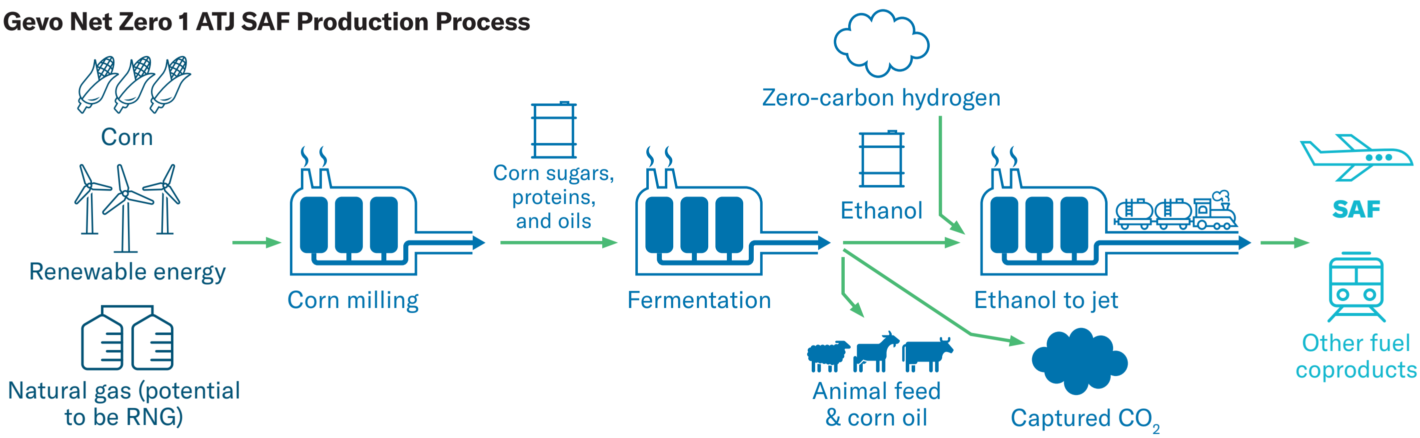
Benefits of Gevo's Alcohol-to-Jet Sustainable Aviation Fuel

Sustainable aviation fuel (SAF) presents the most promising pathway to decarbonize aviation, a key component of the American and broader global economy. Not currently captured in the levelized production cost of SAF are external benefits and economic benefits at the local and state level. The results presented here summarize a cost-benefit analysis prepared by Charles River Associates (CRA) of Gevo Inc.'s (Gevo) planned Net Zero 1 (NZ1) Alcohol-to-Jet (ATJ) SAF facility. The NZ1 facility will produce 65 million gallons per year of liquid hydrocarbons as well as animal feed and corn oil.

Key findings

- Annually, the value of total benefits is estimated to be more than **four to six times** the net cost of current federal incentives.
- Not all benefits could be quantified. Additional benefits from SAF which were considered qualitatively in this analysis include benefits to energy security and to the future competitiveness of the agriculture, ethanol, and aviation industries under a rapid decarbonization scenario.

Gevo Net Zero 1 ATJ SAF Production Process



The ATJ SAF process uses any fermentable sugar sourced from corn or other cellulosic feedstock. The corn feedstock also yields high-protein animal feed and corn oil. The CO_2 released during the fermentation process is captured and sequestered off-site. The ethanol is then converted to ATJ SAF, a process that requires an input of hydrogen to complete the reaction. Electricity will be supplied from a renewable resource and the process will also use natural gas or renewable natural gas.

What is Sustainable Aviation Fuel?

- Sustainable Aviation Fuels (SAFs) are renewable jet fuels derived from renewable feedstocks such as agriculture crops, vegetable and other oils and fats, and forestry and municipal wastes. SAF can be used in existing infrastructure and aircraft today as a drop-in substitute for fossil jet fuel that has significantly lower lifecycle GHG emissions.
- In the United States, eight distinct SAF production pathways have been approved for aircraft use allowing a blend of up to 50% SAF with fossil jet fuel.

Why is it needed?

- Aviation is currently responsible for about 2.7% of domestic greenhouse gas (GHG) emissions.
- Other decarbonization technologies such as battery electric and hydrogen powered airplanes have lower technology readiness levels and are not expected to be deployable for larger aircraft for several decades. SAF is a drop-in replacement for fossil jet fuel and is available now.

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External benefits are positive impacts to third parties that are not directly producing or consuming a product, so the value of external benefits is not captured in the product price. For example, the levelized cost of ATJ SAF does not account for SAF's external benefits. The values of the external benefits were measured in monetary terms using metrics derived from current research to capture resulting impacts. This analysis compares total benefits of SAF with the net incentive costs delivered through current federal programs.

