5. Low-Carbon Alternative Fuels

Draft New York State Energy Plan

July 2025

Key Findings

- **Low-carbon alternative fuels are an important complement to electrification in the State's clean energy transition strategy.** In cases where electrification and zero emissions solutions are impracticable due to technological, safety, cost or reliability constraints, these fuels should be prioritized for end uses where they can deliver the greatest greenhouse gas (GHG) emissions reductions with the lowest cost and environmental impact. The deployment of low-carbon alternative fuels should also ensure net reductions in co-pollutant emissions and avoid disproportionate impacts on disadvantaged communities associated with such emissions. Since supply of these fuels will be limited, analysis indicates that low-carbon alternative fuels are best directed toward targeted and high-impact applications in transportation, supplemental heating, agriculture and industry, and the power sector, areas where full electrification may not yet be practical to maximize environmental benefits and greenhouse gas emissions reductions.

- **Alternative fuels should be carefully managed to realize GHG emissions reductions**. GHG emissions associated with the feedstock, production, transportation, storage, and combustion of low-carbon alternative fuels should be considered. To maximize global GHG emissions reductions, New York State prefers waste-based feedstocks for alternative fuel production. To further maximize in-state benefits and achievement of the State's climate goals, the State prefers fuels and feedstocks sourced within the State. Recognizing the supply limitations, the State remains open to regionally sourced and other low-impact feedstocks to advance global GHG reduction.

- **Both lifecycle analysis and Climate Act accounting of greenhouse gas emissions from low-carbon alternative fuels should play a role in the design and development of programs and policies.** Lifecycle analysis should be used in policy development to evaluate and compare GHG emissions reductions associated with different feedstocks, fuels, and end-uses and to calculate emissions reductions relative to a business-as-usual scenario. The Climate Act accounting framework should be used when calculating emissions impacts that relate to measuring progress towards Climate Act targets.

- **Alternative fuels deployment should be strategic to realize co-pollutant emissions reductions, especially in and near disadvantaged communities.** While reducing global greenhouse gas emissions is important, any potential net increase in local co-pollutant emissions from the use of alternative fuels should be considered and avoided wherever possible. To maximize co-pollutant emission reductions, electrification and other zero-emission solutions should be prioritized unless there are specific technological, safety, or reliability challenges.

- **Policies and tracking systems should balance rigor with feasibility to accelerate alternative fuels deployment while ensuring credible emissions reductions.** The integrity of GHG emission reduction claims depends on transparent, robust, and credible tracking of alternative fuel attributes, however, systems should be designed to avoid excessive administrative burdens that could stifle deployment and prevent emissions reductions. The delivery of fuels to NYS for use within the state is of critical importance. NYS should carefully consider methods to appropriately and accurately measure emissions reductions and should consider designing an attribute tracking process that includes additional considerations such as valuing unique aspects of certain fuels or technologies, avoiding land-use change, or avoiding undesired feedstocks or origin locations.

- **To catalyze low-carbon alternative fuels markets to meet future demand, policy, regulatory, and market interventions such as mandates, market-based mechanisms, and incentives, will likely be needed.** Demand is likely to outpace the current limited supply of these fuels, underscoring the need for supportive policies and regional market development to expand cost-effective production to increase availability. Additional market structures or mechanisms may also be needed to align price structures to realize the needed supply of low-carbon alternative fuels and should be evaluated against any potential consumer cost increases resulting from these policies.
- **To meet State policy goals, a limited amount of alternative fuels will need to be produced, transported and used in the broader energy system.** To minimize costs and other impacts, existing infrastructure should be leveraged for the transport and storage of pure or blended alternative fuels wherever it is safe, technologically, and economically feasible. In cases where existing systems are incompatible or insufficient, limited new, fuel-specific infrastructure may be needed to connect supply with areas of demand. New York State does not currently support the blending of hydrogen into the existing natural gas pipeline system due to safety, system integrity, and indoor air quality concerns as additional research is needed to understand such use.

Key Terms

- **Alternative Fuels:** Liquid or gaseous fuel derived from biomass or clean energy such as biodiesel, renewable natural gas (RNG), renewable diesel, hydrogen, and sustainable aviation fuel (SAF).
- **Biogas:** Biogas is gas resulting from the decomposition of organic matter, most commonly under anaerobic conditions (such as in a landfill, manure storage, or wastewater recovery facility). The principal constituents are methane and carbon dioxide. Some end-uses can use biogas directly as a fuel source with minimal processing, though its lower energy density and purity compared to conventional natural gas or renewable natural gas precludes it from most end-uses.
- **Co-Pollutant Emissions:** Air pollutants that are a byproduct from combustion of fossil fuels and most alternative fuels. These include fine particulate matter ($PM_{2.5}$), nitrogen oxides (NO_x), volatile organic compounds (VOC), sulfur dioxide (SO_2), and various toxic compounds. These pollutants contribute to a range of health issues, including respiratory conditions, asthma, heart attacks, and other serious illness.
- **Conventional Fuels:** The fossil fuel that is typically used today. E.g., conventional diesel, conventional jet fuel, conventional natural gas.
- **Renewable Natural Gas (RNG):** Renewable natural gas (RNG) is biogas that has been processed and upgraded to a higher methane content with less impurities and can be used as a drop-in replacement of natural gas in end-uses such as the power sector, industrial processes, buildings, and transportation.
- **Biofuel:** Fuels produced from biomass such as plants or organic wastes.
- **Biodiesel:** Biodiesel is produced from vegetable oils, animal fat, and recycled cooking oil. It is a liquid fuel that can be blended with conventional diesel but cannot entirely replace it. Biodiesel can be blended in most applications that use diesel.
- **Renewable Diesel:** Renewable diesel is interchangeable with conventional diesel. It is typically produced by hydrotreating, combining fats and hydrogen at high temperatures. Renewable diesel can be used as a drop-in replacement for any application that uses diesel.
- **Sustainable Aviation Fuel:** Sustainable Aviation Fuel (SAF) is typically produced from biomass waste and fats/greases/oils. It is a newer alternative fuel that can be blended with conventional jet fuel.
- **Hydrogen:** Hydrogen is an energy carrier that is typically produced via thermal processes, using high temperatures, or electrolytic processes, using water and electricity. Hydrogen can be used for many end-uses and is either combusted or used in fuel cells to provide electricity. Hydrogen can also be converted to synthetic fuels (see below) Hydrogen is only considered a zero-emission fuel if its production does not include the use of fossil fuels (e.g., electrolysis powered by renewable energy).
- **Synthetic Fuels:** Synthetic fuels are produced by combining hydrogen and carbon dioxide using renewable energy. Synthetic natural gas and other liquid synthetic fuels such as renewable diesel and SAF can be produced.

1. Overview

Zero- and low-carbon alternative fuels such as hydrogen, renewable natural gas (RNG), renewable diesel, and sustainable aviation fuel (SAF) have the potential to replace some fossil fuel use and reduce greenhouse gas (GHG) emissions in New York State. These fuels are especially useful in helping to decarbonize difficult-to-electrify end-uses where liquid or gaseous fuels remain necessary due to energy intensity, infrastructure constraints, or cost barriers. Sectors such as agriculture, marine, aviation, long-distance trucking, and some rail transportation face technological and economic challenges to electrification and are prime candidates for alternative fuel use. Low-carbon alternative fuels could also support electric system reliability by supplementing electricity supply during peak periods, such as winter heating demand when clean electricity alone is insufficient to meet heating and electrical needs and maintain necessary reliability standards.

Two supporting reports, *Considerations for Alternative Fuel Use in New York State* and *Co-Pollutant Impacts of Low-Carbon Fuels and Technologies—2025 Update*,[1] explore the potential role of alternative fuels in achieving New York State's energy and climate goals. The first report examines feedstocks, production pathways, end-uses, infrastructure, market development, and research needs related to alternative fuels. The second report focuses on the impacts of alternative fuel use on health and air quality. These reports, along with ongoing alternative fuels research at NYSERDA, helped inform the development of this chapter.[2,3]

2. State of the Sector and Progress Report

2.1. Alternative Fuel Production and Use in New York State

Alternative fuels currently used in New York include biodiesel, ethanol, RNG, renewable diesel, and SAF. Current alternative fuel use is currently limited compared to conventional fossil fuels. In 2022, New York State consumed approximately 44.2 trillion British thermal units (TBtu) of ethanol, 10.5 TBtu of biodiesel, and 4.6 TBtu of landfill gas, each a small fraction compared to 373 TBtu of diesel and 1,402 TBtu of natural gas consumed that same year.[4] Current production capacity within the state is also limited: New York State does not presently produce biodiesel, renewable diesel, or SAF.

2.1.1. Biogas and RNG

Biogas and RNG are produced through the anaerobic digestion of organic materials such as agricultural waste, food scraps, and wastewater sludge. These fuels are typically used to generate heat and electricity on-site or upgraded into pipeline-quality RNG for broader distribution and use. There are at

---

[1] Available for download on NYSERDA's website: https://www.nyserda.ny.gov/About/Publications/Energy-Analysis-Reports-and-Studies/Greenhouse-Gas-Emissions

[2] New York State Energy Research and Development Authority (NYSERDA). 2025. "Considerations for Low-Carbon Alternative Fuel Use in New York State" Prepared by The Brattle Group, Boston, MA. https://www.nyserda.ny.gov/About/Publications/Energy-Analysis-Reports-and-Studies/Greenhouse-Gas-Emissions

[3] New York State Energy Research and Development Authority (NYSERDA). 2025. "Co-Pollutant Impacts of Low-Carbon Fuels and Technologies—2025 Update" Prepared by Industrial Economics, Inc. https://www.nyserda.ny.gov/About/Publications/Energy-Analysis-Reports-and-Studies/Greenhouse-Gas-Emissions

[4] New York State Energy Research and Development Authority. 2024. "Patterns and Trends: New York State Energy Profile 2008 - 2022." Accessed 2025. https://www.nyserda.ny.gov/About/Publications/Energy-Analysis-Reports-and-Studies/Patterns-and-Trends.

least 39 on-farm anaerobic digesters in New York State, primarily located in agricultural regions of Western New York, the Finger Lakes, and the Southern Tier. Anaerobic digesters producing biogas are also present statewide. The Newtown Creek Wastewater Treatment Plant is an RNG demonstration project, the first of its kind in the nation, and processes 250 million gallons of wastewater and 220 tons of organic waste each day. The plant creates a nutrient-rich slurry suitable for composting and producing biogas. Approximately 40 percent of the biogas is used to power the facility, while the remainder is upgraded by National Grid into RNG. When the biogas-to-grid system is offline, the excess gas is flared.

