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SAF policy scorecard: Evaluating state-level sustainable aviation fuel policies in the United States

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SUMMARY

Policies to promote the use of sustainable aviation fuel (SAF) have been adopted or are being considered by several U.S. states. This paper compares key provisions in these state policies, analyzes the support offered by state programs to U.S.-relevant SAF pathways, and assesses each policy's ability to support the goals of long-term decarbonization, sustainability, and equity.

Our analysis highlights several shortcomings with many current policies. First, state support for some SAF production pathways may not lead to an increase in the total supply of low-carbon fuel; instead, fuel and feedstock could be redirected from other climate-friendly uses to take advantage of state SAF subsidies. Second, the short duration of some policies means they are unlikely to trigger investments in the advanced SAF pathways needed to meet aviation climate targets. And third, existing policy frameworks subsidize the use of SAF without also imposing a penalty on aviation emissions, violating the "polluter pays" principle.

INTRODUCTION

Jet fuel consumption and accompanying greenhouse gas (GHG) emissions have quickly rebounded in the United States following the COVID-19 pandemic. Aviation fuel consumption in 2023 exceeded pre-COVID levels (U.S. Bureau of Transportation Statistics, n.d.) and emissions surpassed 230 million tons of CO_2. The airline industry considers sustainable aviation fuels (SAFs) to be critical for reaching net-zero emissions by 2050, with SAF accounting for 65% of overall reductions in emissions

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(International Air Transport Association, 2023; United States, 2021). However, in 2023 only 26.3 million gallons of SAF were consumed in the United States (U.S. Environmental Protection Agency, n.d.), which represents just 0.1% of the 25.3 billion gallons of jet fuel supplied in the same year (U.S. Energy Information Administration, 2024). Widespread SAF adoption is impeded by high production costs and by the limited efforts to regulate aviation GHG emissions (ICAO Committee on Aviation Environmental Protection, 2022). Further, the existence of multiple SAF pathways—each with distinct cost profiles and sustainability implications—creates a challenge for policymakers seeking an orderly transition away from petroleum-based fuels. The goal of this paper is to explore the effectiveness of existing state-level SAF policies and to provide recommendations for how future policies might best meet these challenges.

At the federal level, the Biden administration's SAF Grand Challenge (U.S. Department of Energy et al., 2021), released in 2021, establishes ambitious but voluntary targets for domestic production: 3 billion gallons of SAF in 2030 increasing to 35 billion gallons in 2050, which would match total estimated U.S. jet fuel consumption in that year. Accompanying these targets are a series of workstreams for federal agencies, many of which are designed to facilitate a large-scale mobilization of domestic biogenic feedstocks for SAF production (U.S. Department of Energy et al., 2022).

The largest single pillar supporting the SAF Grand Challenge consists of tax credits for SAF production, enacted as part of the Inflation Reduction Act (Inflation Reduction Act of 2022, 2022). For the purposes of these credits, SAF is defined as a "drop-in" fuel, meaning that it can be used without modifying the aircraft, with life-cycle GHG reductions of at least 50% compared with fossil jet fuel. Qualifying fuels receive a per-gallon tax credit which increases in value with further GHG savings, making the details of GHG life-cycle analysis (LCA) calculations important to fuel producers. In the case of biogenic SAF, these credits can be combined with support from the federal Renewable Fuel Standard (U.S. Environmental Protection Agency, 2010). Another source of SAF, power-to-liquid (PtL), can benefit from the IRA's 45V credit for producing clean hydrogen and the 45Q credit for capturing and storing carbon. PtL fuel, also known as e-fuel, is created from renewable electricity-derived hydrogen and CO_2.

The IRA specifies two possible methods for determining the GHG reductions of SAF: the International Civil Aviation Organization's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) framework (International Civil Aviation Organization [ICAO], 2019) or a "similar methodology" adhering to standards outlined in the Clean Air Act (O'Malley & Pavlenko, 2023). What counts as a similar methodology was recently resolved by the U.S. Department of the Treasury with the release of 40BSAF-GREET, a SAF-specific version of Argonne National Laboratory's Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET) model (U.S. Department of Treasury & Internal Revenue Service, 2024). Importantly, IRA credits expire after 2027, creating a gap between the long-term ambition of the SAF Grand Challenge and the long-term financial support and market certainty necessary for further investments in SAF production.

To complement federal efforts, several states have recently implemented policies incentivizing SAF production or use. Given the uncertainty at the federal level, state policies may prove critical in driving SAF adoption. To understand the impacts of state-level policies, this brief will assess their strengths and weaknesses in three key areas:

1. *Long-term decarbonization:* to what extent state policies effectively support the lowest GHG fuel pathways with the greatest potential for scale and technological advancement.
2. *Sustainability:* to what extent state policies have sustainability guardrails sufficient to ensure real emission reductions and minimize adverse environmental impacts.
3. *Equity:* to what extent state policies constitute effective industrial policies supporting local economic development and whether incentives are funded from within the aviation sector.

To address these questions, we first review SAF production pathways most relevant to the United States and provide an overview of existing and proposed policies. We then evaluate these policies using criteria based on the three areas identified above—long-term decarbonization, sustainability, and equity—and assign each state an overall letter grade. Next, we analyze how the combined state and federal support available for different fuel pathways compares with the levelized production costs of various SAFs. Following this, we discuss the implications of state-level policies on SAF deployment. The paper then concludes with recommendations for policymakers considering the adoption or revision of state SAF policies.

OVERVIEW OF SAF PATHWAYS

To help assess the potential impact of state-level SAF policies, we first provide an overview of SAF production pathways to highlight differences in costs, availability, and GHG emissions. Each fuel pathway refers to a combination of feedstock and the technology used to process it. As shown in Figure 1, pathways differ widely in carbon intensity (CI), which indicates a fuel's estimated net GHG emissions from production and utilization. Percentage reductions in GHG emissions are calculated by comparing the CI of SAF against the baseline CI value of fossil jet fuel. The CI scores in Figure 1 are default CORSIA values.[1] These scores include direct, supply chain emissions from fuel production and consumption, referred to as "core-LCA" in CORSIA (ICAO, 2019), as well as "consequential" emissions in the case of crop-derived fuels. These consequential emissions account for the GHG impact of induced land-use change (ILUC); ILUC occurs when land is converted to agricultural use in response to an overall increase in demand for crops because of biofuel production (U.S. Environmental Protection Agency [U.S. EPA], 2023a). For the purpose of this paper, "low-carbon" SAFs are fuels with a reduction percentage of 70% or greater, which is in line with ambitious policies such as the United Kingdom's SAF mandate (U.K. Department for Transport [U.K. DfT], 2023).