External benefits

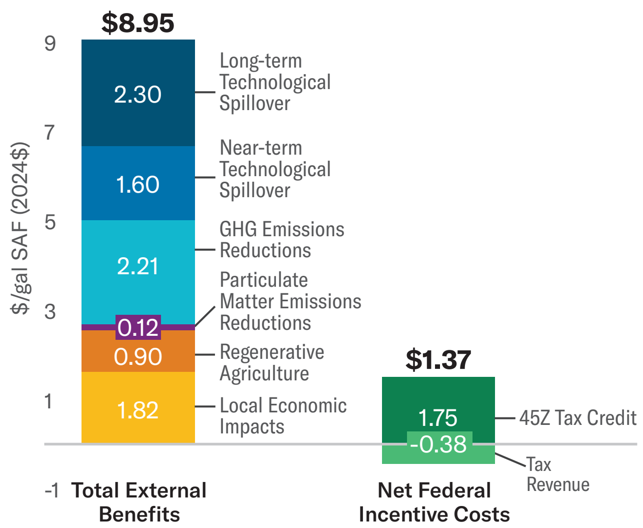
- Avoided climate impacts from **reduced lifecycle GHG emissions** resulting from substituting fossil jet fuel with ATJ SAF. ($2.21/gal)
  - Inclusive of GHG emission impacts due to indirect land use change.
- Avoided health impacts from **reduced particulate matter emissions** during aircraft flight resulting from substituting fossil jet fuel with ATJ SAF. ($0.12/gal)
- Improved air/water quality, reduced GHG emissions and increased farming income from **implementing regenerative agricultural practices** to grow crop feedstocks in place of conventional farming practices. ($0.90/gal)
- The initial investment in the nascent industry will contribute to experiential learning and the resulting **technological spillover** to other firms will yield production cost reductions in the next generation of ATJ SAF plants (near-term spillover $1.60/gal, long-term $2.30/gal)
- **Improved energy security** by reducing reliance on oil imports and distributing jet fuel production more broadly across the country (Only assessed qualitatively).
- The **aviation industry** benefits from investments in foundational low-carbon technologies such as ATJ SAF. In the absence of scaling effective decarbonization pathways such as SAF, the aviation industry and the broader economy would be negatively impacted under a more rapid decarbonization scenario such as net zero by 2050.

The NZ1 facility investment and operations in a rural region of South Dakota will provide economic benefits to the local and state economy. The relative economic impact will be particularly pronounced for this region as the majority of inputs are sourced locally and this region typically receives lower levels of economic investment and development. The economic impact measured includes direct, indirect and induced effects.

Local economic benefits

- Provides **$116 million** of value added annually to the local economy from direct, indirect, and induced impacts of NZ1's operations.
- Supports **100 jobs** at the NZ1 plant and creating an additional **736 local jobs**.
- **Generates $1.82/gal in value (less taxes).**
- Contributes incremental economic value that is returned to the federal government in the form of tax revenue. Estimated at **$23 million annually** or **$0.38/gal SAF annually**.
- Adds temporary benefit of $184 million in local economic value and supports 1,266 jobs during the construction phase.

Total annual benefits and net federal incentive costs



**Note: Net federal incentive costs do not include the value of RFS RINs, which are not a U.S. federal government cost for SAF. Programmatic costs are also excluded.

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Policy implications

- To fully scale up the ATJ SAF industry and produce the volumes needed to meet the goals set by the U.S. SAF Grand Challenge will require longer-term incentives for SAF producers or purchasers.
- The federal government developed the U.S. SAF Grand Challenge to strategically increase production of SAF and lower the lifecycle GHG emission intensity of jet fuel.
  - Set goals to produce 3 billion gallons of SAF annually by 2030 and 35 billion gallons by 2050.
  - Reduce the lifecycle GHG emissions of jet fuel by at least 50% as compared to fossil jet fuel.
- Even though ATJ SAF cash production cost is on par with the commodity price of fossil jet fuel, the levelized cost of ATJ SAF includes return of and on capital and is currently higher. The price of fossil jet fuel also benefits from legacy capital investment and long-term subsidies. Leveraging the current federal incentives narrows but does not eliminate this difference.
- Leveraging both the 45Z tax credit and RFS RINS credit values, the price differential between the price of fossil jet fuel and the levelized cost of ATJ SAF is estimated at $1.24/gal. However, the 45Z tax credit will expire after 2027 under current law. Leveraging only the RFS RIN results in the ATJ SAF being $2.99/gal greater than the fossil jet price.

  State incentive programs could also contribute to reducing this difference. However, none of the current state programs result in a total incentive value that exceeds $2.99/gallon, leaving a gap in the near-term with the pending expiration of the federal 45Z credit.
  - State incentives are specific to the states in which the SAF is delivered or produced. The values of current state incentives are estimated below.