2.1.2. Biodiesel

Biodiesel is produced by chemically converting vegetable oils, animal fats, or recycled cooking oils through a process known as transesterification. In New York State, biodiesel is primarily used for blending with petroleum diesel for on- and off-road transportation and in heating oil. In response to recent changes in state law, data on biodiesel in home heating oil will become increasingly available as a rising percentage of such oil is required to be from biodiesel.[5] Figure 1 reflects only biodiesel consumption in the transportation sector for 2022. Biodiesel use in transportation has increased steadily since 2010, (with the exception of 2020, when the COVID-19 pandemic led to a temporary decrease in transportation fuel demand).[4]

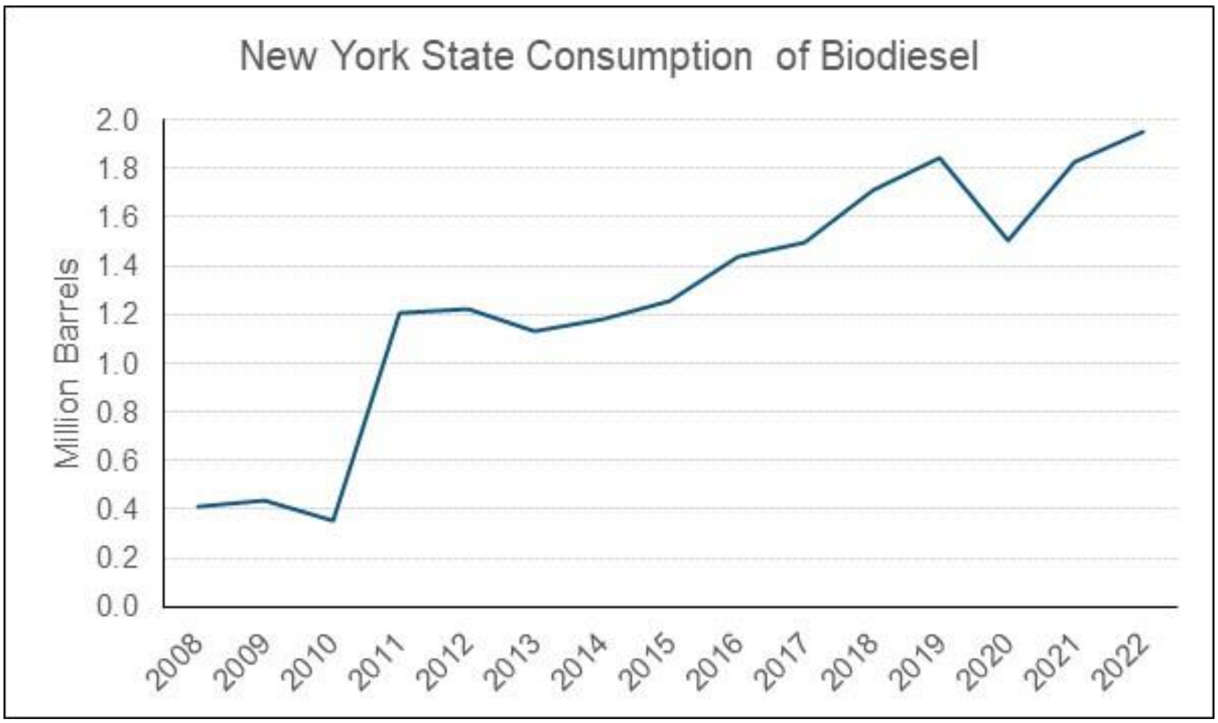

Figure 1: New York State Consumption of Biodiesel

Renewable Diesel

Renewable diesel is produced through the refining of organic feedstocks such as waste oils, animal fats, and vegetable oils through the process of hydrotreating. Unlike biodiesel, renewable diesel is chemically

[5] Section 19-0327 of the Environmental Conservation Law

similar to conventional diesel and can be used as a replacement in existing diesel engines. Currently, there is no commercial-scale renewable diesel production in New York State. Most of the renewable diesel used on the East Coast is imported from other U.S. regions or abroad.[6]

Renewable diesel use in New York State is currently applied in limited targeted end-uses. Specifically, New York City has emerged as a leader in 2023, becoming the first city on the East Coast to transition municipal fleet, vehicles, including garbage trucks, ambulances, work trucks, and emergency generators, to renewable diesel. This shift displaced an estimated 12 million gallons of conventional diesel fuel from September 2023 – October 2024.[7] In October 2024, New York City announced plans to begin testing renewable diesel in the Staten Island Ferry and NYC Ferry systems.[8] In April 2025, New York City completed its first purchase of renewable diesel for use in its ferries.[9]

2.1.3. Sustainable Aviation Fuel

SAF is a recent and promising addition to New York State's alternative fuels landscape. SAF is produced from renewable or waste-derived feedstocks and can significantly reduce GHG emissions compared to conventional jet fuel. The Port Authority of New York and New Jersey (PANYNJ) conducted a logistics and production study that determined SAF would support their commitment to meet the goals of the Paris Agreement by reducing aviation-related GHG emissions. In June 2022, a demonstration project successfully delivered a blend of SAF and conventional jet fuel from a refinery in Houston, Texas to LaGuardia International Airport for use by Delta Airlines via pipeline.[10] Building on this progress, in March 2025, JetBlue and its corporate partners announced a 12-month agreement to procure 1 million gallons of SAF for New York's John F. Kennedy International Airport, with the option to scale up to 5 million gallons with additional corporate partner support. The blended SAF will be used on JetBlue flights departing from the JFK Airport.[11]

2.2. Current New York State Policies

Zero- and low-carbon alternative fuels such as hydrogen, RNG, renewable diesel, and other bio-based fuel products have the potential to displace some fossil fuel use, particularly in sectors that are difficult to electrify, however, additional research, analysis, and technological development are needed to

---

[6] New York State Energy Research and Development Authority (NYSERDA). 2025. "Considerations for Low-Carbon Alternative Fuel Use in New York State" Prepared by The Brattle Group, Boston, MA. https://www.nyserda.ny.gov/About/Publications/Energy-Analysis-Reports-and-Studies/Greenhouse-Gas-Emissions

[7] New York City Website (Official), "Mayor Adams Announces Full City Fleet has Completed Transition to Renewable Diesel," October 3, 2024, https://www.nyc.gov/office-of-the-mayor/news/733-24/mayor-adams-full-city-fleet-has-completed-transition-renewable-diesel.

[8] NYCDOT, "Navigating New York City's Waterways to Become Cleaner and Greener as Staten Island Ferries and NYC Ferry Begin Testing Renewable Diesel," October 21, 2024, https://www.nyc.gov/html/dot/html/pr2024/renewable-diesel.shtml.

[9] EnergyTech, "NYC Harbor, Staten Island Ferries Making First Shift to Renewable Diesel ," April 2, 2025, https://www.energytech.com/emobility/news/55279299/nyc-harbor-staten-island-ferries-shifting-to-renewable-diesel.

[10] Neste, "For the first time, Sustainable Aviation Fuel has been delivered to New York using existing petroleum pipelines," June 15, 2022, https://www.neste.com/news/for-the-first-time-sustainable-aviation-fuel-has-been-delivered-to-new-york-using-existing-petroleum-pipelines.

[11] Business Wire, "JetBlue Marks First Regular Supply of Sustainable Aviation Fuel (SAF) for Commercial Air Travel in New York," March 13, 2025, https://www.businesswire.com/news/home/20250313606888/en/JetBlue-Marks-First-Regular-Supply-of-Sustainable-Aviation-Fuel-SAF-for-Commercial-Air-Travel-in-New-York.

determine the feasibility, climate benefits, and environmental and health impacts of these fuels. The New York State Climate Action Council Scoping Plan highlighted the need for further analysis to prioritize and optimize the use of low-carbon alternative fuels in New York State, while minimizing associated emissions and public health risks.[12]

New York has already taken steps to increase alternative fuel use. In 2023, New York became the largest State in the nation to require that all heating oil sold for use in buildings contain at least five percent biodiesel.[13] This requirement, previously limited to New York City, will increase to 10 percent in 2025 and to 20 percent by 2030.[14] Separately, the Clean Heating Fuel Credit, which began in 2006, provides a one cent per gallon tax credit for every percent of biodiesel blended into heating oil, up to 20 cents per gallon, purchased before January 1, 2026 to help offset the added cost of using biodiesel and support GHG reduction efforts.[15]

2.3. New York State Programs and Initiatives

2.3.1. Clean Transportation Standard Study

As announced in the Governor's 2024 State of the State address, NYSERDA and NYSDEC have initiated a study to evaluate how a Clean Transportation Standard may contribute to clean energy deployment, emissions reductions, health, and equity in New York State. A Clean Transportation Standard would seek to lower the GHG intensity of transportation fuels sold statewide and would include both electrification and low-carbon alternative fuels.

2.3.2. Clean Hydrogen Research & Development

New York State is actively supporting clean hydrogen innovation projects. In 2024, the State awarded nearly $8.1 million to projects to decarbonize industrial process heat, facilitate the integration of clean hydrogen production with renewable energy, and demonstrate hydrogen-based generation systems for grid support services. An additional $1.2 million was awarded for clean hydrogen research and development projects to demonstrate new designs for clean hydrogen electrolyzers that have the potential to lower costs, mitigate supply chain risks, and reduce reliance on fossil fuels in difficult-to-electrify sectors, such as some industrial operations or long-range heavy-duty transportation. NYSERDA recently published the New York State Hydrogen Assessment, a comprehensive analysis of hydrogen's potential to decarbonize hard-to-electrify sectors such as high-temperature industrial processes, heavy-duty transportation, and district heating.[16]

---

[12] New York State Climate Action Council. 2022. "New York State Climate Action Council Scoping Plan, Chapter 13: Electricity." climate.ny.gov/ScopingPlan.

[13] In New York City, City law required this starting in October 2017. https://legistar.council.nyc.gov/LegislationDetail.aspx?ID=2170484&GUID=FB643430-AA04-4B48-BB0D-114D5B7395E7

[14] New York State Senate. 2021. "Senate Bill S3321A." https://www.nysenate.gov/legislation/bills/2021/S3321.

[15] New York State Department of Taxation and Finance. 2023. *Clean Heating Fuel Credit.* Accessed 2024. https://www.tax.ny.gov/pit/credits/clean_heating_fuel_credit.htm.

[16] New York State Energy Research and Development Authority (NYSERDA). 2025. *New York State Hydrogen Assessment, Final Report.* NYSERDA Report Number 25-19, Albany, NY: NYSERDA. https://www.nyserda.ny.gov/All-Programs/Hydrogen.

3. Outlook

3.1. Alternative Fuels End-Uses

As New York State decarbonizes and electrifies its energy system, clean electricity will become the primary energy source and the first solution for emissions reductions. Zero- and low-carbon alternative fuels will play a limited, though critical and strategic, role in decarbonizing end uses that are difficult – to–electrify due to process-specific requirements, technological constraints, safety, or reliability needs. While petroleum and natural gas use is projected to decline significantly between 2025 and 2040 due to increased electrification, fossil fuels are expected to remain primary components of the energy system in 2040. According to the Pathways Analysis, low-carbon alternative fuels are anticipated to grow from meeting just 1 percent of total final energy demand in 2025 to approximately five percent by 2040 (Figure 2).[17] Key contributors to this share include renewable diesel, SAF, RNG, and clean hydrogen.

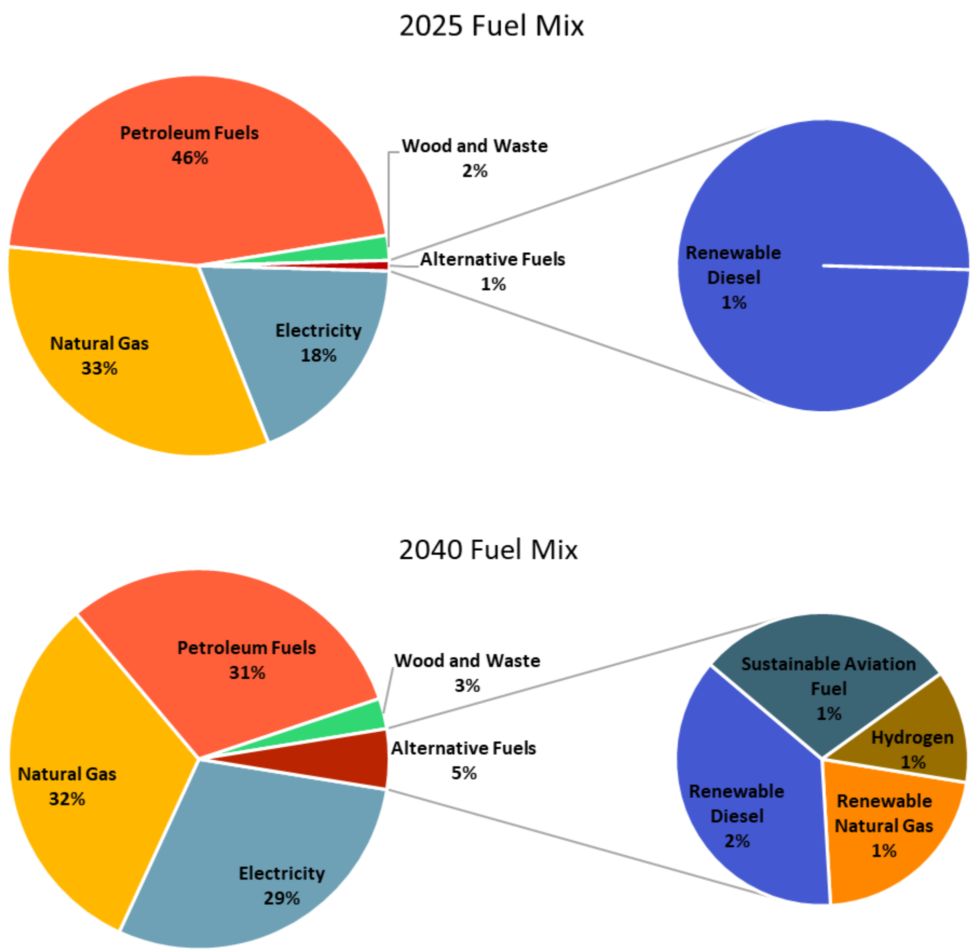

Figure 2: 2025 and 2040 Final Energy Demand by Fuel, from State Energy Plan Pathways Analysis, Additional Action Scenario.

