Caiazza Comment on Draft Scoping Plan Scenarios

Summary
There is a specific request for feedback on the components of the three mitigation scenarios as well as an implicit request for a recommendation for the appropriate scenario going forward. This comment presents my response.

Contrary to the pre-conceived notion of the Climate Leadership and Community Protection Act (Climate Act) that a transition to net-zero by 2050 is only a matter of political will, there are significant technical issues that have to be addressed to maintain current standards of reliability and affordability. For example, the New York Independent System Operator (NYISO) [Power Trends 2022] report notes: "Long-duration, dispatchable, and emission-free resources will be necessary to maintain reliability and meet the objectives of the CLCPA. Resources with this combination of attributes are not commercially available at this time but will be critical to future grid reliability." There are technologies in all the sectors that are included in all the mitigation scenarios of the Draft Scoping Plan that are not commercially available at this time but will critical to the transition requirements. As a result of these technical constraints, I believe that mitigation scenario 2, Strategic Use of Low-Carbon Fuels should be the recommended path forward for the Final Scoping Plan simply because it relies on fewer untested technologies.

The Integration Analysis documentation for the control strategies in the three mitigation scenarios is inadequate. There isn't sufficient information about each control measure to be able to compare emission reductions, costs, and viability to be able to meaningfully comment on the component of the mitigation scenarios. More importantly, the Draft Scoping Plan does not include a feasibility analysis that explains how the control measures will work in the Climate Act transition plan. The strategies are simply listed and the citizens of New York are expected to believe that the projected emissions reductions will occur. The Climate Action Council should address the feasibility of the Integration Analysis control measures as part of the Final Scoping Plan.

These comments address all sectors except the electric sector. Because of the importance of the electric generating sector, I have devoted a comment specifically to Draft Scoping Plan issues associated with it. The buildings and transportation sectors are responsible for emissions on the same order as the electric sector so these comments emphasize those two sectors.

I submitted [comments] on residential heating options in February that highlighted the need for the Climate Action Council to provide a Draft Scoping Plan that fully accounts for costs. I believe that means that all the control measures should be listed, the assumptions used referenced, the expected costs for those measures and the expected emission reductions for the Reference Case, the Advisory Panel scenario and the three mitigation scenarios. That information is not available and considerably hampers the evaluation of the Integration Analysis mitigation scenario projections. Because this information is not available it is not possible to comment on the glaring inconsistency that Scenario 3: Accelerated

Transition Away from Combustion and Scenario 4: Beyond 85% Reductions are projected to cost less than Scenario 2: Strategic Use of Low-Carbon Fuels.

In my opinion, it is necessary to do a feasibility analysis for all three mitigation scenarios. For example, the primary difference for new heat pump sales for the scenarios is the ramp rate. Scenarios 3 and 4 accelerate the deployment of heat pumps in 2030 by mandating early retirement of existing furnaces instead of waiting until their end of useful life. It is easy to include this in a framework but there are at least a couple of implementation issues. What criteria would be used to determine who would get stuck with the added expense for premature retirements? Shouldn't the affected owners get an additional subsidy to cover their costs? Do those issues make this infeasible? Without a feasibility analysis the Final Scoping Plan will be incomplete.

The Integration Analysis mitigation scenarios building sector strategies include "making energy efficiency improvements in all buildings, with the emphasis on improvements to building envelopes (air sealing, insulation, and replacing poorly performing windows) to reduce energy demand by 30% to 50%." The Plan documentation describes building shell improvement characteristics but does not describe the rationale for applying basic vs. deep shell packages. There is an enormous difference ($45K instead of $6K) between the costs of the two types of building shells and there is insufficient documentation to determine how the Integration Analysis apportioned the technology across buildings in the state. The Climate Action Council should ensure that the Final Scoping Plan improves its documentation so that the citizens of New York will be able to understand residential electrification expectations.

In 2050 the percentage of electrified buildings is 92% for all three mitigation scenarios. Scenario 2 projects that 631,351 housing units will still use combustion heating sources and in Scenarios 3 and 4 634,66 housing units will use combustion sources. I believe that the Integration Analysis determined that these buildings could not be electrified and then assumed that they could continue to use their existing combustion heating sources. This is another feasibility issue. How can the Climate Action Council's Final Scoping Plan guarantee that those housing units will have access to their current fuel supplies at a reasonable cost when there are so few of them left? If, for example, those housing units use fuel oil or propane what business model can sustain a delivery company with many fewer customers?

With the limited comment period and large number of control strategies it was impossible for me to do a comprehensive review of transportation sector control strategies in the threee mitigation scenarios. Even in my cursory review it was apparent that the Integration Analysis has calculation assumption errors and there is a tremendous amount of wishful thinking regarding the proposed control strategies. I show in one specific example that the reduction in vehicle miles traveled due to passenger rail transportaton enhancements for Scenario 4 is inconsistent with the primary sources so the projected emission reductions are incorrect.

The most impactful example of wishful thinking concerns the transition to electric vehicles before the zero-emission vehicle legislative mandate in 2035. For all motor vehicle registrations in New York in

May 2022 there are only 62,123 electric vehicles statewide. The Integration Analysis projects that there will be 138,156 light-duty electric vehicles in 2025 in the Reference case. Scenario 2 projects 257,718 LDEV in 2025 and both Scenarios 3 and 4 project 275,417. My comments argue that in the absence of compelling documentation, there is little reason to believe that the transition targets in 2025 will be met and the thought that by 2030 there will be 2.7 million zero-emission light-duty vehicles and that 90% of all new sales will be zero-emission vehicles is highly unlikely.

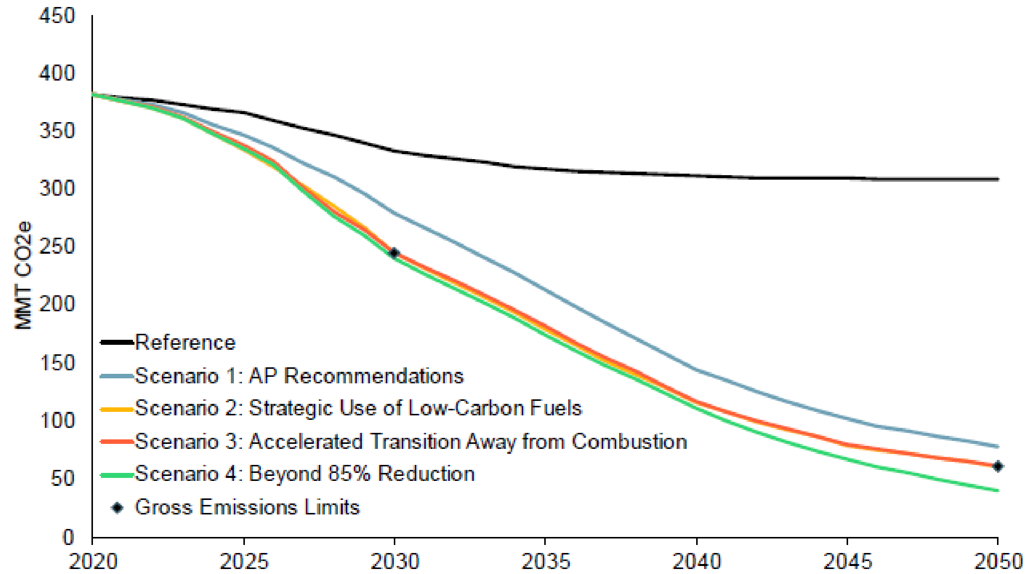
Both the charger cost and zero-emission vehicle cost projections are overly optimistic about the future. The final Scoping Plan must update the analysis to incorporate what has happened since the Integration Analysis projections were completed. Costs have not been going down as projected for 2022. If they cannot forecast a couple of years ahead correctly then estimates out to 2050 are not credible.