Alongside CI, each pathway's scalability, production cost, and technological maturity are also important to consider when assessing policy impacts. In Figure 1, scalability is represented by the ICCT's assessment of production potential based on domestically available feedstocks (O'Malley et al., 2023). Production costs are indicated in dollars per gallon of fuel as found in peer-reviewed studies or assessed by the ICCT in the case of PtL (Pavlenko et al., 2019; Zhou et al., 2022). Technology readiness scores reflect the assessment of the International Energy Agency (International Energy Agency, 2023).

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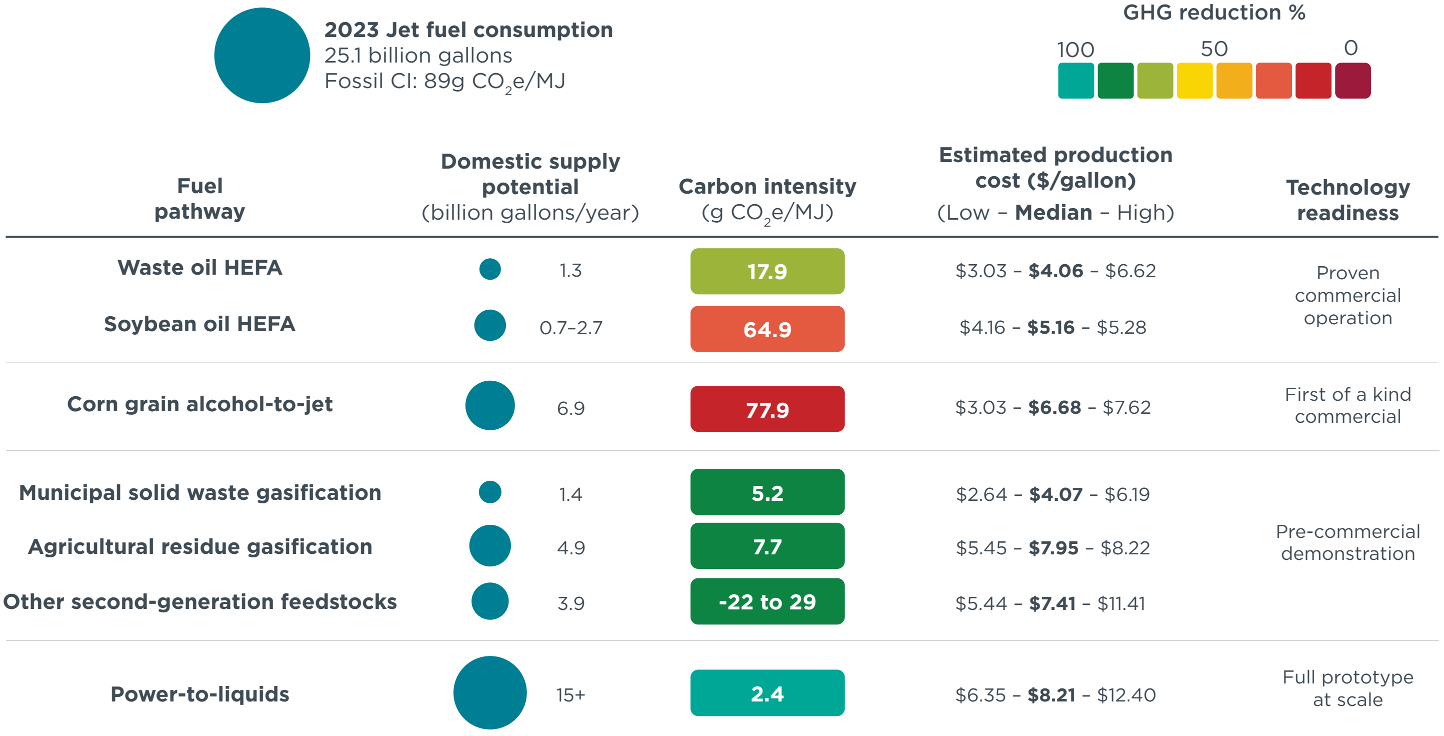
[1] The exception is power-to-liquids, which was estimated using Argonne National Laboratory's GREET model.

Figure 1

Key characteristics of relevant SAF pathways in the United States



2023 Jet fuel consumption
25.1 billion gallons
Fossil CI: 89g CO_2e/MJ

Fuel pathway	Domestic supply potential (billion gallons/year)	Carbon intensity (g CO_2e/MJ)	Estimated production cost ($/gallon) (Low – **Median** – High)	Technology readiness
Waste oil HEFA	1.3	17.9	$3.03 – **$4.06** – $6.62	Proven commercial operation
Soybean oil HEFA	0.7–2.7	64.9	$4.16 – **$5.16** – $5.28	
Corn grain alcohol-to-jet	6.9	77.9	$3.03 – **$6.68** – $7.62	First of a kind commercial
Municipal solid waste gasification	1.4	5.2	$2.64 – **$4.07** – $6.19	Pre-commercial demonstration
Agricultural residue gasification	4.9	7.7	$5.45 – **$7.95** – $8.22	
Other second-generation feedstocks	3.9	-22 to 29	$5.44 – **$7.41** – $11.41	
Power-to-liquids	15+	2.4	$6.35 – **$8.21** – $12.40	Full prototype at scale

Notes: Dollar values are estimated levelized production costs per gallon. Carbon intensities (CI) are CORSIA default values except for power-to-liquids, which was calculated for direct air capture-supplied carbon in R&D GREET 2022 (Wang et al., 2022). Supply-potential estimates are based on domestically supplied feedstock. The range given for soybean oil HEFA is based on maintaining export volumes (low) or maximizing domestic crushing (high). The CI for waste oil HEFA corresponds to the average of CORSIA default values for tallow, used cooking oil, and corn oil feedstock. Waste oil availability is the sum of the potential domestic supply of these feedstocks. The CIs for agricultural residue gasification, corn grain alcohol-to-jet, and other second-generation pathways are the CORSIA default values for agricultural residues FT (Fischer–Tropsch synthesis), corn grain isobutanol ATJ (alcohol-to-jet), and the CI range of herbaceous energy crops FT using miscanthus (low at -29) to waste gases integrated conversion (high at 29). Other second-generation domestic supply is the combined potential of forest residues, energy crops, and flue gases. U.S. power-to-liquids supply potential is taken from the Deutsche Energie Agenture report on e-kerosene for commercial aviation (Breyer et al., 2022).

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The lowest cost and most mature SAF pathways rely on hydroprocessed esters and fatty acids (HEFA) technology. The HEFA process converts oily biological feedstocks into a pure hydrocarbon fuel. However, as seen in Figure 1, a key issue with HEFA-produced SAF is limited scalability. Supplies of more environmentally friendly and lower CI waste oil feedstocks are limited (Greenea, 2021), but using virgin vegetable oil feedstocks for SAF is environmentally risky. For example, there is evidence that increased demand for soy attributable to biofuel production has led to an uptick in palm oil imports to the United States (Santeramo & Searle, 2019). Similarly, the recent decline in U.S. soy exports—caused by more soy being used for domestic biofuel production—has been backfilled with palm and soybean oil produced in Asia and South America (Bukowski & Swearingen, 2023) where deforestation risks are high (Austin et al., 2017; Song et al., 2021).