[17] There may be small amounts of additional alternative fuel use (RNG, hydrogen) in the electricity sector.

By 2040, the transportation sector is expected to be the largest consumer of alternative fuels, primarily relying on renewable diesel and SAF to decarbonize heavy-duty transportation and aviation (Figure 3). The commercial, residential, and industrial sectors will rely on RNG and renewable diesel for heating and high-heat industrial processes. While fossil fuels and electricity will remain the dominant energy sources across all sectors in 2040, alternative fuels will comprise only a small percentage of overall fuel consumption (Figure 3). The scale of alternative fuel use will be shaped by sector-specific energy demands, the technological readiness of fuel options, and production and delivery capacity for each fuel.

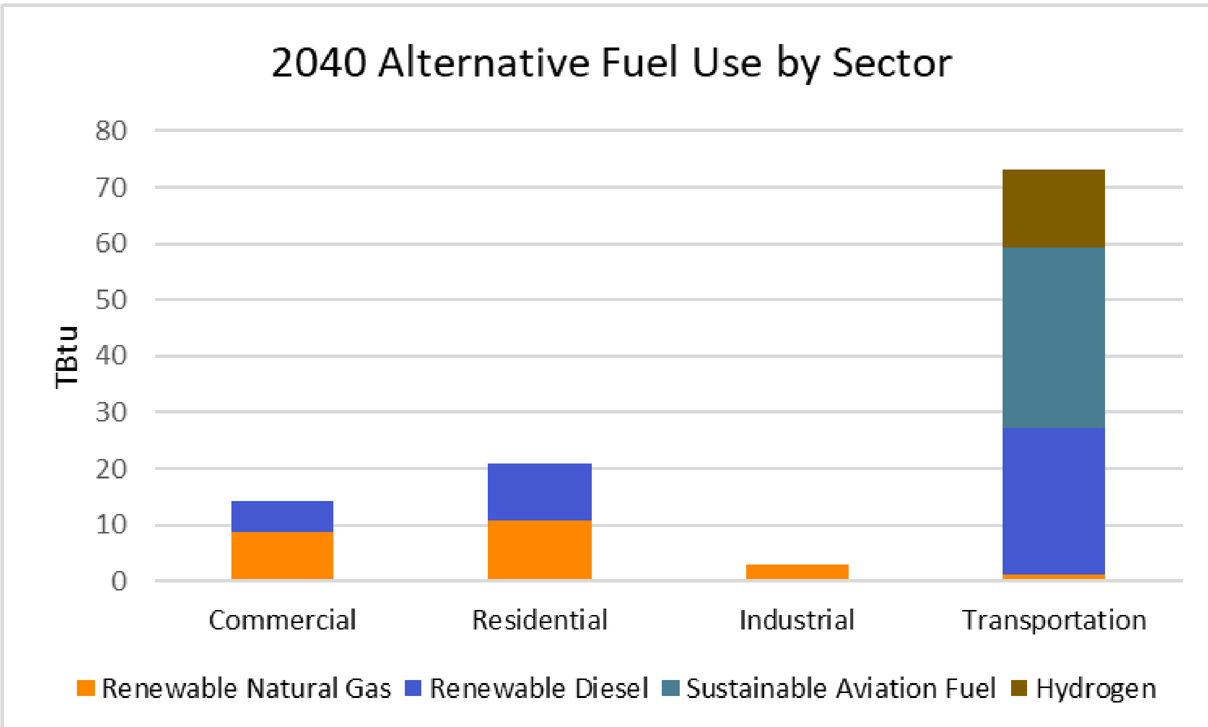

Figure 3: 2040 Alternative Fuel Use by Sector, from State Energy Plan Pathways Analysis, Additional Action Scenario.

In 2040, hydrogen is projected to be used primarily in the transportation sector to decarbonize heavy-duty, long-distance trucking. Beyond 2040, current analysis suggests hydrogen could also play a role in district heating, industrial processes, and select non-road applications, with limited deployment in power generation, aviation, and maritime sectors as production increases. Hydrogen demand is likely to peak during the winter months, driven by heating needs of district steam heating, particularly in New York City where dense industrial, heating, and transportation needs converge.[1616]

3.2. Market Development

Current markets for low-carbon alternative fuels remain limited, as fossil fuels continue to dominate primary energy demand. As such, only small volumes of low-carbon alternative fuels are currently produced in New York State and nationwide.

Low-carbon alternative fuels, with the exception of hydrogen produced using clean electricity, generally depend on a limited supply of organic feedstocks. These feedstocks can be used to produce multiple fuel types, leading to significant competition for their use. In addition to feedstock competition across alternative fuels, neighboring states and Canadian provinces with similar decarbonization targets are also seeking to secure these fuels, creating additional competition for available feedstocks and fuels. As a result, New York State should take a targeted approach to alternative fuel use, prioritizing in-state, waste-based feedstocks when possible, to maximize GHG emissions reductions and other benefits of reducing waste disposal in landfills, affordability, and economic development opportunities (further discussed in Section 4.3). To meet the demand projected in the Pathways Analysis, regional and non-waste feedstocks and fuel production will also be necessary. In order to catalyze the collection of feedstocks and production of new fuels, new policies—including mandates, market-based mechanisms, and incentives—will be needed. As these policies foster increased demand across the region, supply chains and regional markets for the production and delivery of these fuels will emerge.

3.3. Infrastructure Development

New York State has an extensive existing infrastructure for both gaseous and liquid fuels, including pipelines, ports, railways, fueling depots, and storage facilities. Where feasible, leveraging existing fossil infrastructure for alternative fuel production, transport, storage, and use could help reduce costs, avoid stranded assets, and minimize additional environmental and land use impacts. However, the compatibility of existing infrastructure varies by fuel type. For example, RNG and renewable diesel are interchangeable with their fossil-fuel-based counterpart and can be used in existing infrastructure without equipment modifications. Hydrogen, on the other hand, has different, sometimes adverse, infrastructure requirements than conventional natural gas.

Strategic choices will be required to guide infrastructure development to scale alternative fuel production and ensure efficient delivery to areas of demand. For example, downstate New York is expected to have higher energy demand than Upstate areas, where alternative fuel production may be higher.

New infrastructure development or retrofitting of existing infrastructure should align with the long-term needs of a decarbonized energy system to maximize the potential of low-carbon alternative fuels, minimize costs and reduce the risk of stranded assets. Infrastructure investments in long-term low-carbon alternative fuel options (e.g., SAF, renewable diesel) should be prioritized, with a focus on waste-based fuels with fewer technical and environmental challenges and greater greenhouse gas emissions reduction potential.

It is important to recognize that many alternative fuels, such as hydrogen, SAF, renewable diesel, and RNG, can be produced from the same limited pool of feedstocks. As such, infrastructure and policy decisions should prioritize fuels with the greatest long-term strategic value, which are expected to play a role in decarbonizing hard-to-electrify sectors. For example, one possibility is that wastewater treatment facilities could be designed to lower methane generation and instead optimize conditions for producing liquid fuel or hydrogen rather than RNG. Ultimately, infrastructure should reflect a long-term holistic, system-wide vision rather than focused on single fuels.

3.3.1. RNG Infrastructure Needs and Development

Currently, anaerobic digesters in New York State are typically designed to serve individual facilities, processing primarily on-site waste, though sometimes inputs from other facilities, such as food waste, may also be collected. The biogas produced is most often used on-site to generate electricity, with any excess sold to the grid. Though some on-site biogas use may be needed, to meaningfully contribute to the decarbonized energy system, the biogas will need to be refined to RNG and produced, transported, and used at a scale. To maximize production and leverage economies of scale, future RNG production facilities may be sited where they can collect feedstock from multiple sources, such as clusters of farms or food waste producers in an efficient and cost-effective manner and be located near existing pipeline infrastructure to minimize the need for new construction. Whether RNG is injected into the local distribution network or the larger intrastate pipeline transmission system will depend on the location and type of end-uses it is intended to serve, such as residential heating or utility-scale power production.

3.3.2. Biodiesel and Renewable Diesel Infrastructure Needs and Development

Renewable diesel is interchangeable with conventional diesel, allowing it to be used with little or no modification in existing production and transportation infrastructure as well as end uses. existing uses and transportation infrastructure. This compatibility enables renewable diesel to leverage the State's existing diesel production, storage, and transportation system, reducing the need for new infrastructure. However, New York currently has very limited in-state production capacity for both biodiesel and renewable diesel.

While biodiesel can also be blended with conventional diesel, it has greater handling and infrastructure constraints. Blends of up to 20 percent are generally compatible with most engines and infrastructure. As the blends increase, biodiesel becomes more susceptible to gelling in cold temperatures, microbial contamination, and corrosion of metallic infrastructure components. Therefore, biodiesel must be transported by rail, barge or truck rather than through conventional diesel pipelines.

Despite these limitations, biodiesel remains a valuable asset for decarbonization due to its relatively lower cost and production emissions compared to renewable diesel. It can be blended with conventional diesel in the near-term or blended with renewable diesel as those supplies increase.

3.3.3. SAF Infrastructure Needs and Development

SAF can be produced at either retrofitted petroleum refineries or in dedicated biofuel refineries. Nationwide, there are only three known commercial producers of SAF, though this number is expected to grow as airlines continue to sign contracts with existing and future SAF producers.[18] SAF is limited to blends of up to 50 percent with conventional jet fuel, except in research uses.

Transport and handling of SAF involves a multi-step process. SAF is typically transported from production facilities by dedicated railcar or barge or blended with conventional jet fuel for pipeline transport. Pipeline transport of unblended SAF is not currently permitted. At airport terminals, unblended SAF is generally delivered by truck and stored separately from conventional jet fuel. It must undergo

[18] U.S. Department of Energy, *Alternative Fuels Data Center: Sustainable Aviation Fuel*, accessed July 3, 2025, https://afdc.energy.gov/fuels/sustainable-aviation-fuel.

compliance testing to meet fuel quality standards before being blended with conventional jet fuel in a third tank. Fuel terminals located near major New York airports, such as LaGuardia and JFK, already import and transport jet fuel, and are well-positioned to handle SAF.

Additional consideration must be given to jurisdiction over air travel. The federal government has jurisdiction over interstate and international air travel, while New York State has jurisdiction over intrastate flights. The State will need to collaborate with federal agencies to develop SAF infrastructure, expand transport capacity, and support adoption at in-state airports.

3.3.4. Hydrogen Infrastructure Needs and Development

To maximize GHG emissions reduction potential, hydrogen should be produced using zero-emissions electricity and carefully coordinated with other competing demands for electricity. In New York, most projected hydrogen demand is concentrated downstate, which presents transportation and storage challenges. Supply-demand proximity helps to reduce transportation costs and storage requirements.