My comments also addressed other sectors. Following the theme of the other sectors, the differences between the scenarios are mostly increasingly speculative technological innovations that decrease emissions. For example, Scenario 4 includes further agricultural and waste reductions that assume "high (but also highly uncertain) levels of innovation in the waste and agriculture sectors". The addition of these technologies in Scenarios 3 and 4 affirm my recommendation that Scenario 2 is the most feasible approach going forward. In any event the Climate Action Council has to show feasibility for the Final Scoping Plan control measures to have credibility.

Integration Analysis Reference Case and Scenario 1
Appendix G: Integration Analysis Technical Supplement of the Draft Scoping Plan was prepared by Energy and Environmental Economics (E3) and Abt Associates in December 2021. The primary reference for the scenario descriptions is Appendix G Section I: Techno-Economic Analysis (Section I). The Integration Analysis initially "evaluated a future that represents business-as-usual inclusive of implemented policies (Reference Case) and a representation of a future based on the recommendations from the Council's Advisory Panels (Scenario 1)" (Section I p.11). The initial analysis found that the Advisory Panel recommendations in Scenario 1 did not meet the Act emissions limits (Figure 1).

There is another aspect to Figure 1. In order to understand the true impact of these scenarios it is important to know what is included and what is not included. In particular the Reference Case "a business-as-usual forecast "inclusive of implemented policies". The inclusion of implemented policies in the Reference Case means that many New York State policies that exist only to meet climate goals are not included in the expected costs of the three mitigation scenarios. This increases the cost of the Reference Case and decreases the relative difference between the mitigation scenarios and the Reference Case leading to the misleading claim that the costs of the Climate Act are several hundred billion dollars.

Figure 4. Gross Greenhouse Gas Emissions by Mitigation Scenario



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- **Scenario 1: Advisory Panel Recommendations**: Representation of the Advisory Panel recommendations,[7] which provide a foundation for all scenarios through rapid electrification of buildings and transportation, decarbonization of the power sector, and ambitious reductions in non-

[6] The Reference Case is used for evaluating incremental societal costs and benefits of GHG emissions mitigation. The Reference Case includes a business as usual forecast plus implemented policies, including but not limited to federal appliance standards, energy efficiency achieved by funded programs (Housing and Community Renewal, New York Power Authority, Department of Public Service, Long Island Power Authority, NYSERDA Clean Energy Fund), funded building electrification, national Corporate Average Fuel Economy standards, a statewide Zero-emission vehicle mandate, and a statewide Clean Energy Standard including technology carveouts. For more details see Chapter 5.3.

***Figure 1**: Screen capture of Figure 4 and its foornote on Section I - page 12. Note that there is no caption for the figure but there is a footnote. The footnote is the primary reference for the definition of the Reference Case*

The footnote (6) for the preceding figure states that the Reference Case includes a business as usual forecast plus implemented policies, including but not limited to federal appliance standards, energy efficiency achieved by funded programs (Housing and Community Renewal, New York Power Authority, Department of Public Service, Long Island Power Authority, NYSERDA Clean Energy Fund), funded building electrification, national Corporate Average Fuel Economy standards, a statewide Zero-emission vehicle mandate, and a statewide Clean Energy Standard including technology carveouts.

The following table from [Annex 2: Key Drivers and Outputs Spreadsheet](), Tab: Scenario Definitions lists specific programs in the Reference Case but details are lacking. In order to provide a full accounting of the control measures the Scoping Plan documentation should include a control measure description, the emissions reductions expected, and the costs expected for each of the scenarios. That information is not provided so the Climate Action Council has not met the requirements of section 14,b of § 75-0103 in the Climate Act that states that the costs and benefits analysis must:

> "Evaluate, using the best available economic models, emission estimation techniques and other scientific methods, the total potential costs and potential economic and non-economic benefits of the plan for reducing greenhouse gases, and make such evaluation publicly available."

Scenario Name	Scenario Description
Reference Case	Business as usual plus implemented policies • Growth in housing units, population, commercial square footage, and GDP • Federal appliance standards • Economic fuel switching (oil to gas) • Bioheat mandate • Estimate of New Efficiency, New York Energy Efficiency achieved by funded programs: HCR+NYPA, DPS (IOUs), LIPA, NYSERDA CEF (assumes market transformation maintains level of efficiency and electrification post-2025) • Funded building electrification (4% HP stock share by 2030) • Corporate Average Fuel Economy (CAFE) Standards • Zero-emission vehicle mandate (8% LDV ZEV stock share by 2030) • Clean Energy Standard (70x30), including technology carveouts: [6 GW of behind-the-meter solar by 2025, 3 GW of battery storage by 2030; 9 GW of offshore wind by 2035; 1.25 GW of Tier 4 renewables by 2030]
Scenario 1: Advisory Panel Recommendations	A scenario based on Advisory Panel recommendations, with initial assumptions on mitigation measures, including: • Rapid adoption of electric vehicles • Critical role for smart growth, transit, and telework • Rapid building electrification • Zero emission power sector by 2040, including technology carve outs: [6 GW of behind-the-meter solar by 2025, 10 GW by 2030; 3 GW of battery storage by 2030; 9 GW of offshore wind by 2035; 2.55 GW of Tier 4 renewables by 2030] • Ambitious reductions in emissions from refrigerants, agriculture, waste, and fugitive emissions

***Figure 2**: Integration Analysis Technical Supplement, Section I, Annex 2: Key Drivers and Outputs Spreadsheet, Tab: Scenario Definitions*

Integration Analysis Mitigation Scenarios

The consultants developed three mitigation scenarios that were "designed to meet or exceed GHG limits and achieve carbon neutrality". The three mitigation scenarios are described in Appendix G Section I on page 14:

> Transformative 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 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 CO2,

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.

Scenario Name	Scenario Description
All Mitigation Scenarios [2-4]	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, including technology carve outs: [6 GW of behind-the-meter solar by 2025, 10 GW BTM solar by 2030; 3 GW of battery storage by 2030; 9 GW of offshore wind by 2035; 2.55 GW of Tier 4 renewables by 2030] • 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 C	• Low-to-no bioenergy or 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 CO2

Figure 3*: Integration Analysis Technical Supplement, Section I, Annex 2: Key Drivers and Outputs Spreadsheet, Tab: Scenario Definitions*

Chapter 9 of the Draft Scoping Plan includes four figures (starting at page 72) that list projected emission reductions and the strategies employed to achieve them for all four scenarios. The following text reproduces the figures and extracts the sector strategies for multiple dates in the timeline in order to show how the strategies differ between the scenarios.

