Sustainable Aviation Fuel Targeted Opportunity Region

Great Lakes Region

Report / February 2024

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Corey Stewart, Aamir Shams, Lachlan Wright, and Andrew Chen. *Sustainable Aviation Fuel Targeted Opportunity Region — Great Lakes Region*, RMI, 2024, https://rmi.org/insight/refueling-aviation-in-the-us-evolution-of-us-sustainable-aviation-fuel-policy/.

Acknowledgments

Aaron Brickman, Senior Principal — US Program, RMI
Amanda Taylor, Senior Vice President — Business Development, Greater MSP Partnership
Lisa Hughes, Business Development Manager, Minnesota Department of Employment and Economic Development

This research was conducted with support from Breakthrough Energy. Results reflect the views of the authors and not necessarily those of the supporting organization.

About RMI

RMI is an independent nonprofit, founded in 1982 as Rocky Mountain Institute, that transforms global energy systems through market-driven solutions to align with a 1.5°C future and secure a clean, prosperous, zero-carbon future for all. We work in the world's most critical geographies and engage businesses, policymakers, communities, and NGOs to identify and scale energy system interventions that will cut greenhouse gas emissions at least 50 percent by 2030. RMI has offices in Basalt and Boulder, Colorado; New York City; Oakland, California; Washington, D.C.; and Beijing.

Introduction

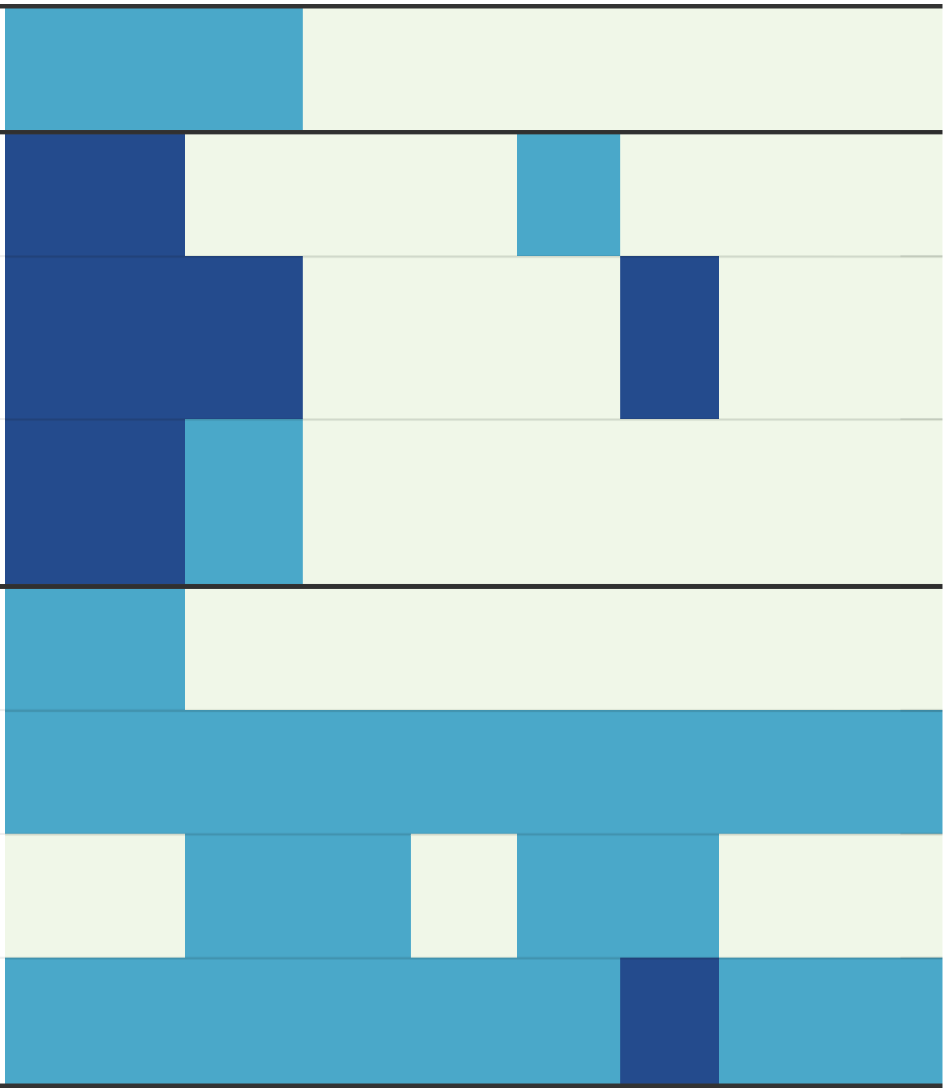
The world is demanding that the aviation sector adopt sustainable aviation fuel (SAF), creating a unique opportunity for the Great Lakes region. Of the many industrial hubs in the United States, the Great Lakes region displays the relevant industrial networks and SAF scaling opportunities that could drive US aviation fuel targets. The region in focus consists of seven states: Illinois, Indiana, Michigan, Minnesota, Ohio, Pennsylvania, and Wisconsin.

Previous learning gleaned from the SAF industry along with a stronger vision of future demand have shown positive signals for the Great Lakes states. The region can handle the entire SAF value chain, which will spur economic growth along with localized environmental benefits. As the SAF value chain scales in the region, these benefits can expand to international markets and compete with global SAF manufacturers.

If the Great Lakes region is to compete internationally in this rapidly growing sector, it needs to look forward and not be content with past success. This report includes a unique industrial policy gap analysis, which finds that no Great Lakes state has a comprehensive or coordinated approach to address the demand and supply challenges necessary to nurture a sustainable fuels sector (see Exhibit 1) — of which SAF is a key component. The federal government, primarily through the Inflation Reduction Act (IRA) of 2022, is providing leadership in this space that regional actors should be looking to complement and integrate into their planning.

Exhibit 1 **Sustainable Fuels Policy Gap Analysis in the Great Lakes Region**

Demand-pull policies are more mature than the production instruments, though performance at the federal level shows potential upside.



Domains	**Policy Instruments**	**Federal**	**MN**	**WI**	**MI**	**IN**	**IL**	**OH**	**PA**
Strategic Coordination	Planning/Strategy	▨	▨	□	□	□	□	□	□
Production Instruments	Research and Development	■	□	□	□	▨	□	□	□
	Incentives to assist facility operation	■	■	□	□	□	■	□	□
	Incentives to expand supply infrastructure	■	▨	□	□	□	□	□	□
Demand-Pull Mechanisms	Mandates	▨	□	□	□	□	□	□	□
	Standards and definitions	▨	▨	▨	▨	▨	▨	▨	▨
	Public Procurement	□	▨	▨	□	▨	▨	□	□
	Consumer Incentives	▨	▨	▨	▨	▨	■	▨	▨

RMI Graphic. Source: RMI analysis

This brief provides an introduction to SAFs, trends in the sector, and why the Great Lakes region has unique strengths in feedstock availability, infrastructure, transport, and demand that could translate into a globally competitive industry. It also provides an overview of the economic impacts and unpacks some of the key policy levers that could unleash SAF's potential in the Great Lakes region.

SAF 101

What Is SAF?

Jet fuel, which accounts for the lion's share of the aviation fuel market, has stringent requirements on composition and performance. Thus, it is critical that the fuel made from new sources and production pathways meet existing standards. SAF is a drop-in replacement for petroleum-based jet fuel. It can be used in existing fuel delivery infrastructure and existing aircraft engines and reduces emissions now while technological leaps for new fuels (e.g., hydrogen- or electric-powered aircraft) take time to develop. Blending limits of SAF with conventional jet fuel can range from 5% to 50% depending on the feedstock and production process used.

The International Civil Aviation Organization (ICAO) describes SAF as "a renewable or waste-derived aviation fuel that meets sustainability criteria."[1] Although the sustainability criteria can be complex and differ between methodologies, there are two widely accepted core characteristics of SAF. The fuel should (1) generate fewer emissions than fossil jet fuel on a life-cycle basis, and (2) in the case of bio-based SAF, the biomass should not be sourced from land with a high carbon stock. In addition to these rules, SAF produced after 2024 will be bound by even more stringent rules on land use, food security, and human rights, among others.