In the near term, it may also be important to consider the implications of feedstock competition between HEFA SAF and biomass-based diesel and, consequently, the GHG reduction value of redirecting these feedstocks from renewable diesel production to SAF. Taking renewable diesel in California made from used cooking oil (UCO) as an example, this pathway has an average CI of 25.45 g CO_2e/MJ (California Air Resources

Board [CARB], 2024a) compared with 100.45 g CO_2e/MJ (Low Carbon Fuel Standard, 2020a) for petroleum-based diesel, a savings of 75 g CO_2e/MJ. In comparison, the savings per MJ of fossil jet fuel displaced by HEFA SAF from UCO are slightly lower at 65.87 g CO_2e/MJ. Diesel consumption in the road sector will remain substantial for the next decade, likely exceeding 30 billion gallons nationwide in 2030 (Ledna et al., 2022). This suggests that any near-term shifting of biological oil feedstocks to SAF production, as incentivized by federal and state SAF policies, would result in no net GHG reductions.

Over the longer term, feedstock limitations mean HEFA SAF alone will be unable to achieve the 2050 Grand Challenge target of 35 billion gallons, so other pathways must be considered. Based on technological maturity and feedstock availability, the alcohol-to-jet (ATJ) from corn grain pathway would appear to be a good candidate. However, the high CI of this pathway means a 100% shift to corn grain ATJ SAF would represent only a 12% reduction in aviation emissions compared with using fossil jet (Figure 1). While process improvements, such as carbon capture at ethanol facilities, are possible, (Neeley, 2022) the high baseline CI of corn grain ATJ SAF will make it more difficult for this pathway to achieve the GHG savings necessary to contribute to meeting long-term decarbonization targets.

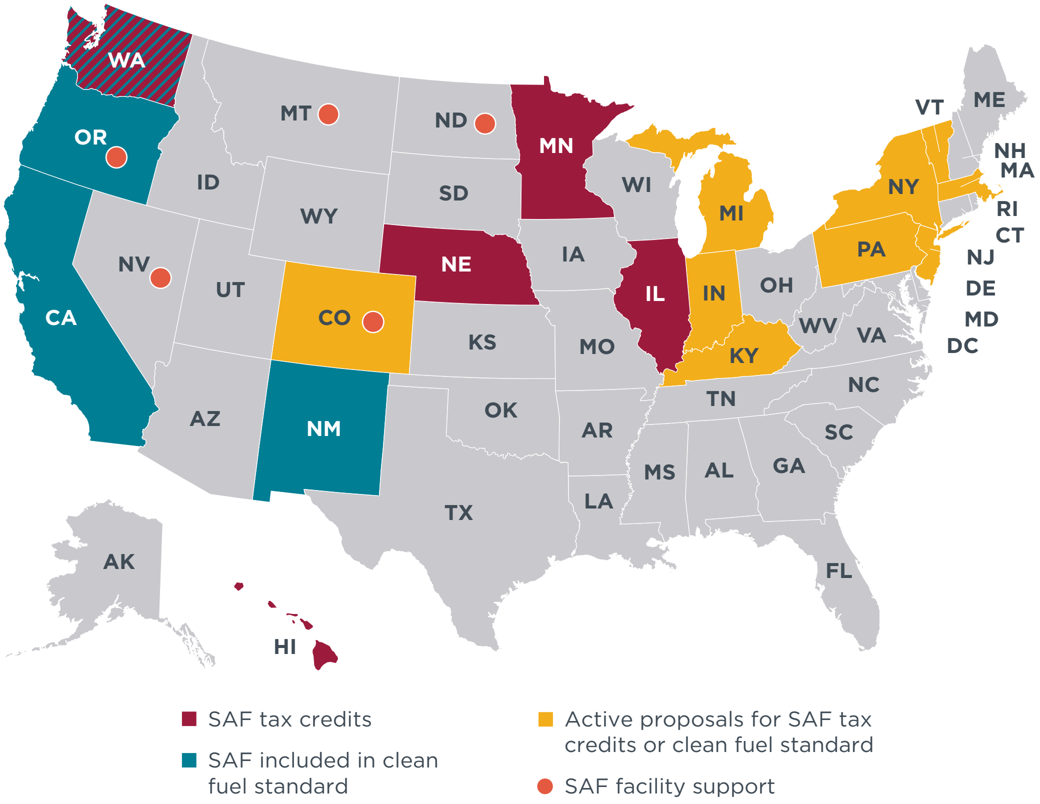
Among the low-carbon pathways represented in Figure 1, agricultural residues and municipal solid waste (MSW) can be processed using emerging second-generation conversion technologies, while renewable electricity can supply energy for PtL synthesis of e-kerosene. For each of these pathways, however, high upfront capital costs and technological impediments present important barriers to investment (Pavlenko et al., 2019). This issue has been partly addressed in the European Union's ReFuelEU Aviation SAF mandate, which excludes crop-based fuels but includes a sub-target for e-kerosene (Baldino, 2023). This could help incentivize investment and provide policy certainty for second-generation and e-kerosene pathways. At present, technology-specific sub-targets or incentives have not been incorporated into any U.S. SAF policy.

OVERVIEW OF EXISTING AND PROPOSED STATE SAF POLICIES

Existing state SAF policies can be broadly divided into three categories, as shown in Figure 2: 1) tax credits applied to each gallon of SAF to offset the costs of production and use; 2) inclusion of SAF into existing, state-level clean fuel standards by allowing SAF to generate program credits; and 3) incentives for constructing SAF facilities. Each of these mechanisms, as implemented or proposed in different states, is described below. A more detailed comparison of these policies, including references to relevant statutes, can be found in Tables A1–A6 in the appendix.