The missing piece for the three scenarios is a feasibility analysis that could be used to determine if the suggested strategies are practical. While there are members of the Climate Action Council who think that there are no conditions relative to implementing control measures to meet the Climate targets that is not the case. According to New York Public Service Law § 66-p. "Establishment of a renewable energy program" there is a safety valve condition: "(4) The commission may temporarily suspend or modify the obligations under such program provided that the commission, after conducting a hearing as provided in section twenty of this chapter, makes a finding that the program impedes the provision of safe and adequate electric service; the program is likely to impair existing obligations and agreements; and/or that there is a significant increase in arrears or service disconnections that the commission determines is related to the program". Therefore, a feasibility analysis the considers safe and adequate electric service reliability constraints and increase in arrears or service disconnections affordability is a necessary prerequisite for initiating control strategies.

Scenario 1: Advisory Panel Recommendations

The following figure is a representation of the Advisory Panel recommendations. They provide a foundation for all scenarios; however, scenario modeling shows that further effort is needed to meet Climate Act emission limits.

Figure 6. Advisory Panel Recommendations

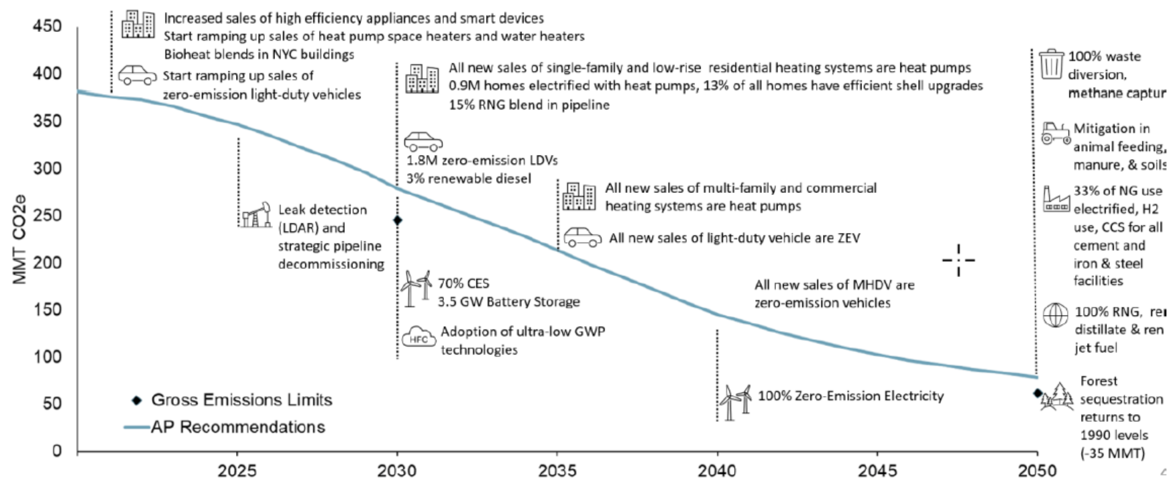


Figure 4: Draft Scoping Plan Page 72

Timeline Components

2022

- Buildings
    - Increased sales of high efficiency appliances and smart devices
    - Start ramping up sales of heat pump space heaters and water heaters
    - Bioheat blends in NYC buildings
- Transportation
    - Start ramping up sales of zero-emission light-duty vehicles

2025

- Oil and Gas Sector
    - Leak detection
    - Strategic pipeline decommissioning

2030

- Buildings
    - All new sales of single-family and low-rise residential heating systems are heat pumps
    - 0.9 million homes electrified with heat pumps
    - 13% of all homes have efficient shell upgrades
    - 15% renewable natural gas in pipeline

- Transportation
  - 1.8 million zero-emission light-duty vehicles
  - 3% renewable diesel
- Generation
  - 70% clean energy standard
  - 3.6 GW battery storage
- Hydrofluorocarbon (HFC)
  - Adoption of ultra-low global warming potential technologies

2035

- Buildings
  - All new sales of multi-family and commercial heating systems are heat pumps
- Transportation
  - All new sales of light-duty vehicles are zero-emission

2040

- Generation
  - 100% zero-emission electricity
- Transportation
  - All new sales of medium and heavy duty vehicles are zero-emission

2050

- Waste
  - 100% waste diversion
  - Methane capture
- Agriculture
  - Mitigation in animal feeding, manure management and soils
- Industry
  - 33% of natural gas use electrified
  - Hydrogen use
  - Carbon capture and sequestration for all cement and iron&steel facilities
- Aviation
  - 100% renewable natural gas, renewable distillate and renewable jet fuel
- Forestry
  - Forest sequestration returnes to 1990 levels (-35 MMT)

Scenario 2: Strategic Use of Low-Carbon Fuels

Advisory Panel recommendations were 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.

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

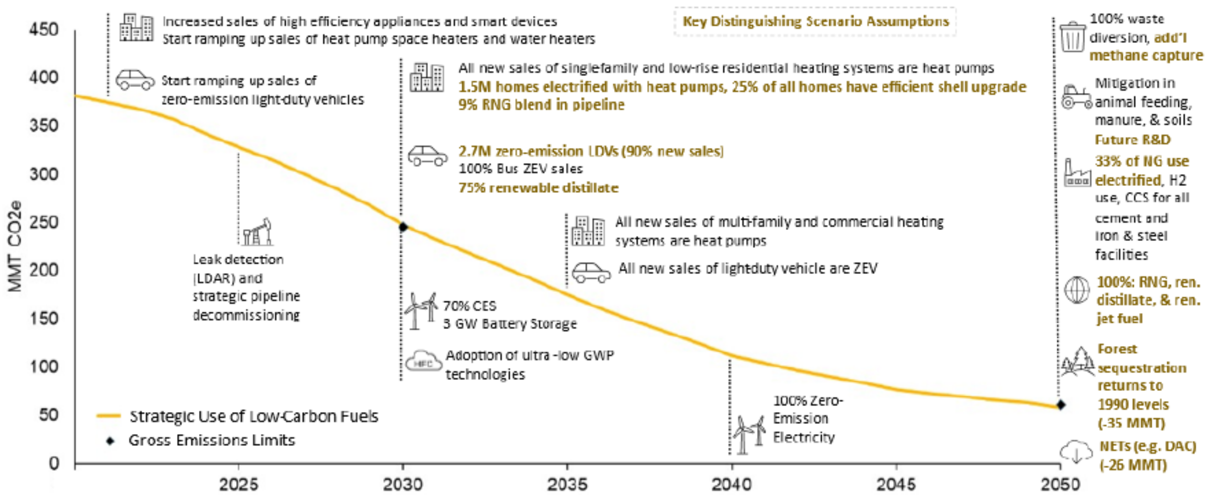


Figure 1 Draft Scoping Plan Page 72

<u>Timeline</u>

Italicized items are changes from Scenario 1

2022

- Buildings
    - Increased sales of high efficiency appliances and smart devices
    - Start ramping up sales of heat pump space heaters and water heaters
    - ~~*Bioheat blends in NYC buildings*~~
- Transportation
    - Start ramping up sales of zero-emission light-duty vehicles

2025

- Oil and Gas Sector
    - Leak detection
    - Strategic pipeline decommissioning