Jet fuel can be considered sustainable when it meets the criteria set forth by a standard issuing body. There are currently two accepted forms of analysis used to account for the life-cycle emissions of SAF: the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) and the Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies (GREET). The GREET modeling and methods were developed by Argonne National Laboratory[2] and measure biofuel life-cycle emissions across the United States.

SAF, with a lower carbon intensity than fossil jet fuel, can already be produced through several conventional pathways. ASTM International, a global standards organization, currently approves nine production pathways for producing SAF, with hydroprocessed esters and fatty acids (HEFA) as the most immediately accessible pathway.[3] Of the nine, HEFA is the only commercially deployed pathway for producing SAF. HEFA can be derived from tallow, crop residues and oils, woody biomass, and even municipal waste. These sources provide a consistent feedstock to be refined into SAF but they are limited and other solutions will be needed to meet projected future demand.

Fuel produced from the power-to-liquid (PtL) process is called eSAF, a drop-in synthetic fuel that can significantly lower carbon intensity when it is produced with renewable energy. Effective PtL processes, like Fischer-Tropsch, are being repurposed to fill the technology gaps present in the SAF industry. Hydrogen and CO_2 are key inputs for eSAF production. Waste CO_2 utilization keeps the aviation fuel within sustainability criteria, although the hydrogen can be produced with near-zero carbon when renewable energy is sourced. More pathways and innovations will likely develop as new industrial hubs improve the understanding of these processes.

Though the production of SAF has upward potential, barriers to deployment exist. Currently, SAF production expenses result in market prices two to four times greater than those for traditional fossil jet fuel, limiting the potential for market-driven scaling. Long-term demand signals for SAF from airlines are increasing, but this price premium remains a major barrier for scaling up SAF.

Nonetheless, opportunities for stakeholders are emerging as production costs continue to drop. Pioneering retrofits of existing systems and industrial symbiosis that optimizes assets are mitigating the high up-front costs of developing SAF projects. Key feedstocks like hydrogen and renewable energy are decreasing in price, which will lower operating costs and build a more robust supply chain for production.

Shifting from Conventional Jet Fuel to SAF

The benefits of SAF cascade through the value chain and local environment. The most tangible benefit is air quality improvement. SAF contains fewer aromatic components than conventional jet fuel, helping it burn cleaner while reducing life-cycle carbon emissions. Travelers may notice immediate changes as fumes at the airport wane, but the advantages will lift the Great Lakes region through a variety of levers.

The resulting growth of the bioeconomy will allow jobs in certain traditional sectors to transition into new yet similar roles, while opportunities for new advanced jobs will open to the current and future workforce. Broader uses for agricultural feedstocks create a more dynamic and robust revenue stream for farmers. Growing techniques endorsed by GREET and CORSIA require responsible stewardship of land use, further promoting soil quality benefits and longevity.

Regional by-products and waste streams can be converted into value-generating fuels — a net positive for the economy rather than a burden to be managed.

SAF Trends

The SAF market has recently experienced a series of shifts in the form of positive commitments and legislation from major biofuel-producing countries. The United States, EU, and United Kingdom carved out their own pathways for SAF development, including how to position demand in favor of domestic supply chains.

The EU and UK have mandates in place that are positioned to meet a portion of the SAF demand by 2030. With the adoption of the IRA, the United States also offers the incentives for competitive low-carbon SAF through Sections 40B and 45Z, hydrogen through Section 45V, and carbon capture through Section 45Q. Even with these commitments, more will be required to fulfill the full need for a global SAF market.
On a global scale, blending mandates and production goals could see the SAF market dealing with 4.5 billion gallons of fuel by 2030, an over 50-fold increase from 2023. However, SAF production today remains well short of these demand projections.[4]

The US SAF market will have similar upward trends in supply and demand, with the latter expected to exceed production supply. The Sustainable Aviation Fuel Grand Challenge, the result of a government-wide memorandum of understanding published by the US Department of Energy (DOE), Department of Transportation, and US Department of Agriculture (USDA), challenges the United States to build enough supply infrastructure to produce 3 billion gallons per year by 2030 and 35 billion by 2050.

Although domestic SAF facilities aim to produce 3 billion gallons of drop-in fuel by 2030, currently announced SAF projects are expected to support only 2.2 billion gallons by then. Today's SAF production levels will need to scale severalfold across all technologies to approach the 27 billion gallons that could be in domestic demand by 2050.[5]

A majority (66%) of announced SAF projects will use HEFA derived from vegetable oils, waste oils, and other fats. Most of the remaining projects (27%) will use alcohol-to-jet (ATJ) processes for SAF. The near-term allocation of biomass feedstocks is therefore integral for SAF to proliferate in the United States.

Great Lakes Region Strengths and Industrial Capabilities

The emerging SAF opportunity could further contribute to the Great Lakes region's potential as a center of innovation and future industry. Its existing network of infrastructure and industry can make the region one of the vital hubs for meeting SAF targets. Its foundations in manufacturing and adjacent industries, agriculture, and technology, along with its high feedstock availability, can transition into a successful bioeconomy network.

Feedstock Availability

SAF can be produced through a variety of technologies using a wide range of feedstocks such as biomass, renewable fuels and electricity, hydrogen, and waste CO_2. To be viable for SAF, feedstocks need to be effective in cost, sustainability criteria (including carbon content), and scalability. The Great Lakes region has the capacity to compete in a wide range of feedstocks, but it will require sustained and strategic investments in supply chain development to mature those pathways.

Biofuel is produced abundantly in the Great Lakes and wider Midwest regions, with most of the focus on ethanol produced from corn. The Great Lakes region accounts for over 35% of US ethanol production capacity, and Illinois alone generates more than 10%.[6] This is just a part of the United States' total production of 15 billion gallons of ethanol, or over 55% of the world's ethanol.[7]

The significance of corn and soy as feedstocks has driven the ATJ and HEFA pathways to maturity, leaving less room for advancement. However, these crops' entrenched supply chains do not negate the food versus fuel dilemma often vocalized by biofuel opponents. Still, new opportunities for biofuel feedstocks continue to emerge as regulation and agricultural science improve knowledge about land management.

Agricultural residues and food waste are considered second-generation feedstocks, which are effective sources because of their lower life-cycle carbon and land use competition compared with first-generation crops like corn and soy. Biomass feedstocks separated from edible agriculture supply chains are considered third generation and include sources like forest residues and other woody waste. These third-generation feedstocks have high potential for SAF refinement because their soil carbon benefits often result in negative carbon intensity.

Renewable natural gas (RNG) is a promising feedstock that can be captured and repurposed for SAF production. RNG is used to produce synthetic gas in the refining process, replacing the role of natural gas but with far less fossil carbon. RNG has a diverse and growing supply chain that is sourced from landfills, wastewater treatment facilities, agricultural residues, livestock, and other biomass waste.

The high population density of Great Lakes cities creates an abundance of potential RNG. Large population centers generate municipal waste that must be managed effectively. It is common today for landfills to recover methane leakages and abate the gases through either flaring or recovery. As a better alternative to flaring, recovered landfill gas can be processed into RNG and sold. The region currently boasts a high capacity of landfill gas recovery because over 95% of annual landfill waste is sent to a facility equipped for gas recovery. Minnesota and Pennsylvania have already invested heavily in municipal waste incineration, making the region's other states more likely to adopt RNG through landfill gas recovery.[8]

Many other feedstocks exist, and new sources in the region may become apparent as SAF pathways mature. The abundance of feedstocks is only a part of a successful SAF value chain. Resources and crude wastes must be managed effectively down the value chain to have a viable SAF pathway.

Existing Infrastructure

SAF plants require specialized infrastructure to ship, store, and process feedstocks into jet fuel. Developing new pipelines and refineries is capital intensive — a similar obstacle to expanding many energy transition technologies. One of the key advantages of SAF is its versatility to fit into established supply chains. The need for new infrastructure and capital is lessened, while the value of current systems is stretched.
The vast network of ethanol supply chains in the Great Lakes and wider Midwest regions can be tapped for SAF production. The ATJ pathway benefits from its maturity and ethanol's economy of scale. Key infrastructure and learnings used in ethanol processing can be leveraged for a more profitable SAF production pathway.

Incorporating SAF into the jet fuel mix requires a series of transport modes, storage, and blend points that are currently used for ethanol-derived SAF. Aside from up-front capital to finance these operations, regulatory standards are in place at each point, adding further burden to the startup costs and time line.[9] These types of correlated relationships between supply chains can help leapfrog solutions and expedite the scaling of SAF in the Great Lakes.