Figure 2

State-level SAF policies



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SAF production or consumption tax credits

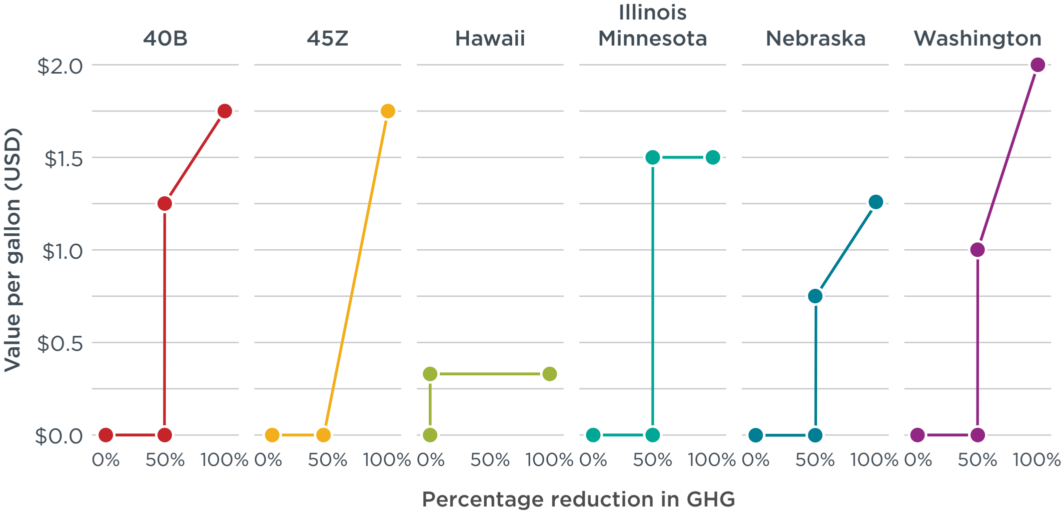
Policies adopted in five states include a tax credit providing a specific amount of tax relief for every gallon of SAF produced or consumed. This framework—which is also found in the IRA 40B Sustainable Aviation Fuel Credit (Sustainable Aviation Fuel Credit, 2022) and the 45Z Clean Fuel Production Credit (Clean Fuel Production Credit, 2022) starting in 2025—has been adopted by Hawaii, Illinois, Minnesota, Nebraska, and Washington, and has been proposed in Kentucky and Michigan (see Tables A1 and A2). Credits in all states except Hawaii borrow language and structure from the SAF credits in the IRA while changing the level of support, which ranges from a fixed $0.33 per gallon credit in Hawaii to a proposed $2.50 per gallon credit in Kentucky.

As with IRA credits, eligibility for the state tax credits is primarily determined via thresholds for a fuel's life-cycle carbon intensity. Hawaii has the least stringent requirements: Any fuel produced using a renewable feedstock that has a CI below that of fossil fuels qualifies for the credit. Other states have adopted the IRA's 50% reduction threshold. IRA credits also provide additional value for each percentage point reduction in CI below the 50% threshold. This mechanism has been adopted in Nebraska and Washington and is part of the proposed SAF legislation in Michigan

(Figure 3). Indiana is unique in being the only state with a proposed tax credit for producers of grain feedstocks that are grown in the state and used in SAF production.

Figure 3

Tax credit values compared with greenhouse gas reductions



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Given the role of life-cycle GHG accounting in determining tax credit eligibility and the value of subsidies, it is important to clarify which LCA methods are applicable to state SAF policies. The 40BSAF-GREET model or its successor will likely be applicable to tax credits enacted in Illinois, Minnesota, and Nebraska; these states require an LCA methodology for SAF that must either adhere to federal standards or the most recent version of GREET.

Washington State will apply CI values based on the WA-GREET model used in its clean fuels program. Notably, the WA-GREET model uses ILUC values derived from the California Low Carbon Fuel Standard (LCFS) regulatory assessment. LCFS values are similar to CORSIA and EPA values but are approximately double those of 40BSAF-GREET (Table A9).

Other differences in state production tax credits include restrictions on palm oil, imported feedstocks, and non-biogenic feedstocks. Some states also set minimums for the volume of SAF a taxpayer must supply to qualify for credits and annual caps on the dollar value of credits dispersed either to individual taxpayers or through the program as a whole. Particularly noteworthy is a cap in Illinois on the total volume of eligible soybean oil-based SAF of 10 million gallons per year. States also differ on giving taxpayers a direct payment or refund for any credits earned that exceed what they owe in taxes. Minnesota's SAF credits are refundable while Nebraska and Washington expressly forbid refunds. In most states fuel providers apply for credits, while in Illinois and in the proposed Kentucky legislation, it is the fuel users who are eligible for tax credits.

SAF in clean fuel standards

An alternative way to subsidize SAF is to include it in a state's existing policies for promoting clean fuels, which until recently have focused exclusively on the road sector. CI-based clean fuels programs have been adopted in New Mexico, Oregon, and Washington (Table A3) and are largely based on the LCFS adopted by California in

2007. In this style of program, providers of fuels with CIs below a benchmark threshold receive credits which can be sold to producers or importers of fuels with CI scores above the benchmark. In this way, the use of conventional fuels with CI scores above the benchmark becomes more expensive—because producers must buy credits to offset the too-high CI score—while the use of lower CI fuel is subsidized via the sale of credits. Importantly, the target CI benchmark decreases over time, though these trajectories differ by state. Clean fuel standards have also been proposed in Colorado, Illinois, Massachusetts, Michigan, Minnesota, New Jersey, New York, Pennsylvania, and Vermont, (Table A4).

To incentivize SAF, the states of California, Oregon, and Washington have allowed SAF to generate credits through what is known as an "opt-in" provision (Low Carbon Fuel Standard, 2020b). Under this opt-in framework, SAFs generate credits that producers can sell or bank; the value of these credits depend on the current price of credits and the difference between the CI of the SAF and the current CI benchmark for jet fuel. However, fossil-based aviation fuels—unlike fossil gasoline and diesel for road transport—do not generate deficits that must be offset by the purchase of credits. California, Oregon, and Washington use state-specific versions of the GREET model to determine fuel CI, with the primary difference being higher ILUC values than the default 40BSAF-GREET emission factors (Table A9).

Though opt-in provisions can generate value for SAF producers, the market impacts may be muted (Pavlenko & Zheng, 2024). Because these opt-in programs do not obligate the purchase of credits to offset the high CI of fossil jet fuel, the cost gap between SAF and fossil jet is less effectively narrowed. Additionally, under this framework, subsidies for SAFs are funded through the purchase of credits to offset excess GHG emissions generated by gasoline and diesel used in road transport, which results in a cross-sectoral subsidy (Pavlenko & Mukhopadhaya, 2023). To help address this inconsistency, California issued a proposal to include jet fuel used on intrastate flights, which represents approximately 10% of the state's overall jet fuel consumption, in the LCFS (CARB, 2023). However, that proposal has been withdrawn (CARB, 2024b).

Other state SAF policies

Rather than subsidize in-state use or production of SAF, some states have implemented policies to directly support construction of in-state SAF production facilities (Table A5). Colorado enacted a tax credit covering 30% of in-state capital investment for SAF facilities constructed before 2027; the eligible percentage of investment gradually declines to 12% for facilities constructed after 2029 and expires in 2033. Meanwhile, Montana and North Dakota have updated existing tax provisions to support SAF facilities. Montana included SAF facilities in its reduced "Clean and Green" property tax rate. North Dakota is exempting materials used for construction of SAF facilities from state property and use taxes. Two states have used industrial revenue bonds to support specific projects: the Fulcrum Sierra Biofuels plant in Nevada (Associated Press, 2017) and the Red Rock Biofuels facility in Oregon (Lane, 2018). Both projects failed before starting commercial operations.

