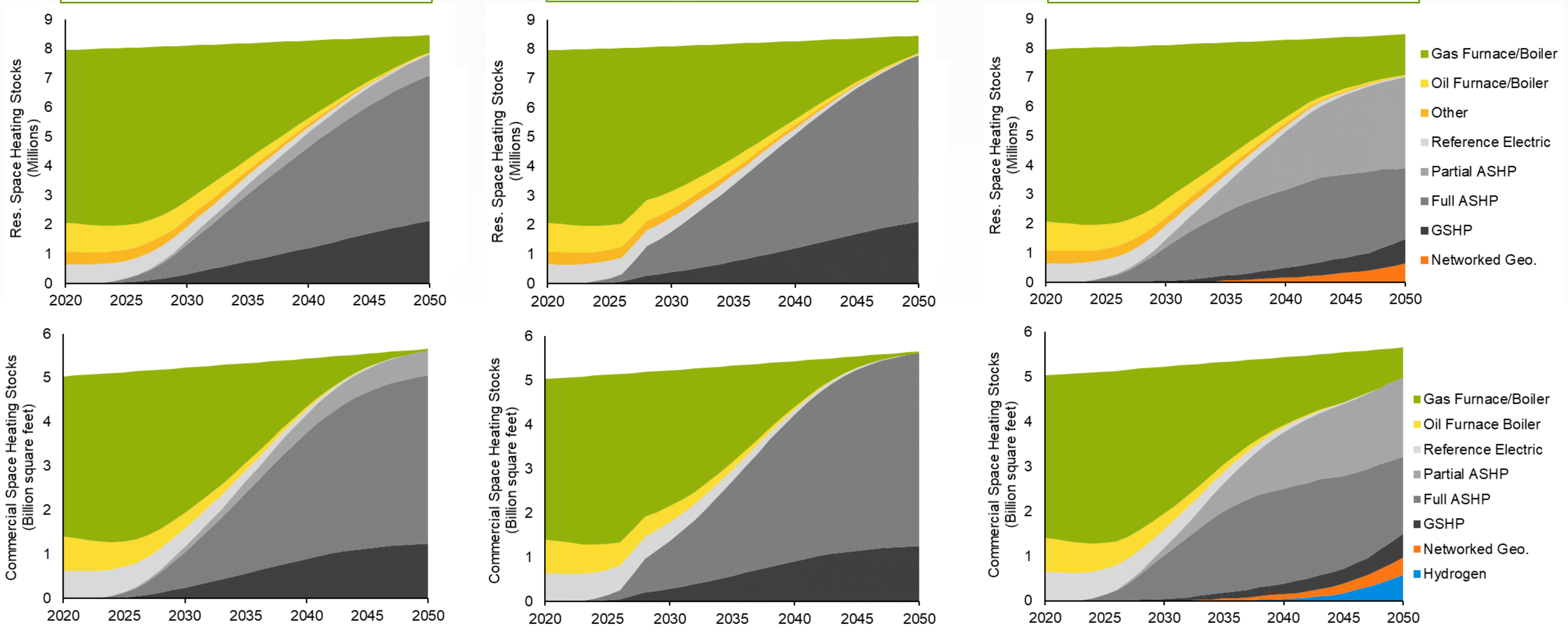
Strategic Use of Low-Carbon Fuels | **Accelerated Transition Away from Combustion** | **National Grid Clean Energy Vision - NY**

Residential

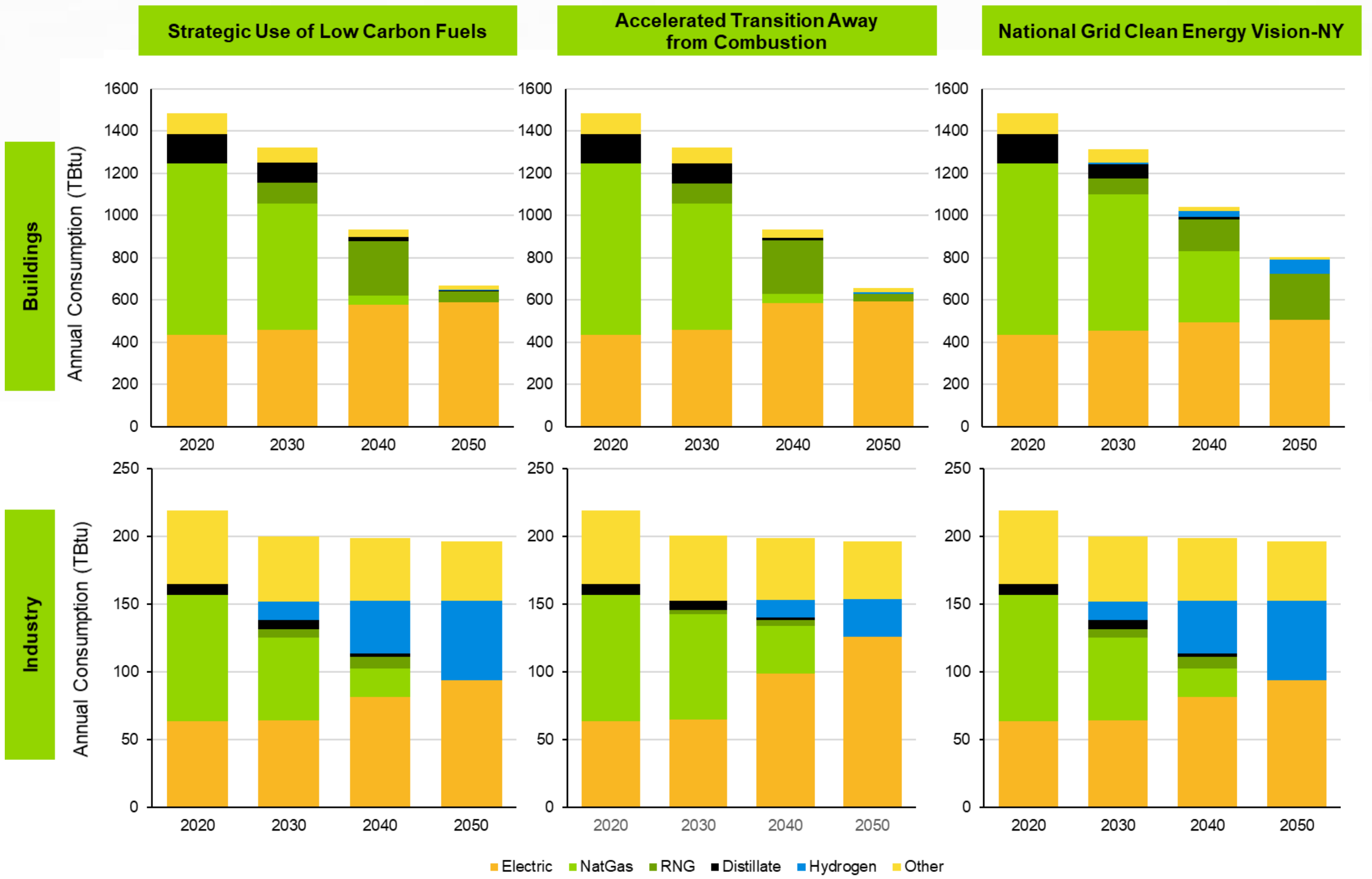
Commercial



Building energy use is almost fully electrified in CAC scenarios, while CEV.NY scenario balances electrification with RNG-fueled hybrid heating and pure H_2 systems. Industrial gas use shifts to electricity and hydrogen.

- All scenarios assume that, by 2050:
  - Energy efficiency reduces space heating and cooling loads by 30%.
  - Over 95% of buildings heated by fuel oil and propane are electrified.
- CAC scenarios assume >90% of gas-heated buildings are fully electrified by 2050.
- In 2050, CEV.NY shows hydrogen use in buildings, from hydrogen pipeline blending, and from a portion of customers receiving 100% H2 service.
- For industry sector, CEV.NY assumes same projections as in CAC "Strategic Use" scenario: Industry gas use is electrified or converted to H2.

NY State – Energy Consumption by Sector and Energy Carrier



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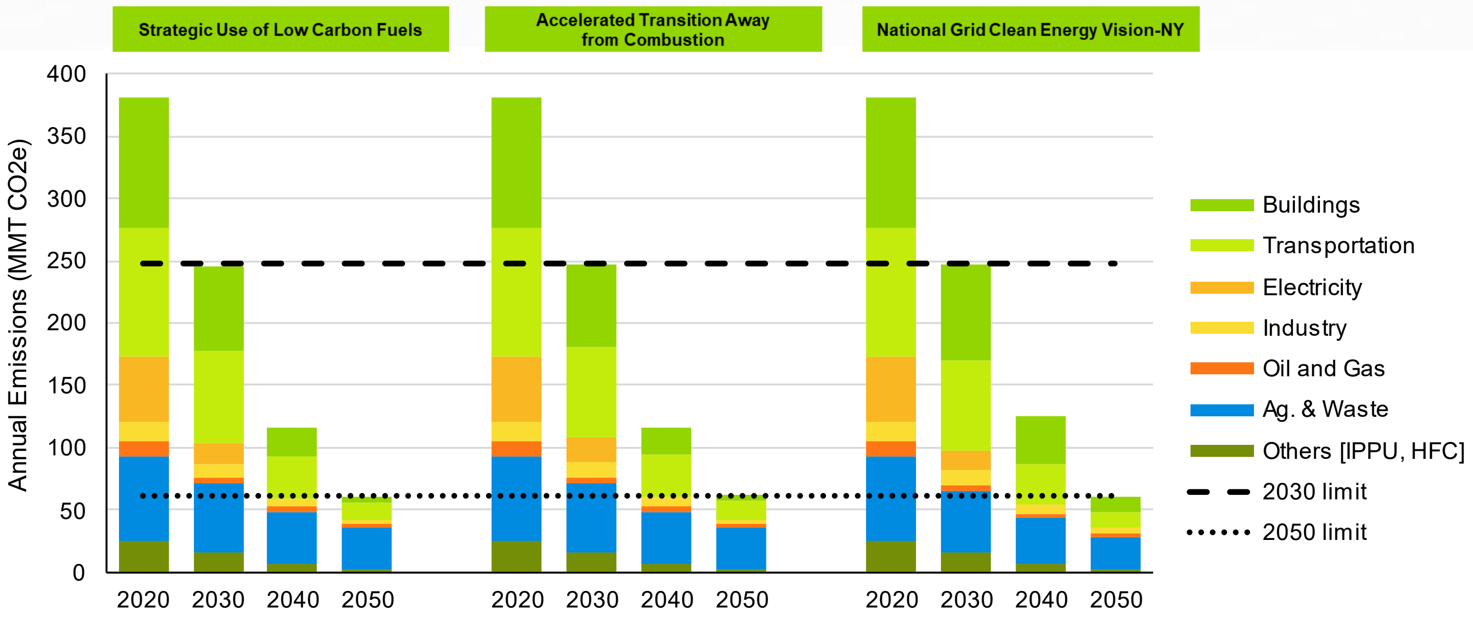
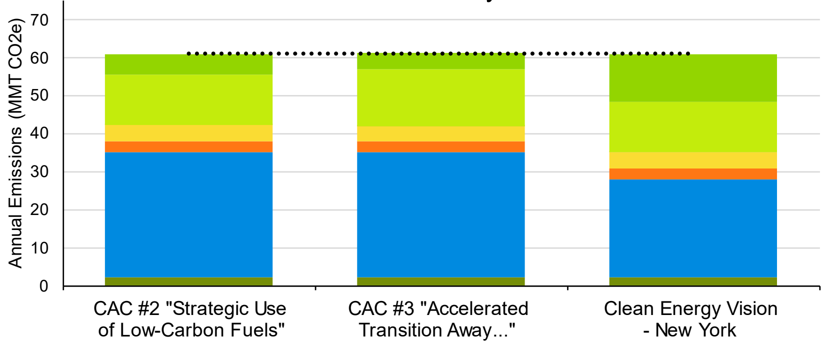
Each scenario is CLCPA compliant under Draft DEC Emission Guidelines.

- All scenarios will achieve CLCPA gross emissions limits in 2030 and 2050.
- In 2050, CEV.NY scenario has a higher proportion of emissions from buildings, due to higher rate of RNG use in hybrid heating and gas heating systems.
- Compared to CAC scenarios, the CEV.NY scenario assumes greater reduction in non-energy emissions from agriculture and waste sectors, due to increased investment in methane capture for RNG production.
- CEV.NY scenario adopts Integration Analysis emissions assumptions for oil & gas and other sources, including industrial processes and product use (IPPU) and hydrofluorocarbons (HFC).

NY State – Gross Annual Emissions by Scenario (2020-2050)



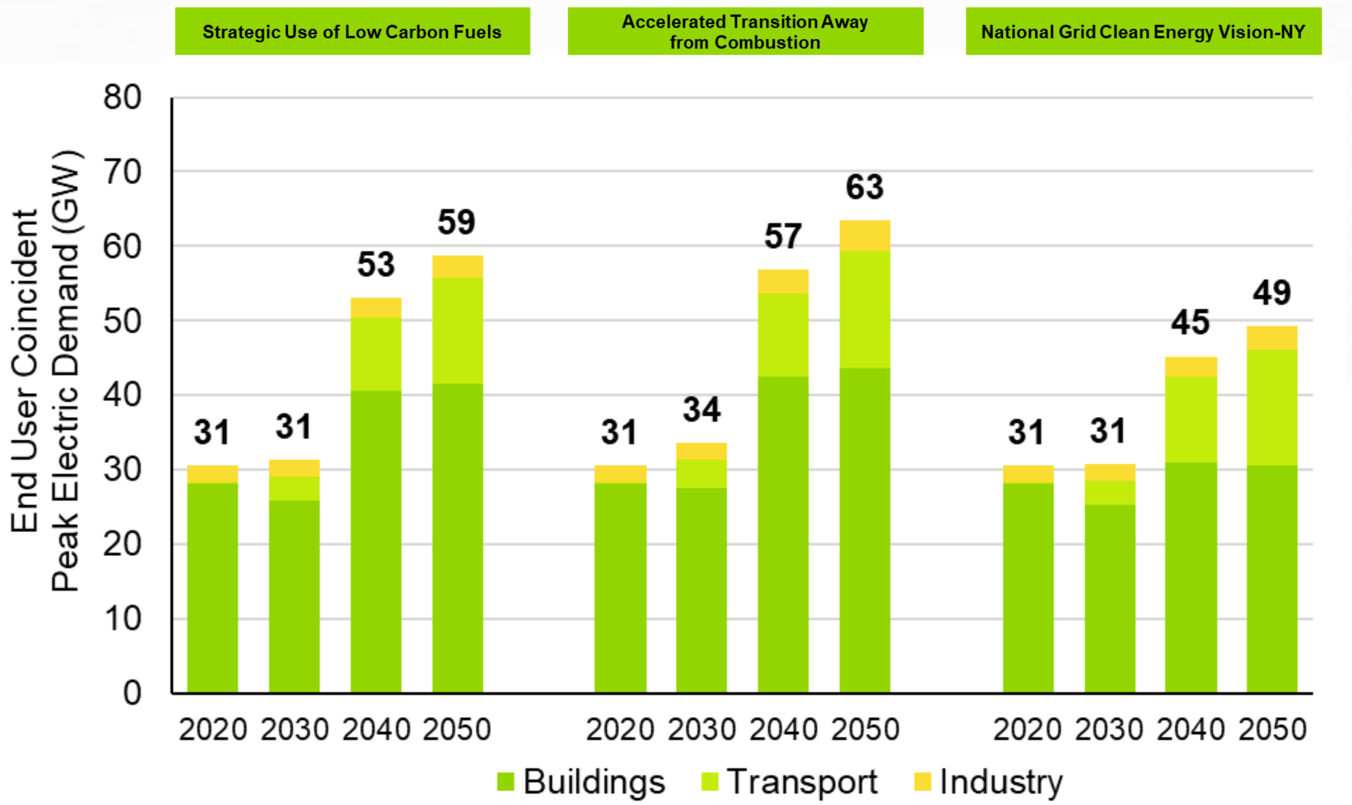
Detail: 2050 Gross Emissions by Scenario and Source



Coincident peak electric demand grows less in the CEV.NY scenario than the CAC scenarios due to increased adoption of hybrid heating systems.