2030

- Buildings
    - All new sales of single-family and low-rise residential heating systems are heat pumps
    - *1.5 instead of 0.9 million homes electrified with heat pumps*

    - *25% instead of 13% of all homes have efficient shell upgrades*
    - *9% instead of 15% renewable natural gas in pipeline*
- Transportation
    - *2.7 instead of 1.8 million zero-emission light-duty vehicles (90% new sales)*
    - *100% zero-emission bus sales*
    - *75% renewable distillate instead of 3% renewable diesel*
- Generation
    - 70% clean energy standard
    - *3 GW instead of 3.6 GW battery storage*
- HFC
    - Adoption of ultra-low global warming potential technologies

2035
- Buildings
    - All new sales of multi-family and commercial heating systems are heat pumps
- Transportation
    - All new sales of light-duty vehicles are zero-emission

2040
- Generation
    - 100% zero-emission electricity
- Transportation
    - All new sales of medium and heavy duty vehicles are zero-emission

2050
- Waste
    - 100% waste diversion
    - *Additional methane capture*
- Agriculture
    - Mitigation in animal feeding, manure management and soils
    - *Future R&D*
- Industry
    - 33% of natural gas use electrified
    - Hydrogen use
    - Carbon capture and sequestration for all cement and iron&steel facilities
- Aviation - Note that Appendix G, Figure 6 on Section I page 14 has a different set of strategies
    - 100% renewable natural gas, renewable distillate and renewable jet fuel
- Forestry
    - Forest sequestration returnes to 1990 levels (-35 MMT)
- *Negative Emission Technology, for example, direct air capture*
    - *-26 MMT*

Scenario 3: Accelerated Transition Away from Combustion

Advisory Panel recommendations adjusted to include a very limited role for bioenergy and hydrogen combustion and accelerated electrification of buildings and transportation. This scenario includes a role for negative emissions technologies to reach carbon neutrality.

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

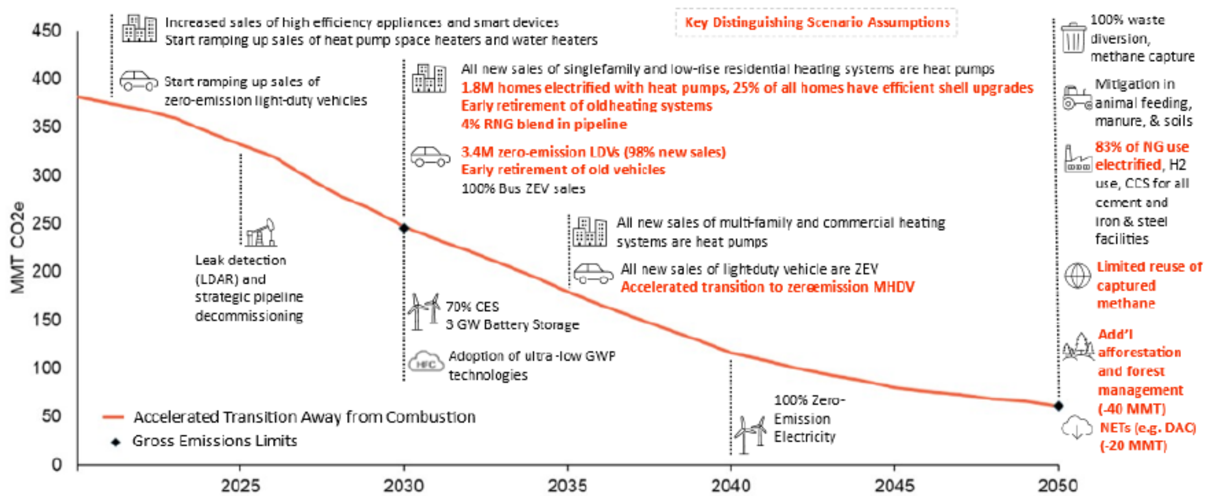


Figure 2 Draft Scoping Plan Page 73

<u>Timeline</u>

Italicized items are changes from Scenario 2

2022

- Buildings
  - Increased sales of high efficiency appliances and smart devices
  - Start ramping up sales of heat pump space heaters and water heaters
- Transportation
  - Start ramping up sales of zero-emission light-duty vehicles

2025

- Oil and Gas Sector
  - Leak detection
  - Strategic pipeline decommissioning

2030

- Buildings
  - All new sales of single-family and low-rise residential heating systems are heat pumps
  - *1.8 instead of 1.5 million homes electrified with heat pumps*
  - 25% of all homes have efficient shell upgrades
  - *Early retirement of old heating systems*
  - *4% instead of 9% renewable natural gas in pipeline*
- Transportation

    - *3.4 instead of 3.7 million zero-emission light-duty vehicles (98% new sales)*
    - *Early retirement of old vehicles*
    - 100% zero-emission bus sales
    - ~~*75% renewable distillate instead of 3% renewable diesel*~~
- Generation
    - 70% clean energy standard
    - 3 GW battery storage
- HFC
    - Adoption of ultra-low global warming potential technologies

2035
- Buildings
    - All new sales of multi-family and commercial heating systems are heat pumps
- Transportation
    - All new sales of light-duty vehicles are zero-emission
    - *Accelerated transition to zero-emission medium and heavy duty vehicles*

2040
- Generation
    - 100% zero-emission electricity
- Transportation
    - All new sales of medium and heavy duty vehicles are zero-emission

2050
- Waste
    - 100% waste diversion
    - *Additional methane capture*
- Agriculture
    - Mitigation in animal feeding, manure management and soils
    - *Future R&D*
- Industry
    - *83% instead of 33% of natural gas use electrified*
    - Hydrogen use
    - Carbon capture and sequestration for all cement and iron&steel facilities
- Aviation – Note that Appendix G, Figure 7 on Section I page 15 has a different set of strategies
    - ~~*100% renewable natural gas, renewable distillate and renewable jet fuel*~~
    - *Limited reuse of captured methane*
- Forestry
    - *Additional afforestration and forest management -40 MMT instead of -35 MMT*
- Negative Emission Technology, for example, direct air capture
    - *-20 MMT instead of -26 MMT*