CRITERIA FOR COMPARING STATE-LEVEL SAF POLICIES

Achieving successful SAF deployment will require a balance between spurring investment in SAF production and safeguarding against negative environmental impacts. To assess the likely effectiveness of each policy in achieving this balance, we developed criteria related to three overall goals: long-term decarbonization, sustainability, and equity. These goals and the related criteria are outlined in Figure 4.

We then assigned ratings (1-poor, 2-fair, or 3-strong) for each criterion as explained in Table 1. To determine overall grades, the scores were averaged and letter grades were assigned using the cutoff values in Table A7. A more detailed explanation of these categories and the criteria for assigning ratings is provided below.

Figure 4

Overview of evaluation criteria for state SAF policies

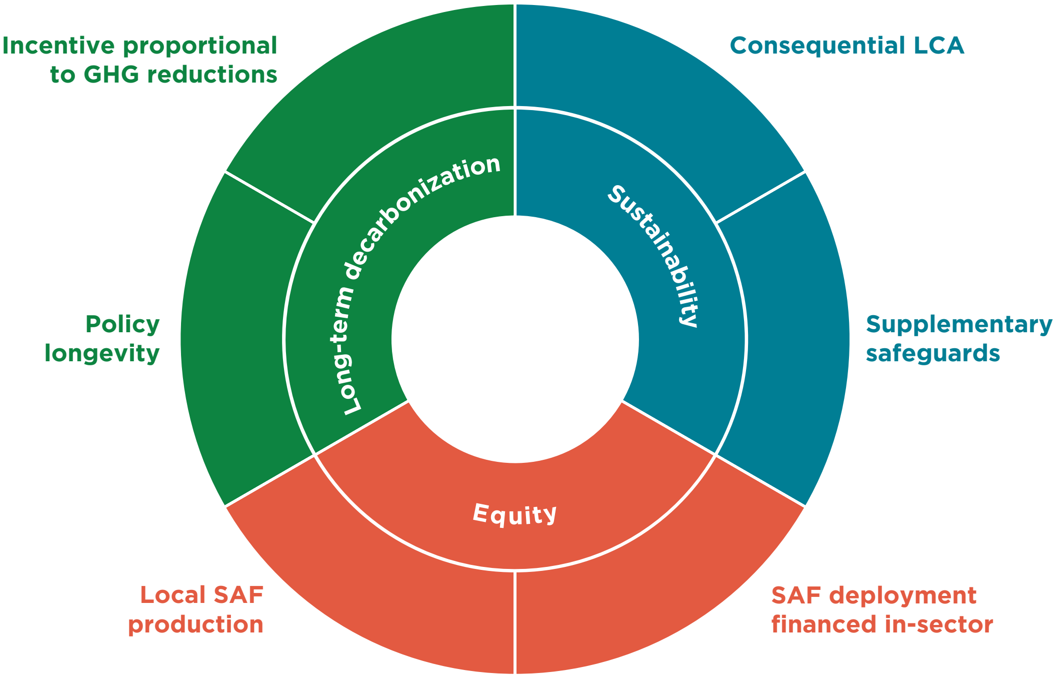

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Table 1

Policy grading criteria

Category	Parameter	Poor (1)	Fair (2)	Strong (3)
Long-term decarbonization	Incentive proportional to GHG reductions	No GHG savings threshold	Equal treament of fuels meeting 50% threshold	Support increases with greater CI reductions
	Policy longevity	Support is for less than 10 years	Support is for 10 years	Support is for longer than 10 years
Sustainability safeguards	Consequential LCA	No consequential LCA	Consequential LCA	Consequential LCA with CORSIA ILUC values or similar
	Other safeguards	No feedstock restrictions or palm oil exclusion only	Feedstock restrictions or non-GHG criteria	Combines feedstock restrictions and non-GHG criteria
Equity	In-state production or feedstock requirements	Only criteria is in-state fueling of aircraft	Policy preference for locally produced fuels	Policy supports SAF made in local facilities only
	Funding from within aviation sector	Support funding comes from outside the aviation sector	Support is funded from mixed sources including aviation	Support funding comes from aviation sector

LONG-TERM DECARBONIZATION

Achieving long-term aviation decarbonization will require the deployment of scalable SAF pathways that are both abundant and offer deep GHG savings (Graver et al., 2022). Figure 1 provides an overview of how the cost, GHG impact, and resource availability of different SAF pathways compare to one another. Scalability of SAF produced using mature HEFA technology is limited by the availability of feedstocks also used to produce biomass-based diesel for the road sector (O'Malley et al., 2023; Zhou et al., 2020). As a consequence, policies with strong incentives for HEFA SAF production may lead to the "shuffling" or moving of resources between sectors and locations rather than a net expansion of low-GHG liquid fuel production (Pavlenko & Zheng, 2024). This is especially true for short-term policies which fail to provide a meaningful signal for less technologically mature fuel pathways (Markel et al., 2018). These pathways face additional challenges securing buyers, as well as regulatory, feedstock, and financing barriers (Peters et al., 2016). Therefore, this study assigns greater value to those policies which deliver proportionally more incentives toward SAF pathways with lower CI and establish long-term policy certainty for SAF producers. In contrast, policies that are short term, or which have incentives that can be easily accessed by shuffling existing feedstocks consumed in the road sector, score lower. To assess the ability of state policies to support these pathways we have scored them on the following two criteria:

Incentive proportional to greenhouse gas reductions

Though low carbon second-generation and PtL SAF pathways generate substantial GHG savings, they also have much higher costs than existing, commercialized fuel pathways, creating a meaningful barrier to their deployment. To help overcome this barrier, policies can provide an extra incentive to producers of these fuels and differentiate them from existing, commercialized pathways. To assess the strength of the relationship between incentives and carbon reductions, we have scored policies using a 50% reduction threshold as a baseline.

- **Poor:** No threshold CI to qualify
- **Fair:** 50% GHG reduction required to qualify for support
- **Strong:** Incentive increases for GHG reductions beyond 50%

Policy longevity

SAF facilities are generally expected to operate for 20 to 30 years (Wang et al., 2021). Even with technological improvements, SAF production costs are unlikely to achieve parity with fossil jet production in the foreseeable future (Bonnefoy & Schaufele, 2022). For investors in new facilities to include state SAF policies in their revenue expectations, it is therefore critical that state support can be counted on for at least 10 years. In contrast, a short-lived policy is more likely to incentivize redirection of feedstock to boost production at existing eligible facilities. To assess policy longevity, we have scored state policies using a 10-year baseline.