- In all scenarios, electrification leads to increased peak electricity demand, and a system shift from summer peak to winter peak.
- The CAC's "Strategic Use" scenario shows slightly lower peak demand in 2030 and beyond, due to some limited adoption of building hybrid heating systems.
- In the CEV.NY scenario:
  - The greater deployment of hybrid heat in buildings leads to less electric peak growth, since hybrid systems meet a portion of peak heating load using combustion.
  - Lower projected peak demand leads to lower projected investments in new electric system infrastructure.

NY State – Total Annual Coincident Peak Demand for End User (i.e., Direct) Electric Consumption



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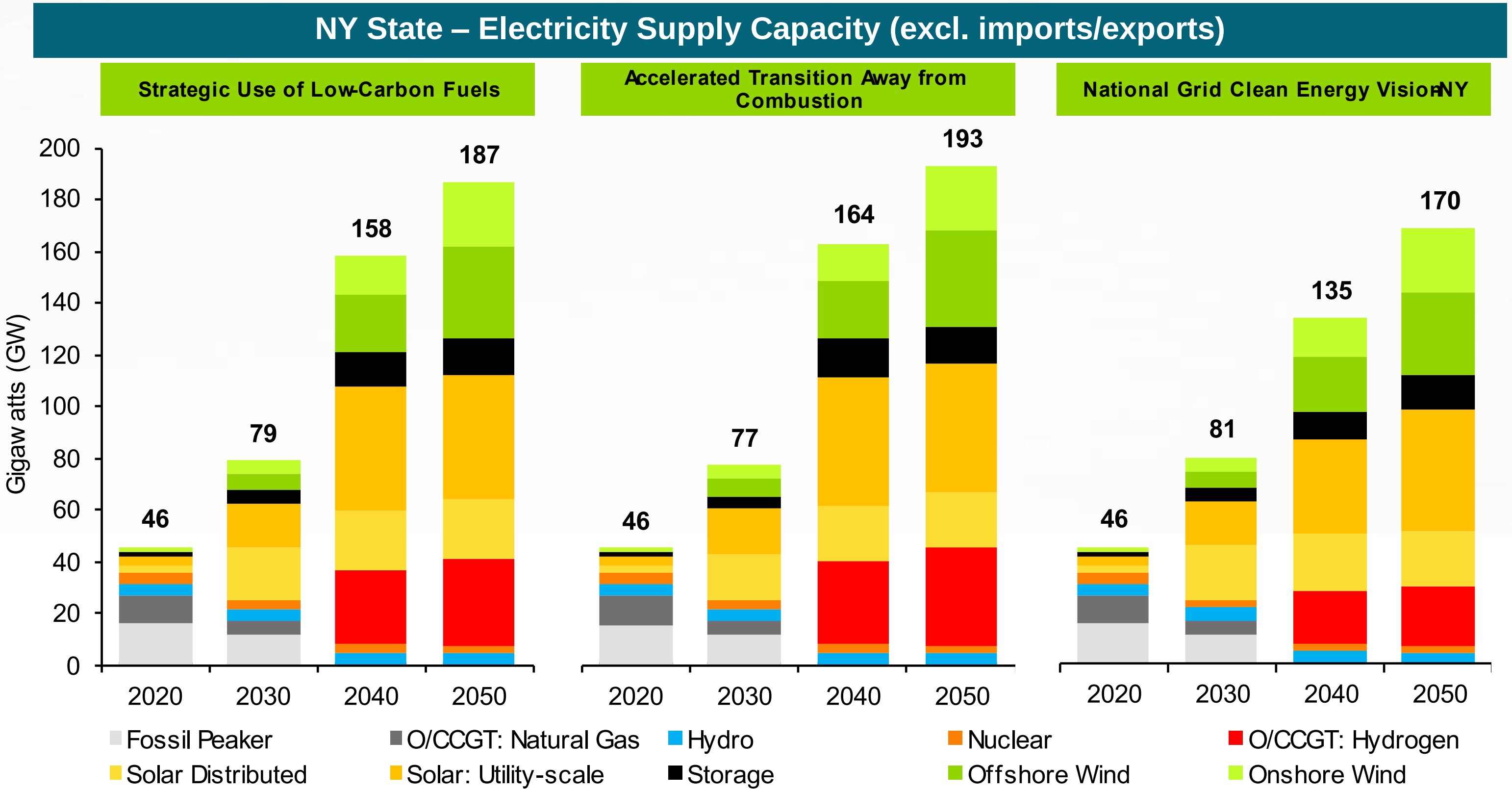
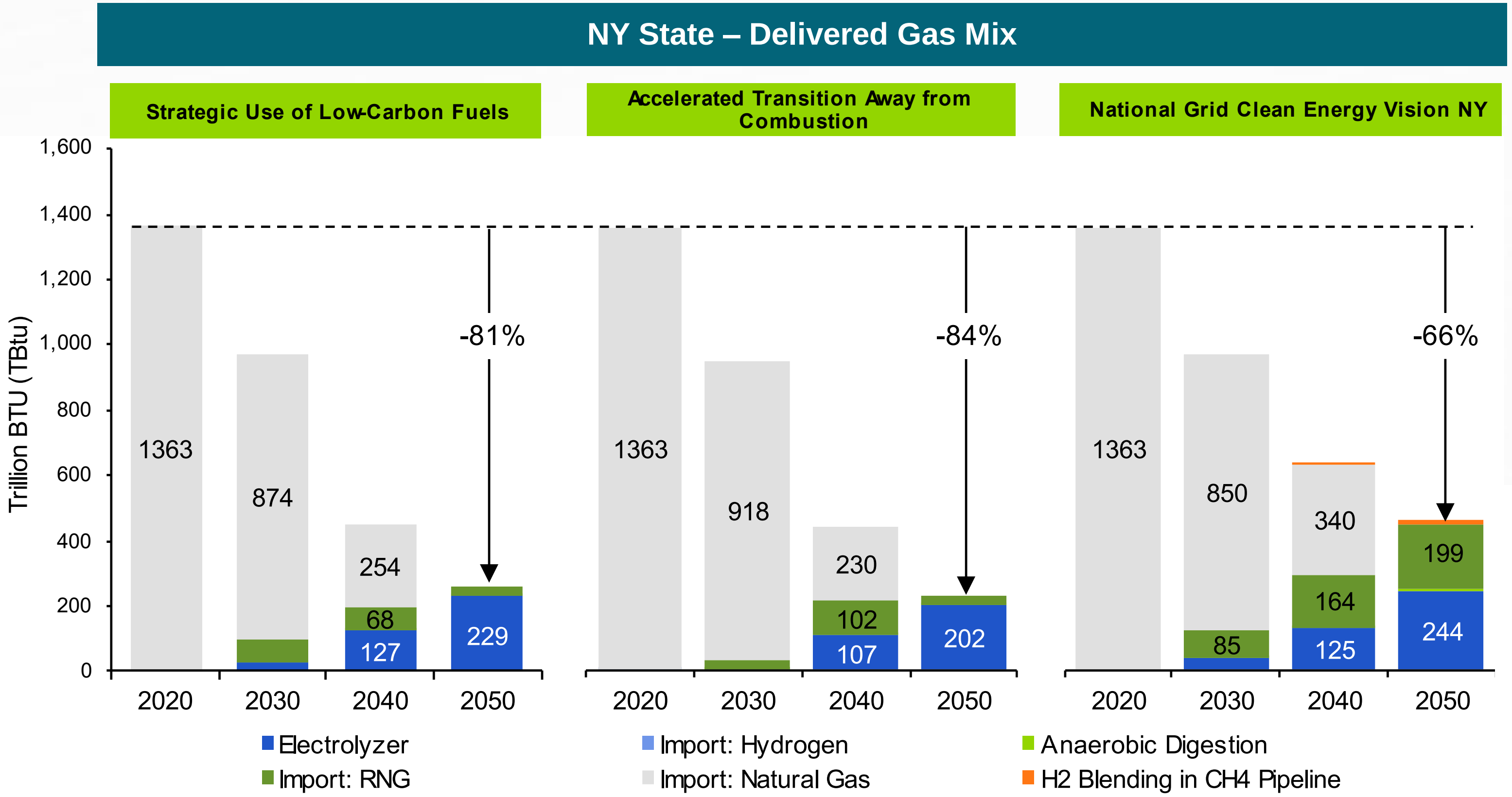
Electric supply capacity increases and fossil fuel generation is phased out in all scenarios; CEV.NY scenario requires less hydrogen turbine peaking capacity and less battery storage.

- Electric supply capacity expands over time to meet demand in 4 representative seasonal days, Summer and Winter peak days, and a Winter peak day with limited renewable availability (e.g., low wind speed)
- All scenarios:
  - Assume retirement of fossil generators before 2040.
  - Use the same assumptions for nuclear and hydropower baseload capacity.
  - Project that most solar capacity will be at the utility scale, with some BTM adoption.
- CAC scenarios show more hydrogen gas turbine capacity post-2030, to meet winter peak demand in low renewable resource periods.
- The CEV.NY scenario projects higher solar development, to support hydrogen production for storage in non-winter seasons.



In all scenarios, gas customer counts and delivery volumes decline, and fossil methane is gradually replaced by RNG and H2. Total gas use declines less in the CEV.NY scenario, which repurposes existing infrastructure to deliver renewable, low-carbon gas.

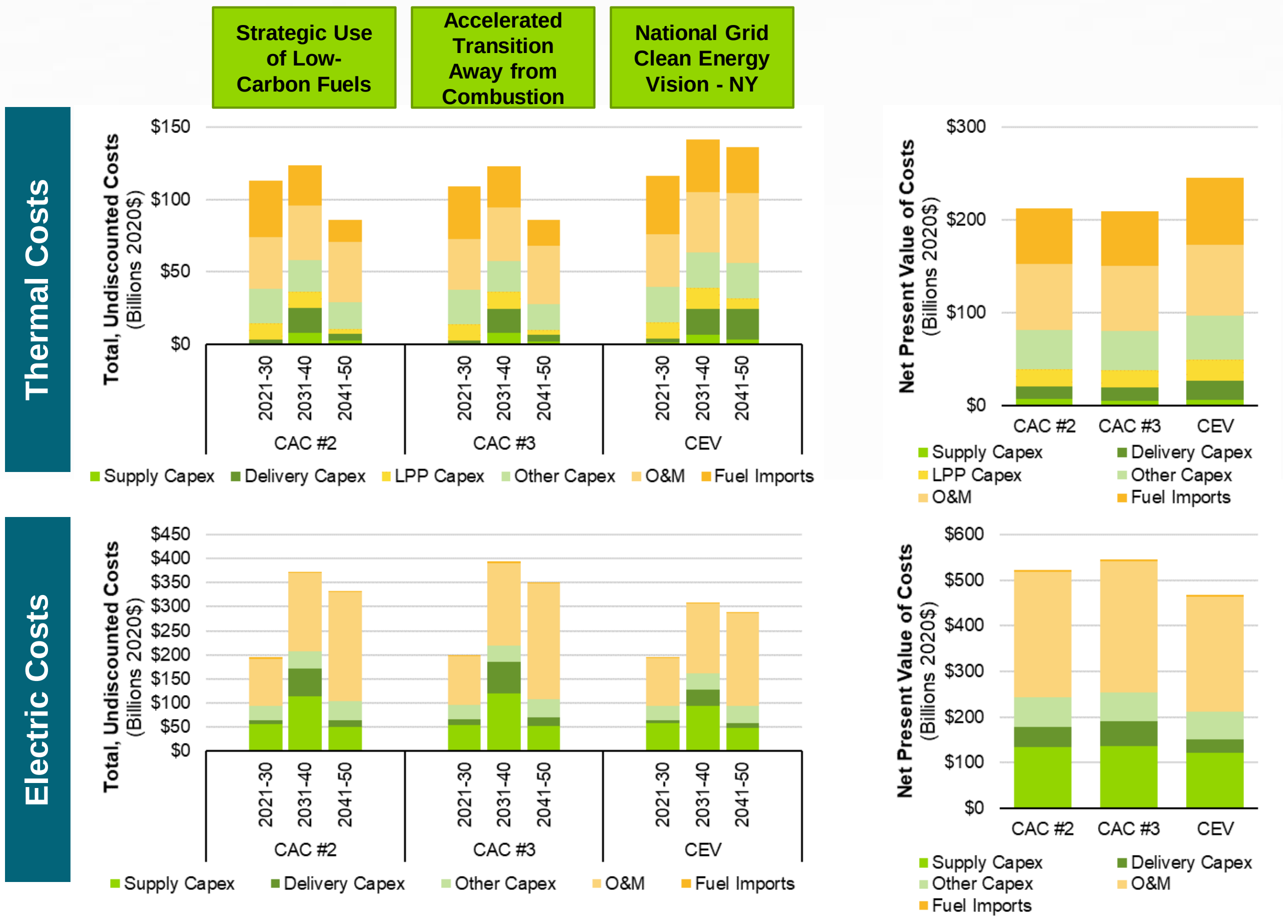
- Energy efficiency and fuel switching drive the downward trend in gas deliveries.
- All scenarios retain some amount of gas sales, and transition from delivering fossil natural gas to delivering RNG and H2.
- In all scenarios, most RNG deliveries are to the buildings sector, and most H2 deliveries serve the transportation and industry sectors.
- The CEV.NY scenario shows:
  - Higher RNG delivery volumes serving the ~40% of customers that adopt hybrid heating.
  - Higher H2 delivery volumes than CAC scenarios due to CEV.NY's pipeline blending of H2 and dedicated H2 service to some NonRes customers.