Financial incentives depend on individual state policies, although geographic location will determine access to feedstocks and supply chains. World Energy, a SAF producer, capitalized on the concept of converting well-located refineries into biofuel plants. Its Paramount, California, facility is built on existing refinery infrastructure with a turnkey-like quality for many of the processes. Fuel storage, truck loading bays, rail connections, and pipelines were all transitioned to handle SAF and biofuels.[10] Fuel is now shipped and sold to airlines at Los Angeles International Airport to satisfy local SAF demand.

Illinois is home to O'Hare International Airport in Chicago — the fourth-busiest airport in the United States by passenger volume in 2022.[11] Aside from O'Hare being a major source of potential SAF demand, its scale means existing infrastructure can accommodate SAF produced in the region. A study[12] by the National Renewable Energy Laboratory (NREL) suggests a successful dynamic between Great Lakes region SAF production and supply for O'Hare's fuel needs. The study found that a combination of local feedstocks could replace up to 55% of conventional jet fuel at O'Hare with SAF. Carbon reductions compared with conventional Jet-A could be 86% lower, making Great Lakes SAF a competitive fuel on the market.

Two experienced names in biofuel, LanzaJet and Marquis SAF, have tapped into the region's ethanol supply chain to produce ATJ and biodiesel in Illinois. When completed, the facility at the Marquis Industrial Complex will supply 120 million gallons of biofuel annually, with much of the SAF portion sold to O'Hare as well as Chicago's other international airport, Midway. The location was a strategic move by developers, not only because of the proximity to local demand centers but also because of access to waterways, railroads, and highway systems for transport.[13]

Transportation

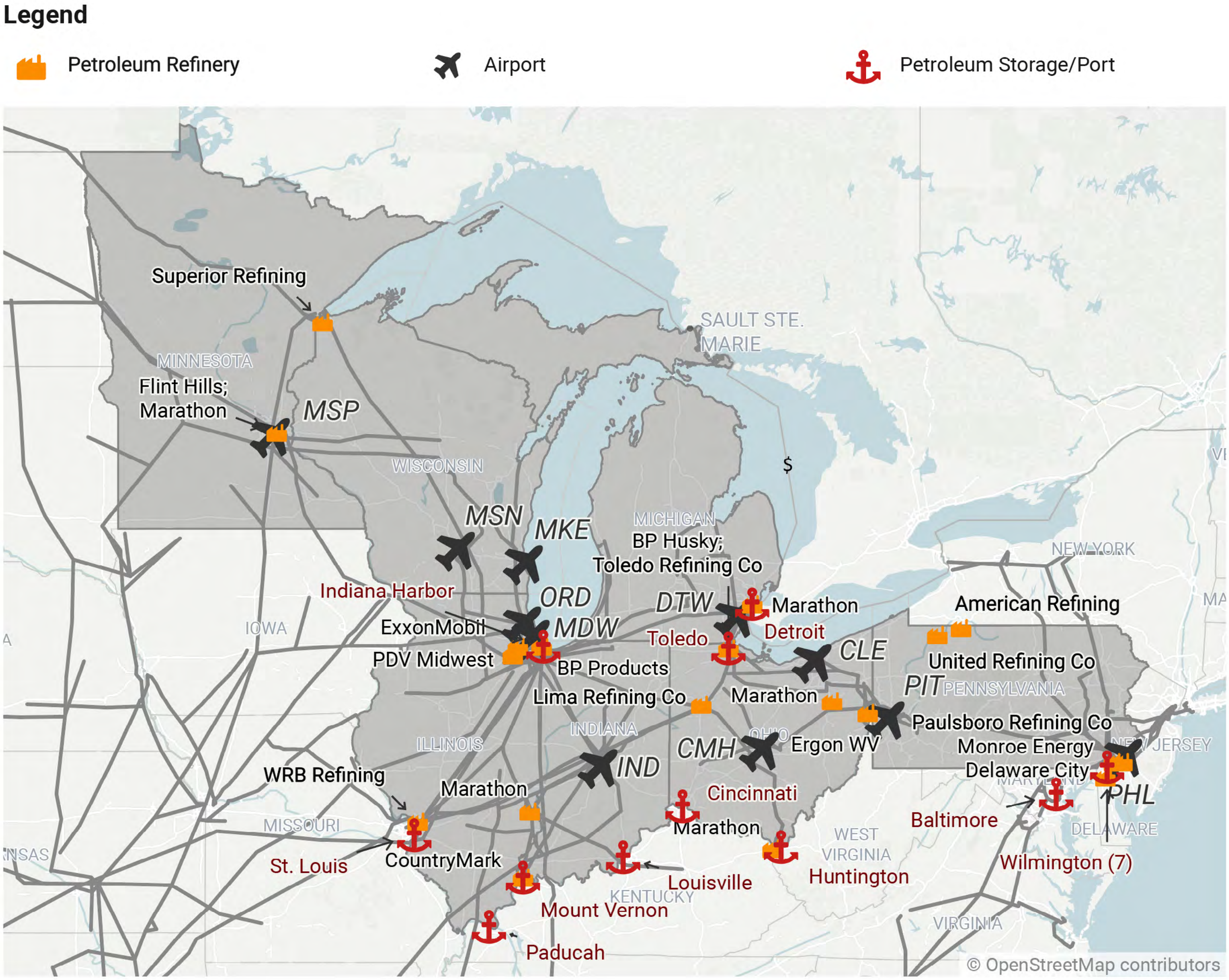
Each stage of transporting feedstocks to biorefineries and SAF to aircraft introduces embodied carbon, reducing eligibility for financial incentives while introducing higher logistics costs. The NREL study on O'Hare feedstocks reflects this by using parameters of 50, 100, and 200 miles from the airport to determine feedstock viability. Carbon intensity–based incentives can be diminished because spatially unfavorable feedstocks add to the life-cycle carbon.

The IRA incentivizes lower-carbon SAF through Section 40B. It includes a tax credit of $1.25 per gallon of SAF produced with life-cycle carbon savings of 50% or greater compared with conventional jet fuel (89 grams CO_2e per megajoule), plus $0.01 for every percentage above the minimum.[14] SAF plants deal with millions of gallons of biofuel annually, making every opportunity for supply chain decarbonization a valuable lever.

The Great Lakes already host an advanced shipping and logistics network that can be used to support competitive SAF production. The St. Lawrence Seaway allows for goods to be shipped in bulk to the Atlantic market with less carbon intensity than ground options. The same is true for the Mississippi River system, which would connect biorefineries to the massive Gulf Coast petroleum networks and ultimately through the Panama Canal to the Asia-Pacific market.

There are numerous ports along the Great Lakes (see Exhibit 2) that are equipped to accommodate 1 million tons or more of commodities per year. Two ports — Duluth, Minnesota, and Toledo, Ohio — contain grain elevators that could be used for handling biomass feedstock from suppliers.[15] Great Lakes ports have historically had the capacity to deal with fuel commodity exports. The region shipped 1.3 million short tons of diesel and gasoline in 2019, up from levels in the 1990s but still far lower than the 3 million recorded almost 45 years ago in 1979. The gap from previous highs shows that the fuel shipping capacity of the region could meet initial export demand for finished products if needed.

Exhibit 2 **Key Infrastructure in the Great Lakes Region**



RMI Graphic. Source: EIA, https://atlas.eia.gov/apps/e1c92d7601b9490697d22dfe2da1b4ac/explore

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Connecting feedstocks and fuel to value chain partners also relies on extensive ground freight. The Chicago regional freight system is a hub for shipping, with $3 trillion in goods passing through every year. Its location bridges eastern and western railroads where 50% of all intermodal trains and 25% of all freight trains travel annually.[16] Rail is a relatively low-carbon means of shipping and should be prioritized for long freight distances in the SAF value chain. When the tracks end, trucks can utilize the 10 interstate highways in Illinois connecting to regions of high feedstock potential.