- **Poor:** Support expires in less than 10 years
- **Fair:** Support continues for 10 years
- **Strong:** Support extends beyond 10 years

SUSTAINABILITY

The sustainability implications of alternative fuels can vary widely depending on what feedstock they are sourced from and their conversion process to fuel. As seen in Figure 1, domestically sourced SAFs considered in this paper can have GHG reductions ranging from just a 12% improvement over fossil jet fuel in the case of the corn grain alcohol-to-jet pathway, to nearly 100% in the case of power-to-liquid SAF derived from renewable electricity. It is therefore essential that incentives for the production and utilization of SAF have safeguards to ensure that intended emission reductions are achieved while avoiding negative environmental impacts. In particular, policies which do not adequately account for limited global feedstock supplies and the market-related effects of feedstock production could overstate the GHG reductions benefit of using crop-based fuels (Arima et al., 2011; U.S. Environmental Protection Agency, 2023b). The carbon emissions and ecological damage (National Research Council, 2011) associated with land-use conversion may even exceed those of the fossil fuels they replace (Pavlenko & Searle, 2021). Likewise, policies which support fuel production from waste oil feedstocks without ensuring these resources are truly waste oils may exaggerate the environmental benefits of policy support and incentivize fraudulent imports (Moskowitz et al., 2023). To assess the strength of sustainability safeguards in state SAF policies, we have scored policies based on the following criteria:

Use of consequential life-cycle analysis

Accurately evaluating the GHG impact of alternative fuels requires assessing not just the direct emissions from fuel production and consumption but also the "consequential" emissions that result from the diversion of resources from existing uses to fuel production (Malins et al., 2014). For crop-derived fuels in particular, consequential LCA is critical to accounting for the GHG impact of induced land-use changes from biofuel production. To ensure that accompanying indirect emissions are not undercounted, it is important to use consequential LCA with conservative ILUC values. To assess each policy's strength in this area we have used the following criteria.

- **Poor**: No consequential LCA
- **Fair:** Consequential LCA
- **Strong**: Consequential LCA with ILUC values in line with CORSIA standards or previous regulatory assessments

Supplementary, non-GHG sustainability safeguards

The environmental impacts of fuel production and utilization extend beyond the climate effects captured in a fuel's carbon intensity. For example, feedstock cultivation may impact biodiversity and deplete or pollute water resources (Gerbens-Leenes et al., 2009; Tudge et al., 2021; U.S. EPA, 2023b). Increased demand for feedstock may also drive up food prices (O'Malley & Searle, 2021). To address these issues, policies may restrict fuel eligibility based on non-GHG sustainability criteria. Restrictions may take the form of exclusions or limits to fuel produced using certain feedstocks or alternatively require that feedstock and fuel production minimize environmental harm. For example, the exclusion of palm oil-based fuels is widespread in biofuel policy. There is also increasing recognition that the interchangeability of vegetable oils in global markets means limiting the use of virgin vegetable feedstocks more generally could help prevent environmental and food price impacts (Gibbs et al., 2024). CORSIA requires the assessment of non-GHG life-cycle impacts and sets standards for fuel eligibility in categories such as soil, air, water, and conservation (ICAO, 2022). In the absence of volume limits, incorporating sustainability criteria such as that found in CORSIA or the EU Renewable Energy Directive II (Giuntoli, 2018) into statutes may enable state policy administrators to exclude SAF production with demonstratable negative environmental impacts. We use the following criteria to judge additional sustainability safeguards:

- **Poor:** No feedstock restrictions or an exclusion of palm oil only
- **Fair:** Includes limits on risky feedstocks or non-GHG sustainability criteria
- **Strong:** Includes both limits on risky feedstocks and non-GHG sustainability criteria

EQUITY

The climate-related provisions in the IRA have a dual goal of creating positive economic opportunities while also decreasing long-term GHG emissions (Van Nostrand & Levinson, 2023). Ideally, state-level SAF policies can mirror these ambitions. Additionally, given that wealthy frequent fliers are disproportionally responsibility for aviation emissions (Gössling & Humpe, 2020; Zheng & Rutherford, 2022), it would therefore be regressive for state SAF incentives to draw funding from unrelated sectors or from general government funds. These goals can be accomplished by prioritizing support for local SAF production and by also requiring that subsidies be offset by sector-specific taxation or obligations under clean fuel standards.

Local SAF production

Policies which focus support on local production can boost in-state employment, generate taxes to offset SAF subsidies, reduce the environmental burden of fuel transport, and help ensure that state-supported SAF production is additional to what might have been produced in the absence of state policies. To score policies on local production criteria we use the following categories:

- **Poor:** Covers in-state fueling of aircraft only
- **Fair:** Includes preference for locally produced fuels or feedstocks but still subsidizes imports from out of state
- **Strong:** Supports SAF made in local facilities or with local feedstocks only

SAF deployment financed in-sector

A drawback of opt-in SAF provisions in fuels policies is that SAF credits are funded by obligated parties in the road sector that must pay to obtain the credits (Pavlenko & Zheng, 2024). Likewise, SAF tax credits which are not offset by taxes on fossil fuel use in the aviation sector violate the “polluter pays” principle of smart environmental policy (Rutherford, 2022). To score policies on the source of SAF subsidy funding, we use the following criteria:

- **Poor:** Incentives are funded from outside the aviation sector
- **Fair:** Incentives are funded from mixed sources including the aviation sector
- **Strong:** Incentives are funded from within the aviation sector

CREDIT VALUE CALCULATIONS

In addition to scoring each policy on the criteria described above, we have also assessed the likely total level of support available to key SAF pathways which are either currently producing or have the potential to contribute significant future volumes. To calculate the total support values for each SAF pathway in each state, we added state-specific policy support to federal support. Credit values are calculated for the year 2027 to include the value of federal tax credits; we note that the future value of Renewable Fuel Standard (RFS) credits is an estimate and that the actual value in 2027 will be subject to biofuel supply dynamics in the road sector. Beyond 2027, Federal 45Z tax credits expire and the level of federal SAF support becomes uncertain. The combined value of 45V hydrogen credits and 45Q carbon capture credits for the power-to-liquids pathway is estimated to be $4 per gallon based on Cheng et al. (2023).

Except for Hawaii, each state's policy has a specific life-cycle GHG emission criteria. To determine the credit values in each state, we calculated CI values using the applicable LCA methodology as shown in Table A8. CI scores for California were calculated by averaging the CI scores of certified SAF pathways currently registered in the LCFS in each category using domestically supplied feedstocks (CARB, 2024a). A summary of CI scores for each pathway and LCA method can be found in Table A10. To determine per gallon credit values in California, Oregon, and Washington, we applied average values of $150, $130, and $100 per credit, respectively, to reflect 5-year-average values in California and Oregon and recent values in the Washington program. Per-gallon subsidies were calculated using each state's credit calculator tool for the year 2027 (CARB, 2019; Oregon Department of Environmental Quality, 2022; Washington State Department of Ecology, 2023).