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

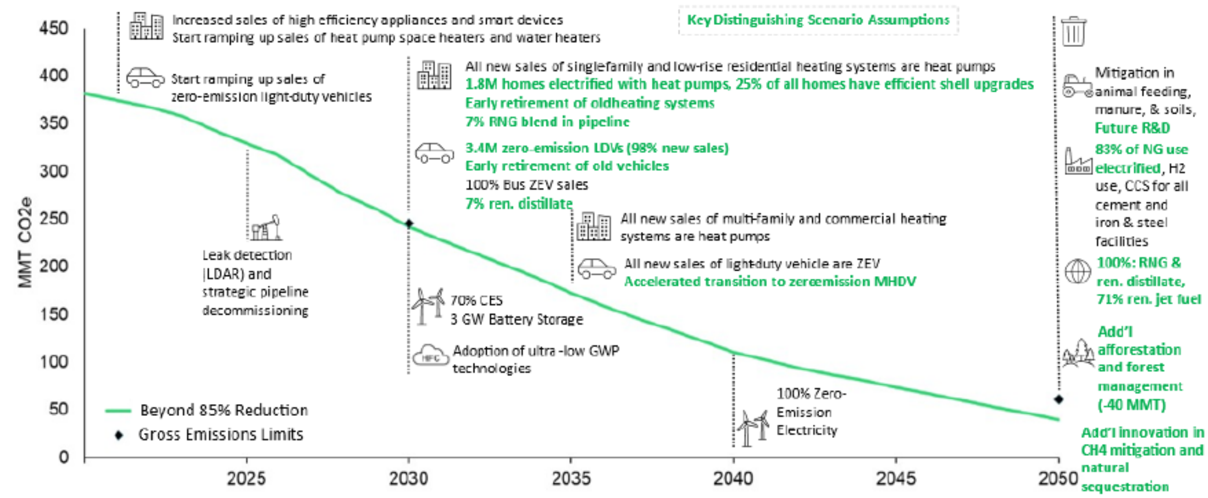


Figure 3 Draft Scoping Plan Page 73

Timeline

Italicized items are changes from Scenario 3

2022

- Buildings
  - Increased sales of high efficiency appliances and smart devices
  - Start ramping up sales of heat pump space heaters and water heaters
- Transportation
  - Start ramping up sales of zero-emission light-duty vehicles

2025

- Oil and Gas Sector
  - Leak detection
  - Strategic pipeline decommissioning

2030

- Buildings
  - All new sales of single-family and low-rise residential heating systems are heat pumps
  - 1.8 instead of 1.5 million homes electrified with heat pumps
  - 25% of all homes have efficient shell upgrades

    - *Early retirement of old heating systems*
    - *7% instead of 4% renewable natural gas in pipeline*
- Transportation
    - 3.4 instead of 3.7 million zero-emission light-duty vehicles (98% new sales)
    - Early retirement of old vehicles
    - 100% zero-emission bus sales
    - *7% renewable distillate*
- Generation
    - 70% clean energy standard
    - 3 GW battery storage
- HFC
    - Adoption of ultra-low global warming potential technologies

2035
- Buildings
    - All new sales of multi-family and commercial heating systems are heat pumps
- Transportation
    - All new sales of light-duty vehicles are zero-emission
    - Accelerated transition to zero-emission medium and heavy duty vehicles

2040
- Generation
    - 100% zero-emission electricity
- Transportation
    - All new sales of medium and heavy duty vehicles are zero-emission

2050
- Waste
    - 100% waste diversion
    - *Additional methane capture*
- Agriculture
    - Mitigation in animal feeding, manure management and soils
    - Future R&D
- Industry
    - 83% of natural gas use electrified
    - Hydrogen use
    - Carbon capture and sequestration for all cement and iron&steel facilities
- Aviation
    - *100% renewable natural gas and renewable distillate*
    - *71% renewable jet fuel*
    - ~~*Limited reuse of captured methane*~~

- Forestry
    - Additional afforestration and forest management -40 MMT instead of -35 MMT
- Negative Emission Technology, for example, direct air capture
    - -20 MMT instead of -26 MMT
- *Additional innovation in methane mitigation and natural sequestration*

Building Sector Scenarios

The Annex 2: Key Drivers and Outputs Spreadsheet, Tab: Scenario Definitions table lists specific programs in the Reference Case. The entire description of the contents of this information in Appendix G text is: "Scenario assumptions and level of transformation by sector and action for mitigation scenarios 2, 3, and 4 are summarized in the tables below." The lack of documentation makes it difficult to provide meaningful comments.

Table 1 extracts assumption data from that spreadsheet so that the Reference Case and four scenarios can be compared. The table lists data for four categories of energy efficiency and electrification. Note that I have added some numbers from the IA-Tech-Supplement-Annex-2-Key-Drivers-Outputs spreadsheet Space Heating-Res tables. There are some slight differences between those tables and the Scenario Definitions table which could be because the table lists data for all buildings and I am only using the data for residences because that is my primary interest.

Table 1: Building Sector Heating, Electrification, and Building Shell Assumptions

Efficiency and Electrification	Condition	Year	Reference Case	Scenario 1	Scenario 2	Scenario 3	Scenario 4
New Sales of Heat Pumps		2025	4%	18%	23%	23%	23%
		2029	4%	30%	77%	80%	80%
	Single Family	2030	4%	100%	100%	100%	100%
	Early Retirement					10%	10%
	Multi-Family/Commercial	2035		100%	100%	100%	100%
Mix of heat pump technologies	Air Source Heat Pumps		100%	70%	70%	77%	77%
	ASHP + Fuel Backup			10%	10%		
	Ground Source Heat Pumps			20%	20%	23%	23%
Share of Electrified Buildings	Percentage	2030	1%	11%	18%	22%	22%
		2050	3%	89%	92%	92%	92%
	Households (millions)	2030	0.1	0.9	1.5	1.8	1.8
		2050	0.2	7.5	7.8	7.8	7.8
	Commercial Square feet (billions)	2030	0.1	0.6	1.1	1.4	1.4
		2050	0.2	5.3	5.3	5.6	5.6
Share of Buildings with Efficient Shell	Percentage with Deep Shell	2030	3%	3%	7%	7%	7%
		2050	5%	12%	26%	26%	26%
	Percentage with Basic Shell	2030	4%	10%	18%	18%	18%
		2050	10%	56%	66%	66%	66%

New Sales of Heat Pumps

The primary difference for new heat pump sales for the scenarios is the ramp rate. Note that according to this modeling that the rate of heat pump sales for the Reference Case stays at 4% through 2030 in the table and until 2050 in the Reference Case Space Heating-Res table. If heat pumps are all that they are cracked up to be then shouldn't the rate of adoption be higher in the business-as-usual case? As it is, it seems to confirm that heat pump adoption cannot stand on its own. The Final Scoping Plan should explain this inconsistency.

Scenarios 3 and 4 accelerate the deployment of heat pumps in 2030 by mandating early retirement of existing furnaces instead of waiting until their end of useful life. It is easy to include this in a framework but there are at least a couple of implementation issues. What criteria would be used to determine who would get stuck with the added expense for premature retirements? Shouldn't the affected owners get an additional subsidy to cover their costs? These questions need to be answered in the Final Plan.

The final condition in this category combines multi-family/commercial sales. These numbers are not listed together anywhere in the Space Heating-Res tables. Moreover, in 2030 none of the commercial or multi-family residential building sub-sectors are 100% so there is an inconsistency between the Space Heating-Res tables and Scenario Definitions table.

Mix of Heat Pump Technologies

I believe that this category represents the mix of heat pump technologies sold. Another problem with the residential heating documentation is that the types of heating technology are not the same across all the different tables. For example, the table that lists device costs provides values for four kinds of heat pumps (air source, hybrid oil electric heat pump, hybrid gas electric heat pump, and ground source heat pump). The Space Heating-Res tables add ductless air source heat pump. Unfortunately, for Scenarios 2-4 the ductless air source heat pump is the most common type of heat pump sold in the modeling results. It was not my understanding that the ductless air source heat pumps were the primary choice for air source heat pumps. Instead, I thought that the plan was to replace an existing furnace with an air source heat pump furnace. The lack of documentation makes it impossible to determine the intent of the Integration Analysis modeling. The Final Scoping Plan should resolve these differences.