Off-Take Agreements Can Ripen Great Lakes Region SAF Potential

Airlines are setting their own targets for introducing SAF into their portfolios and securing their supply lines through off-take agreements. Off-take agreements take place between fuel producers and buyers to establish a source of supply and demand. Delta Air Lines announced a target of 10% SAF in its flights by 2030, translating to 400 million gallons per year. Delta secured an off-take agreement with biofuel company Gevo Inc. for 75 million gallons of SAF per year to prepare for the 2030 target; this is just a fraction of Gevo's total annual agreements worth 375 million gallons.[17]

O'Hare Airport hosts an SAF procurement venture led by United Airlines. Its partner bioenergy producers, helped by an injection of $50 million in venture funding, aim to produce 135 million gallons of SAF annually to supply the Chicago–Denver flight hubs.[18]

The global growth in SAF demand toward 2050 compared with limited geographies producing SAF illustrates the need for a market-based system to deliver fuel benefits across the world. Registries for accounting SAF certificates (SAFc) are in place to solve the connection challenge and are quickly maturing as more SAF comes to market.

SAFc are produced per ton of drop-in fuel and they are ideally born out of SAF consumed in airports. Commercial and private customers can purchase these SAFc to reduce their upstream (i.e., Scope 3) emissions from flights, even if the journey itself does not use SAF.

The market-based concept contains similar logic to renewable energy credits: produce renewable energy in regions with the best availability of resources (hydro, wind, solar) and allow market players to purchase blocks for their own accounting. The system incentivizes efficient SAF production by removing the geographic boundaries from customer demand.

Economic Impact

SAF development can present economic benefits for communities and regions. The value chain to deploy SAF provides a long-term fixed revenue stream and employment for regional stakeholders. Although the emerging bioeconomy may partially drive its own development, meeting SAF deployment targets will require a skilled workforce, public–private partnerships, and unique industry collaborations.

Job Creation Potential and Workforce Development Opportunities

The DOE’s Bioenergy Technologies Office (BETO) assists in promoting awareness of and addressing gaps in the current workforce. The expertise that already exists in certain sectors can translate to many of the operations of SAF production.

The value chain to produce SAF is extensive and will require new job creation that expands across the economy. The new jobs created will be available for the broader workforce, with positions needed from early and mid-level careers to advanced roles and specialists. BETO expects some of the highest job growth in the areas of:

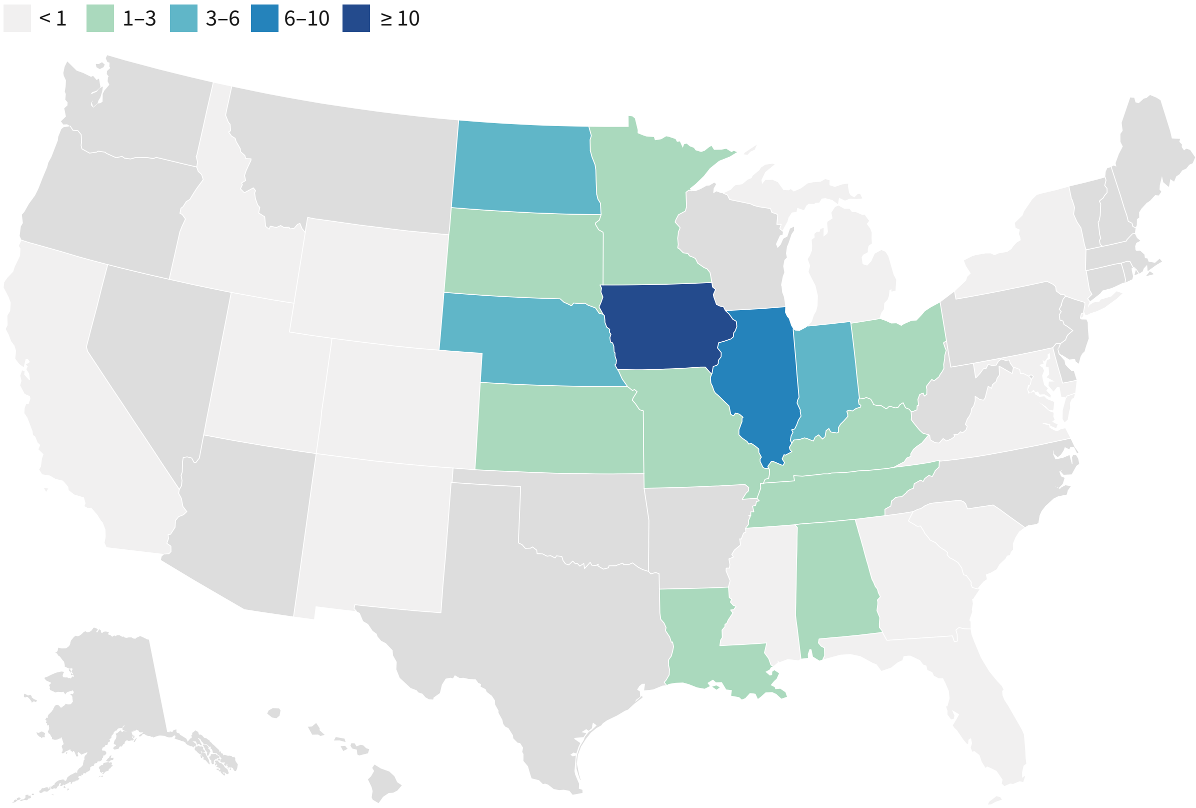
- Biomass and hydrogen production and logistics
- Facility operation and quality control
- Research and development
- Feedstock production in farming communities
- Construction, engineering, and manufacturing

An examination of the job market in the biorefinery sector shows that the Great Lakes and wider Midwest regions are above the average location quotient (LQ) compared with the rest of the country (see Exhibit 3). States that fall below the national average, such as Michigan and Wisconsin, will need to scale their biorefinery workforce to fully experience the benefits of a Great Lakes region bioeconomy.

Exhibit 3

Biofeedstocks Processing Industry Employment Statistics

Annual Average Employment Location Quotient (LQ) above 1.00 indicates above employment in the sector is above the national average.



Analysis features data from NAICS code 31122 as a proxy for bio feedstock processing.

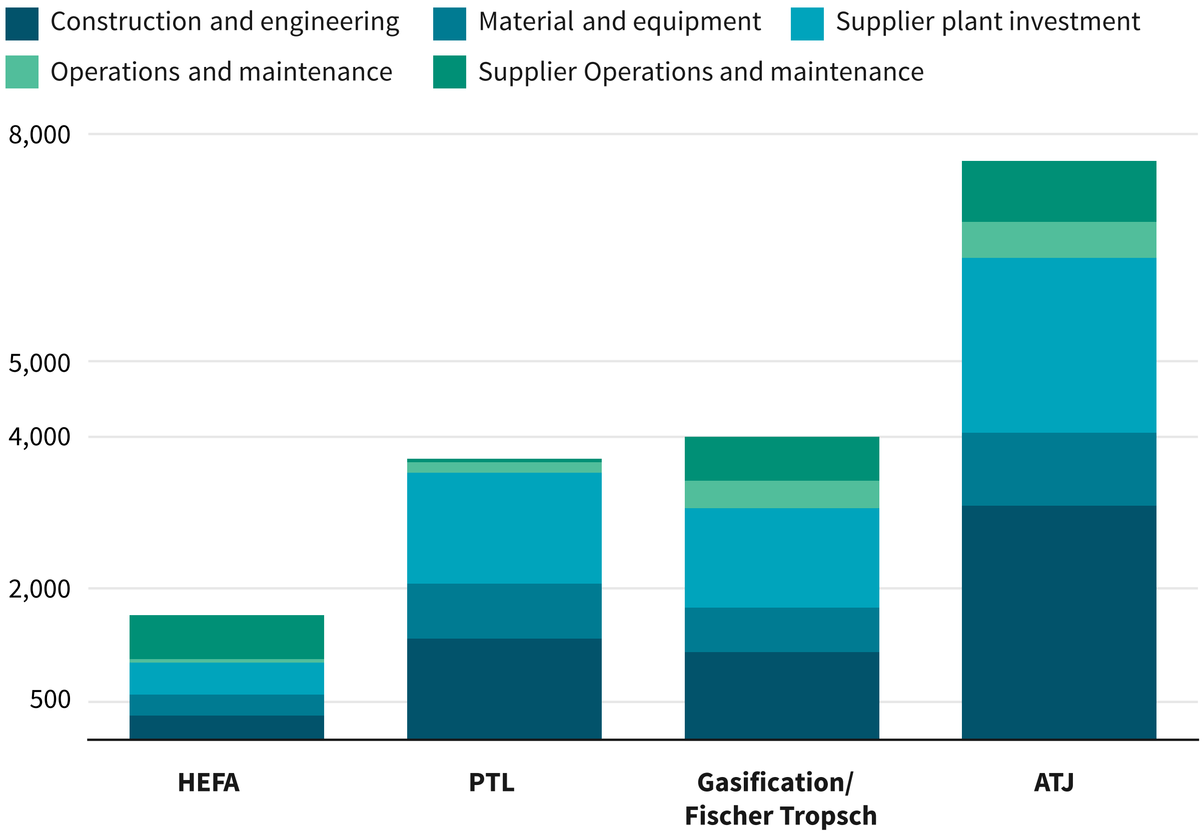
RMI Graphic. Source: US Bureau of Statistics 2023

Job figures for biorefineries vary based on the technological pathway for SAF (see Exhibit 4). Employment projections for each pathway focus on up-front labor for development and fixed labor for operations and management. The ATJ refinery can provide the most job opportunities during both development phase and post-completion.