Assumed fuel production costs and federal credit values are taken from O'Malley et al. (2023), except for PtL e-kerosene production costs which are taken from Zhou et al. (2022). The 45Z credit values were computed using CI scores from 40BSAF-GREET for soybean, distillers corn oil, used cooking oil, and tallow HEFA and corn grain ATJ fuels. E-kerosene production cost in 2027 was estimated by averaging 2025 and 2030 cost projections for the United States. Corn oil, UCO, and tallow HEFA values credit values were averaged to produce the waste oil HEFA credit values as shown in Figure 4.

STATE SAF POLICY RANKINGS

As can be seen from the ratings in Table 2, current and proposed SAF polices generally lack provisions to ensure that the goals of long-term decarbonization, sustainable fuel production, and local benefits are all fully met.

Table 2

State SAF policy scorecard

			Long-term decarbonization		Sustainability safeguards		Equity	
	State	Grade	GHG reduction bonus	Policy longevity	Consequential LCA	Other safeguards	In-state production	Funding within sector
Active	**California**	**B**	3	3	3	2[a]	1	1
	Washington	**B**	3	3	3	1	2	1
	Nebraska	**C+**	3	1	2	1	3	1
	Oregon	**C+**	3	3	2	1	1	1
	Illinois	**C**	2	2	2	2	1	1
	Minnesota	**D**	2	1	2	1	1	1
	Hawaii	**D-**	1	2	1	1	1	1
Proposed	**Indiana**	**C+**	2	3	1	1	3	1
	Michigan	**C-**	3	NA	2	1	1	1
	Kentucky	**D**	2	1	2	1	1	1

🟥 Poor: 1 🟧 Fair: 2 🟩 Strong: 3

[a] Sustainability requirements for biomass feedstocks are proposed.

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The grades, ranging from B to D-, reflect both the stronger and weaker aspects of SAF policies in the states:

» In California, Oregon, and Washington, the combination of policy longevity and crediting mechanisms provide a greater incentive for low-carbon SAF; this should create a favorable environment for investment in SAF production facilities aligned with long-term decarbonization goals. However, serious drawbacks include the absence of caps on limited-feedstock HEFA fuels and the opt-in nature of SAF support, which places the burden of SAF subsidies on the road sector.

» Washington's tax credit, which can be combined with clean fuels program support, could create an additional incentive for deployment of second-generation facilities.

» In Illinois and Minnesota, tax credits with fixed per-gallon subsidies do not prioritize low-carbon fuels, and the limited longevity of these policies make them less relevant for developers seeking to finance construction of new facilities. These policies likewise fail the "polluter pays" test, as tax incentives are not offset by an additional penalty for fossil jet consumption.

» Illinois' inclusion of a cap on SAF derived from soybean oil is noteworthy, as this provision is unique among state and federal policies in directly addressing the issue of feedstock supply limitations.

» Finally, California's proposed sustainability requirement for biomass-derived fuels is an important first step in recognizing the non-GHG impacts of biofuel production.

COMPARING THE VALUE OF STATE-LEVEL SAF POLICIES

To analyze the effects of state policies on a particular SAF pathway, it is helpful to compare estimated fuel production costs to the revenue the fuel would generate by combining fuel sales with federal and state policy support. Cost-effective pathways with adequate feedstock availability are likely targets for investment, while those that remain costlier than fossil jet even with incentives are unlikely to be pursued.

For cost-effective but feedstock-constrained pathways, competition for feedstock and limits to total fuel production volume must be considered. If state policy support increases demand for these fuels, demand for feedstock should increase as well, but without additional supply, an increase in feedstock prices is likely. This could make the use of these fuels more expensive rather than less expensive as a result of state support. Redirection of fuels to jurisdictions with the most valuable combination of subsidies is also possible (Eggert & Greaker, 2012; Whistance et al., 2017).

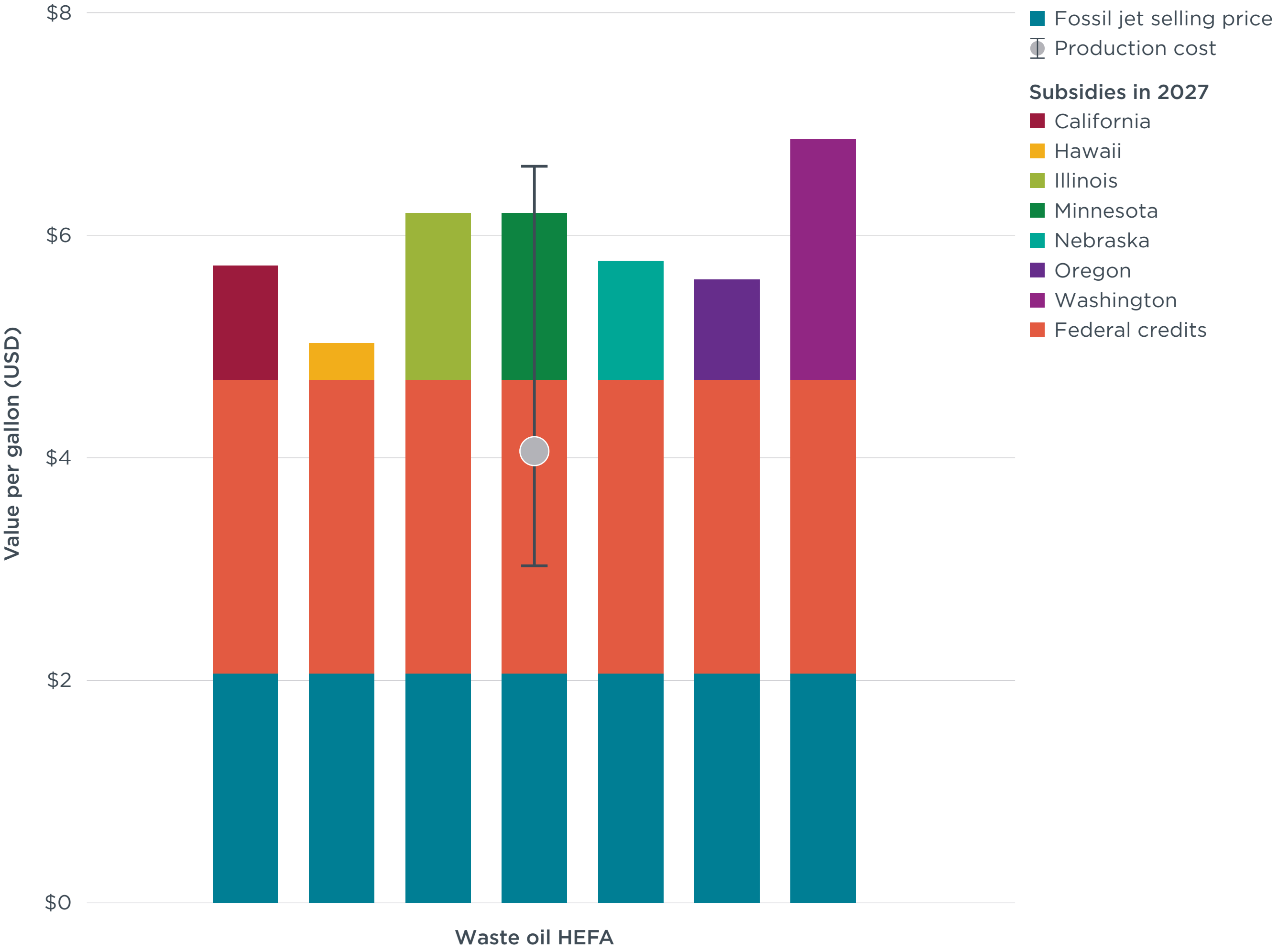
For this analysis, we have grouped pathways which share important feedstock and sustainability characteristics. The values of RFS credits, clean fuel standard credits, and the selling price of fossil jet are intended to be representative. Actual values will depend on market conditions.