The biggest difference between mitigation Scenario 2 and Scenarios 3 and 4 is that Scenario 2 includes an option to use air source heat pumps with fuel backup. This option is included to address the following statement in the Draft Scoping Plan:

> In the State's coldest regions, where heating systems are designed for temperatures of zero (0F) or lower, some homes that install cold climate ASHPs may therefore use supplemental heat (wood, home heating oil, propane, or gas) for peak cold conditions to avoid unnecessary oversizing of heat pumps and to mitigate electric grid impacts.

I agree that this is necessary but I think that there are issues with this option. In the first place I presume that in Scenarios 3 and 4 these homes will have to rely on electric resistance heating for the supplemental backup needed. What are the impacts of oversizing heat pumps and the electric grid impacts on affordability? Oversizing the heat pump adds direct costs which are not reflected in device cost table. If too many people have to rely on electric resistance heating, then there will be a spike in energy demand during the coldest periods. That could mean the electric distribution system will have to be over built for those conditions. The Final Scoping Plan has to address these issues.

In order for heat pumps to work they have to transfer energy. At some extreme of cold weather air source heat pumps won't have enough energy to provide heat. This issue is an example of a clean energy technology that doesn't work all of the time and the time when it does not work it is needed the most. Advocates for the net-zero transition often ignore the significant costs needed to provide a reliable system for these worst-case conditions. In this instance homeowners can address the problem by installing a ground source heat pump ($34K instead of $15K), installing a deep shell insulation and infiltration envelope instead of a basic shell ($45K instead of $6K), or adding electric resistance heat ($1K). The problem with just adding electric resistance heat is that electric service to the home and neighborhood will have to be upgraded and that adds costs between $4K and $9K and who knows how much more for the distribution system upgrades and added generation needed. The alleged lower costs of Scenarios 3 and 4 suggest that this issue has not been included in the costs.

The other issue with this option is that the alternative to use home heating oil, propane, or gas may not be viable when most homes have converted to electricity. Fuel oil and propane dealers probably won't have enough customers to remain in business. Delivering natural gas to an ever-decreasing number of homes will also likely have similar viability issues. How does the Climate Action Council plan to address this?

Share of Electrified Buildings

In 2050 the percentage of electrified buildings is 92% for all three mitigation scenarios. Scenario 2 projects that 631,351 housing units will still use combustion heating sources and in Scenarios 3 and 4 634,66 housing units will use combustion sources. First point is that it is not clear why the two scenarios that are supposed to get away from combustion are projected to have more residences on combustion sources. The same viability issues with oil, propane and gas suppliers are also a concern.

Share of Buildings with Efficient Shell

The Draft Scoping Plan approach depends upon "making energy efficiency improvements in all buildings, with the emphasis on improvements to building envelopes (air sealing, insulation, and replacing poorly performing windows) to reduce energy demand by 30% to 50%." The Plan documentation describes building shell improvement characteristics but does not describe the rationale for applying basic vs. deep shell packages. There is an enormous difference ($45K instead of $6K) between the costs of the two types of building shells and there is insufficient documentation to determine how the Integration Analysis apportioned the technology across buildings in the state. I submitted comments earlier that addressed the types of building shells. I concluded that the Draft Scoping Plan underestimates the number of buildings that need deep shell upgrades. That affects the cost projections significantly.

There is no difference in the percentage of building shell types for all three mitigation scenarios. Importantly, note that 8% of the buildings are projected to not receive shell upgrades. I guess that the same 8% of buildings that are not electrified don't get building shell upgrades. The Final Scoping Plan should clarify this situation.

Transportation Scenarios

Table 16. Level of Transformation by Scenario: Transportation from Appendix G Section I page 118 lists the transformation strategies for the transportation sector. It would take an extraordinary amount of work to debunk these wishful thinking strategies that may sound good for the Draft Scoping Plan but will not necessarily work in the real world. I will give just one example: rail transportation.

I published a blog article on one particular aspect of transportation sector costs: the transportation sector vehicle miles traveled difference between Scenarios 2 and 3 relative to Scenario 4. The Draft Scoping Plan claims that "Incremental reductions from enhanced in-state rail aligning with 125 MPH alternative detailed in Empire Corridor Tier 1 Draft EIS" will provide a reduction of 200 million light duty vehicle miles at a per unit cost of $6 per mile or $1.2 billion. I estimate that the only valid cost for the difference between the rail alternatives is $8.4 billion and that it would only provide a reduction of 64.7 million miles. While my estimate is for 2035, consistent with the Empire Corridor evaluation, and the Draft Scoping Plan is for 2050, I don't think there is any question that the numbers are inconsistent and that, as a result, the emission reduction projections are incorrect.

Within the non-road transportation category in Table 16, the rail component for all three scenarios states "90% electrification, 10% hydrogen use in 2050". There is no detail of how those categories are broken out. According to Appendix G, Scenario 4 would get additional vehicle miles traveled reductions by using the "125 MPH alternative detailed in Empire Corridor Tier 1 Draft EIS". That alternative calls for an electrified passenger rail line from New York to Buffalo, including a completely new line between Albany and Buffalo. I cannot say if the plan is to add catenary to electrify the railroads or use battery-electric locomotives. Hydrogen (via electrolysis) is listed under the low-carbon fuels category and is supposed to be used for medium and heavy-duty vehicles and freight rail. Because freight transportation energy use exceeds passenger energy use, I assume that freight locomotives will be a mix of hydrogen and electric power.

There are two issues. The Appendix G Scenario 2 transportation investment category is only $3 billion more than the Reference Case, $15 billion for Scenario 3 and $40 billion for Scenario 4. In the absence of documentation, I can only guess that the different railroad transportation strategies in Scenario 4 reflect the added costs. Secondly, my interpretation of this strategy is that the Draft Scoping Plan expects that within New York State, railroad locomotives will have state-specific limitations. The problem is that the major railroads operate their locomotives over much greater distances than New York State. A train carrying containers from the West Coast might change locomotives once or twice but certainly runs through into New York from the Midwest. Is the Scoping Plan expectation that there will be a change of locomotives at the state line? Theory may be fine but the practical implementation introduces a whole host of logistical issues and hidden costs.

Electric Vehicles

The Annex 2: Key Drivers and Outputs Spreadsheet, Tab: Scenario Definitions table lists specific programs in the Reference Case. Table 2 extracts assumption data from that spreadsheet so that the Reference Case and mitigation scenarios can be compared.