Hydrogen can be consumed immediately or stored in underground caverns or in above ground steel tanks for future use. Hydrogen can either be used on-site (as energy storage or with co-located industrial use) or transported by truck or pipeline to areas of demand. However, New York's existing natural gas pipeline system is incompatible with hydrogen due to its lower volumetric density, risk of embrittlement and leakage, and end-use compatibility. Retrofitting the existing natural gas infrastructure to blend or carry hydrogen is likely infeasible and not cost-effective, unless future research and development shows otherwise. Given these constraints, hydrogen use is expected to remain targeted in the near-term, with on-road truck transportation being the most viable option. If hydrogen demand increases to an estimated 100 tons per day, investment in dedicated hydrogen pipeline infrastructure may become economically viable.[16]

3.4. Technology Development

Alternative fuels are at varying stages of technological maturity. For example, anaerobic digestion is a well-established process compared to hydrogen production, which requires additional research and development. Over the next fifteen years, continued research, development, and deployment can be done to refine production processes and increase efficiencies, reduce costs, increase fuel flexibility and application designs, and improve infrastructure across the prioritized alternative fuels. NYSERDA's 2025 Regional Greenhouse Gas Initiative Draft Operating Plan allocated $24.5 million over three years to accelerate the development of alternative fuels. This funding will support identification, scoping, engineering measurement, verification, and execution of pilot demonstrations statewide that showcase alternative fuels processes. It will also establish a program that accelerates the development of advanced feedstock conversion technologies for alternative fuels produced with waste-based feedstocks.[19] NYSERDA recently released a Clean Fuels R&D and Pilot Request for Information, which seeks information related to low-carbon alternative fuel technology development in New York State to

---

[19] New York State Energy Research and Development Authority (NYSERDA), *Alternative Fuels*, accessed July 3, 2025, https://www.nyserda.ny.gov/All-Programs/Innovation-at-NYSERDA/Focus-Areas/Advanced-Fuels-and-Thermal-Energy-Storage/Alternative-Fuels.

help guide future competitive solicitations.[20] In addition, NYSERDA's recent Hydrogen Assessment identified technology challenges and research needs for hydrogen production, transportation, storage, and end-use applications.[16]

4. Themes and Recommended Actions

4.1. End-Uses of Alternative Fuels

Low-carbon alternative fuels will be an important and complementary decarbonization strategy alongside electrification in a variety of settings, such as supplemental heating and difficult-to-electrify end-uses. It is important to consider that the supply of alternative fuels will be limited due to regional competition and supply constraints on organic feedstocks used to produce most alternative fuels as well as the supply of clean electricity for hydrogen production. Electrification typically delivers greater health and GHG emission reduction benefits at lower cost compared to alternative fuels. Therefore, electrification should remain the State's primary decarbonization solution. The use of low-carbon alternative fuels should be prioritized for end uses to maximize GHG emissions reductions, minimize costs, ensure net co-pollutant emission reductions, and avoid localized co-pollutant emission impacts.

The development and use of alternative fuels should support the State's long-term GHG reduction targets and long-term energy vision. Some fuels, such as biodiesel, may incrementally decrease emissions relative to fossil fuels, but would not enable the deep emission reductions required to meet the State's goals. Renewable diesel, for example, provides near-term decarbonization in the transportation sector without extensive buildout of infrastructure while allowing the production infrastructure and feedstock supplies to be redirected towards SAF in future years as heavy-duty transportation electrification develops. Similarly, investing in hydrogen production using today's electric grid can deliver incremental GHG emissions reductions, recognizing that electricity emissions will continue to decline as more renewable generation is added to the mix.

Recommendations

- Electrification should remain the first decarbonization solution and the use of low-carbon alternative fuels should be directed towards end-uses to maximize GHG emissions reductions while minimizing the cost of the energy transition, ensuring net co-pollutant emission reductions, and avoiding impacts associated with co-pollutant emissions.
- The use of alternative fuels should be oriented such that technologies for near-term decarbonization can effectively transition to longer-term solutions as technologies and markets develop, consistent with long-term GHG reduction targets.

[20] NYSERDA, *Funding Opportunity Detail: Clean Fuels R&D and Pilot (RFI 5985)*, accessed July 3, 2025, https://portal.nyserda.ny.gov/CORE_Solicitation_Detail_Page?SolicitationId=a0rcr00000K5TyyAAF&_gl=1*97ai76*_gcl_au*OTYzNDg5MjEzLjE3NDU4NTUzMjU.*_ga*MTUzODcxNzQwMC4xNzQ1ODU0OTA5*_ga_DRYJB34TXH*czE3NDg1MzQ5NTckbzI2JGcxJHQxNzQ4NTM2NDA1JGo1MiRsMCRoMA.

4.2. Prioritization of Alternative Fuels

Given the limited supply of common feedstocks, the long-term considerations for fuel use described above, and the GHG and co-pollutant concerns described below, the development of long-term fuel infrastructure should prioritize certain fuel types. There are several factors that drive this prioritization:

- **Maximizing the use of New York's waste resources**. Utilizing NYS waste resources and waste feedstocks avoids unnecessary emissions in the waste sector, further reducing GHG emissions and reducing the need for purpose-grown feedstocks that have increased production emissions and uncertain land-use impacts.
- **The long-term needs of the energy system and interchangeability of fuel types.** For example, designing wastewater treatment plants to optimize methane production for RNG would require a different configuration than designing for liquid fuel production for renewable diesel or SAF. Given that liquid fuels share a common production pathway, designing infrastructure to produce renewable diesel could be compatible with a later shift towards SAF.
- **Minimizing risks associated with land-use changes driven by purpose-grown energy crops.** While changes in global GHG emissions can and should be evaluated using Life Cycle Analysis (LCA) methods for specific fuel pathways, significant uncertainty remains around the GHG impacts of purpose-grown energy crops and the associated land-use change. Applying the precautionary principle, suggests a preference for waste-based feedstocks over purpose-grown crops, and where purpose- grown resources are necessary, prioritize those with minimal land-use impact, such as cover crops or algae.

Recommendations

- New York State should prioritize alternative fuels by maximizing in-state waste resources, aligning the long-term needs of the energy system, and accounting for the uncertainty of land-use impacts and emissions from purpose-grown crops.

4.3. GHG Impacts of Alternative Fuels

Alternative Fuels should be carefully managed to realize global GHG emissions reductions, including those associated with the production, transportation, storage and combustion of low-carbon alternative fuels. These emissions vary based on the feedstock, equipment used, and end-use. Policies, programs, and regulations should appropriately consider the GHG emissions associated with alternative fuel use. This section recommends that GHG emissions accounting for alternative fuels in New York State can be done in two frameworks: New York State Climate Act accounting, as directed by the Climate Act, and LCA. LCA should be used in policy development to evaluate and compare GHG emissions reductions associated with different feedstocks, fuels, and end-uses and to calculate emissions reductions relative to a business-as-usual scenario. However, entities in NYS, such as individual facilities or utilities, should use the Climate Act accounting framework when making emissions claims related to measuring progress towards the Climate Act's targets.

Climate Act and LCA accounting are described in further detail below, along with analysis of how fuels and feedstocks are treated under each framework. While numerical examples are illustrative, they demonstrate how these accounting methods can be used in the State's policies, programs, and regulations to maximize GHG emissions reductions while supporting in-state economic development.

4.3.1. Climate Act Accounting of Alternative Fuels

The methodology used in the Statewide GHG Emissions Report[21] is based upon the requirements defined in the Climate Act which differ from typical jurisdictional GHG accounting done in other states or at the federal level. The main components of the methodology relevant to alternative fuels GHG emissions accounting are:

- Emissions are calculated using a 20-year Global Warming Potential (GWP20).
- Emissions from the production and transport of fossil fuels outside of New York for combustion and use in the state are included in the Statewide GHG Emissions Report. However, this provision does not apply to alternative fuels. Therefore, any emissions, or avoided emissions, associated with the production and transport of alternative fuels outside of New York for use in-state are not included the Statewide GHG Emissions Report.
- For alternative fuels produced, transported, and combusted or used within New York, associated emissions (e.g., sequestration, production, delivery) or emissions reductions (e.g., capturing manure waste for RNG production) are included in the Statewide GHG Emissions Report, though these emissions are attributed to the relevant sector, such as transportation, agriculture, or waste, rather than being reported as energy emissions.
- Gross emissions accounting is used to measure progress towards the Climate Act's statutory GHG emissions targets: 40 percent reduction by 2030 and 85 percent by 2050, relative to 1990 levels. This includes biogenic CO_2 from the combustion of biofuels, which is counted towards gross emissions totals. Emission removals occurring in New York, such as through carbon sequestration and storage in plants, are reported in the Statewide GHG Emissions Report for tracking progress toward the Climate Act's net-zero target.

Another difference from the Climate Act accounting as relates to alternative fuels is that benefit-cost analyses typically treat biogenic emissions as carbon neutral.[22]

While reporting using other accounting methods, like LCA, may be appropriate and informative in certain contexts, the inclusion of these is not a replacement for Climate Act accounting and should be treated as supplementary.

---

[21] New York State Department of Environmental Conservation, "Statewide Greenhouse Gas Emissions Report," 2024, accessed July 3, 2025, https://dec.ny.gov/environmental-protection/climate-change/greenhouse-gas-emissions-report.

[22] Additional detail on benefit-cost analysis practices associated with fuel use can be found in NYSERDA's Fossil and Biogenic Fuel Greenhouse Gas Emissions Factor white paper at https://www.nyserda.ny.gov/About/Publications/Energy-Analysis-Reports-and-Studies/Greenhouse-Gas-Emissions .

4.3.2. Lifecycle Analysis of Alternative Fuels

Under an LCA approach, all GHG emissions from the feedstock, production, transport, and use of the fuel are accounted for, regardless of the location of emission (Table 1). Biogenic combustion is considered carbon neutral, or zero. On an LCA basis, alternative fuels can contribute meaningfully to global GHG emissions reductions. Though Climate Act accounting methodology governs the emissions inventory and progress towards Climate Act emission targets, LCA can provide valuable information to differentiate and select between alternative fuels based on their feedstock, production method, and end-use. For example, avoided emissions from RNG production are much greater when comparing anaerobic digestion of animal manure, where the business-as-usual treatment of the feedstock is from a manure storage producing and releasing significant amounts of methane, versus landfill gas which is often already captured and flared resulting in CO_2 emissions under business-as-usual conditions. Climate Act accounting would only capture this difference if the RNG feedstock and production occurred in-state.

Avoided emissions may also vary within a feedstock. For example, if a farm is already implementing sustainable manure management practices, avoided emissions would be significantly lower when using the manure to produce RNG compared to a farm utilizing an uncovered anaerobic manure pit allowing unmitigated methane release. Therefore, LCA is beneficial for assessing the global contribution to GHG emission mitigation for specific alternative fuel projects. All else being equal, entities using alternative fuels should prioritize those with lower LCA-calculated GHG emissions. In this way, LCA provides a guide for maximizing the global emissions benefits of using alternative fuels. While LCA can estimate the relative emissions performance of various fuels, additional considerations are warranted—particularly for crop-based fuels, in line with the precautionary principle described above.

LCA may be applied within specific programs to support environmental outcomes aligned with New York State's policy goals. As a general rule, LCAs should use GWP20 except where, in the judgment of the State, doing so would yield outcomes contrary to the State's policy goals, in which case it may be appropriate to instead use a 100-year GWP (GWP100).

The key categories of emissions considered in the LCA, and Climate Act accounting for both out-of-state fuel production and in-state fuel production are depicted in Table 1.

Table 1: Treatment of GHG Emissions for LCA and Climate Act Accounting for Various Emissions Categories.