The CEV.NY scenario includes higher relative thermal network costs, but that increase is offset by lower relative electric investment and O&M costs

- CEV.NY scenario requires more thermal network T&D expenses after 2040, primarily from geothermal network investment.
- In all scenarios, major investment in the electric grid is necessary to meet growing electric demand.
- CEV.NY scenario requires relatively less investment in electric grid and associated O&M compared to the relative increase in thermal network costs.
- Note this study does not consider incremental costs of decommissioning thermal network segments, such as removal of system pipe and related equipment where necessary, environmental cleanup costs, regulatory costs, and other costs associated with maintaining safe and reliable operation of remaining network segments during the decommissioning process.

NYS Energy Network Costs

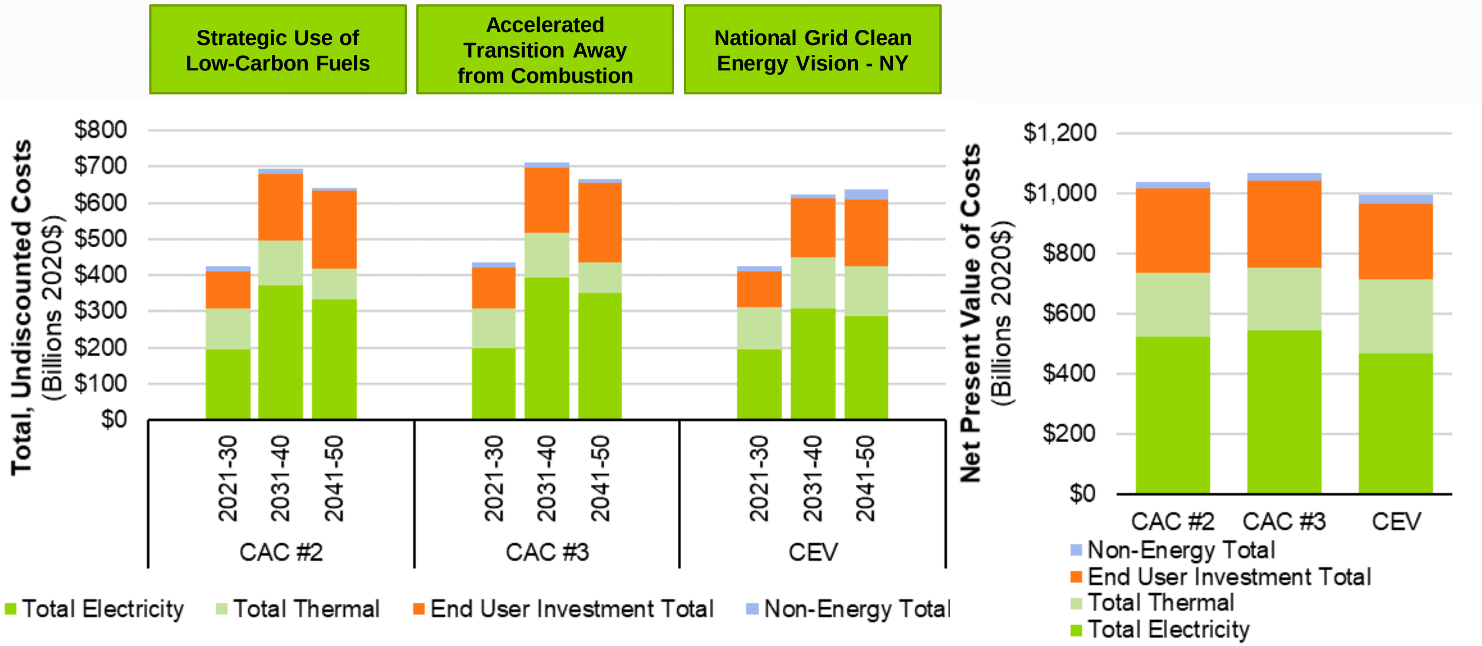


Note: Energy network costs include all upfront investments and all ongoing costs incurred within 2020-2050. Thermal network fuel import costs include cost of imported NG/RNG/H2 used for electric generation. NPV uses a 3.6% real discount rate, consistent with NY CAC Integration Analysis.

In addition to lower energy system costs, end users have lower heating equipment expenses under the CEV.NY scenario

- On a “cash basis” the CEV.NY scenario is estimated to be the least expensive, though the total scenario costs are similar.
- Note that end user heating equipment costs count total equipment costs, **excluding federal incentives**.
- The CEV.NY scenario requires relatively more investment in waste and agriculture emissions savings, especially after 2040, but it has a relatively minor impact on total costs.
- CEV.NY scenario calls for less end user investment in heating equipment

NYS Total Cash Expenses

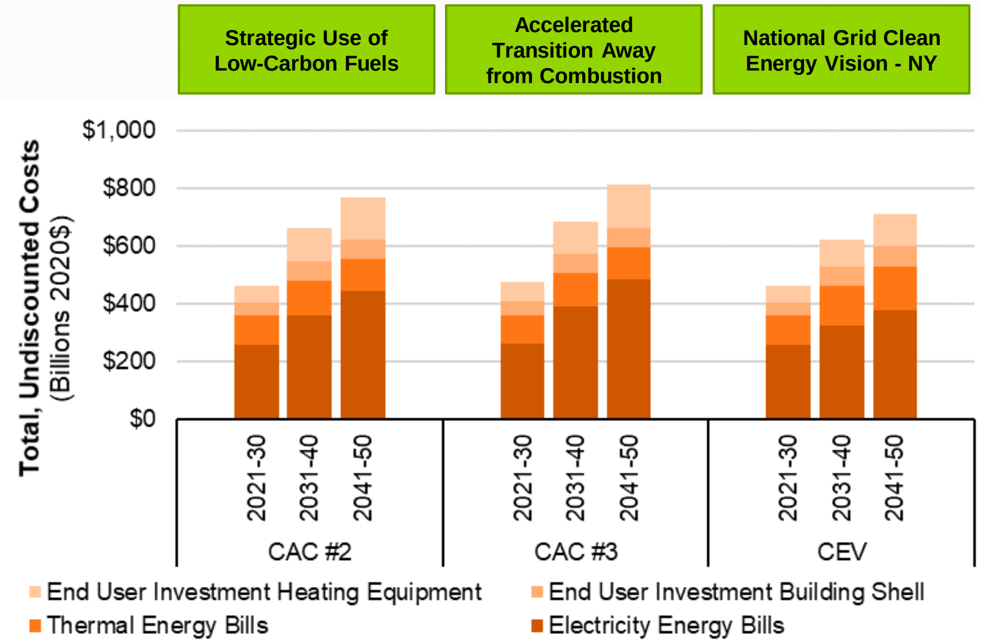


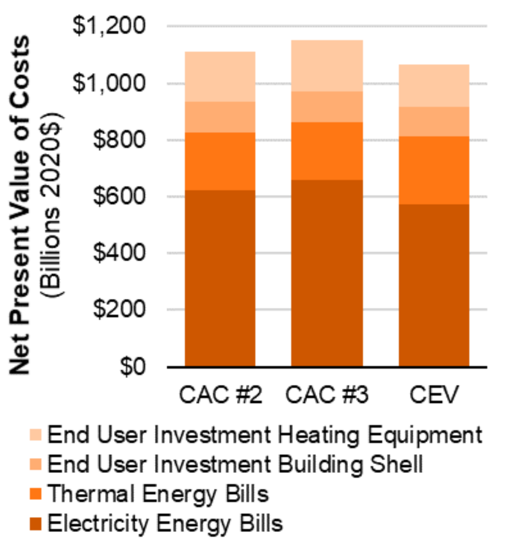
Note: Energy network costs include all upfront investments and all ongoing costs incurred within 2020-2050 (e.g., generation and T&D capacity costs, LPP investments, O&M, fuel import costs, etc.). Thermal network fuel import costs include cost of imported NG/RNG/H2 used for electric generation. End User costs include building shell efficiency investments and heating equipment investment costs to the customer (excluding any federal incentives). Non-Energy costs include investments in waste, agriculture, forestry, and land use necessary to achieve NYS emissions targets. NPV uses a 3.6% real discount rate, consistent with NY CAC Integration Analysis.

Lower heating equipment investment costs and lower energy system costs are passed on as lower total end user costs under the CEV.NY scenario

- Heating equipment costs are aligned with CAC Integration Analysis and are specified on a per-customer (Res) or per-1000-sq.ft. basis.
- The CEV.NY scenario assumes a greater proportion of gas furnaces, which are less expensive than heat pumps or other electrified options before federal incentives.
- Federal and state incentives will impact actual individual end user costs across scenarios

NYS Total End User Investments + Energy Bills





Note: Energy bill line items reflect total annual revenue requirement by energy carrier times. End user investment includes building shell upgrade and heating equipment costs. NPV uses a 3.6% real discount rate, consistent with NY CAC Integration Analysis.

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A decarbonization pathway that uses low-carbon fuels with hybrid heating systems results in lower total NYS system costs and reduced customer energy costs compared to a less diverse approach.

Approach: Low Carbon Pathways analysis compared three scenarios that comply with CLCPA emissions requirements: Two CAC Integration Analysis scenarios that focus on electrification, and a National Grid Clean Energy Vision NY (CEV.NY) scenario that uses hybrid heating, networked geothermal, and increased deployment of RNG and hydrogen.

Key Findings

1. **Utility System Costs:** Due to more diverse investment across sectors and later in time, the CEV.NY scenario yields lower total NYS system costs than greater, earlier investment primarily in increased electric capacity.
2. **Customer Costs:** In addition to lower energy system costs being passed on to end users through energy prices, end users have lower heating equipment investment in the CEV.NY scenario
3. **Energy Use:** All scenarios assume some transition to RNG and hydrogen. In CAC scenarios, building energy use is almost fully electrified, while the CEV.NY scenario balances electrification with the deployment of hybrid heating systems (fueled by electricity and RNG) and pure H2 boilers. Industrial gas use shifts to electricity and hydrogen.
4. **Electric Peak Demand:** Coincident peak electric demand grows less in the CEV.NY scenario than the CAC scenarios due to increased adoption of hybrid heating systems. As a result, the CEV.NY scenario requires less development of new electric generation capacity and less peaking resources.
5. **Gas Throughput and Customer Count:** In all scenarios, gas customer counts and delivery volumes decline, and fossil methane is gradually replaced by RNG and H2. Total gas use and customer counts decline less in the CEV.NY scenario, which repurposes existing infrastructure to deliver renewable, low-carbon gas.

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Niagara Mohawk

Upstate New York

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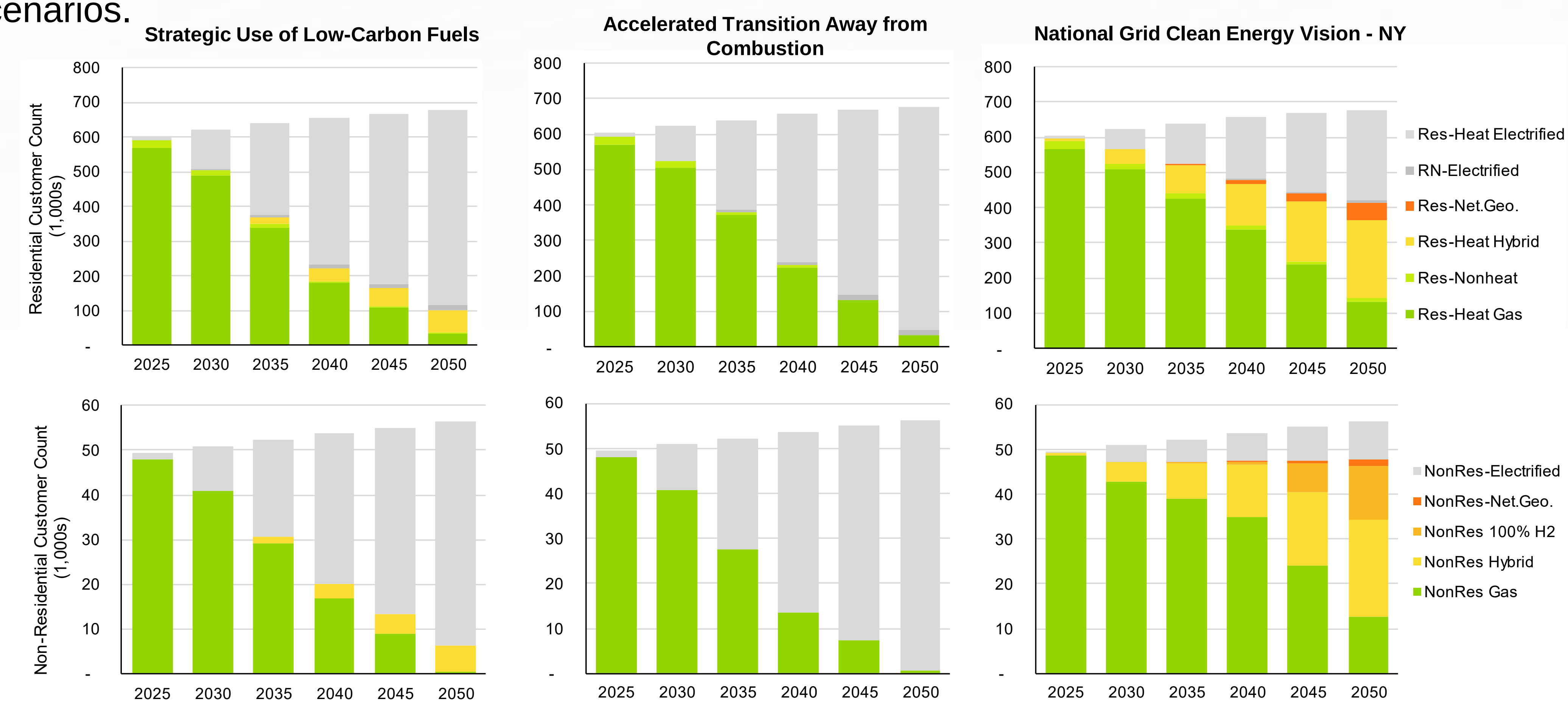
Customer Counts

NMPC

- Residential and Non-Res. Gas customer counts show full & partial electric conversions over time for 3 scenarios.



