Evaluation of the Plan

Chapter 9. Analysis of the Plan

9.1 Integration Analysis Approach

The objective of the integration analysis is to develop greenhouse gas (GHG) mitigation scenarios for the Scoping Plan that capture and account for how various strategies interact across sectors and evaluate the benefits and costs of the suite of strategies for achieving the Climate Act's GHG emissions reduction requirements and goals. These mitigation scenarios incorporate Advisory Panel and Working Group recommendations, feedback from the Climate Action Council (Council), and Climate Justice Working Group (CJWG) input. The integration analysis is built within the New York Pathways model, which is a multi-model framework that includes a representation of all categories of GHG emissions in New York and takes as inputs relevant complementary analyses, including the Power Grid Study, building and transportation roadmap efforts, oil and gas system analysis, and refrigerant management analysis.

This chapter contains a high-level summary of the integration analysis results. The analysis has been updated since original publication of results in the draft Scoping Plan to align with the latest information available, including the Statewide GHG Emissions Report, key technology and fuel price forecasts, and other general improvements where appropriate (this update has been referred to as the "2022 vintage").[190] This update does not affect the modeling structure, scenario definitions, key pathway themes, adoption trajectories, and performance of key technologies and measures. Detailed technical information on the mitigation scenarios presented in this chapter, including further description of the 2022 vintage updates, can be found in the Integration Analysis Technical Supplement (Appendix G).

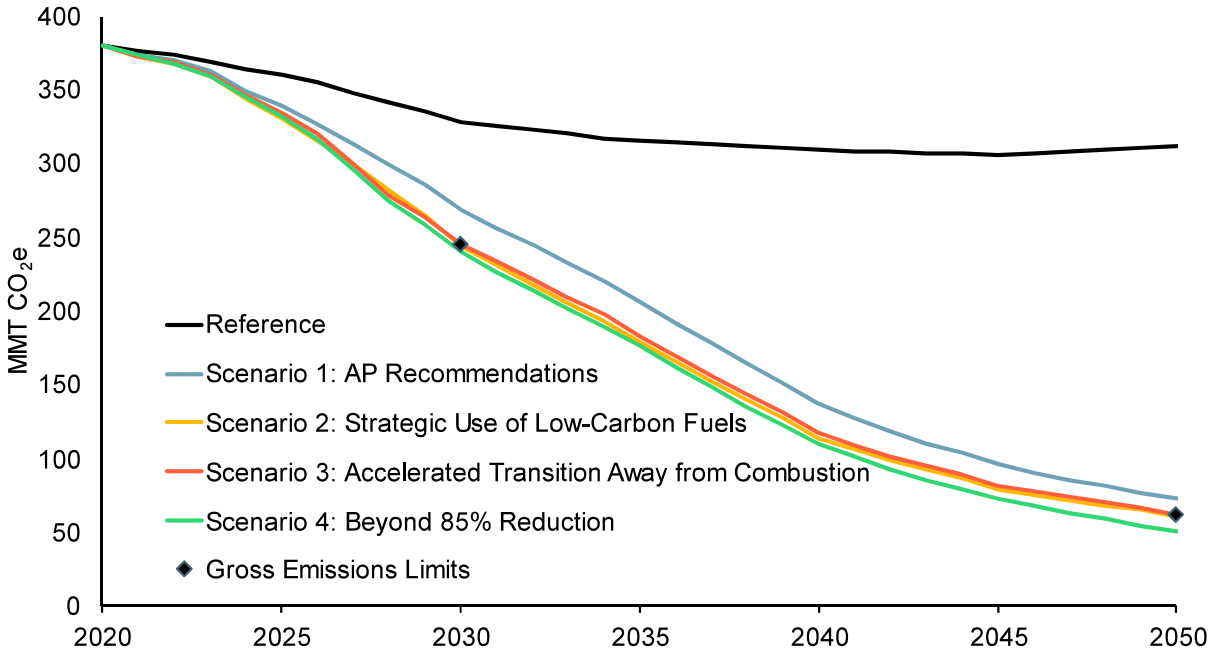
9.2 Scenario Design

The initial runs of the integration analysis evaluated a business-as-usual future (Reference Case) and a representation of a future based on an ambitious interpretation of the recommendations from the Council's Advisory Panels (Scenario 1). Analytical results indicated that the Advisory Panel recommendations alone were not sufficient to achieve the Climate Act emission limits (Figure 4). These results were presented to the Council in July 2021 and initiated a scenario design planning exercise by the Council, facilitated by the analytical team and informed by feedback from the CJWG on the Advisory Panel recommendations, to develop scenarios with additional GHG emissions reductions. This exercise

[190] The latest Statewide GHG Emissions Report can be found at https://www.dec.ny.gov/energy/99223.html.

resulted in three additional scenarios designed to meet or exceed GHG limits and achieve carbon neutrality. Scenarios 2, 3, and 4 all share foundational themes based on findings from Advisory Panels and supporting analysis but represent different approaches based on Council feedback and CJWG input. The Council continued deliberations on these scenarios in 2022, informed by public comment on the draft Scoping Plan.