    Tax Credits:
    - IL: $1.50/gal for purchasers
    - MN: $1.50/gal for producers
    - WA: $2/gal for producers

    Low carbon fuel credits:
    - CA: $0.86/gal for producers
    - OR: $1.45/gal for producers
    - WA: $0.84/gal for producers
- The next generation of ATJ SAF will benefit from the cumulative experiential learnings of the first generation of production facilities. These future production facilities could realize production costs that are 53% lower by 2030. However, this decrease in production costs will only be realized if the private sector and government work together to rapidly scale production to meet the U.S. SAF Grand Challenge goals.
- Federal tax incentives don't need to be permanent. However, near-term investment to build a SAF production facility will be based on current technology, current production costs and currently available incentives. Extension of the 45Z tax credit will support these needed investments.

Methodology

- This fact sheet summarizes the results of a Cost-Benefit analysis performed by Charles River Associates based on Gevo's planned NZ1 ATJ SAF production facility.
- The values derived in this report are estimates derived from currently available data and should be interpreted as approximations. Reference sources include both publicly available data and research papers as well as information provided by Gevo.
- Additional information on the methodology can be found in the full-length report.

About CRA's Energy Practice

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Glossary

Animal feed: A coproduct of the NZ1 facility. The animal feed produced has lower sugar content and carbon intensity than conventionally produced animal feed, thus reducing the overall carbon intensity of the animal farming supply chain.

Avoided emissions: Emissions that would otherwise be produced based on a reference scenario.

Carbon Capture and Storage (CCS): To sequester carbon dioxide from a process or emission point and confine to long-term storage.

Corn oil: A coproduct of the NZ1 facility. This corn oil has a lower carbon intensity than conventionally produced corn oil. End uses include feedstock for low-carbon biodiesels or as a supplement in animal feed.

Corn milling: The first step of the NZ1 process entails grinding the corn kernels and liquefying the corn flour into a slurry. This slurry mix is then fed into the fermentation process.

Direct economic impact: Economic impact resulting from the inputs purchased by the plant directly.

Economic benefits: Value-added to the economy through increased revenue, increased earnings, and generation of new jobs.

Energy independence: Decreasing reliance on foreign energy sources.

Energy security: Ensuring available energy at an affordable price.

Fermentation: Process that converts sugars to ethanol and CO_2. In the NZ1 process the CO_2 produced is captured. The outputs of the process are ethanol, animal feed, and corn oil.

Foundational technologies: A key technology whose development can produce advances in several pivotal areas.

Greenhouse gas (GHG): Gases that contribute to atmospheric warming.

Gross domestic product (GDP): A measure of the value of the final output of the goods/services produced within a country or region's borders.

Indirect economic impact: Economic impacts resulting from inputs purchased by the supporting industries.

Induced economic impact: Economic impacts resulting from the earnings spent by workers in the local region.

Land use change: Changes to land use occur either directly to a specific unit of land or indirectly due to induced changes from market impacts. The changes can impact the soil conditions and affect the soil carbon sequestration.

Levelized production cost: A measure of the average net present cost of production for a production facility over its lifetime, taking into account returns of and on all investment capital and all operating costs.

Lifecycle greenhouse gas emissions: A lifecycle accounting of all GHG emissions produced in making and consuming a product. The boundaries of this assessment begin with emissions from farming and soil sequestration related to the biomass feedstock and end with the aircraft's combustion of the fuel.

Local economic impact: The local region that was analyzed includes Kingsbury County, South Dakota and the surrounding counties/region.

Other fuel coproducts: The NZ1 process also yields lesser quantities of renewable diesel and naphtha, which have a lower carbon intensity than conventional fuels. End uses include industrial and fuel applications.

Particulate matter: Fine airborne particles emitted from numerous air pollution sources.

Regenerative agriculture: Practices that aim to improve soil health and farming sustainability by minimizing soil disturbances, increasing soil cover, and increasing crop diversity.

Technological spillover: Spillovers occur when a firm's investment reduces production costs for other firms, thereby enhancing the industry-wide cost-reduction effect. The next generation of plants reap the benefits of the experiential learnings that have accumulated from the prior generations.

- Long-term: In this analysis, defined as the period between 2030-2050. The spillover effects from the initial NZ1 plant diminish over time as other advancements contribute to future developments.
- Near-term: In this analysis, defined as the period up to 2030. The spillover effects from the initial NZ1 plant are more pronounced in the near-term, as this period more directly benefits from these contributions.

Value-added economic benefit: The gross output less intermediates to capture the contribution to the gross domestic product (GDP).

Zero-carbon hydrogen: Hydrogen produced via electrolysis powered by renewable energy, a process that does not produce direct GHG emissions.