Annual Gas Consumption

NMPC: Westgate + Eastgate

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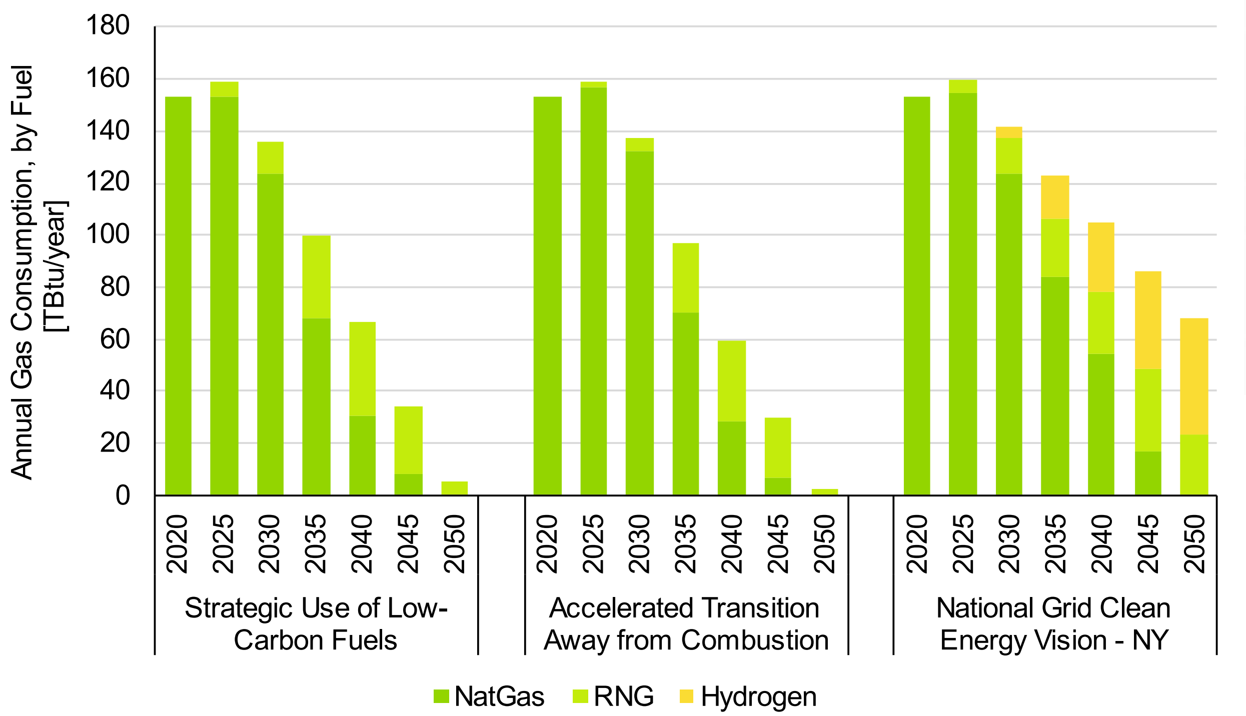
- In CAC scenarios, methane consumption is reduced to near zero.
- In CEV.NY scenario, methane consumption declines, and fossil natural gas consumption is displaced by RNG and blended H2.
- Upstate hydrogen consumption in 2050 is driven by a high proportion of industry and transportation activity.

NMPC Annual Gas Consumption, by scenario and by fuel



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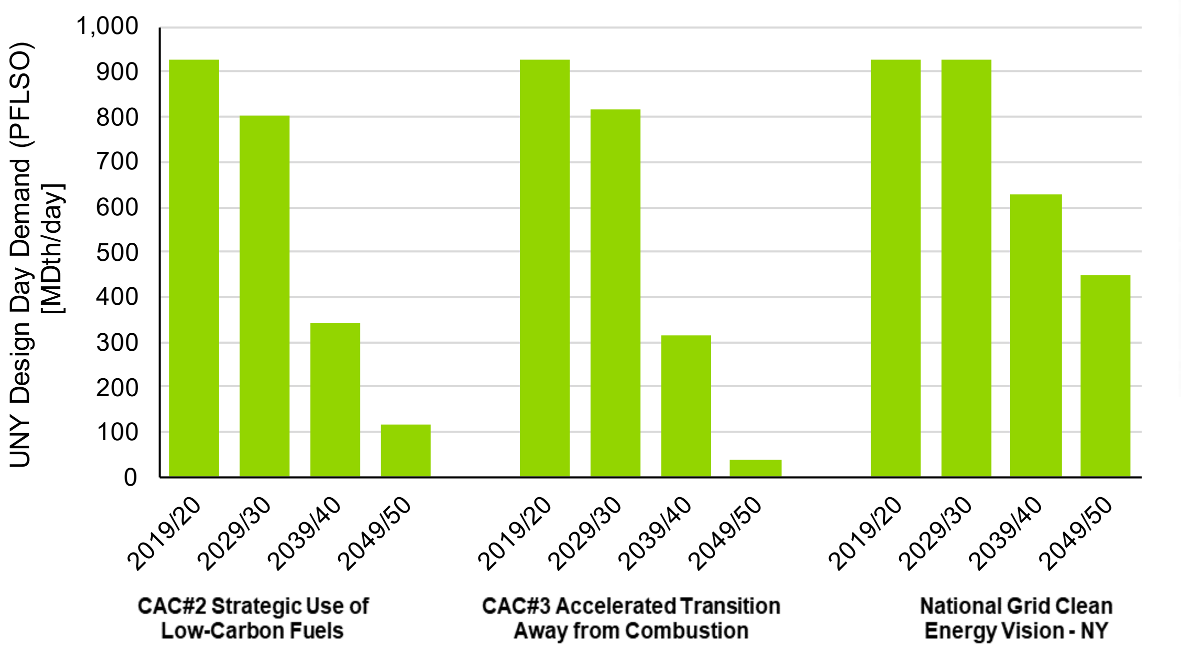
Design Day Demand

NMPC: Westgate + Eastgate

- In CAC scenarios, design day demand decreases significantly very quickly, and continues declining through 2050.
- In CEV.NY scenario, design day demand does not fall as dramatically because gas use by hybrid heating systems on coldest day to support heat pumps.
- By 2050, UNY design day demand decreases:
  - -52% for CEV.NY scenario
  - -87% for CAC #2 scenario
  - -96% for CAC #3 scenario

UNY Design Day Gas Demand



Figures include fossil natural gas, RNG, and pipeline-blended H2 (blended H2 is only used in CEV.NY scenario).

Primary Firm Load Sendout (PFLSO) is those sales classes for which NMPC must plan its interstate pipeline capacity portfolio.

Aggregate Revenue Requirement

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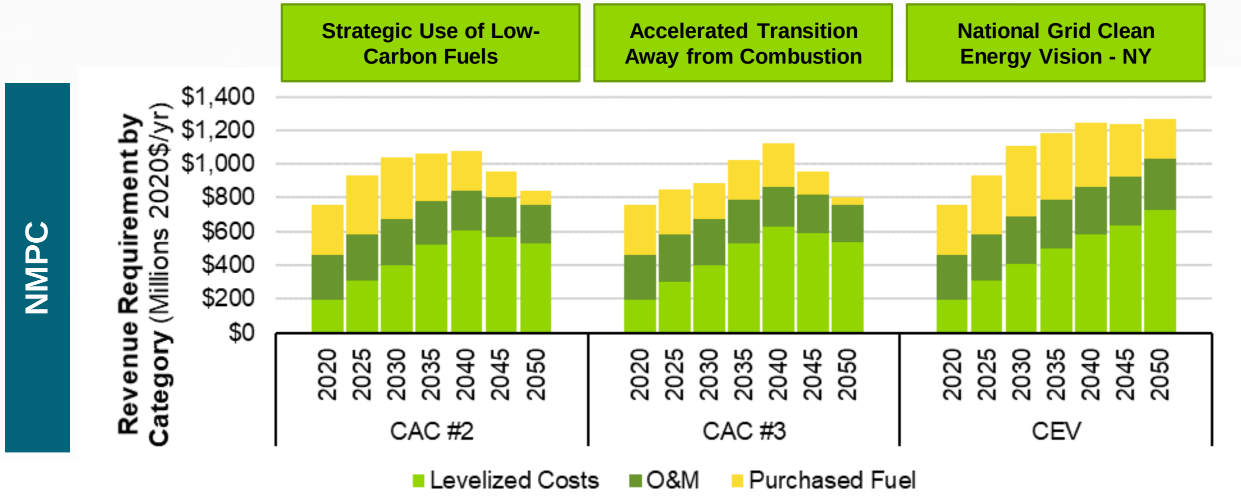
NMPC

- Revenue requirement metric includes:
  - Incremental capital costs, including hydrogen retrofit costs, LPP investment, and other thermal capex based on regional customer counts & throughput by scenario
  - "Baseline" depreciation of existing assets
  - "Baseline" plus incremental O&M costs
  - Fuel imports/purchases to buildings & industry
  - Tax & return based on latest rate case
- Around 2040, gas rate base growth slows in CEV.NY scenario and declines in CAC scenarios
- Continued elevation in purchased fuel due to high electrolysis & anaerobic digestion in upstate New York

Gas Revenue Requirement, including Transported Fuel Purchases



Note: "CAC #2" refers to "Strategic Use of Low-Carbon Fuels" scenario
"CAC #3" refers to "Accelerated Transition Away from Combustion" scenario
"CEV" refers to "National Grid Clean Energy Vision - NY" scenario

"Purchased Fuel" includes fuel supplied to transport-only C&I customers

Implied Thermal Customer Cost & Unit Price

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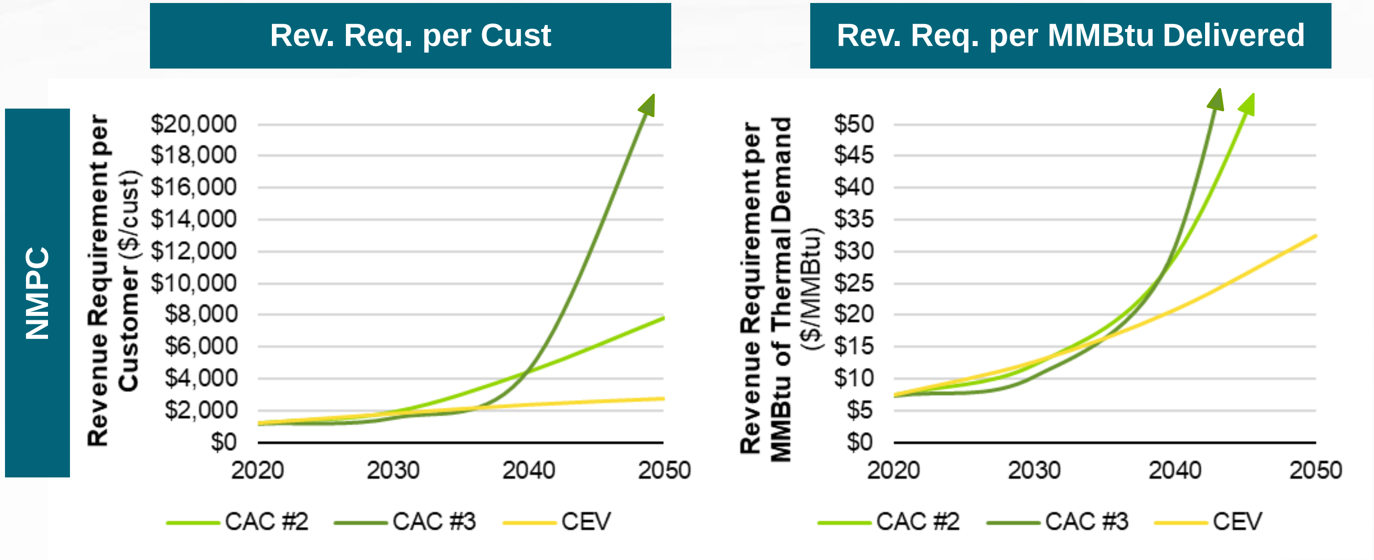
NMPC

- Dividing the annual revenue requirement by the projected number of gas customers yields a proxy "average annual bill" across all customer classes
- Dividing the annual revenue requirement by the projected NG/RNG/H2 deliveries yields a proxy "average unit price" across all customer classes
- Thermal prices rise significantly by 2050 in all scenarios, though relatively less in the CEV.NY scenario



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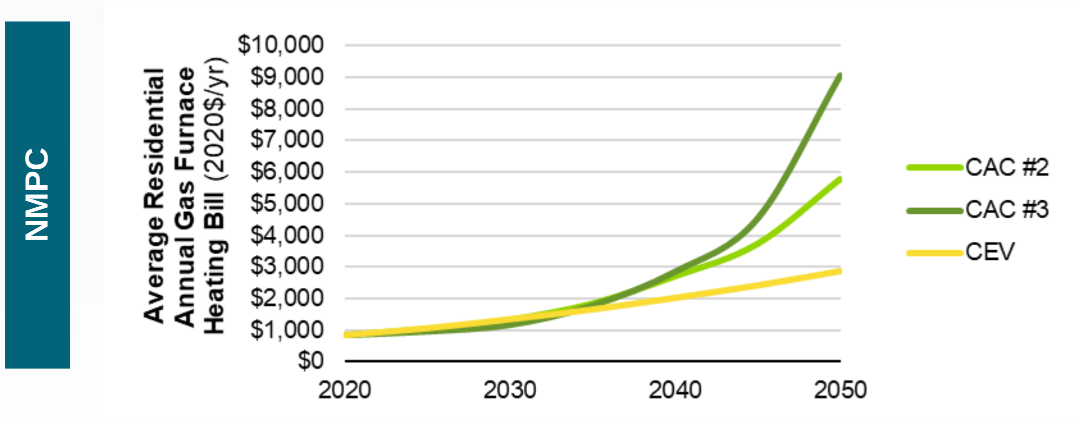
Average Residential Space Heating Bill

NMPC

- Multiplying the assumed annual space heating usage of residential gas furnaces by the estimated thermal price yields an average space heating bill for residential thermal customers
- On an inflation-adjusted basis, space heating bills more than double under the CEV.NY scenario by 2050, but increase more than 5-fold under the CAC scenarios

Indicative Residential Furnace Heating Bill



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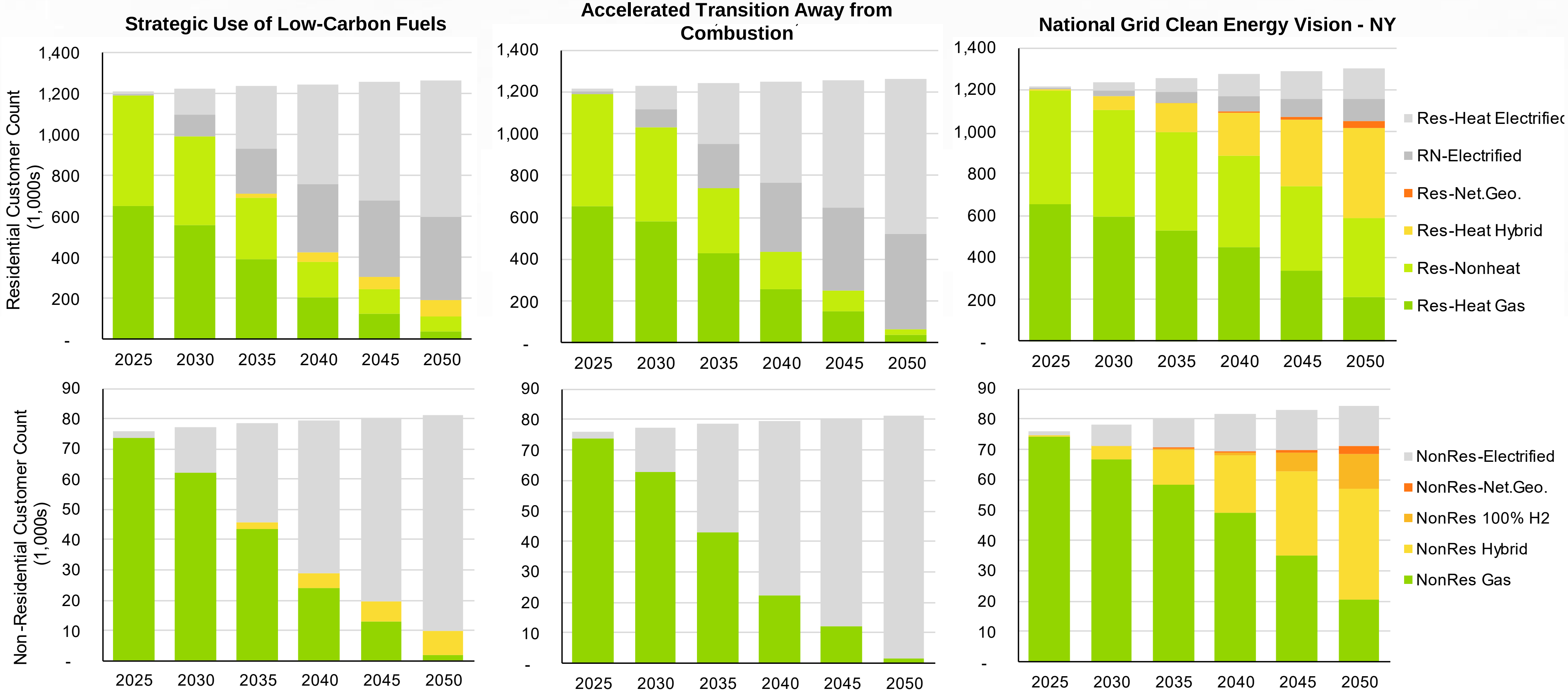
KEDNY and KEDLI

Downstate New York

Customer Counts

KEDNY

- Residential and Non-Res. Customer counts show full & partial electric conversions over time for 3 scenarios.