Figure 4. Greenhouse Gas Emissions by Mitigation Scenario



- **Reference Case:** Business as usual plus implemented policies.[191]
- **Scenario 1: Advisory Panel Recommendations:** Representation of the Advisory Panel recommendations, which provide a foundation for all scenarios; however, scenario modeling shows that further effort is needed to meet Climate Act emission limits.
- **Scenario 2: Strategic Use of Low-Carbon Fuels:** Advisory Panel recommendations adjusted for strategic use of bioenergy derived from biogenic waste, agriculture and forest residues, and limited purpose grown biomass, as well as a critical role for green hydrogen for difficult-to-electrify applications. This scenario includes a role for negative emissions technologies to reach carbon neutrality.
- **Scenario 3: Accelerated Transition Away from Combustion:** Advisory Panel recommendations adjusted to include accelerated electrification of buildings and transportation

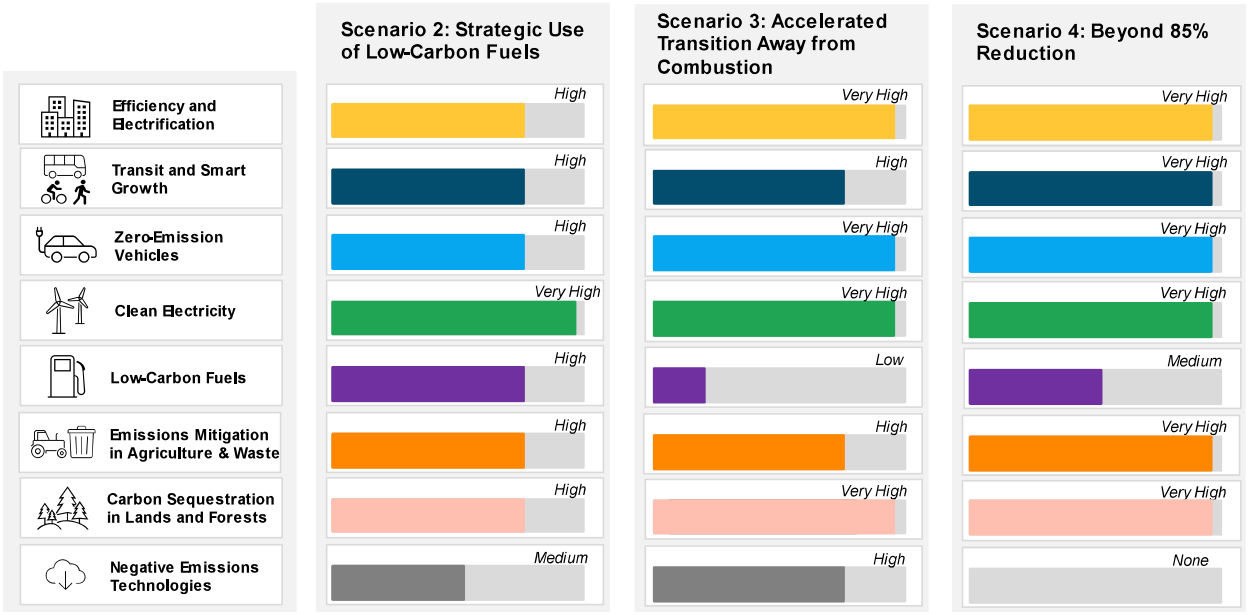
[191] The Reference Case is used for evaluating incremental societal costs and benefits of GHG emissions mitigation.

and a very limited role for bioenergy and hydrogen combustion. This scenario includes a role for negative GHG emissions technologies to reach carbon neutrality.

- **Scenario 4: Beyond 85% Reduction:** Advisory Panel recommendations adjusted to reflect accelerated electrification and targeted use of low-carbon fuels. This scenario includes additional reductions in vehicle miles traveled (VMT) and innovation in methane abatement. This scenario reduces gross GHG emissions beyond the 2050 limit and avoids the need for negative emission technologies.