Table 2: Transportation Sector Scenario Summary

Light duty vehicles transition to battery electric technology

Parameter	Year	Reference	Scenario 2	Scenario 3	Scenario 4
ZEV New Sales	2030	19%	90%	98%	98%
	2035	27%	100%	100%	100%
Early Retirements	2030			10%	10%
ZEV Stocks	2030	5%	21%	26%	26%
	2050	34%	95%	95%	95%

Medium and heavy-duty vehicles are slower to transition, and rely on a combination of battery electric and hydrogen fuel cell technologies

Parameter	Year	Reference	Scenario 2	Scenario 3	Scenario 4
MDV New Sales	2030	7%	40%	50%	50%
	2045	27%	100%	100%	100%
HDV New Sales	2030		DNR	40%	40%
	2045		DNR	100%	100%
BEV & HFCV Split	MDV	DNR	50/50	75/25	75/25
	HDV	DNR	25/75	50/50	50/50
ZEV MHDV stocks	2030	1%	7%	9%	9%
	2050	17%	76%	85%	85%

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

Parameter	Year	Reference	Scenario 2	Scenario 3	Scenario 4
VMT Reduction	2035	DNR	6%	DNR	5%
	2050	DNR	6%	DNR	5%

Aviation

Parameter	Year	Reference	Scenario 2	Scenario 3	Scenario 4
Electric short-haul	2050	DNR	DNR	DNR	16%
Hydrogen aviation	2050	DNR	DNR	DNR	50%

Consider the light duty vehicle strategies. For all motor vehicle registrations in New York in May 2022 there are only 62,123 electric vehicles statewide. The Integration Analysis projects that there will be 138,156 light-duty electric vehicles in 2025 in the Reference case. Scenario 2 projects 257,718 LDEV in 2025 and both Scenarios 3 and 4 project 275,417. In order to reach those levels, there will have to be a significant increase in electric vehicle sales.

My concern is that this increase in EV sales is based on no documented references. As Christian Twiste writes the current reality is very much different:

> The average electric vehicle cost $65,977 as of March, compared to an average price of $45,927 across the entire industry, and a much lower price of $26,052 for a compact car, meaning going electric will cost a frugal family over 250% more than opting for a small car mainstay like a Toyota Corolla or Honda Civic. Even if you have the funds and are willing to spend them, *Politico* reported last weekend that most models are sold out until next year. Ford and Volkswagen both anticipate no new vehicles being available until 2023. Tesla's least expensive model won't be available until December, and Rivian, a new entry in the market, was forced to cut production in half this year due to supply chain issues.

The unprecedented buildout proposed in these Draft Scoping Plan scenarios has to be documented to be considered viable for the Final Scoping Plan.

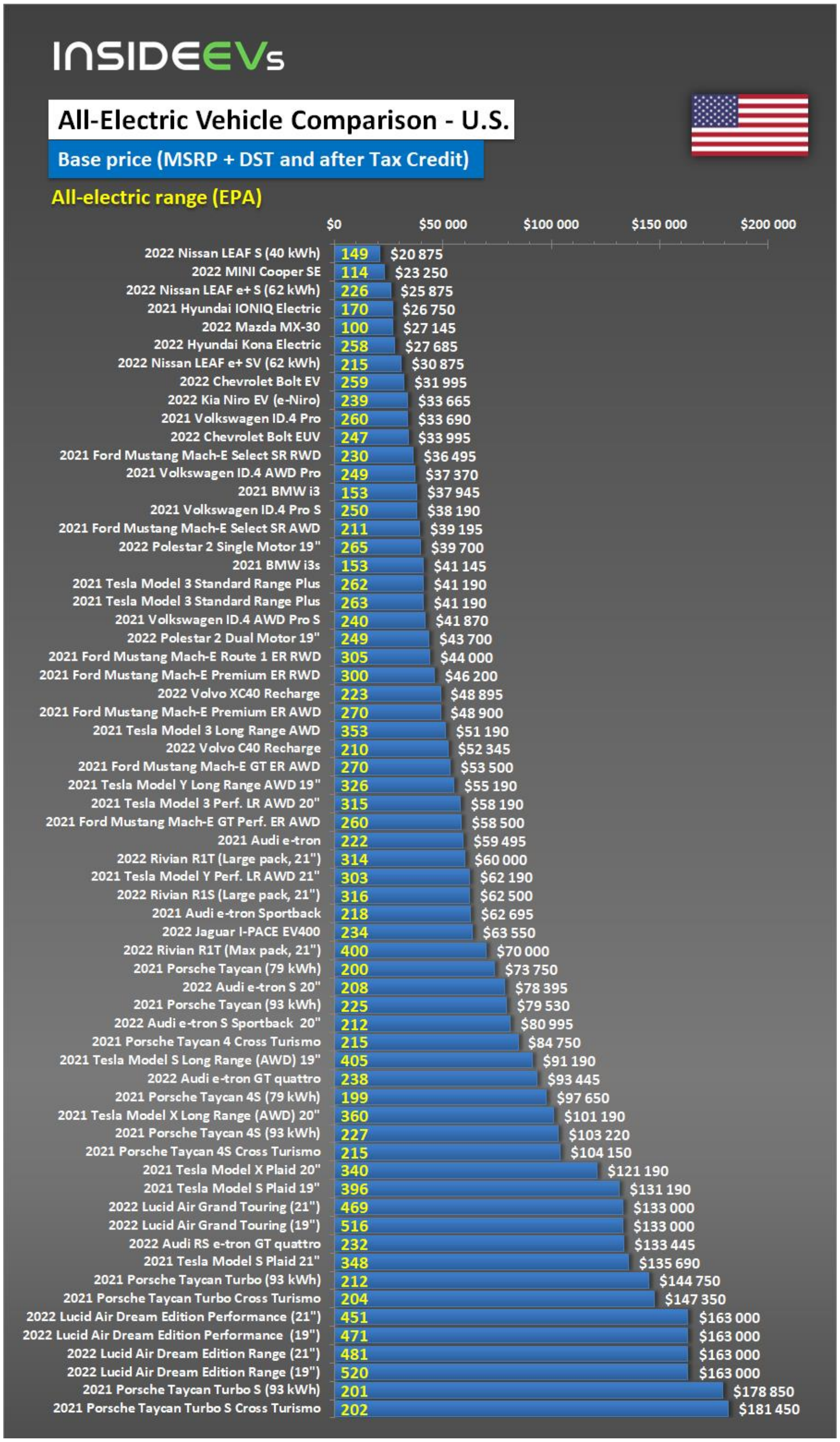
EV Charging

The LDV charger cost comparison table extracts data from the IA-Tech-Supplement-Annex-2-Key-Drivers-Outputs spreadsheet related to charger systems. The Electric Vehicle Supply Equipment: Per-Vehicle Costs section at the top of the table lists cost directly from the Integration Analysis spreadsheet. I found a reference for bus charging infrastructure that I used in a blog article. The Center for Transportation and the Environment (CTE) Charging Infrastructure webinar listed costs between $5,000 and $7,000 for an AC level 2 charger and between $50,000 and $70,000 for a DC level 3 charger. There is an obvious disconnect between those numbers and the $24,000 value for 2020 in this table. More disturbing are the cost projections over time. The Integration Analysis projects a cost decrease of 18% for light duty vehicle battery chargers between 2020 and 2030, a 41% decrease between 2020 and 2040, and a 61% decrease between 2020 and 2050. The first ten years the price decreases by 18%, the second ten years the price decreases another 27% and the last ten years the price decreases another 34%. Sorry I am not buying this incredibly optimistic assessment of future cost reductions without documentation. The fact that the battery charging cost reductions are identical to the hydrogen fuel cell cost reductions suggests that some analyst simply made an assumption. If these numbers are used in the Final Scoping Plan they have to be documented.