Emissions	LCA	Gross Climate Act Accounting: Out-of-State Alternative Fuel Production, In-State Use	Gross Climate Act Accounting: In-State Alternative Fuel Production, In-State Use
Land Use	✓	X	X
Feedstock Production/Processing	✓	X	✓
Fuel Production	✓	X	✓
Biogenic Combustion	0	✓	✓

GHG emissions from out-of-state fuel production, for both fossil and alternative fuels, is typically not included in state GHG inventories. The Climate Act requires accounting for emissions from the production and transportation of imported fuels, but this requirement applies only to fossil fuels. Under

Climate Act accounting, emissions and emissions removals associated with out-of-state production of alternative fuels are not included in statewide gross emissions reported in the Statewide GHG Emissions Report. This creates an incomplete picture of the emissions from alternative fuel use, either under- or over-reporting the benefits compared to fossil fuel use. For example, under Climate Act accounting, in-state tallow-based or used-cooking oil-based renewable diesel have similar emissions to conventional diesel, while imports of the same fuel would represent reductions in apparent emissions (see Figure 5). From the perspective of global climate change, the imported fuel would have equal emissions to a fuel produced in-state, if not higher due to additional emissions from transportation. Moreover, under gross emissions accounting, biogenic fuel combustion is treated the same as fossil fuel combustion. LCA would demonstrate the global GHG emissions impact of both imported and in-state renewable diesel accurately and considering biogenic emissions as carbon neutral would demonstrate further GHG emissions reductions compared to conventional diesel. Both renewable diesel and biodiesel, in reality, represent GHG emissions improvement over conventional diesel.

In addition, if there is a demand for alternative fuels driven by State policy, whether produced in-state or out-of-state, the impact on global emissions is the same. The Climate Act calls for consideration of impacts on both New York economic and business competitiveness and emissions leakage. In-state fuel production offers greater oversight and control over alternative fuel feedstocks and production methods, helping to maximize GHG emissions reductions. In-state production also has the potential to support economic development, job creation, and energy supply security, while fostering innovation in supply chains. In addition, the use of in-state waste feedstocks directly contributes to achieving the Climate Act's target to reduce in-state emissions by 85 percent by 2050.

4.3.3. Comparison of GHG Emissions for Alternative Fuels

In Figures 4 through 7 below, Climate Act accounting is used to measure gross emissions from both in-state emissions and out-of-state sources. The orange squares represent gross emissions that occur in New York State from alternative fuels that are sourced, produced, and then consumed in New York. The pink squares represent gross emissions that occur in New York from alternative fuels that are used within the State but are sourced and produced outside of New York and then transported to the State for use. The yellow diamond on each bar in the figures indicates estimated LCA-calculated emissions for different feedstocks and fuels. The emissions values in the figures are indicative examples which do not include all potentially prioritized fuel type or feedstocks, and do not represent project-specific emissions nor the emissions factors used in the Statewide GHG Emissions Report. These figures are intended to illustrate general preferences among fuels expressed in the State Energy Plan. Individual projects and programs should engage in LCAs that are specific to the feedstock and fuel used where possible and additional considerations may apply.[23]

RNG

On an LCA basis, RNG reduces emissions compared to natural gas across all feedstocks (Figure 4). However, under Climate Act accounting, RNG derived from in-state, waste-based feedstocks, such as anaerobic digestion of manure waste, wastewater recovery facilities, and food or organic municipal solid

[23] For more information on emission factors for alternative fuel use in New York State, see the Statewide GHG Emissions Report or NYSERDA's Fossil and Biogenic Fuel Greenhouse Gas Emission Factors White Paper.

waste, is preferred. These sources not only support reductions in the State's GHG inventory and global emissions, but also offer potential co-benefits including economic development, improved waste management, and enhanced supply reliability. Landfill Gas shows more limited emissions benefit in this framework, as methane is typically captured and flared at these facilities, reducing the relative avoided emissions by diverting it to energy use, though the energy benefit of diverting the methane still exists. There is potential for greater emissions reductions if the digester is run using clean electricity, methane leak detection and repair is performed on the digester and associated equipment, energy efficiency measures are taken, and the digester and gas production equipment is right-sized for its operations.

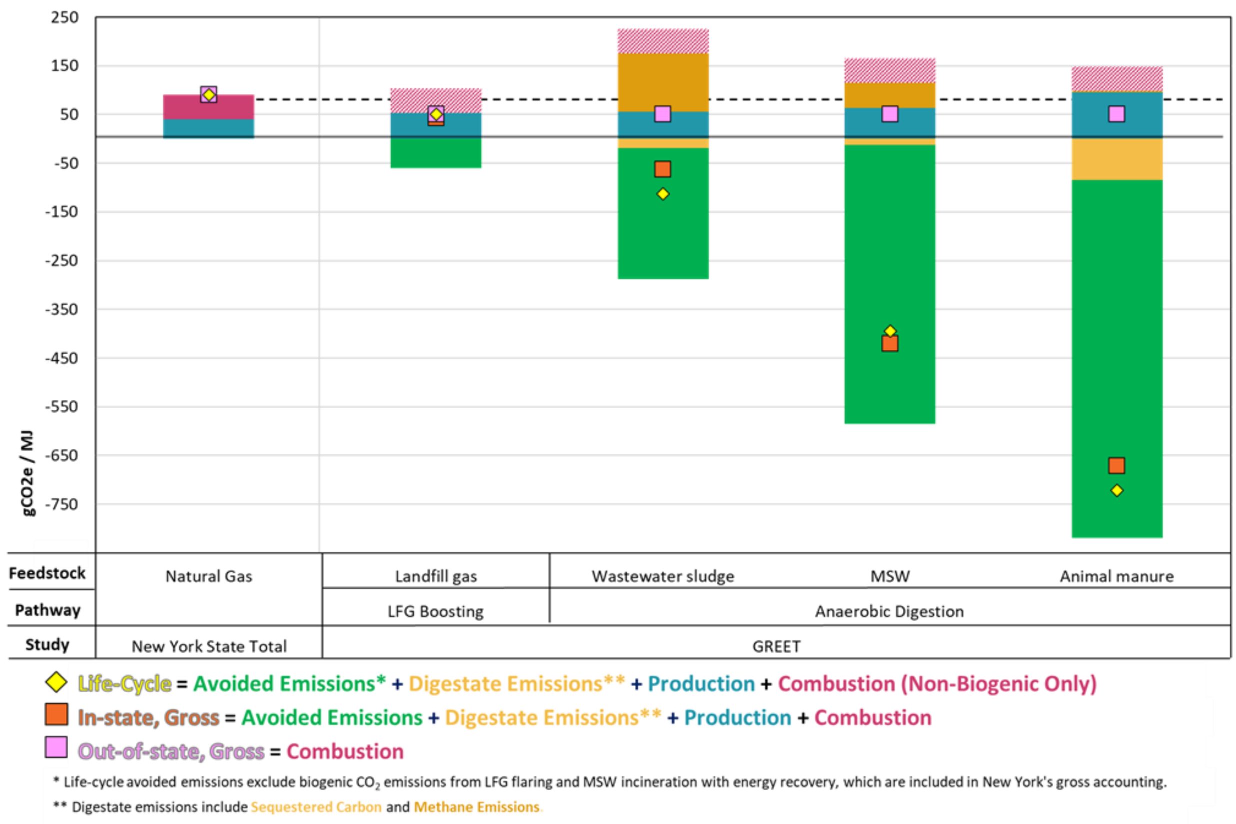

Figure 4: Comparison of Emissions Accounting Frameworks for RNG.

Source: Considerations for Low-Carbon Alternative Fuel Use in New York State.[2]

Biodiesel and Renewable Diesel

As shown in Figure 5 and Figure 6, on an LCA basis, both biodiesel and renewable diesel reduce emissions compared to conventional diesel, especially for waste-based feedstocks. Emissions for renewable diesel are slightly higher than biodiesel due to its more energy-intensive production process.

Both renewable diesel and biodiesel reduce fossil fuel emissions, but biodiesel alone cannot phase out fossil fuels from hard-to-electrify uses because it typically has a 20 percent blend limit. Yet, biodiesel is easier and less costly to produce with less energy input and can make use of smaller, dispersed feedstock sources including in-state waste feedstocks. Blends of 20 percent biodiesel and 80 percent renewable diesel can directly replace fossil fuel. Renewable diesel supplies are currently limited, and therefore biodiesel may be an interim solution for near-term GHG emissions reductions.

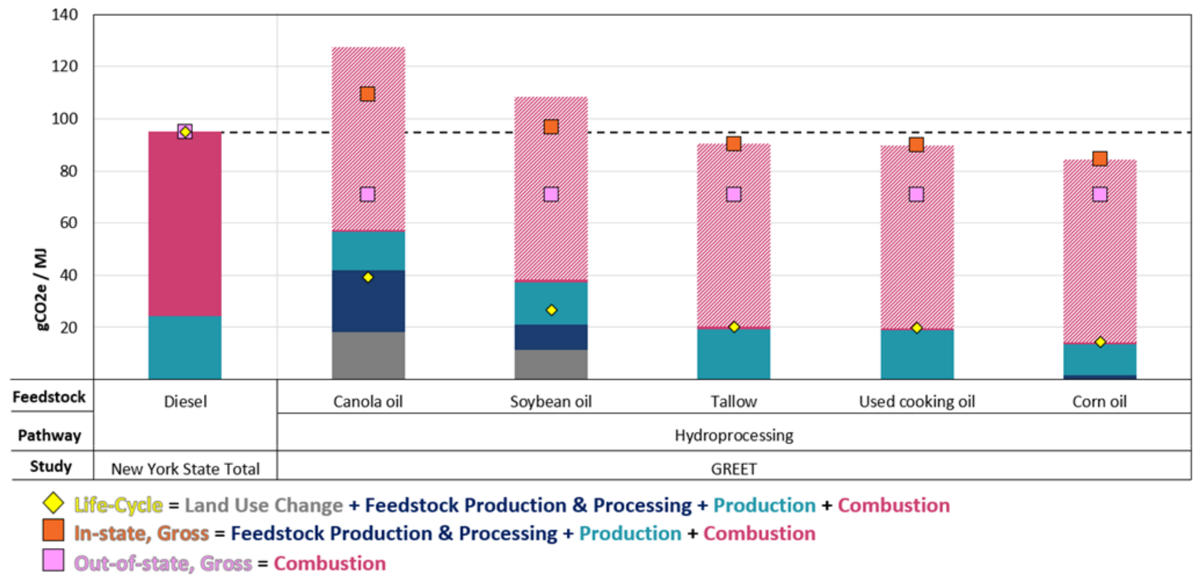

Figure 5: Comparison of Emissions Accounting Frameworks for Renewable Diesel.

Source: Considerations for Low-Carbon Alternative Fuel Use in New York State.[2]

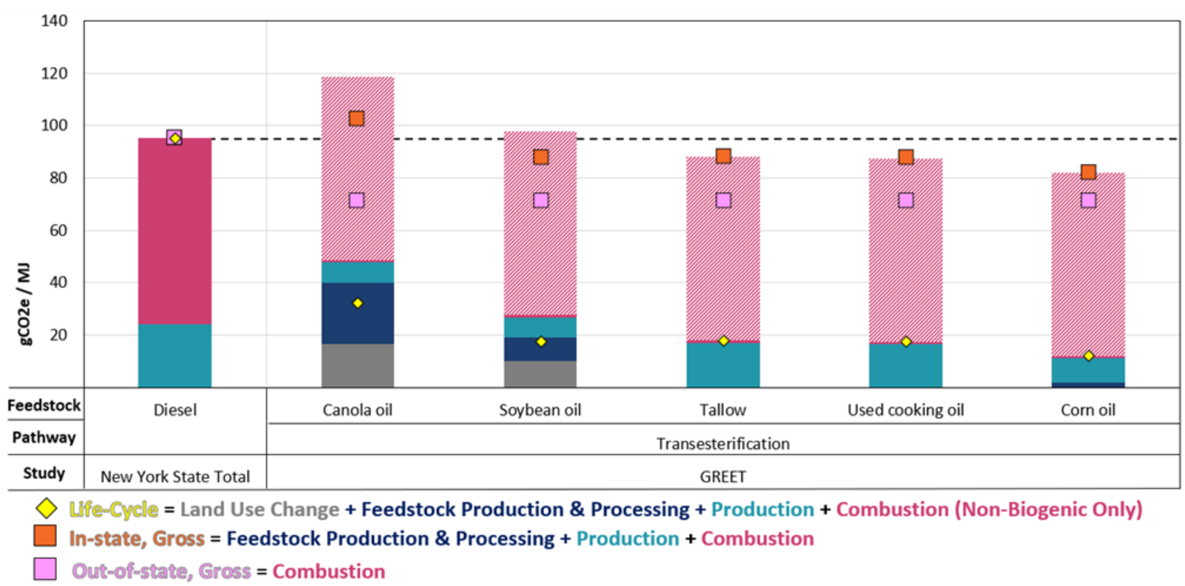

Figure 6: Comparison of Emissions Accounting Frameworks for Biodiesel.