Figure 5 highlights the key differences in assumptions across the three scenarios that meet or achieve New York's GHG emission limits and achieve carbon neutrality by 2050. All scenarios share common foundational themes of decarbonization, including a zero-emission power sector by 2040, enhancement and expansion of transit, unprecedented rapid and widespread efficiency and electrification, electric end-use load flexibility, and methane mitigation in agriculture and waste.

Figure 5. Level of Transformation by Mitigation Scenario



Note: More detailed scenario assumptions are available in Appendix G: Integration Analysis Technical Supplement.

Transformative, challenging, and potentially disruptive levels of effort are required across all sectors, and all three scenarios include high levels of electrification, including Scenario 2, which also incorporates the strategic use of low-carbon fuels. Scenario 3 pushes harder on accelerated electrification to meet the GHG emission limits using a very low-bioenergy and low-combustion mix of strategies. Scenario 4 pushes beyond 85% direct reductions in 2050 by layering some low-carbon fuels back in, examining very high

VMT reduction, and assuming high (but also highly uncertain) levels of innovation in the waste and agriculture sectors. Scenario 4 is the only evaluated scenario that achieves carbon neutrality without the use of negative emissions technologies like direct air capture of carbon dioxide (CO_2), which is also subject to high uncertainty, but is required in Scenarios 2 and 3 to address the gap between remaining gross emissions in 2050 and the ambitious assumed projections of natural sequestration. Figure 6 shows the emissions reductions under Scenario 1. Key assumptions for scenarios 2, 3, and 4 are shown in Figure 7, Figure 8, and Figure 9. Additional documentation of scenario assumptions can be found in the Integration Analysis Technical Supplement (Appendix G).