The total costs of course reflect these optimistic charger costs. Assuming that every new car needs a new charger, I multiplied the number of new battery electric light duty vehicles by the charger cost. Relative to the Reference Case the projected costs of battery electric light duty vehicles is projected to be $15 billion for Scenario 2 and $18.5 billion for Scenarios 3 and 4. Note that if the cost for chargers stays the same then the projected cost is $37 billion for Scenario 2 and $42 billion for Scenarios 3 and 4. There is an associated issue that I could not address due to the poor documentation. The expected lifespan of an electric vehicle charging system is ten years. I don't know if the final costs in the Draft Scoping Plan incorporate the lifespan adjustment that is going to increase costs markedly. That adjustment means that the real charger cost has to account for all the cars in the New York fleet. The final Scoping Plan should clarify whether those costs were included.

Light-Duty Vehicle Costs

The LDV Zero-Emission Vehicle Costs table extracts data from the IA-Tech-Supplement-Annex-2-Key-Drivers-Outputs spreadsheet related to the costs of light-duty vehicles themselves. The Transportation - Vehicle Cost by Technology: Reference Trajectory section at the top of the table lists cost directly from the Integration Analysis spreadsheet. Note the cost of zero-emissions battery electric $43,794 and hydrogen fuel cell vehicles $58,392. The following table from Inside EVs lists the costs of battery electric vehicles on September 18 2022. There are 63 car models listed and there are only 13 models less than the Integration Analysis estimate.



https://insideevs.com/news/534027/electric-car-prices-us-20210918/

Similar to the car charging the EV cost projections over time are disturbing. The Integration Analysis projects a cost decrease of 35% for light duty battery electric vehicles between 2020 and 2030, a 42% decrease between 2020 and 2040, and a 44% decrease between 2020 and 2050. The first ten years the price decreases by 18%, the second ten years the price decreases another 11% and the last ten years the price decreases another 3.4%. Sorry I am not buying this optimistic assessment of future cost reductions without documentation that should be included in the Final Scoping Plan if these numbers are used.

I also calculated the total costs for vehicles over the period 2020 to 2050 in the LDV Zero-Emission Vehicle Costs table. The total cost for new vehicles in the Reference Case is $619.6 billion. Scenario 2, Strategic Use of Low-Carbon Fuels, total costs are $575.6 billion so the Draft Scoping Plan claims that converting to zero-emission vehicles will cost less than the Reference Case by $44 billion. The assumptions for Scenarios 3 and 4 must be identical because they both have a total cost of $581.8 billion for a difference of $37.8 billion. The massive cost reductions projected for zero-emissions vehicles is most of the reason that converting to zero-emissions is cheaper. Note that the apparent difference between the scenarios is the use of hydrogen fuel cell vehicles in Scenario 2.

Miscellaneous Sectors

All the oil and gas sector scenarios include strategic pipeline decommissioning in 2025. This is a very good example of an easy strategy to propose but one that has enormous logistical consequences that have to be addressed in a feasibility analysis. The Climate Action Council workgroup on the natural gas transition will have to address this as a priority.

The generation sector scenarios just list the Climate Act targets. I addressed the electric system in separate comments. The building and transportation sectors have already been discussed.

The hydrofluorocarbon (HFC) sector strategy in the Advisory Panel Scenario is to adopt ultra-low global warming potential technologies in 2030. This is stragegy is not included in the mitigation scenarios.

Scenario 1 proposes that the waste sector have 100% waste diversion and methane capture in 2050. The only difference in the figures for the mitigation scenarios is to add more methane capture in 2050. In my opinion the idea that all wastes can be diverted from landfills is an aspirational target not rooted in reality. Setting the target over 25 years ago ensures that the authors won't be held accountable. The IA-Tech Supplement Annex 2 Emissions Key Drivers spreadsheet "Emissions Wedges" table shows no changes in emission reductions between the scenarios until 2041 when Scenario 4 reduces emissions 9.1% more than the other two scenarios. According to Appendix G, the waste reductions assume "high (but also highly uncertain) levels of innovation in the waste and agriculture sectors". This kind of arbitrary strategy inclusion weakens the case for Scenario 4 as a viable alternative.

Scenario 1 proposes that the agriculture sector do mitigation in animal feeding, manure management and soils in 2050. The only difference in the figures for the mitigation scenarios is to do "future R&D" in 2050. The IA-Tech Supplement Annex 2 Emissions Key Drivers spreadsheet "Emissions Wedges" table shows no changes in emission reductions between the scenarios until 2031 when Scenario 4 reduces emissions 1.1% more than the other two scenarios. According to Appendix G, the waste reductions assume “high (but also highly uncertain) levels of innovation in the waste and agriculture sectors”.

There are three strategies for the industrial sector. Scenarios 1 and 2 project 33% of natural gas use becomes electrified and Scenarios 3 and 4 kick that up to 83%. In my opinion the 83% was based on how much of a reduction was needed to meet the target emissions level rather than an analysis of which additional industrial processes could be converted. In addition, control strategies for hydrogen use and carbon capture and sequestration for all cement and iron & steel facilities are included. Carbon sequestration is highly dependent upon the availability of suitable geologic formations so presuming this strategy is highly speculative. The emission wedges spreadsheet does not break out these strategies so I could not compare the emission reductions expected for each scenario.

There also are strategies for the aviation sector that I believe are completely divorced from reality. Aviation is an international sector and in order to get compliance New York would need to get buy-in from airlines around the world. The most likely outcome would be a near-complete transfer of all international flights elsewhere. In Scenario 1 three strategies are suggested: 100% renewable natural gas, renewable distillate and renewable jet fuel. I am unaware of much use of any kind of natural gas for aviation so that needs to be documented. There is a typographical inconsistency for the Scenario 2 strategies. In Appendix G, Figure 6 on Section I page 14 the only strategy listed is “limited reuse of captured methane”. However in Draft Scoping Plan Chapter 9 page 72, Figure 7 lists three strategies: 100% renewable natural gas, renewable distillate and renewable jet fuel. Scenario 3 also has a typographical inconsistency. In Appendix G, Figure 7 on Section I page 15 three strategies are listed: 100% renewable natural gas, renewable distillate and renewable jet fuel. On the other hand, in Draft Scoping Plan Chapter 9 page 73 Figure 8 the only strategy listed is “limited reuse of captured methane”. The emissions wedges data do not break out aviation emissions and there is insufficient documentation so I cannot speculate what the Integration Analysis did. Scenario 4 has the only variation amongst the three strategies: 100% renewable natural gas and renewable distillate stays the same, the description for renewable jet fuel changes to 71% renewable jet fuel, and limited use of captured methane is eliminated. This is another example of arbitrary strategy inclusion that weakens the case for Scenario 4 as a viable alternative.

The forestry sector is important because it provides a large natural sink for GHG emissions. In Scenarios 1 and 2, forest sequestration returns to 1990 levels (-35 mmt). In Scenarios 3 and 4, “Additional afforestration and forest management -40 MMT instead of -35 MMT”. Again I cannot help but think that the additional efforts are an excuse for getting five MMT reductions needed to meet an arbitrary target. I don’t think these strategies have been documented well enough to be included as viable so they weaken the case for both scenarios.