Exhibit 4

Projected Job Creation of SAF Refineries Delineated by Support Sector

Job figures for a simulated 50 million gallon/year SAF plant by value chain stakeholder



Note: Projections are dependent on SAF plant design.

RMI Graphic. Source: Rhodium Group, https://rhg.com/research/sustainable-aviation-fuels/

Public–Private Partnerships and Research Institutions Driving SAF Innovation

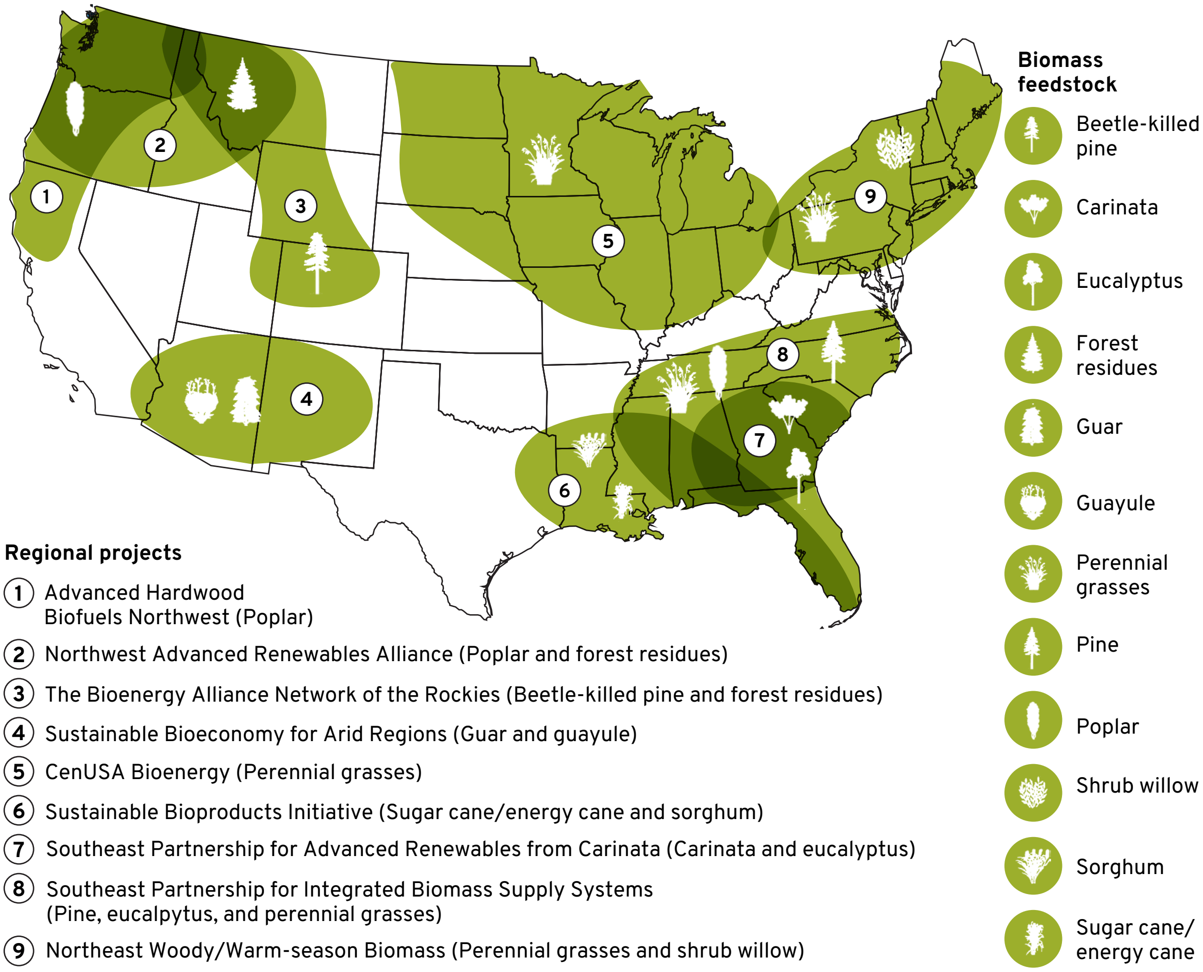
A skilled workforce needs an entire network of collaborations to scale. Public research partnerships are being used to drive innovation and knowledge centers for the industry. In 2007, the DOE endorsed a joint effort between the University of Wisconsin and Michigan State University with a $125 million grant for the formation of the Great Lakes Bioenergy Research Center (GLBRC). The GLBRC conducts a large variety of biofuel research and tool development, consequently building knowledge centers around an emerging bioeconomy. Prospective SAF developers can now use the center’s Biomass Utilization Superstructure tool to evaluate new and existing biofuel strategies.[19]

Because the Agriculture and Food Research Initiative is a grant program of the National Institute of Food and Agriculture, over $183 million has been awarded for coordinated agricultural projects (CAPs). The CAPs are targeted at rural regional development for, among other things, biofuel production from non-food-competitive agriculture. Of the several CAPs supported by the USDA, three span states within the Great Lakes region (see Exhibit 5).

The Integrated Pennycress Research Enabling Farm and Energy Resilience (IPREFER) project includes public–private collaborators from Illinois, Minnesota, Ohio, and Wisconsin. The CenUSA project includes Midwestern states and does research on perennial grasses as biofuel feedstocks. The Northeast Woody/Warm Season Biomass Consortium (NEWBio), hosted by Pennsylvania State University, includes partnerships with institutions in New York and Ohio.

Exhibit 5

Map of CAPs Funded Through the USDA



Biomass feedstock

- Beetle-killed pine
- Carinata
- Eucalyptus
- Forest residues
- Guar
- Guayule
- Perennial grasses
- Pine
- Poplar
- Shrub willow
- Sorghum
- Sugar cane/energy cane

Regional projects

① Advanced Hardwood Biofuels Northwest (Poplar)
② Northwest Advanced Renewables Alliance (Poplar and forest residues)
③ The Bioenergy Alliance Network of the Rockies (Beetle-killed pine and forest residues)
④ Sustainable Bioeconomy for Arid Regions (Guar and guayule)
⑤ CenUSA Bioenergy (Perennial grasses)
⑥ Sustainable Bioproducts Initiative (Sugar cane/energy cane and sorghum)
⑦ Southeast Partnership for Advanced Renewables from Carinata (Carinata and eucalyptus)
⑧ Southeast Partnership for Integrated Biomass Supply Systems (Pine, eucalyptus, and perennial grasses)
⑨ Northeast Woody/Warm-season Biomass (Perennial grasses and shrub willow)

RMI Graphic. Source: National Institute of Food and Agriculture

Policy Landscape and Supportive Measures

Public policy has significantly influenced the growth of biofuels for transportation and the scaling up of renewable energy industries like wind and solar. In the United States, at the federal level, two policies are critical for an SAF market at scale: the Renewable Fuel Standard (RFS)[i] and the IRA. The RFS has no provisions for PtL SAF and has mechanisms that lead to intersectoral competition. The IRA, when stacked with other credits, would narrow — though not completely close — the premium gap with conventional jet fuel.

At the state level, only a handful of states have low-carbon fuel standards (LCFSs) that are conducive to the development and growth of an SAF market. More states are considering adopting similar standards; however, intersectoral competition is a key issue in these standards.