Source: Considerations for Low-Carbon Alternative Fuel Use in New York State.[2]

For the reasons described above, the State prefers in-state fuel feedstock sourcing and waste-based feedstocks, including tallow, used cooking oil, wastewater, and organic municipal solid waste, for biodiesel and renewable diesel production. Feedstocks with low LCA scores, especially those with low land use impacts, are next in preference order. However, the State will continue to consider other sources in light of their contribution to global and local emissions reductions. Biodiesel and renewable diesel produced from purpose-grown energy crops should be minimized, with a strong preference for waste-based fuels.

Energy crop use as an interim fuel until more waste-based fuels are available may be appropriate if needed, though policies and programs should create preferences for transition over time and for prioritization of waste feedstocks and other fuels with low LCA scores. Energy crop use and associated GHG emissions should be carefully monitored and reported within any such policy or program. However, in instances where there are meaningful global climate benefits, their use should not be disqualified entirely, especially because the supply of waste-based fuels may be limited as demand increases regionally to achieve Climate Act targets.

SAF

Production of SAF utilizes the same feedstocks and a very similar process to renewable diesel. The main difference is additional refinement needed to upgrade the fuel to aviation standards, which requires additional energy input and expenses. Consistent with renewable diesel, the State prefers in-state, waste-based feedstocks, including tallow, used cooking oil, agricultural and forest residues for SAF production but will continue to remain open to other sources while considering their contribution to global and local emissions reduction (Figure 7). SAF is an essential component of achieving long-term policy goals as technology options for aviation decarbonization are currently extremely limited. SAF produced with purpose-grown energy crops such as canola or soybean oil should be minimized in New York, with a strong preference for waste-based fuels followed by fuels with low LCA scores, especially those with low or no land use impacts. The use of crop-based SAF may be appropriate in the near-term, particularly while waste-based fuels remain limited, provided these fuels deliver meaningful emissions reduction benefits. Given the increasing regional demand for low-emissions and waste-based feedstocks, crop-based SAF should not be categorically excluded, especially if it enables early market development and emissions reductions.

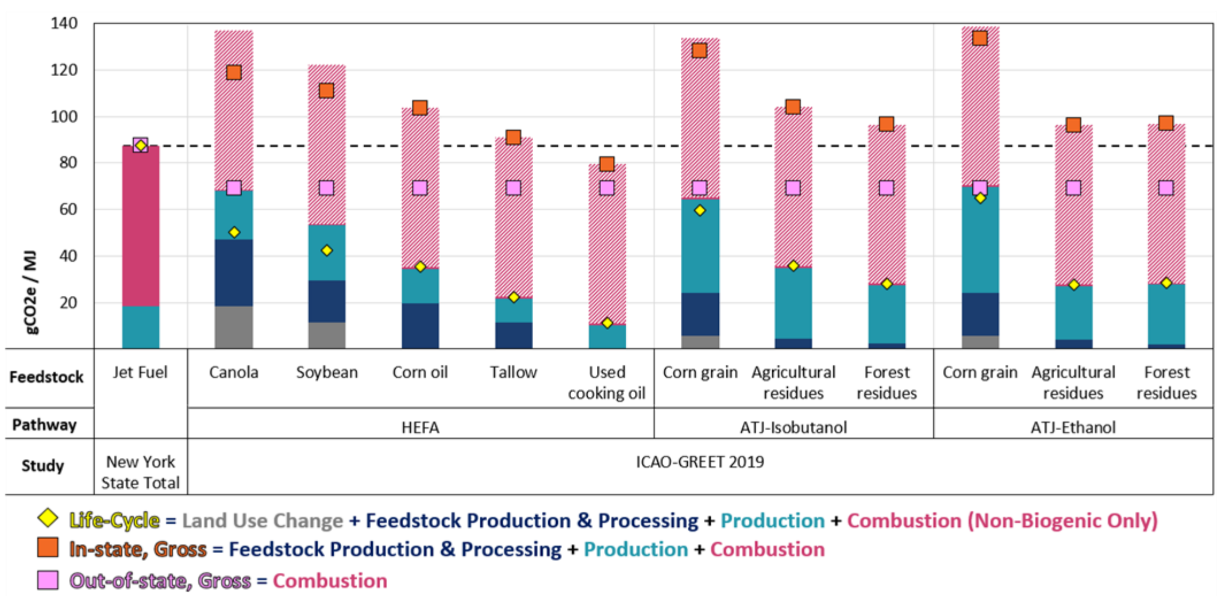

Figure 7: Comparison of Emissions Accounting Frameworks for SAF.

Source: Considerations for Low-Carbon Alternative Fuel Use in New York State.[2]

In contrast to renewable diesel and recognizing the high priority for SAF deployment in New York State to achieve long-term policy goals, the extra hurdles producers and users face for SAF, and the local air quality and health benefits associated with SAF substitution discussed below, State policy should adopt a more expansive approach to SAF sourcing to avoid creating insurmountable barriers to entry or economic preference for easier-to-produce fuels.

SAF is currently the only viable method to significantly reduce GHG emissions from the aviation sector. Though regional feedstock and/or production will be needed, in-state production is also preferred to help maintain the integrity of GHG emissions reductions and benefit economic development within the State, and the use of in-state waste feedstocks remains a priority to ensure the beneficial use of waste while eliminating emissions from waste sources in-state.

Hydrogen

Hydrogen can be produced through a variety of methods with varying emissions implications. At this time, the State prefers hydrogen produced with clean energy. The State will continue to assess hydrogen production technologies as they become available. Under current Climate Act accounting methodology, as with biofuels, when imported hydrogen is used in New York, emissions from out-of-state hydrogen production are not included, though there are methods of hydrogen production that use significant inputs of fossil fuels. When making policy decisions, the upstream and combustion emissions associated with the fossil fuels used in the production of hydrogen should be considered. For example, some hydrogen production processes use steam reformation of natural gas. The process can be paired with carbon capture and sequestration at the hydrogen production location, also known as blue hydrogen, to reduce CO_2 emissions produced from natural gas combustion. Yet, the carbon captured does not mitigate the upstream production and transport emissions of the natural gas feedstock. Including these emissions significantly reduces the global GHG emissions benefits, shown in Figure 8. In their recent white paper, the New York State Department of Public Service (DPS) proposed including out-of-state emissions from the production of “energy carrier” fuels (e.g., hydrogen) in the power sector and to require a facility that consumes “energy carrier” fuels verify and attest that those fuels’ production process not yield GHG emissions to address this issue.[24]

New York State supports the development of in-state hydrogen production infrastructure using current grid electricity because, although the current grid emissions profile would result in emissions from hydrogen production, the GHG emissions are expected to trend towards to zero as we progress towards the Climate Act 2040 zero emissions electricity target and aligns with the long-term development prospects for hydrogen systems. For hydrogen produced out-of-state, NYS should require substantiation that the hydrogen was produced using clean energy.

[24] Case 15-E-0302, *Implementation of a Clean Energy Standard*, Department of Public Service Staff Proposed Definitions of Key Terms in PSL §66-p, (dated November 4, 2024). https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={F09DF892-0000-CE4F-ACD5-E3FCF99B210B}

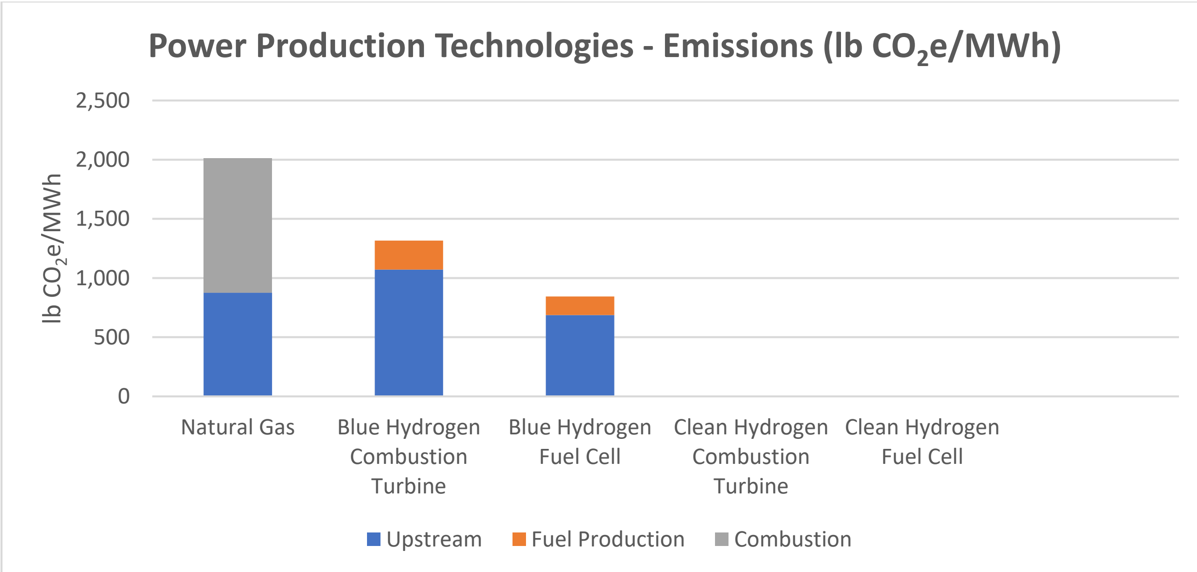

Figure 8: Emissions from Different Hydrogen Production and Combustion Methods Compared to Natural Gas.[25]

Recommendations

- LCA should be used in policy development to compare GHG emissions reductions across feedstocks, fuels, and end-uses and to calculate emissions reductions relative to business-as-usual and alternative fuel production pathways.
- Entities in NYS, such as individual facilities or utilities, should use the Climate Act accounting framework when making emissions claims related to measuring progress towards the Climate Act's targets.
- Both LCA and Climate Act accounting will have roles in the design of programs, policies, and regulations to provide a more holistic picture of the GHG emissions associated with alternative fuels, to inform policy decisions, and to understand how those policy decisions intersect with measuring emissions reduction progress.
- New York should prioritize the use of in-state waste-based feedstocks and fuels whenever possible due to their potential to reduce emissions from the waste sector, support economic development, and improve supply chain security and integrity. The scale of projected demand

[25] Emissions data is based on hydrogen production (50,000 kg/day) from steam methane reforming (SMR) with post-combustion CO_2 capture. The fuel is natural gas, the plant is designed to capture 90 percent of CO_2. Hydrogen combustion in turbine emits NO_x. The NO_x emission after water injection is assumed to be <10ppmv based on common permits on natural gas fuels and the GWP is not considered. Downstream emissions related to blue hydrogen usage are not included. Included emissions are those related to compression, storage and transportation of hydrogen from production facility to power generation facilities. Emissions related to compression, transportation and sequestration/utilization of captured carbon are not included. Grid electricity - Emissions Intensity assumption 251g CO_2eq/kWh (source: Projected Emissions Factors for NYS Grid Electricity).

for alternative fuels will require regional sourcing across a range of feedstocks and technologies. Fuels produced with purpose-grown energy crops should be minimized.