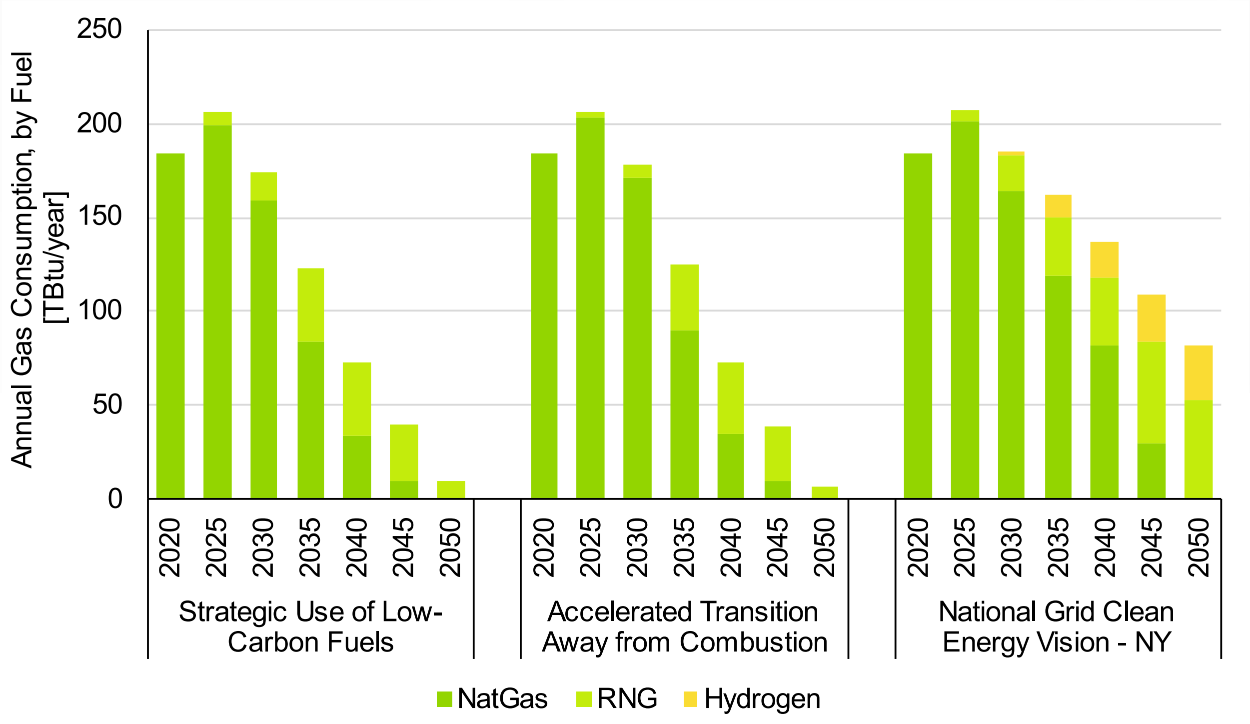


Annual Gas Consumption

KEDNY

- Compared to other OpCos, KEDNY has lower rate of building electrification in Res & Com classes, leading to less reduction in annual methane sales.
- Compared to other OpCos, KEDNY has less industrial and transportation sector activity, so has less hydrogen conversion.

KEDNY Annual Gas Consumption, by scenario and by fuel



Customer Counts

KEDLI

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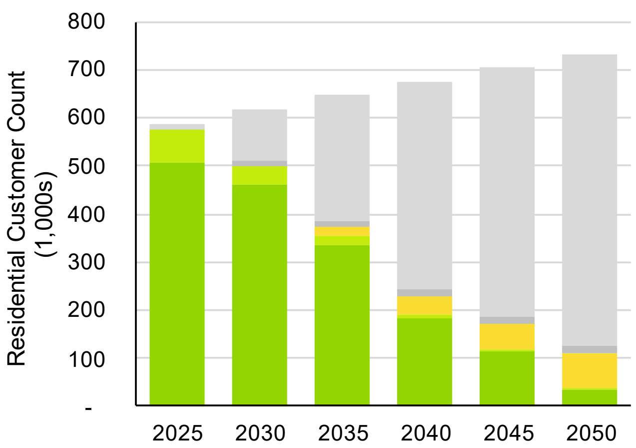
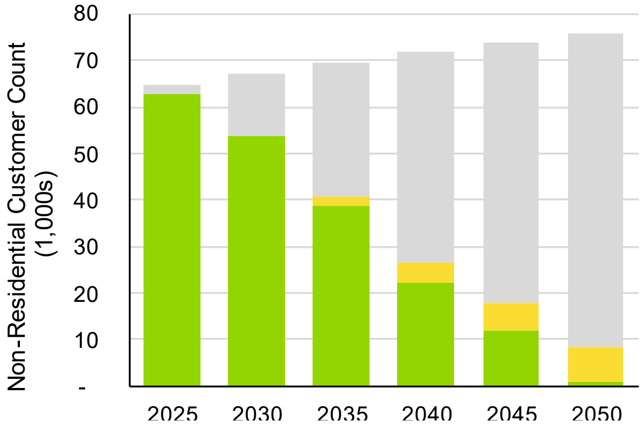
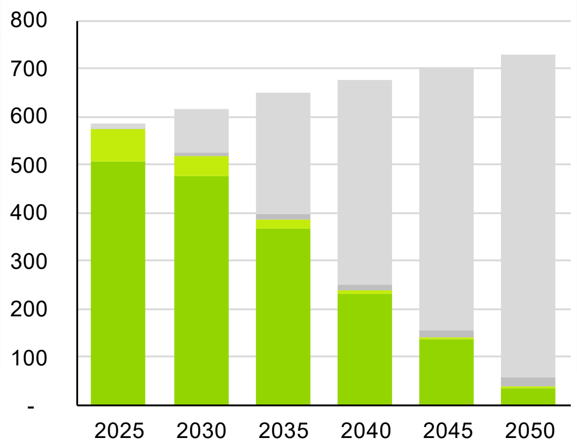
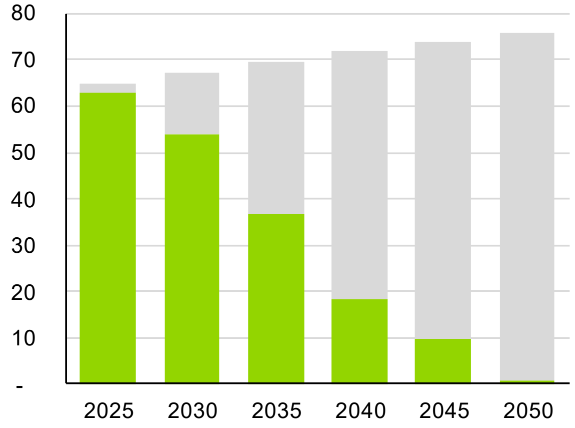
Strategic Use of Low-Carbon Fuels



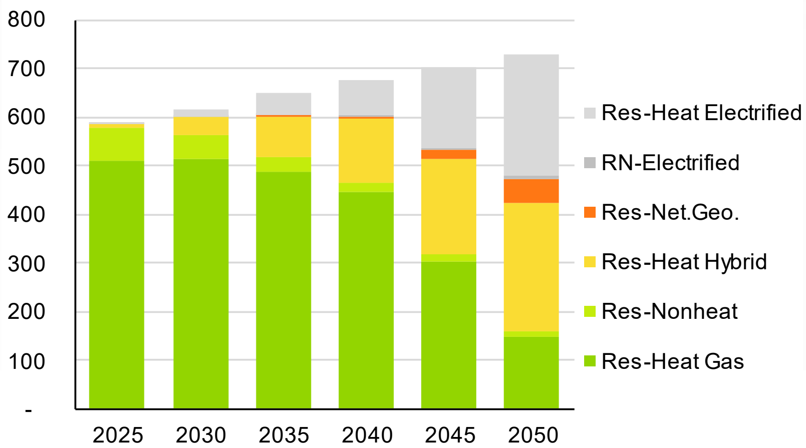


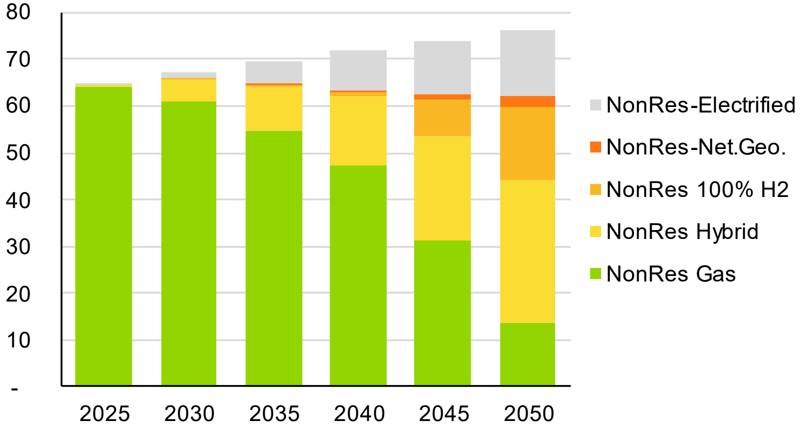
Accelerated Transition Away from Combustion





National Grid Clean Energy Vision - NY





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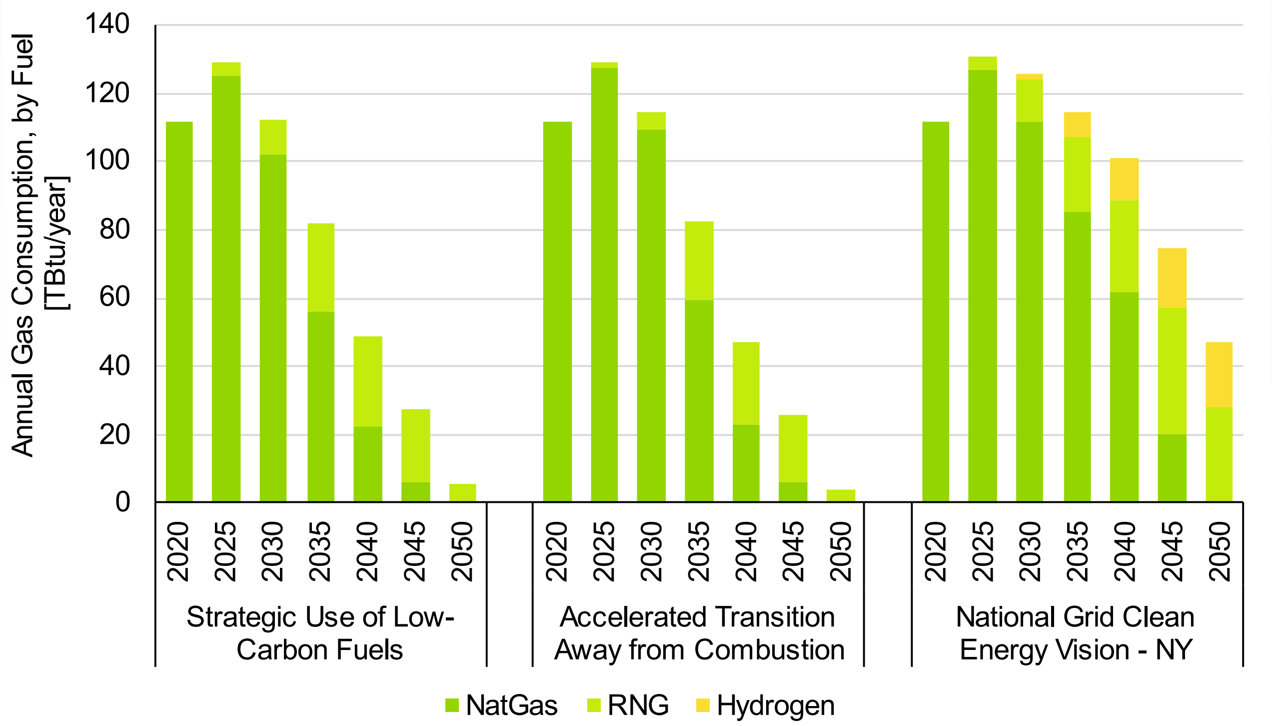
Annual Gas Consumption

KEDLI

- In CAC scenarios, methane consumption is reduced to near zero.
- In CEV.NY scenario, methane consumption declines and fossil natural gas consumption is displaced by RNG and blended H2.
- KEDLI hydrogen consumption in 2050 is partly driven by industry and transportation activity.