Figure 6. Advisory Panel Recommendations

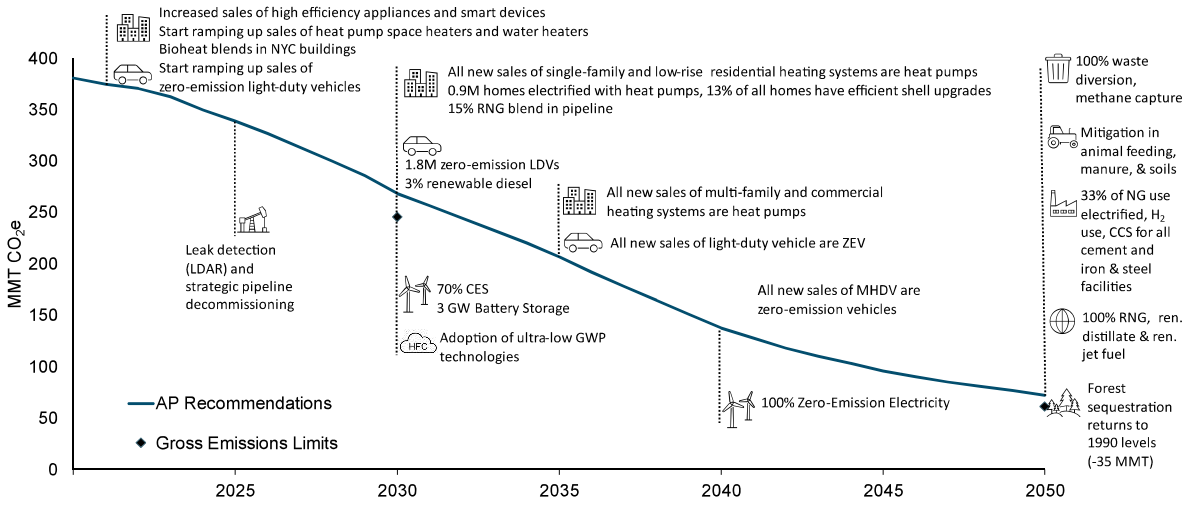


Figure 7. Key Assumptions in Scenario 2: Strategic Use of Low-Carbon Fuels

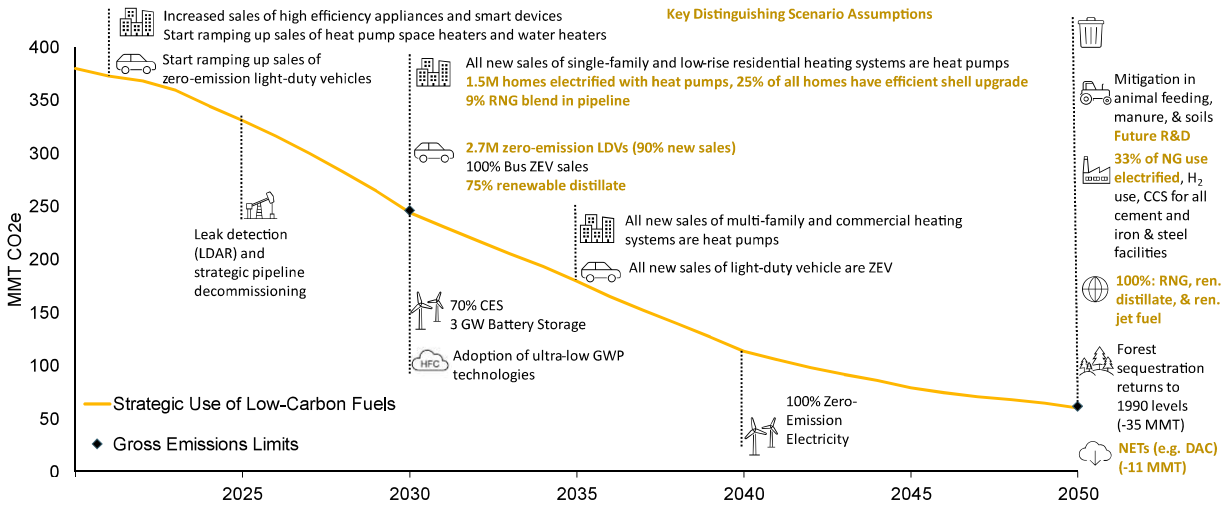


Figure 8. Key Assumptions in Scenario 3: Accelerated Transition Away from Combustion

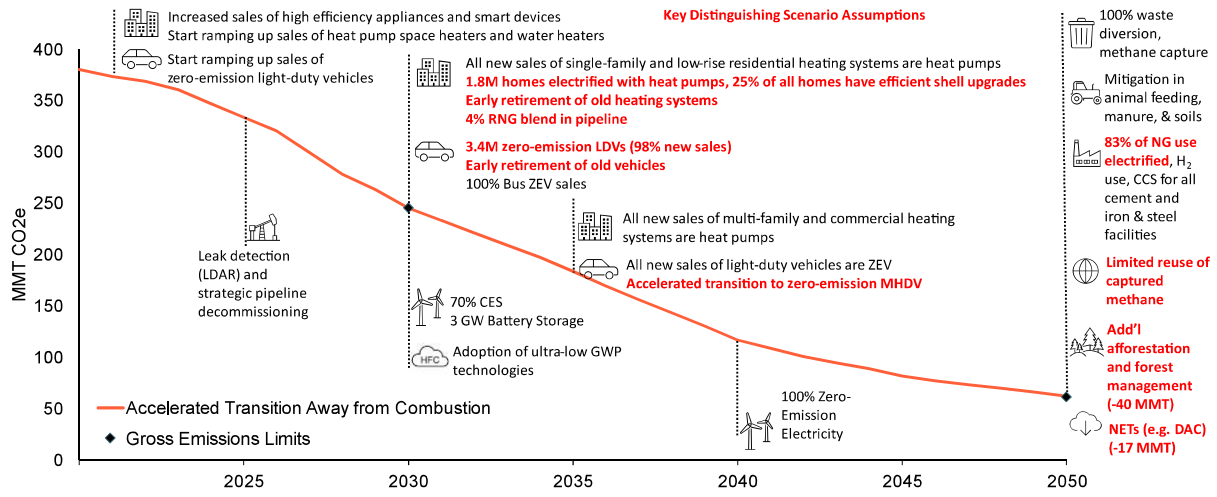
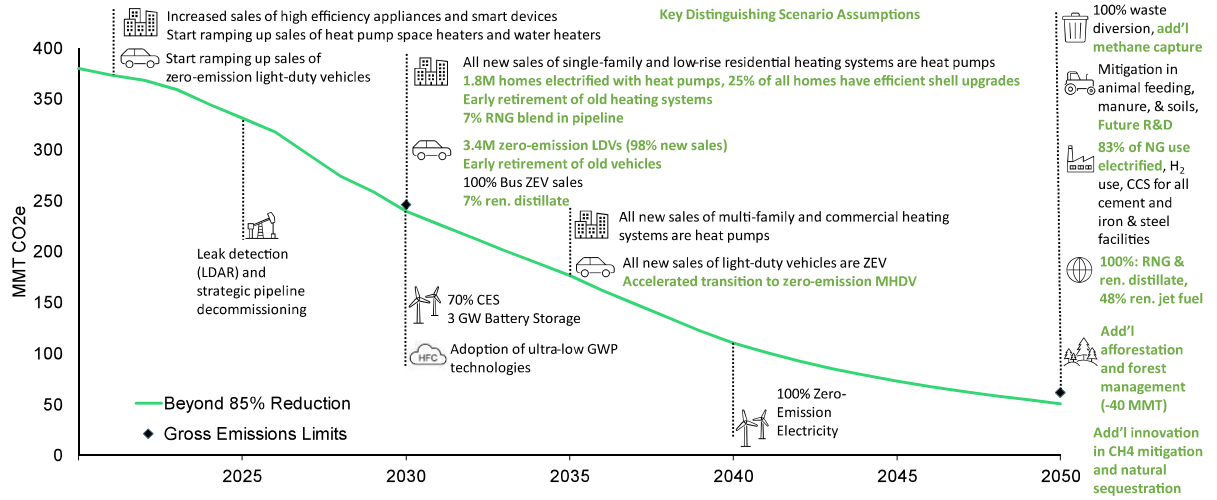