- Anaerobic digestion and RNG production should focus on energy efficiency, leak detection and repair, right-sizing digester and gas production operations, and using clean energy in production processes in order to further reduce GHG emissions.
- Both renewable diesel and biodiesel contribute to fossil fuel displacement. Biodiesel offers a near-term decarbonization strategy, including the potential for blending with renewable diesel as supplies of renewable diesel expand to offer long-term decarbonization.
- SAF is essential to achieving long-term decarbonization goals, particularly as aviation is a sector with limited near-term alternatives. Given the barriers SAF producers and users face and the GHG reduction and local air pollution benefits (discussed below), State policy should take a more flexible and expansive approach to SAF sourcing compared to other fuels. While fuel derived from waste and with low LCA score feedstocks are preferred, the use of crop-based SAF may be appropriate in the near-term, until other feedstocks scale.
- Based on currently available technologies, New York State is focused on using hydrogen produced with clean energy, both in- and out-of-state, to avoid using hydrogen that may have been produced with fossil fuels and therefore has unintended emission consequences.

4.4. Co-Pollutant Emissions and Air Quality Impacts of Alternative Fuels

Many air pollutants are byproducts of the combustion of carbonaceous fuels, including fossil fuels and most alternative fuels. These include fine particulate matter ($PM_{2.5}$), nitrogen oxides (NO_x), volatile organic compounds (VOC), sulfur dioxide (SO_2), and various toxic compounds. $PM_{2.5}$ is a primary pollutant of public health concern, as is NO_2 (nitrogen dioxide, one component of NO_x), and ozone (produced in the atmosphere from VOCs and NO_x in the presence of sunlight). These pollutants contribute to a range of health issues, including respiratory conditions, asthma, heart attacks, and other serious illness, leading to premature mortality, increased hospitalizations, emergency room visits, and widespread health burdens.

While fossil fuels and most alternative fuels emit similar air pollutants when combusted, there are important differences to consider when evaluating alternative fuels as replacements. The use of low-carbon alternative fuels and technologies can either improve or worsen air quality relative to their fossil counterparts, depending on the specific fuel type, application, and emissions controls in place. In general, replacing fossil fuels with zero-emission solutions, such as electrification or hydrogen fuel cells, will always result in the greatest health benefits, but those solutions may not always be feasible, especially in the near-term. In such cases, switching to alternative fuels may still offer public health benefits associated with fuel swapping, depending on the fuel, end use, emissions controls, and other considerations discussed here. The discussion below focuses on the direct emissions of air pollutants associated with the combustion of alternative fuels, which would most directly affect public health, and does not include the additional emissions associated with producing and delivering both fossil and alternative fuels. Additional details are available in the memorandum Co-Pollutant Impacts of Low-Carbon Fuels and Technologies—2025 Update (2025).[3]

Renewable Natural Gas (RNG)

RNG is chemically similar to natural gas. As such, its combustion emissions are generally expected to be comparable to those from natural gas combustion.

Biogas

Biogas combustion emissions may differ from those of natural gas depending on the feedstock and end use. Biogas feedstocks may include trace gases and impurities such as VOCs, siloxanes, and hydrogen sulfide (H_2S); if H_2S is not removed before combustion, SO_2 emissions would be produced. Combusting biogas for on-site electricity rather than natural gas will produce similar NO_x emissions and may increase SO_2 emissions if trace sulfur gases are not removed.

Note that biogas is often combusted on-site as an alternative to flaring which is done to avoid worse emissions and is not necessarily replacing natural gas combustion on-site. Compared to flaring, biogas combustion in boilers or steam turbines for electricity generation would decrease $PM_{2.5}$ and NO_x emissions while combustion in gas turbines or internal combustion engines would increase $PM_{2.5}$ and NO_x emissions relative to flaring biogas. However, beyond the local impact, there would be an additional benefit of reducing emissions from electricity generation elsewhere that is replaced by the biogas electricity production on-site.

Biodiesel

Biodiesel combustion in on-road engines, which are equipped with diesel particle filters and NO_x controls, is expected to have similar $PM_{2.5}$ and SO_2 emissions as those from conventional diesel, which is currently all ultra-low sulfur diesel (ULSD) in New York. NO_x emissions from biodiesel combustion in engines equipped with NO_x controls (virtually all on-road engines and newer non-road engines) will be low to begin with, and variations will be affected by the feedstock, engine load, and vehicle speed; thus, NO_x emissions are expected to be similar to ULSD.

Older engines, often still used in various non-road applications, would not be equipped with diesel particle filters unless they are retrofitted. In these older engines, using biodiesel can reduce $PM_{2.5}$ emissions by up to 25 percent with 20 percent biodiesel blends and reduce $PM_{2.5}$ emissions up to 58 percent with 100 percent biodiesel. Note that the biodiesel blend is usually limited to 20 percent unless both engine and fuel storage systems are specially designed and managed.

There is limited literature comparing emissions from biodiesel used in boilers to those from ULSD, which currently serves as the standard heating oil in New York State and contains at least 5 percent biodiesel content, with mandated increases over time.

Renewable Diesel

While renewable diesel has very low sulfur content and emits less $PM_{2.5}$ than conventional diesel when combusted, all on-road diesel engines today use ULSD and are equipped with substantial $PM_{2.5}$ and NO_x

controls. Therefore, emissions of SO_2, NO_x, and $PM_{2.5}$ from renewable diesel in on-road engines are similar to conventional diesel.

However, $PM_{2.5}$ emissions from renewable diesel could be up to 38 percent lower than ULSD in older engines not equipped with diesel particle filters, which is still common in many non-road applications. As such, there are likely near-term benefits from substituting renewable diesel for fossil fuels in limited subsectors such as rail, agricultural engines, and some construction engines,[26] though these benefits may decline as equipment in these sectors are replaced. For example, pure renewable diesel has been shown to reduce $PM_{2.5}$ emissions by 22 percent and NO_x emissions by 13 percent compared to ULSD in agricultural tractors and reduce $PM_{2.5}$ emissions by up to 36 percent and NO_x emissions by up to 17 percent in locomotives. While there may be some reductions in toxic emissions (e.g., benzene) from renewable diesel, it is not expected to result in substantial health benefits as diesel is not a large source of air toxics in New York.

SAF

Emissions from the combustion of aviation fuel during idling and landing and takeoff cycle (LTO) are the most relevant for air quality and public health impacts as they commonly occur at locations and elevations that impact local air quality. Differences in pollutant emissions from SAF compared to conventional jet fuel depend on the production method, engine technology, and operation mode. A 50 percent SAF blend (the maximum blend currently allowed) can reduce $PM_{2.5}$ by 63 to 73 percent during idling and 39 to 80 percent during LTO compared to conventional jet fuel. $PM_{2.5}$ emission reductions are expected to scale roughly linearly by blending percentage for blends below 50 percent SAF. Unlike conventional jet fuel, SAF generally has ultra-lower sulfur content and SO_2 emission reductions from SAF will directly correlate with the reduction in sulfur content. A 50 percent SAF blend is expected to reduce SO_2 emission by 36 to 50 percent compared to conventional jet fuel. NO_x emissions primarily depend on turbine inlet temperature rather than fuel composition, so no changes in NO_x emissions are expected from SAF use. On balance, increased deployment of SAF is likely to produce beneficial outcomes for communities located near airports.

Hydrogen

Combustion of pure hydrogen fuel does not produce most co-pollutants. NO_x production varies with combustion temperature, and as hydrogen combustion generally occurs at a higher temperature than natural gas, its use in systems designed for natural gas without modification have the potential to emit higher levels of NO_x per unit of energy. Overall, the reduction in co-pollutant emissions when replacing natural gas with hydrogen — including the elimination of $PM_{2.5}$ emissions — can be beneficial, as long as NO_x emissions are controlled. NO_x control technologies, such as selective catalytic reduction, are available, and operational controls can be varied to adjust the air to fuel ratio and reduce NO_x emissions. Importantly, systems designed explicitly for hydrogen combustion can benefit from efficiencies that avoid producing high NO_x levels.

[26] In New York City substantial effort has been undertaken to require Tier 4 engines for construction where local communities are impacted. However, this is less pronounced throughout the state and some engines, especially in less common but very large equipment, are often kept in service for decades.

Electricity generation systems designed for hydrogen combustion can substantially reduce the potential for NO_x emissions, and traditional control technologies such as selective catalytic reduction, can be applied to further reduce NO_x emissions if needed. This indicates the need to carefully design new or repurposed systems to ensure hydrogen use doesn't result in notable increases in $NO_{x,}$ but these emissions should be considered manageable. In addition, DEC Regulation 6 NYCRR Subparts 227-2 and 227-3 (place limits on NO_x emissions, and the robust permitting process provides increased assurance that hydrogen combustion for electricity generation would not be inconsistent with protecting public health in adjacent communities.

Pure hydrogen combustion in industrial boilers and turbines can emit high levels of uncontrolled NO_x compared to natural gas. As with electricity generation, the use of hydrogen in industrial systems should be reviewed to ensure NO_x emissions don't increase appreciably, if at all. Systems should be purpose-designed for hydrogen combustion where practicable to avoid excess NO_x emissions, and available NO_x control technologies and operational controls should be utilized as needed. Such sources would also be subject to permitting requirements. As is the case for any source combusting hydrogen, the elimination of $PM_{2.5}$ emissions would always represent a public health benefit.

Low levels of hydrogen blended into existing natural gas infrastructure and combusted in industrial, commercial, or residential systems not designed or retrofitted for the blended fuel would have uncertain impacts on NO_x emissions depending on the appliance, configuration, and blend level. While the hydrogen portion of the blend is not expected to emit $PM_{2.5}$ or other co-pollutants and may offer overall health benefits, any potential increase in NO_x emissions, particularly in indoor environments such as in residential kitchen stoves and ovens, would raise health concerns that may be more difficult to mitigate in residential settings. Careful consideration of any potential net increase in local co-pollutant emissions from blended hydrogen is needed and should be avoided wherever possible.

Recommendations

- Replacing fuel combustion with zero-emission alternatives, such as electrification or hydrogen fuel cells, will always yield the highest co-pollutant reductions. Therefore, these should always be prioritized where practicable.
- In on-road applications, biodiesel and renewable diesel are expected to produce co-pollutant emissions similar to their fossil counterparts. However, some emissions benefits would be expected in non-road applications where older engines without emission controls are used. Implementation of biodiesel and renewable diesel should focus, where practicable, on non-road subsectors that often use old engines such as rail yards, intermodal facilities, ports, and construction — especially in close proximity to residential and other sensitive uses.
- SAF is expected to provide co-pollutant reduction. Applying SAF, especially for use in urban airports, is recommended to benefit local air quality.
- Hydrogen combustion may increase NO_x but eliminates $PM_{2.5}$ and other pollutant emissions relative to natural gas combustion. For power and industrial applications of hydrogen

combustion, system design and operating procedures should be required to ensure low NO_x emissions.

- General use of blended hydrogen through pipeline injection would result in uncertain co-pollutant emissions consequences.
- Collection and use of biogas either as a fuel consumed locally as a beneficial energy source, or as a feedstock for production of other alternative fuels, can reduce local emissions associated with flaring. Therefore, efforts should be made to ensure collection or beneficial use of biogas produced at all New York landfill sites, and to ensure collection or beneficial use of biogas associated with New York's exported waste through contract requirements.

4.5. Other Environmental Impacts

4.5.1. RNG

Anerobic digestion, which is the process that creates the biogas which is then refined to RNG, can be a valuable tool for waste management. A byproduct of anerobic digestion is digestate, a stable nutrient source which can be used as a fertilizer for growing crops in place of synthetic fertilizers. Its use can improve water quality, reduce odors, reduce the spread of invasive plants, and increase carbon uptake in soils.[2] Digestate has lower, and in most cases no, animal and plant pathogens compared to raw manure, reducing the risk of water contamination after application.[27]

4.5.2. Biodiesel, Renewable Diesel, and SAF

As previously discussed, use of energy-crop-based fuels requires careful oversight. Concerns include uncertainties associated with the emissions impacts from land use change, loss of biodiversity, and water quality impacts.

Biodiesel production generates alkaline wastewater containing methanol residues, glycerin, and soap byproducts, requiring treatment before discharge. Wastewater from renewable diesel or SAF production using hydroprocessing includes traces of sulfides, ammonia, and other byproducts that must also be treated and properly managed. However, the amount of water used in production is small.