KEDLI Annual Gas Consumption, by scenario and by fuel

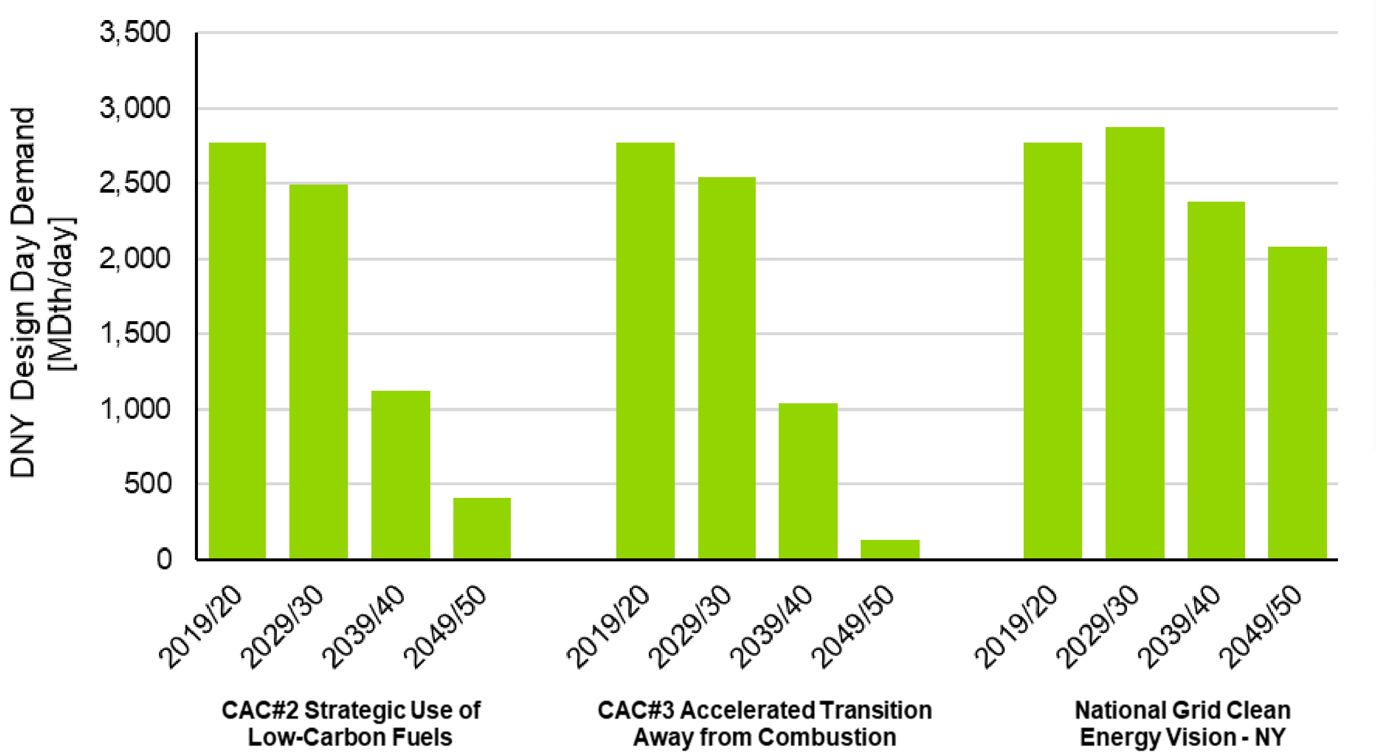


Design Day Demand

DNY: KEDNY + KEDLI

- In CAC scenarios, design day demand decreases significantly very quickly, and continues declining through 2050.
- In CEV.NY scenario, design day demand does not fall as dramatically because gas use by hybrid heating systems on coldest day to support heat pumps.
- By 2050, DNY design day demand decreases:
  - -25% for CEV.NY scenario
  - -85% for CAC #2 scenario
  - -95% for CAC #3 scenario

DNY Design Day Gas Demand



Figures include fossil natural gas, RNG, and pipeline-blended H2 (blended H2 is only used in CEV.NY scenario)

Aggregate Revenue Requirement

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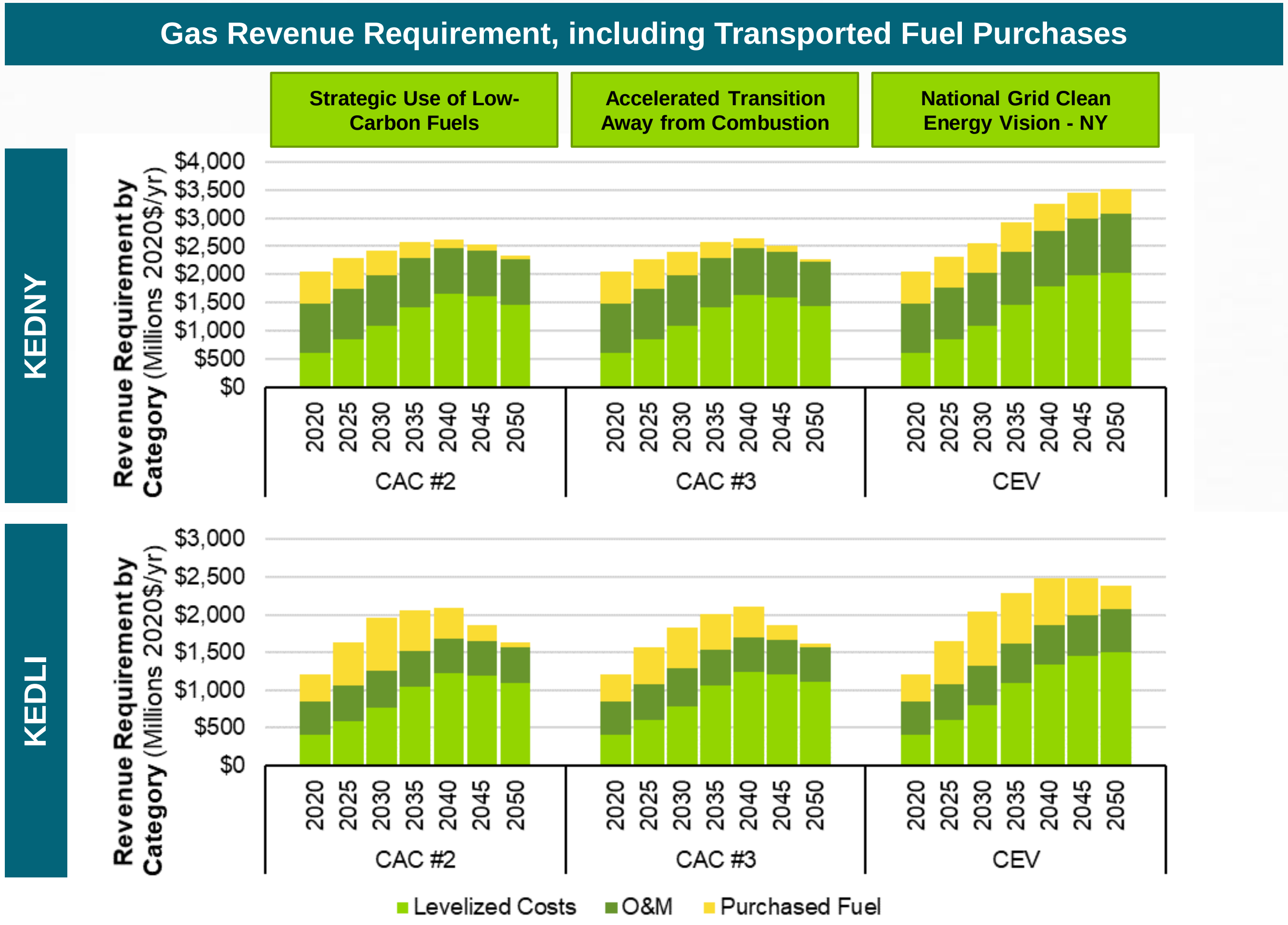
DNY: KEDNY & KEDLI

- Revenue requirement metric includes:
  - Incremental capital costs, including hydrogen retrofit costs, significant LPP investment, and other thermal capex based on regional customer counts & throughput by scenario
  - “Baseline” depreciation of existing assets
  - “Baseline” plus incremental O&M costs
  - Fuel imports/purchases, **including NG/RNG/H2 used by transport customers & electric power generation**
  - Tax & return based on latest rate case
- Around 2040, gas rate base growth slows in CEV.NY scenario and declines in CAC scenarios



Note: “Purchased Fuel” includes fuel purchased by transport-only C&I customers

Implied Thermal Customer Cost & Unit Price

DNY: KEDNY & KEDLI

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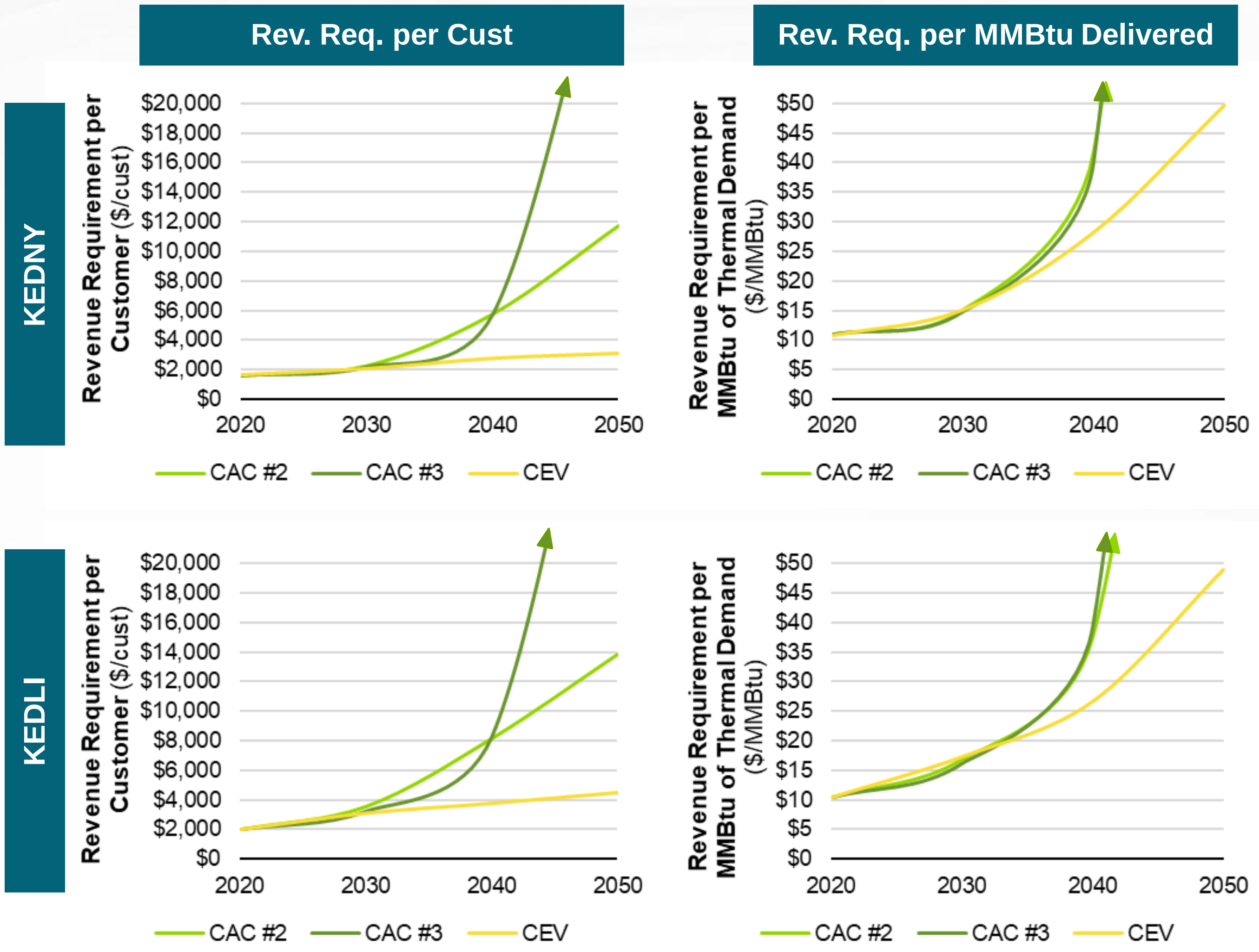
- Dividing the annual revenue requirement by the projected NG/RNG/H2 deliveries yields a proxy “average unit price” across all customer classes
- Thermal prices rise significantly by 2050 in all scenarios, especially in KEDNY



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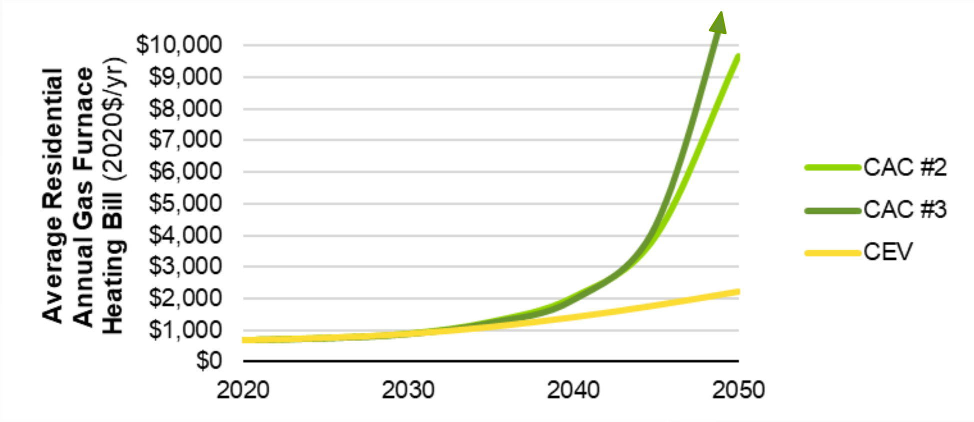
Average Residential Space Heating Bill

DNY: KEDNY & KEDLI

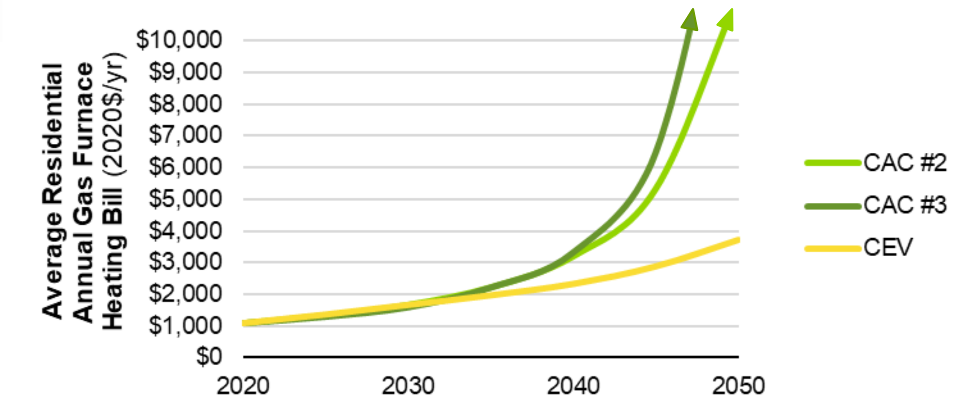
- Multiplying the assumed annual space heating usage of residential gas furnaces by the estimated thermal price yields an average space heating bill for residential thermal customers
- On an inflation-adjusted basis, space heating bills more than double under the CEV.NY scenario by 2050, but increase as much as 10-times under the CAC scenarios

Indicative Residential Furnace Heating Bill

KEDNY



KEDLI



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Addressing Challenges and Risks

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Across pathways, there are many barriers and challenges to decarbonization that can inform regulatory and policy actions.