Figure 9. Key Assumptions in Scenario 4: Beyond 85% Reduction



9.3 Key Findings

The integration analysis presented multiple pathways to achieving the GHG emission limits and led to several key findings:

- **Achieving deep decarbonization is feasible by mid-century.** Achieving the GHG emission limits **requires action in all sectors**, especially considering the Climate Act's emissions accounting, as described in *Chapter 4. Current Emissions*. 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 are essential parts of any pathway that achieves New York State emission limits.** Approximately 1 to 2 million efficient homes will need to be electrified with heat pumps by 2030. Approximately 3 million zero-emission vehicles (predominantly battery electric) will need to be sold by 2030.
- **A transition to low global warming potential (GWP) refrigerants and enhanced refrigerant management will be required** to electrify while reducing and ultimately eliminating GHG emissions from hydrofluorocarbon (HFC)-based refrigerants used in today's heat pumps.
- **Consumer and community decision-making is key, and especially important for the purchase of new passenger vehicles and heating systems for homes and businesses through the next decade.** In all modeled scenarios, zero-emission vehicles and heat pumps will need to become the majority of new purchases by the late 2020s, and fossil fuel-emitting cars and appliances will no longer be sold after 2035. This represents an unprecedented rate of adoption of novel and potentially disruptive technologies and measures.
- **New York will need to substantially reduce VMT while increasing access to public transportation.** This should include expanding transit services structured around community needs, smart growth inclusive of equitable transit-oriented development (E-TOD), and transportation demand management.
- **Wind, water, and sunlight will power most of New York's economy in 2050 in all pathways.** Even with aggressively managed load, electric consumption doubles and peak load nearly doubles by 2050, and New York becomes a winter peaking system by 2035, with offshore wind of around 15 gigawatts (GW), solar of around 60 GW, and four- and eight-hour battery storage of around 20 GW by 2050. Firm, zero-emission resources, such as green hydrogen or long-duration storage, will be important to ensuring a reliable electricity system beyond 2040.
- **Low-carbon fuels such as bioenergy or hydrogen may help to decarbonize sectors that are challenging to electrify.** By 2030, scenarios include initial market adoption of green hydrogen in several applications, including medium- and heavy-duty (MHD) vehicles and high-temperature industrial. Additional promising end-use applications include district heating and non-road transportation such as aviation and rail.
- **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 (such as the direct air capture of CO_2) may be required if the state cannot exceed 85% direct GHG emissions reductions by 2050. Strategic land use planning will be essential to balance natural carbon sequestration, agriculture activities, new renewables development, and smart urban planning (smart growth).

- **Necessary methane emissions mitigation in waste and agriculture will require transformative solutions.** Diversion of organic waste and the capture of fugitive methane emissions are key in the waste sector. Alternative manure management and animal feeding practices will be critical in reducing methane emissions in agriculture.
- **Continued research, development, and demonstration (RD&D) is key to advancing a full portfolio of options and mitigating risk.** 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 (such as Earthshots).
- **The largest three remaining sources** of emissions in 2050 across scenarios are landfills, aviation, and animal feeding.

More detailed economywide and sectoral results are presented in the Integration Analysis Technical Supplement (Appendix G).