Four of the Great Lakes states are considering LCFS policies that would include support for SAF (see Exhibit 6). Minnesota has taken the lead in providing direct incentives to SAF producers — Minnesota's Legislature approved $11.6 million for tax credits worth $1.50 for each gallon of fuel that is produced or blended with aviation fuel in Minnesota and sold in the state for use at Minnesota airports.[20] Illinois has enacted an SAF purchasers' credit (SAFPC) that can be combined with other incentives. From July 2023 to December 2032, the SAFPC provides $1.50 per gallon of SAF used or purchased in Illinois.[21]

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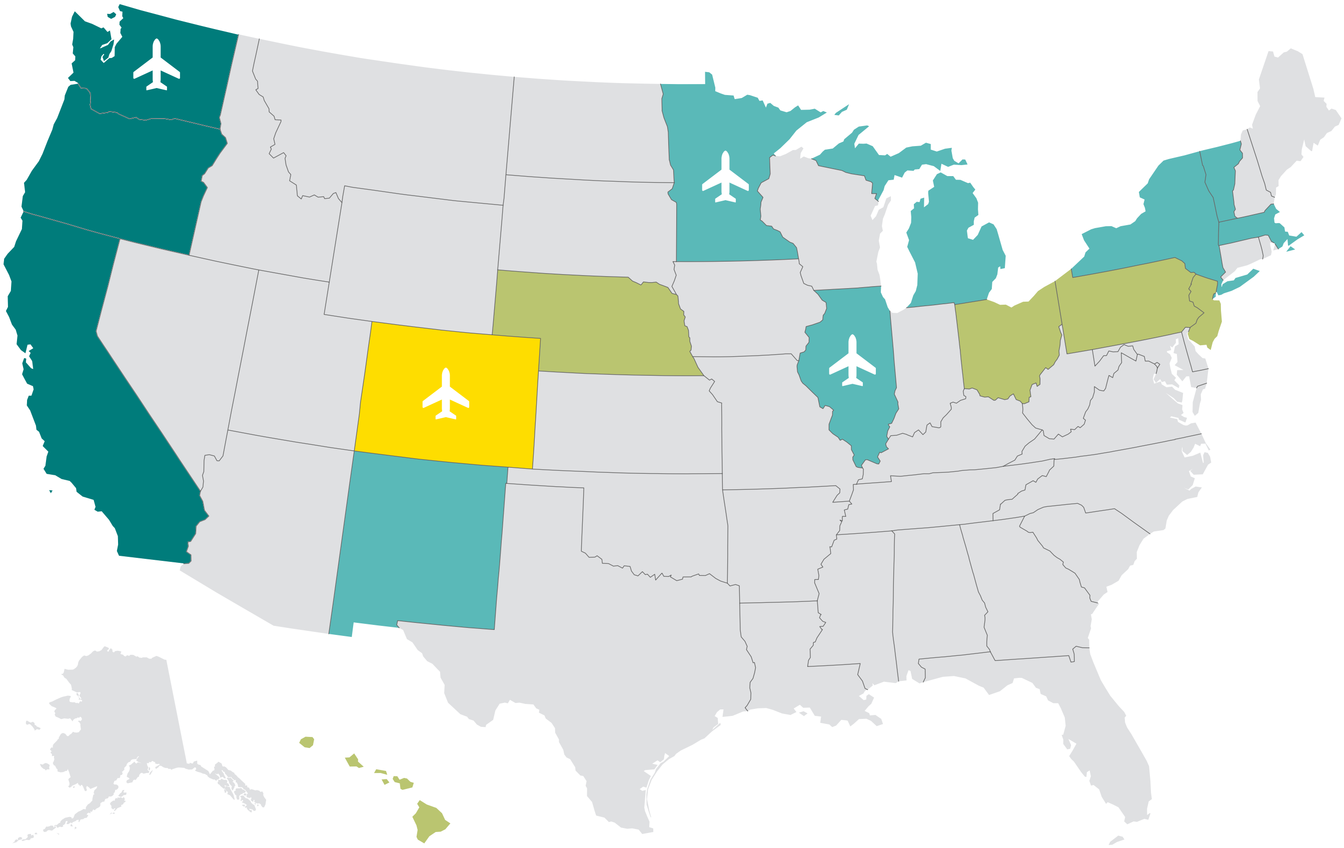
[i] The US RFS was created by the Energy Policy Act of 2005 and was later updated through the Energy Independence and Security Act of 2007. This regulation focused on renewable fuel for ground transportation, requiring a minimum amount of renewable fuel on an annual basis, to be increased over time. The RFS is administered by the Environmental Protection Agency (EPA).

Exhibit 6 States' Progress on SAF Policy Including LCFS

■ LCFS or similar policy in force 🟦 Pending or failed LCFS or similar policy ⬜ No reported activity
🟩 Conversations in progress on LCFS or similar policy 🟨 Previously considered LCFS

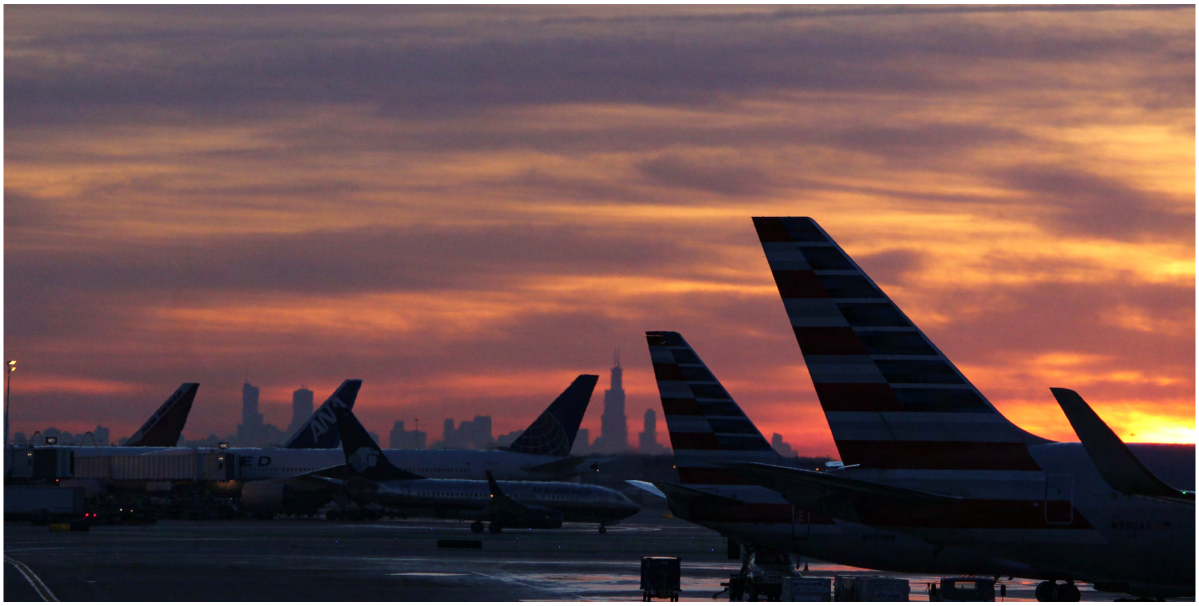


✈ = Direct incentives for SAF in the states of Washington, Colorado, Minnesota, and Illinois.

RMI Graphic. Source: RMI analysis of state policy offices

Other favorable SAF policies have been enacted through bipartisan legislation in the Great Lakes region. The most recent of these efforts was led by Senators Tammy Duckworth (D-IL) and Deb Fischer (R-NE) and backed by other senators. They put forth the Sustainable Aviation Fuels Accuracy Act of 2023, which endorses the use of GREET as the accepted way to account for life-cycle emissions of SAF fuel — a methodological win for domestic agriculture and industry.

Challenges and Next Steps



The SAF Grand Challenge is aptly named due to the hurdles that need to be crossed to build this industry. Aside from the price premium incurred by SAF production, other barriers range from investment opportunities to moral arguments of food versus fuel.

Identification and Analysis of Economic and Industrial Challenges to SAF Development in the Great Lakes Region

Several SAF feedstocks come from primary sources rather than waste or by-products. Corn that could otherwise be used as food is a key ingredient in many SAF blends and will continue to play an important role in ATJ fuel. There are also fears that arable, food-producing land could be converted for biofuel. These concerns unite environmentalists questioning land use changes and agricultural producers worried about the impact on their animal feed supply.