Challenge / Risk	Potential Options to Address
Demand-Side Feasibility - Pace of customer equipment turnover - Limitations on supply chain & HVAC workforce - Customer willingness/ability to electrify	- **Coordinated, geotargeted customer programs** (e.g., demand-side management, heat electrification, and non-pipe alternatives) - Increased investment in **building envelope improvements** and adoption of **heat pump technologies**
Supply-Side Feasibility - Siting, permitting, construction of new electric renewable generation and transmission facilities - Limitations on supply chain & power sector workforce - Expansion of electric transmission & distribution	- **Address siting and permitting challenges** that may be driven by local, state, or federal restrictions or requirements. - Regional **planning and coordination** for large transmission projects that cross state or international borders - Accelerate **funding, programs** to support clean energy workforce development.
Customer Impacts / Affordability / Equity - Up-front equipment costs - On-going energy bills - Program access and participation	- **Modified depreciation approaches** to advance recovery and balance near and long-term affordability. - Longer-term **socialization of gas network costs** (e.g., electric utility-funded exit fee) - Development of **energy transition equity programs** - **Rate restructuring** to better align recovery of fixed, volumetric costs
Energy System Considerations - Integration of electric and gas systems, including planning - Avoidance of gas network costs requires coordinated electrification - Procurement of renewable fuels - Legal obligations and regulatory coordination	- **Pilot coordinated gas/electric planning** to assess opportunities to avoid costs - **Clean fuel standard** for thermal energy service to gas distribution customers that includes low carbon or carbon-free resources (RNG, green hydrogen, networked geothermal) - Broadening of **procurement standards** to include renewable fuels and enable long-term contracting to support project development
Technology Readiness and Scalability - Most mature: renewables, heat pumps, EVs - Moderately mature: RNG, networked geothermal - Least mature: direct air capture, hydrogen	- Fund and deploy **technology demonstrations and pilots**, leveraging federal funding opportunities where possible

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Agenda

Introduction and Recap

Response to Stakeholder Feedback on Assumptions

Modeling Results and Cost Outcomes

Stakeholder Feedback and Q&A

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Questions?

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Appendix

LCP Model Overview
Model structure, scenarios, and outputs

Detailed Modeling Results
Electric consumption

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Modeling Approach – Demand Forecasting

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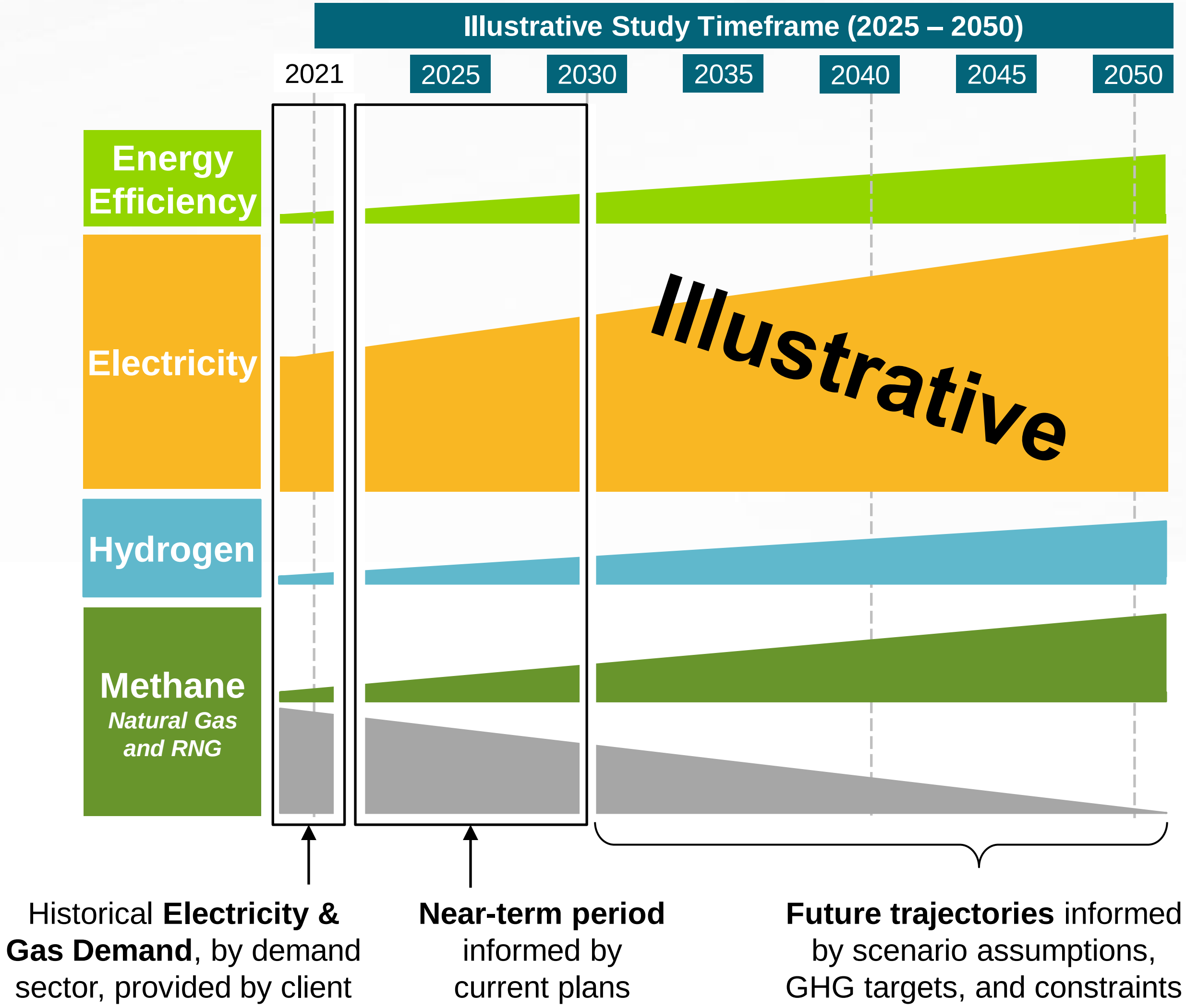
1 | Characterize base year – Establish historical electricity and gas demand, for each demand sector (buildings, transport and industry) in each region.

2 | Incorporate Planning Inputs – Include supply- and demand-side assumptions and inputs from clients' recent plans (e.g., capacity additions, planned retirements, interconnection projects, etc.) as "planned" or "expected" investments. Account for energy efficiency programs.

3 | Develop decarbonization scenarios – Each scenario has assumptions for the demand sectors (*e.g.*, 90% of residential building heating is electrified).

Note: Region-specific adjustments are applied to individual sectors, to account for regional variations like climate, buildings mix & industry mix.



Modeling Approach – LCP Model Overview

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OBJECTIVE FUNCTION

The model's primary objective function is to minimize energy system costs over the analysis horizon (e.g., 2020-2050) – including supply, infrastructure, and demand costs.

Supply Costs

- Cost of new entry. (CONE)
- Fixed O&M. (FOM)
- Variable O&M. (VOM)
- Fuel cost.
- Emissions cost.

Infrastructure Costs

- CONE, FOM, VOM by energy carrier. (electricity, CH4, H2, heat)
- Both inter- and intraconnections are considered.

Demand Costs

- Demand technology costs.
- Others as needed.

DECISION VARIABLES

The model determines the optimal capacity and dispatch for supply and infrastructure, as well as the optimal mix of demand-side technologies.

Supply Tech Capacity & Dispatch

- Installed cap. by supply tech, year, region.
- Fossil gen, renewables, crossloads, short- and long-term storage.
- Energy dispatched by supply tech, year, season, hour, region.

Infrastructure Capacity & Dispatch

- Installed capacity by energy carrier, region, year.
- Energy transferred by energy carrier, region, season, timestep, year.

Demand Technology Mix

- Gas boilers/furnaces

CONSTRAINTS

The model is constrained by existing and planned supply and infrastructure capacity, interim & final emissions reduction targets, and balancing energy supply and demand.

Emissions

- Total emissions are <= the target.
- Targets can be set by year.

Supply & Infrastructure Capacity

- MaxSupply Capacity: by supply tech, region, and year.
- Sufficient Infrastructure Capacity: by energy carrier, region, and year.

Energy Balance

- Demand = Supply
- Electricity, CH4, H2, Heat
- Energy is balanced by energy carrier, year, season, hour, and region.

Statewide electricity consumption increases in all scenarios; wind and solar resources grow to supply >75% of consumption.

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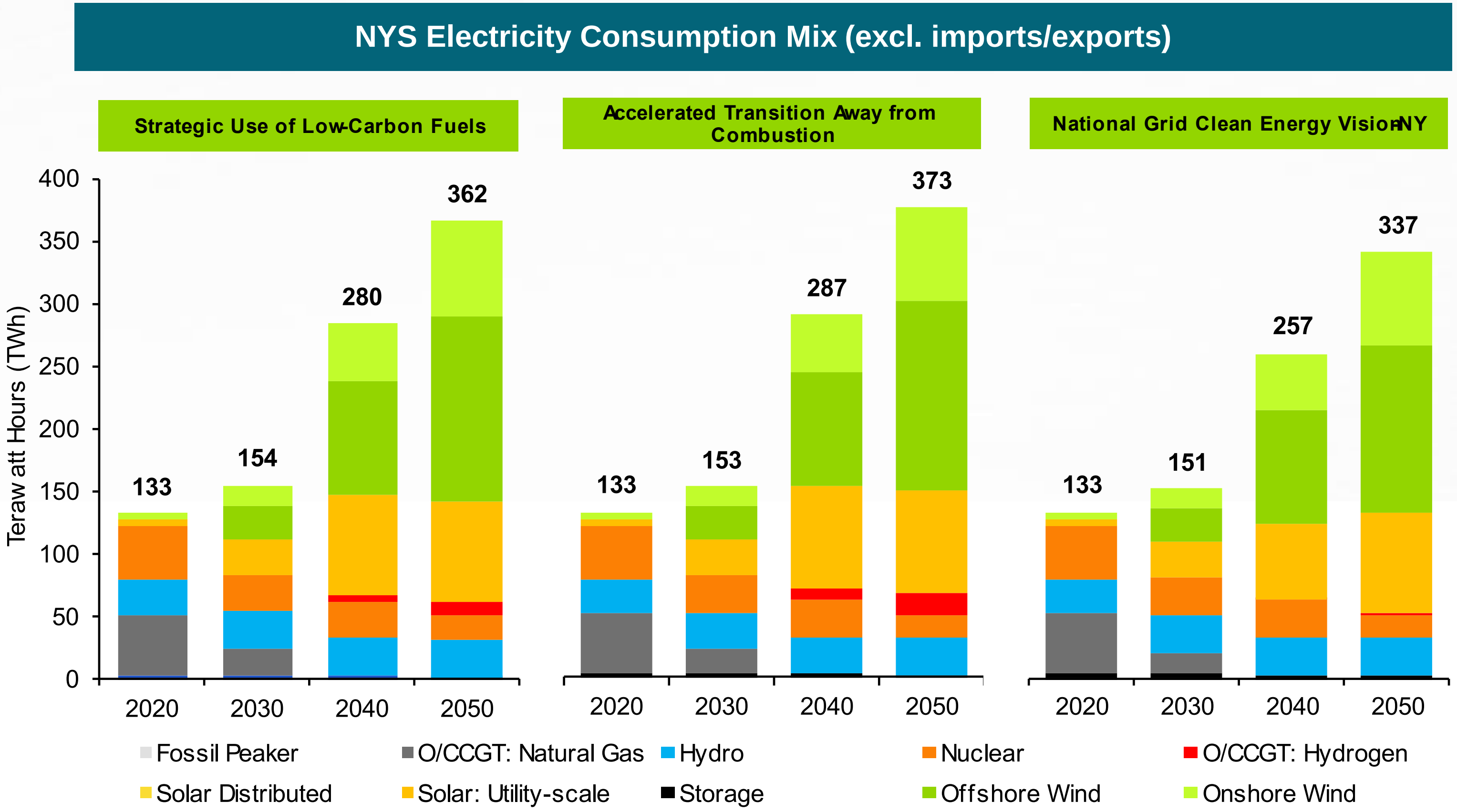
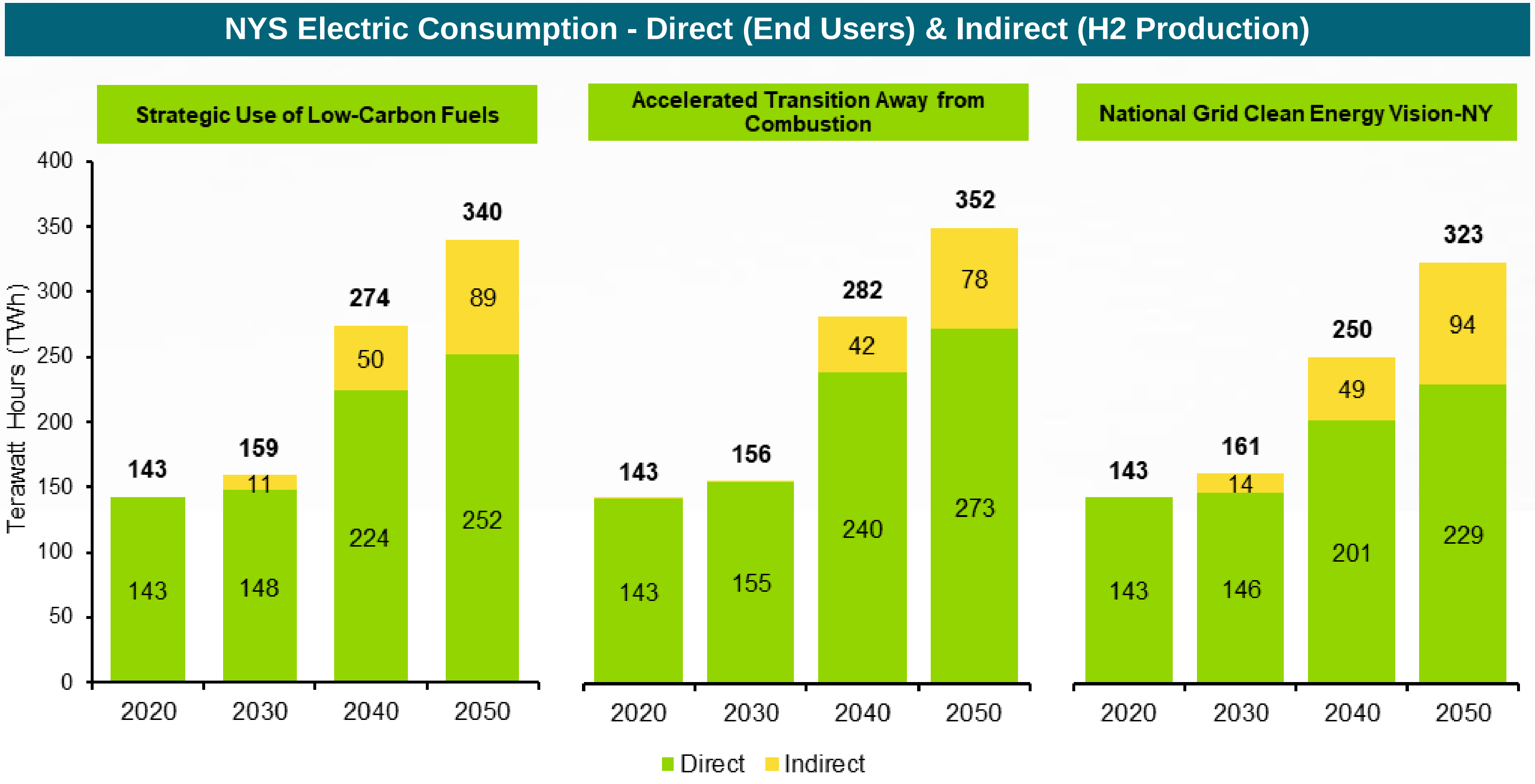
- CAC scenarios show more dispatch from hydrogen peak resources, to meet winter peak demand in low renewable resource periods.
- The CEV.NY scenario has the largest dispatch of solar, driven by H2 production in non-winter seasons
- All scenarios:
  - Assume retirement of fossil generators before 2040.
  - Use the same assumptions for nuclear and hydropower baseload capacity.
  - Project that most solar capacity will be at the utility scale, with some BTM adoption.