Alcohol-to-jet pathways for SAF production is water-intensive and can require more water than conventional diesel production. The U.S. Environmental Protection Agency (EPA) estimates one gallon of corn ethanol, the base product, requires an average of 76 gallons of water compared to only 5.7 gallons for a gallon of conventional diesel.[2]

4.5.3. Hydrogen

Hydrogen production requires significant water consumption, though less than typical a gas power plant requires. A 1-gigawatt (GW) coal-fired or combined-cycle gas power plant typically uses between 18.2

---

[27] European Biogas Association, "Digestate Factsheet: the value of organic fertilisers for Europe's economy, society and environment Anaerobic Digestion," accessed July 3, 2025, https://europeanbiogas.eu/wp-content/uploads/2015/07/Digestate-paper-final-08072015.pdf.

and 14.8 million cubic meters of water per year, while a clean hydrogen facility producing the same amount of energy would use 7.6 million cubic meters.[2]

Recommendations

- In addition to GHG and co-pollutant emissions, the broader environmental impacts of alternative fuels, including effects on water use, water quality, land use, biodiversity, and waste management, should be considered in New York State's energy planning, policy development, and project evaluation. These impacts vary significantly by fuel type and production pathway and should be evaluated alongside climate and health outcomes to support sustainable decision-making.

4.6. Market and Policy Mechanisms

New York State will need to advance market and policy mechanisms to encourage development of feedstock and alternative fuel supply and demand and direct available fuels to high-priority end-uses, consistent with the discussion in Section 4.1.

Currently, alternative fuels remain more expensive and less widely available than fossil fuels and their treatment under the Climate Act, as discussed above, decreases the relative value of any dollar invested in alternative fuels to reduce emissions as compared to in other sectors. To accelerate deployment, targeted market-based mechanisms can help expand production and direct supply to the sectors and locations where these fuels will have the greatest long-term climate and system benefits. Federal production and investment incentives could reduce costs, thereby increasing production and use, though alternative fuel policy at the federal level is currently uncertain. Coordinating with neighboring states and provinces to develop broader regional markets can facilitate efficiency of scale and flexibility, price formation, and transparency while increasing fuels and feedstocks import and export efficiency. Where possible, collaborating with regional, federal, and industry partners to develop consistent technical and emission accounting systems and standards for alternative fuels, infrastructure, and end-use equipment can foster market uptake. See the Local, Regional, and Federal Government Collaboration Chapter of this Plan for more information.

4.6.1. Attribute Tracking to Ensure Emissions Reductions

To ensure GHG emissions reductions from the use of alternative fuels, their associated emissions must be accurately tracked from production, both in- and out-of-state, through to end use within New York. Environmental attributes are tracked under four frameworks: (1) identity preservation models, (2) segregation chain of custody models, (3) mass balance, and (4) book and claim.[2] These tracking frameworks offer varying levels of credibility in asserting the use of alternative fuels and associated GHG emissions reductions, as well as differing levels of operational complexity. For example, *identity preservation* tracks the fuel product in detail from production to end use and does now allow mixing of the product with any other fuels. While the method has high credibility for making fuel use claims, it is administratively burdensome and would require substantial infrastructure buildout, making it infeasible for some fuels. *Book and claim*, on the other hand, separates the environmental attribute from the fuel product and allows trade of attributes on a secondary market, independent of the underlying fuel sale.

This method is easier to facilitate and manage but has the potential for double-counting GHG emissions reductions and lower integrity for use claims.

As the alternative fuel market grows, the State should consider implementing an environmental attribute tracking framework, balancing the verifiability and administrative burden. Without such a framework, the following outcomes could result: reduced deployment, leading to increased emissions and missed economic and environmental benefit; or enabling unverified claims of fuel use without actual deployment, resulting in similar consequences of higher emissions and lost opportunities. An adopted framework could establish clear guidelines for participants to ensure market clarity, while documentation and certification processes should be robust to ensure emissions reduction claims are valid. A designated State authority or an independent third party should have the ability to systematically audit emission reduction claims and address noncompliance.

To facilitate deployment of alternative fuels at the scale described in the Pathways Analysis at the capacity necessary to achieve State policy targets, existing transmission and distribution infrastructure currently used for fossil fuels will need to be leveraged during the transition. Purpose-built infrastructure like pipelines and storage may be used in isolated situations but are not adequate or practical to meet all needs and would entail substantial cost and environmental impact. As such, New York should not adopt a chain-of-custody framework that requires physical segregation of fuels to substantiate a use claim; New York should continue to pursue high integrity standards for use claims.

A critical consideration for New York State is the deliverability of alternative fuels for use in-state and to ensure that emissions reductions are both real and claimable in support of the Climate Act targets. This challenge is not new: New York has previously addressed similar issues in the Clean Energy Standard by implementing rigorous verification requirements, which established the New York Generation Attribute Tracking System, where a renewable energy credit (REC) generated by a clean electricity project is closely tracked and bundled with the megawatt-hour (MWh) of renewable generation. To support a claim under the Clean Energy Standard, a REC is accepted only if the associated generation is delivered within the New York Control Area boundaries. This approach is similar to the mass balance framework, where energy is tracked “from source to sink,” with clear delivery requirements.

If New York develops a supportive legal and/or regulatory framework for alternative fuels, it is critical to consider adopting similar requirements where both the fuel attribute and the fuel itself travel together from source to a sink in New York, with a clear physical and contractual path linking the two. The specific infrastructure used, however, does need not be dedicated exclusively to alternative fuels. Provided that deliverability can be clearly established via this kind of clear physical and contractual path, the use of common carrier pipelines, storage facilities, and other infrastructure is acceptable. Similar to the New York Generation Attribute Tracking, the deliverability for alternative fuels ensures that New York is supporting genuine GHG emissions reductions and therefore aiding global climate change mitigation.

The Climate Act accounting and the Statewide GHG Emissions Report are not market-based programs and do not solely direct policy choices. The Statewide GHG Emissions Report was developed to inventory GHG emissions, as required by the Climate Act, which is distinct from any market or financial claims, such as attributes. While New York cannot control the actions of other jurisdictions, the State should engage in best efforts to ensure the validity of claims made by New York State market-based programs. While fuels may be claimed across multiple programs (and often intentionally are in order to create stacked values, for example state-based Clean Fuels Standards and the federal Renewable Fuel Standard), care should be taken to prevent unintended dual claims. For example, a fuel used to substantiate an emission reduction claim in another jurisdiction's program, should not also be claimed in New York's program; likewise, two entities should not be able to claim emission reduction from the same fuel. Further refinement to provisions around double counting will continue to be determined through relevant regulatory proceedings and programs development efforts.

New York State can consider integrating the preferences described in this chapter into its tracking and accounting framework.[28] In alignment with the State's climate policy goals, GHG emissions should serve as the primary metric for fuel selection. While policy decisions can shape preference for specific feedstock and fuels, the use of LCA pathways allows for a more comprehensive evaluation, capturing not only emissions but also land use change risks, avoided emissions, and the distinct characteristics of fuels based on technology, geographic origin, and feedstock type. To safeguard against adverse impacts, the State should establish clear guardrails to avoid land use changes, such as tracking crop- and forestry-based feedstocks to their point of origin or prohibiting certain feedstocks such as palm oil are important to avoid loss of food production or deforestation. The State can also adopt a framework to prioritize development and use of specific fuels or pathways that yield the greatest GHG emissions reductions, such as a cap on the amount of a certain feedstock or fuel a producer can claim, or requirements for feedstocks and fuels or other preferences. While it is not likely the State can mandate in-state sourcing, complementary policies can foster local sourcing.

Recommendations

- To catalyze the collection of feedstocks and production of new fuels, new policies—such as mandates, market-based mechanisms, and incentives—will likely be needed and should be weighed with respect to their customer costs and relative benefit under Climate Act accounting. As these policies generate demand across the region, supply chains and regional markets for the production and delivery of these fuels will emerge. While it is not likely New York can reasonably rely upon in-state sourcing, the State should consider developing complementary policies, such as production incentives and emissions-based preferences, to prioritize local sourcing.

- To ensure that alternative fuel use results in real, verifiable GHG reductions, it is important to accurately and robustly track and account for fuels and their associated emissions from production through combustion. New York State should look to strike a balance between integrity and credibility of emissions reduction claims and the administrative burden to ensure

[28] As part of the State's ongoing efforts to gather information regarding sources of air pollutant emissions and to support the reduction of GHG emissions to meet the statutory mandates of the Climate Act, NYSDEC is establishing a mandatory GHG reporting program that would require certain GHG emission sources, including the use of certain alternative fuels, to report emissions. The reporting program would be implemented through Part 253, Mandatory Greenhouse Gas Reporting, which has been proposed as a draft regulation. See also: NYSDEC, Air Pollution Regulatory Revisions, Recently Proposed and Adopted Regulations and Policies," accessed July 3, 2025, https://dec.ny.gov/regulatory/regulations/proposed-emergency-recently-adopted-regulations/air-pollution-regulatory-revisions.

emissions reductions and alternative fuel deployment. When considering an attribute tracking system New York State should be guided by the following principles:

- The State prefers a mass balance approach to attribute tracking, which supports regional sourcing and local benefits, while allowing alternative fuels to leverage existing infrastructure. There should be a clear, verifiable physical and contractual connection between the production source and location of use within New York State.
- The State should prevent double counting of emissions reductions. If a fuel is used to substantiate an emission reduction claim in another jurisdiction's program, it should not also be claimed in New York's program. Double counting should be addressed in relevant proceedings and program rules.
- If developed, New York's attribute tracking process should allow for integration of additional safeguards and priorities. These could include rewarding low-impact or waste-based feedstocks or recognizing innovative production technologies. These provisions can help align fuel sourcing with broader environmental and economic development goals.

4.7. Production and Delivery Infrastructure

While electrification remains the State's primary decarbonization solution, alternative fuels will play a necessary and complementary role within the broader energy system to meaningfully contribute to the energy transition and help achieve Climate Act targets, as identified in the Pathways Analysis. Sufficient production, delivery, and storage infrastructure will be needed to produce and move alternative fuels to areas of demand. Where feasible, existing production and delivery infrastructure should be leveraged to minimize costs and other impacts associated with new infrastructure development, provided that technological, economic, and safety considerations are met. Limited alternative fuel-specific transportation infrastructure may be needed to connect supply and demand for alternative fuels, where the use of existing infrastructure is not feasible. New York State should continue to review alternative fuels production and delivery technologies and best practices for necessary infrastructure development, and any infrastructure development should be done with the future energy system in mind. As discussed in Section 4.6, the alternative fuels market will expand regionally and therefore infrastructure needs should be coordinated across neighboring states and provinces to increase efficiency and reduce costs.

Recommendations

- To meet New York State's climate and energy goals, alternative fuels must be produced, transported, stored, and utilized within the broader energy system.
- Infrastructure development and retrofits should be aligned with the needs of the future energy system to maximize the potential of low-carbon alternative fuels, minimize costs, and reduce the risk of stranded assets.

- Where feasible, preference should be given to alternative fuels that can leverage existing fossil fuel infrastructure with little or no modifications, thereby accelerating deployment and reducing costs and environmental disruption.
- The blending of hydrogen into existing natural gas pipeline infrastructure remains untenable due to safety, integrity, and indoor air quality concerns.

4.8. Technology Research, Development, and Deployment

Over the next fifteen years, continued research, development, and deployment efforts will enhance production processes, increase efficiencies, reduce costs, expand fuel and application flexibility, and improve infrastructure. NYSERDA's Innovation and Research program plays a central role in accelerating the development and demonstration of high-impact energy technologies, including alternative fuels. NYSERDA also implements rigorous research and assessment of current and future technologies. See the Energy Innovation Chapter of this Plan for more information.

Recommendations

- NYSERDA should continue supporting alternative fuel research, development, and deployment in New York.