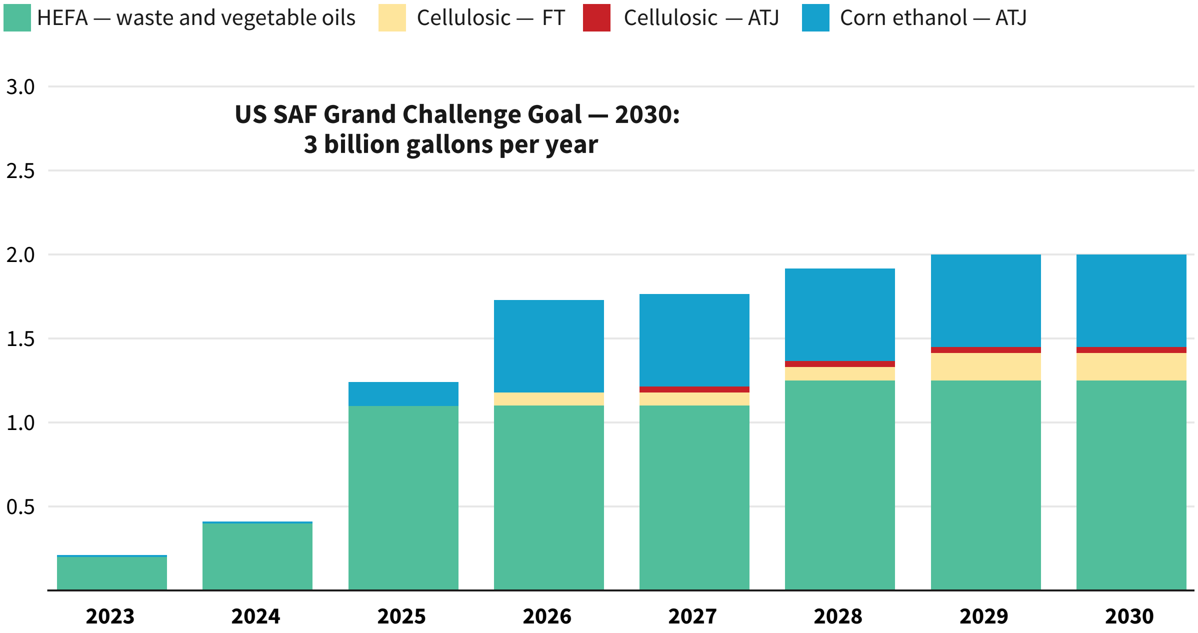
Competition among sectors for sources of low-carbon feedstocks will be a hurdle for incentivizing SAF. Currently, the road sector uses the majority of renewable fuels. Higher production costs associated with SAF output and more limited demand uptake are disincentives for producers to redirect feedstock to aviation. Nationally, and in many states, there is typically little intersectoral coordination (often reflected in their respective renewable fuel–related policies), which compounds the challenge.

Pathways for refined SAF vary greatly in terms of technology-readiness levels, with HEFA and ATJ already in production while many others await certification from ASTM International. HEFA, using a more limited feedstock like waste fats, oils, and greases, can fill supply to an extent, but ultimately other technologies like PtL need to expand along with their respective supply chains.

The transition to SAF requires major investment. Although existing infrastructure may reduce some capital investment, it may be necessary to build or remodel entire processing facilities and develop entire supply chains. Current investments represent a fraction of the required annual investment, and current announced investments are not on track to meet SAF Grand Challenge targets (see Exhibit 7).

Exhibit 7

Announced US SAF Capacity by Billions of Gallons (Bgal)



RMI Graphic. Source: RMI Analysis; S&P Global; SkyNRG, https://skynrg.com/safmo2023/

Strategies to Mitigate Risks and Address Challenges

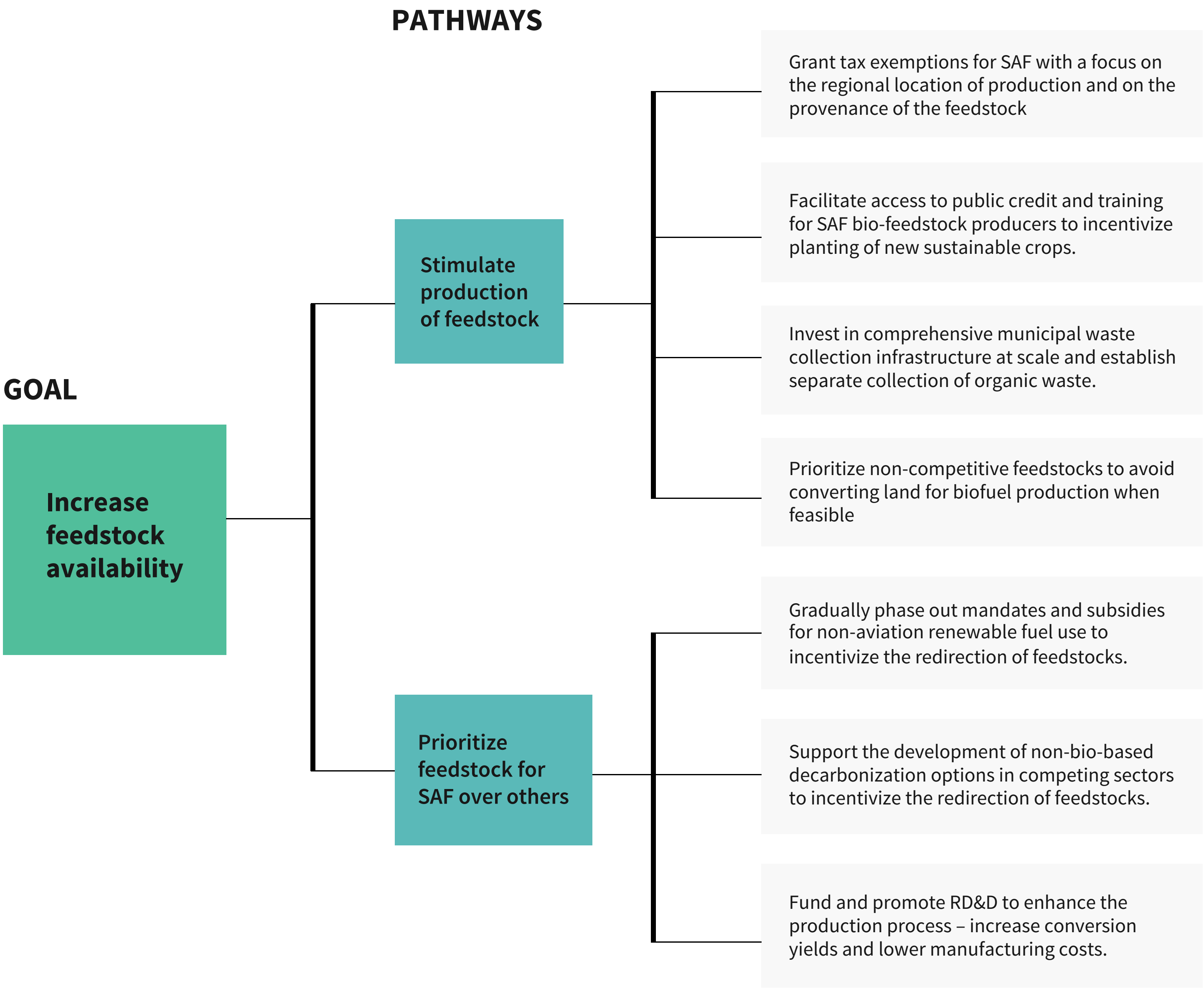
The assorted challenges to SAF deployment can be met through levers that increase availability of feedstock and production capacity. On the supply side, prioritizing feedstocks toward SAF while stimulating production incentives can ensure enough feedstocks are available to meet future refining demands.

Prioritizing SAF development requires a balance of removing mandates that incentivize non-SAF fuel pathways using the same feedstocks, while providing another avenue forward for those pathways. Road transport is a common example where feedstocks are used to refine biodiesel as a drop-in fuel but would be more effectively allocated to industries with fewer alternatives for decarbonization, such as aviation.