In 2050, about one third of electric consumption in CEV.NY scenario will be used to produce hydrogen for buildings, industry, and transport end uses. Compared to CEV.NY, the CAC scenarios show more electricity distributed to non-hydrogen customers.

- Direct electric consumption is consumption by energy customers in the buildings, industry, and transportation sectors.
- Indirect electric consumption powers electrolyzers for H2 production.
- The CAC and CEV.NY scenarios have about the same total electric consumption, but electricity serves different purposes in these scenarios.
  - In the CAC scenarios, a higher portion of annual electricity is sold to end users.
  - In the CEV.NY scenario, over 1/3 of electric consumption in 2050 is to produce hydrogen that may be stored or sold to end users.



NMPC Region Annual Gas Consumption

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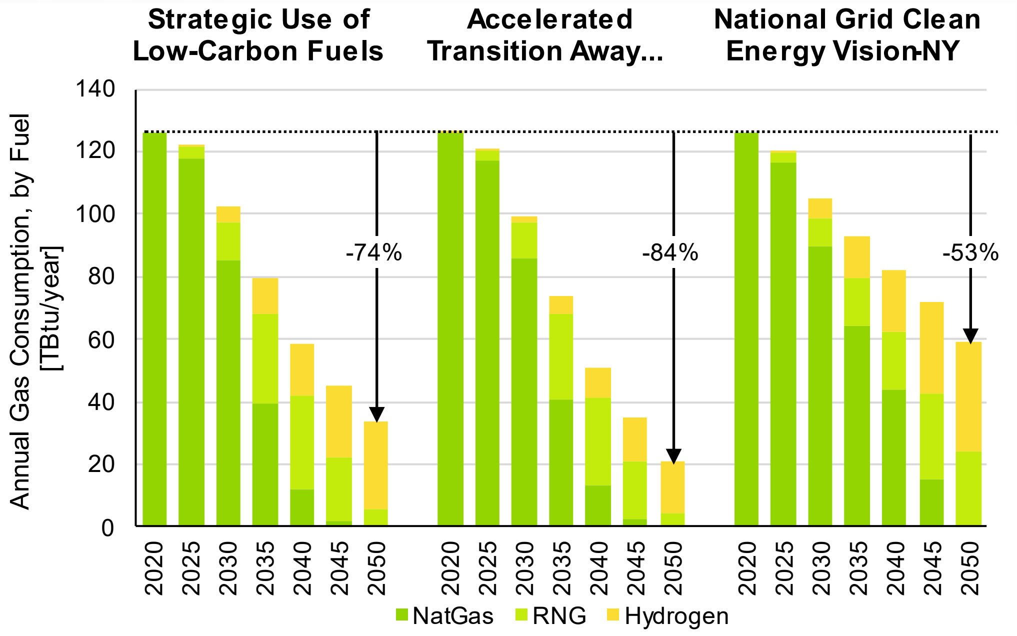
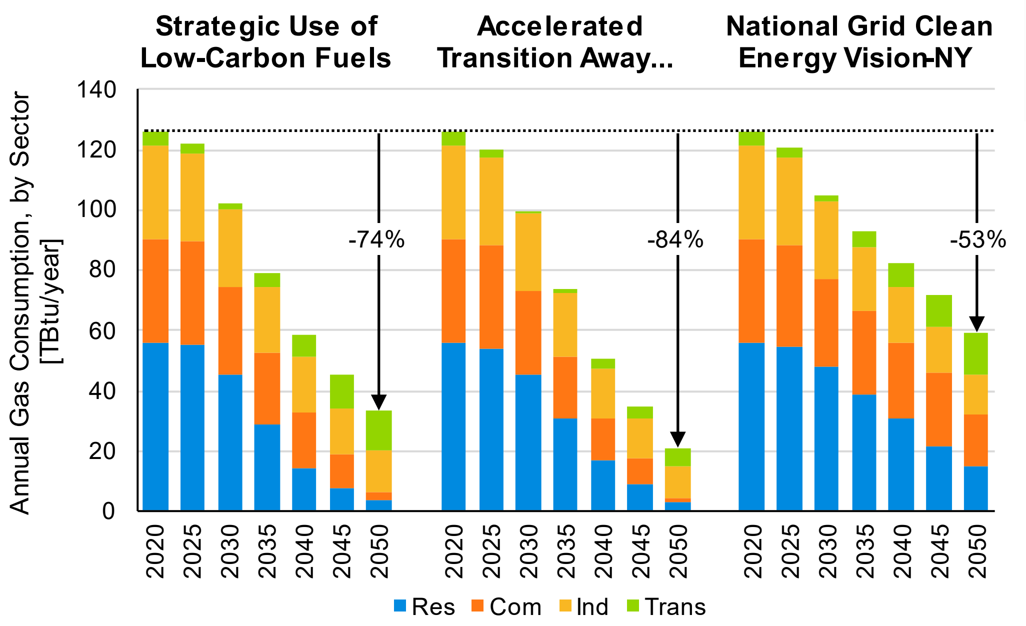
NMPC: Westgate + Eastgate

- In CAC scenarios, methane consumption is reduced to near zero.
- In CEV.NY scenario, methane consumption declines, and fossil natural gas consumption is displaced by RNG and blended H2.
- Upstate hydrogen consumption in 2050 is driven by a high proportion of industry and transportation activity.

Note: Includes OpCo region sales to future industry and transport hydrogen consumers who may be outside city gate.





KEDNY Region Annual Gas Consumption

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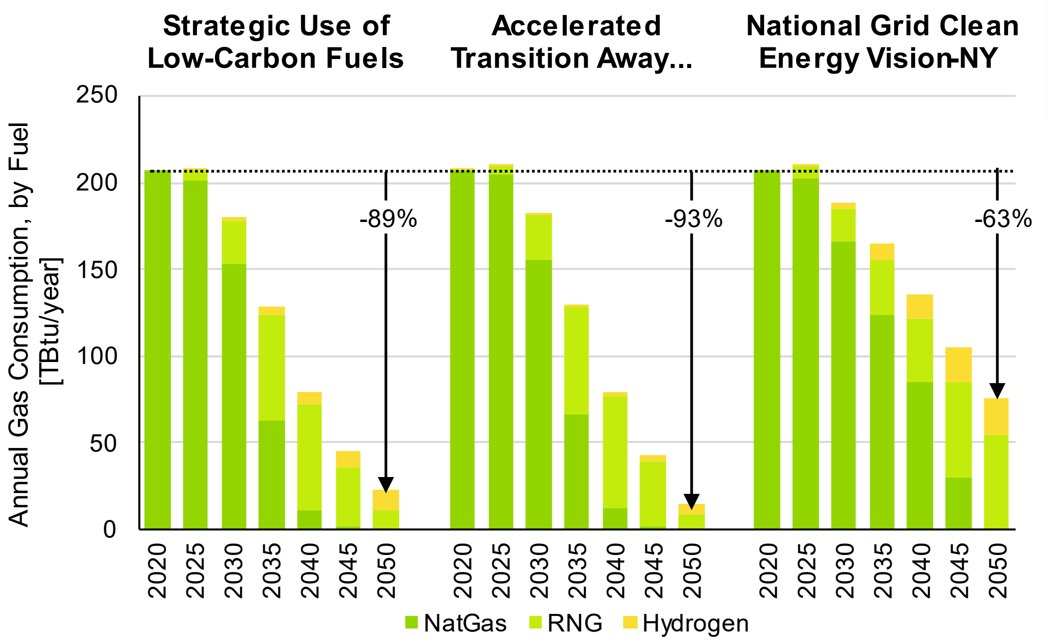

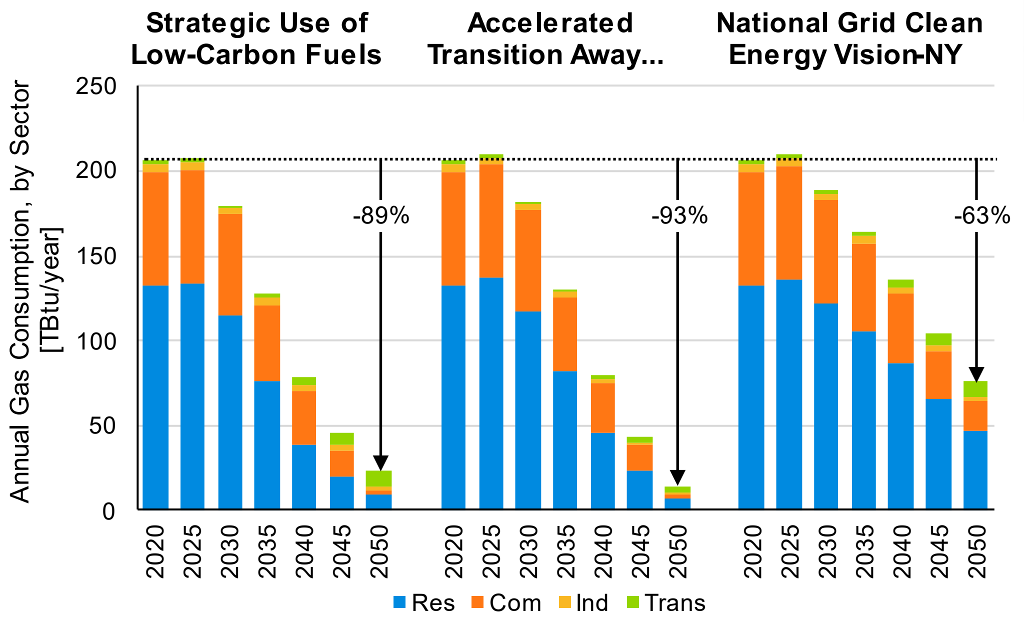

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KEDLI Region Annual Gas Consumption

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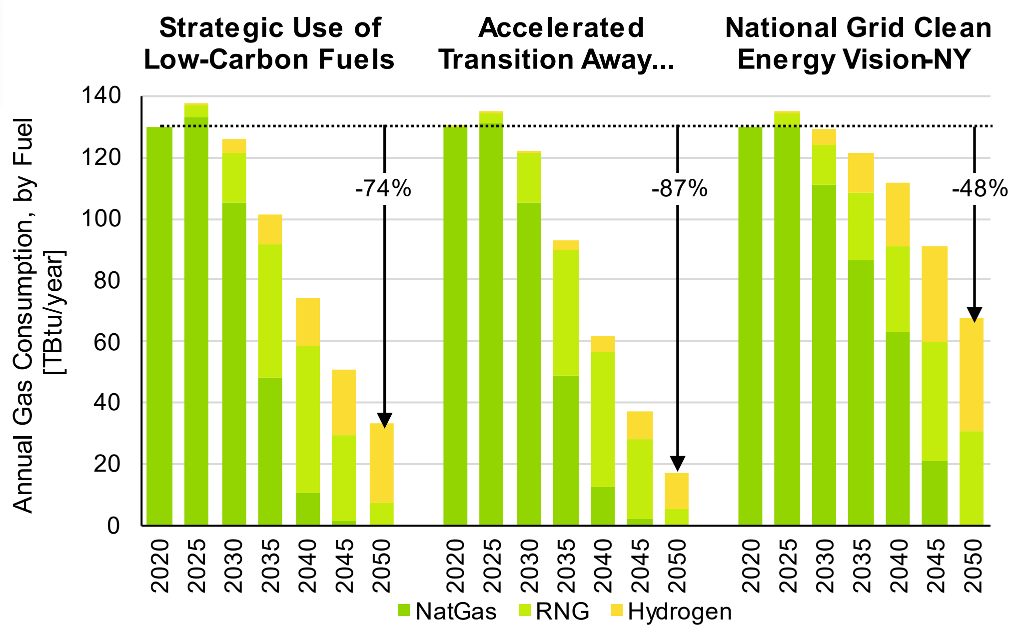

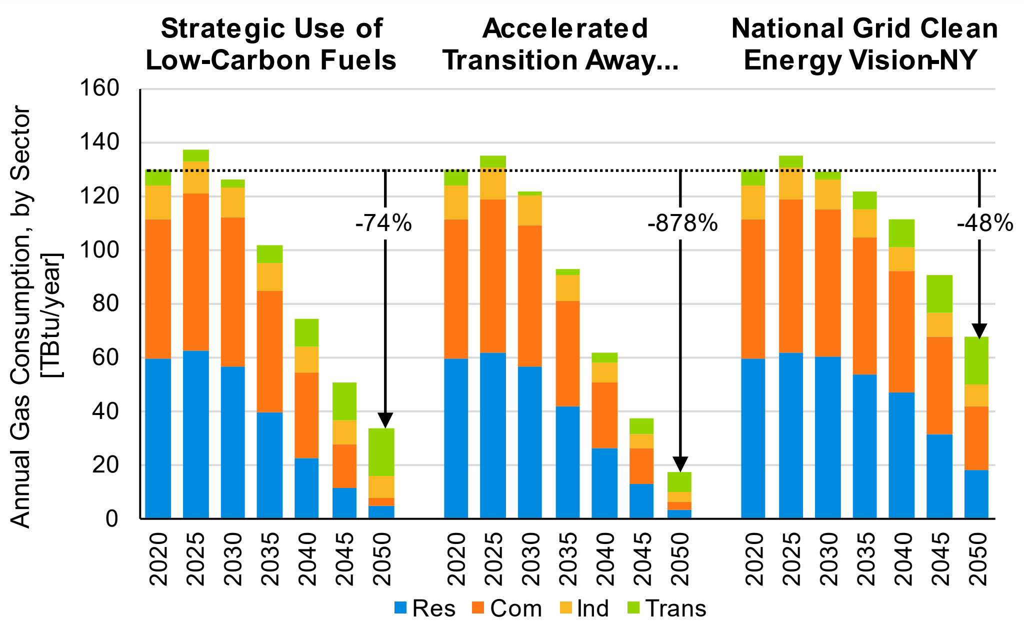

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