Stimulating the production of feedstocks will ensure that SAF is produced at quantity, but also able to scale with increasing demand (see Exhibit 8). Financial mechanisms can be drafted to target regional feedstock development and incentivize growing crops that support a more sustainable SAF blend.

When shifting crops into an SAF feedstock, it is vital to prioritize feedstocks that are not currently in competition for food production. Agricultural land conversion will need up-front training and assurances for farmers that there will be a market for their crops. Assurances go beyond mandating market demand because the chain of custody for SAF feedstocks must be traceable back to the farm. Creating a digestible yet robust method for tracking feedstock attributes, such as carbon intensity, has been a challenge that the private sector is starting to address.

Exhibit 8 Levers to Increase SAF Feedstock Availability



GOAL

PATHWAYS

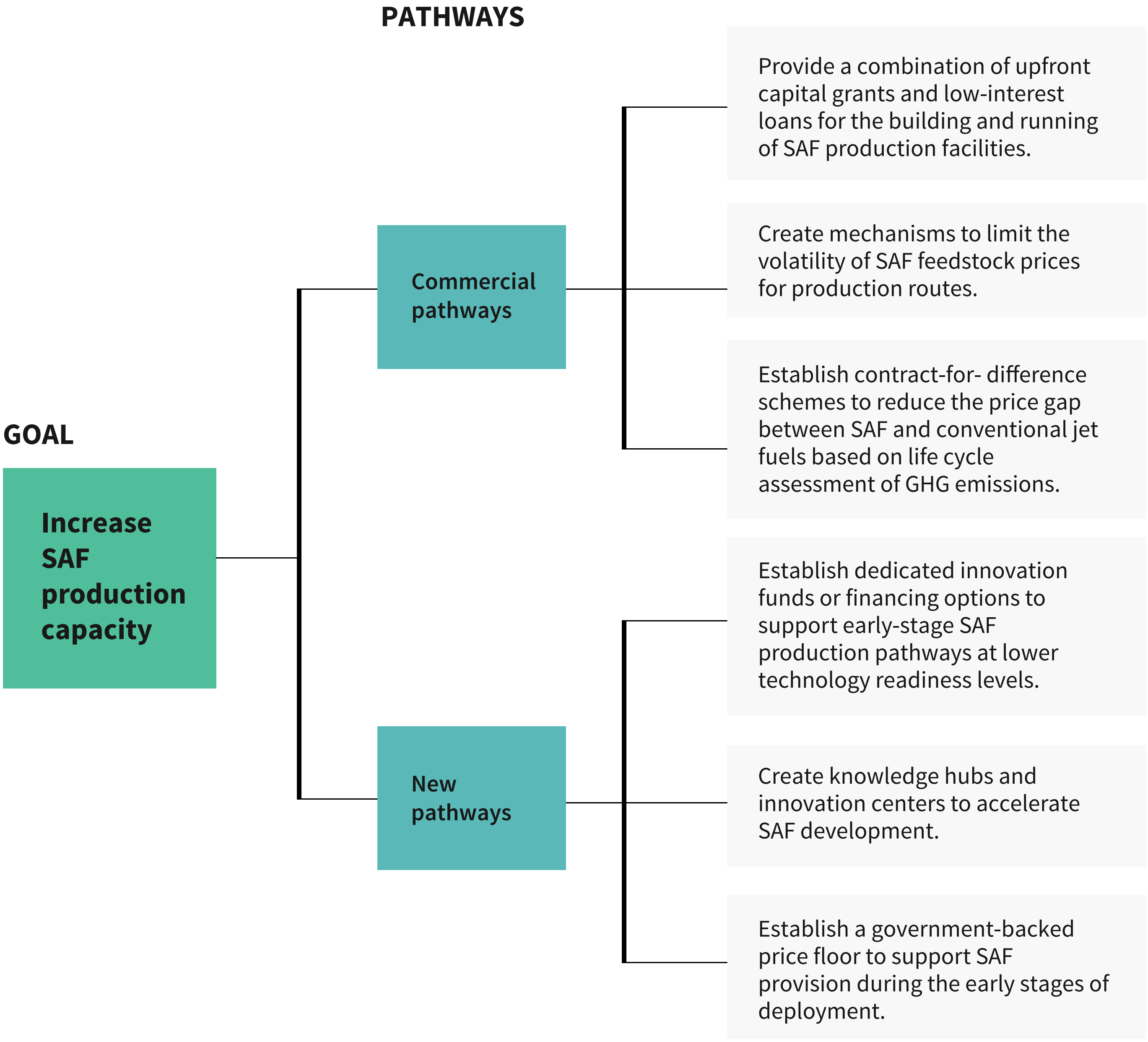
- **Increase feedstock availability**
  - **Stimulate production of feedstock**
    - Grant tax exemptions for SAF with a focus on the regional location of production and on the provenance of the feedstock
    - Facilitate access to public credit and training for SAF bio-feedstock producers to incentivize planting of new sustainable crops.
    - Invest in comprehensive municipal waste collection infrastructure at scale and establish separate collection of organic waste.
    - Prioritize non-competitive feedstocks to avoid converting land for biofuel production when feasible
  - **Prioritize feedstock for SAF over others**
    - Gradually phase out mandates and subsidies for non-aviation renewable fuel use to incentivize the redirection of feedstocks.
    - Support the development of non-bio-based decarbonization options in competing sectors to incentivize the redirection of feedstocks.
    - Fund and promote RD&D to enhance the production process – increase conversion yields and lower manufacturing costs.

RMI Graphic. Source: World Economic Forum,
https://www3.weforum.org/docs/WEF_Clean_Skies_for_Tomorrow_Sustainable_Aviation_Fuel_Policy_Toolkit_2021.pdf

Production capacity gains can be made through concretizing the near-term commercial pathways and supporting development of new pathways for scaling beyond 2030. Triggering the growth of commercial pathways requires up-front assurances on the financial prospects. Low-interest loans or grants coupled with fuel tax credits can help improve the chances of commercial SAF plants reaching fruition.

New pathways for SAF are being carefully explored as the market reveals more demand in the future (see Exhibit 9). Nascent technologies can be matured through innovation funding and the establishment of knowledge hubs (e.g., IPREFER). Financial support mechanisms for novel refineries are crucial to ensure scalability while competing not only with conventional and renewable fuels, but with possibly other more reputable SAF technologies as well.

Exhibit 9 **Levers to Increase SAF Production Capacity**



PATHWAYS

GOAL

Increase SAF production capacity

Commercial pathways

- Provide a combination of upfront capital grants and low-interest loans for the building and running of SAF production facilities.
- Create mechanisms to limit the volatility of SAF feedstock prices for production routes.
- Establish contract-for- difference schemes to reduce the price gap between SAF and conventional jet fuels based on life cycle assessment of GHG emissions.

New pathways

- Establish dedicated innovation funds or financing options to support early-stage SAF production pathways at lower technology readiness levels.
- Create knowledge hubs and innovation centers to accelerate SAF development.
- Establish a government-backed price floor to support SAF provision during the early stages of deployment.

RMI Graphic. Source: World Economic Forum, https://www3.weforum.org/docs/WEF_Clean_Skies_for_Tomorrow_Sustainable_Aviation_Fuel_Policy_Toolkit_2021.pdf

Conclusion

The identification of potential growth areas and emerging opportunities for SAF within the Great Lakes region has highlighted pivotal factors that will shape the trajectory of the industry.

The significance of hubs boasting accessible infrastructure capable of integrating transportation and industrial facilities cannot be overstated because they underpin the marketability and distribution efficiency of SAF.

The regional availability of feedstock is equally crucial in terms of both quantity and strategic placement, rendering the region's SAF competitive on a broader scale. Moreover, the alignment of regional biofuel legislation with the necessary feedstock incentives and demand-side mechanisms provides a robust foundation for SAF scalability in the region.

Looking forward, the recommendations for future actions, investments, and policy support underscore the potential to harness existing systems to propel a cost-effective and sustainable bioeconomy. By leveraging the research, development, and deployment capabilities of knowledge hubs, a bridge can be built between innovative research and successful project development.

In the face of these prospects, stakeholders must collaborate synergistically to steer the course of SAF development within the Great Lakes region. The convergence of favorable conditions, supportive legislation, and proven technologies offers a unique opportunity to not only transform the aviation sector but also catalyze positive environmental and economic impact on a regional and global scale.

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