SUBSIDIZED VALUE OF HEFA SAF FROM WASTE OIL

The majority of SAF in the market today is produced using waste and byproduct lipid feedstocks processed using HEFA technology (Washington, 2023). As seen in Figure 1, this pathway combines technological maturity, low cost, and GHG reductions of 70%–80%, but feedstock supplies are limited. Figure 5 compares the per-gallon cost of fuel production with the combined value of the fuel to producers, which we assess by stacking federal and state subsidies, with an assumed selling price equivalent to fossil jet. At the bottom of the stack is the $2.06 per gallon selling price for jet fuel. On top of this we add the value of federal renewable fuel standard (RFS) credits and IRA 45Z credits, worth an estimated $1.48 and $1.15 respectively, for a total federal credit value of $2.63 per gallon. Finally, we add the value of credits from statewide SAF policies, which range from $0.33 in Hawaii to $2.17 in Washington, for a total fuel value of $5.03 per gallon to $6.86 per gallon. Also shown in Figure 5 is the estimated cost of producing waste oil HEFA SAF at $4.06 per gallon, along with error bars showing the range of production costs for this pathway compiled in Pavlenko et al. (2019). We find that even in the absence of state policies, the net value of the waste oil SAF HEFA pathways would exceed production costs.

Figure 5

Subsidies for HEFA SAF from waste oil compared with production cost



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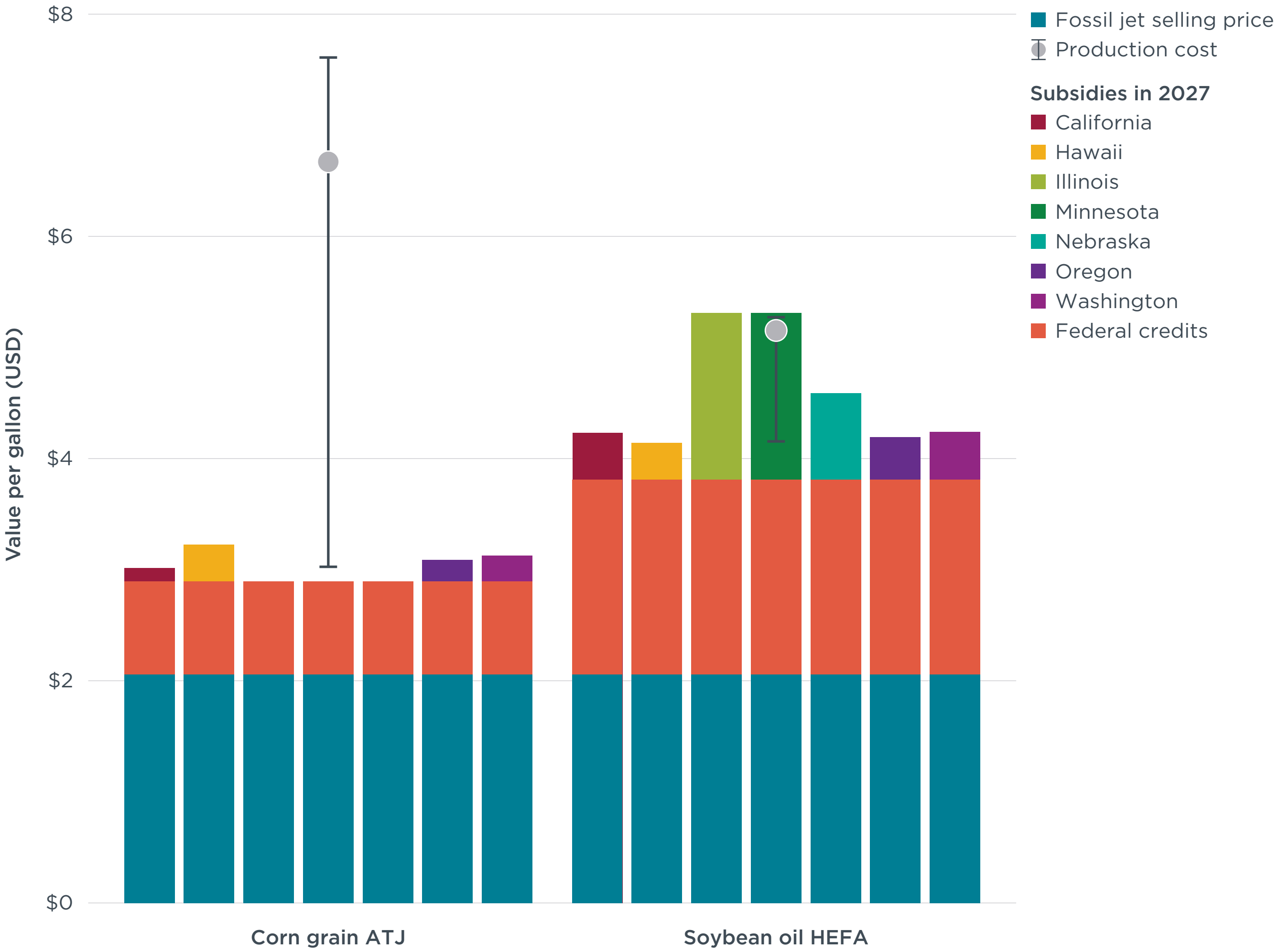
As seen in Figure 5, subsidies for waste oil HEFA in Minnesota and Illinois add an additional $1.50 per gallon to federal credits. Additionally, once the in-state production facility requirement is met for Washington, SAF credits there would exceed those in other states by 60 cents per gallon, making Washington an attractive destination for SAF made from waste oil feedstock.

SUBSIDIZED VALUE OF CROP-BASED SAF

Figure 6 compares the production cost of crop-based SAF with policy credits and the likely sales price to determine the overall market value of these fuels. Based on this analysis, the relatively high production costs and CI of corn grain ATJ mean that this pathway is not projected to be economically viable in 2027 in any state under current federal policies. In contrast, tax credits in Illinois and Minnesota could contribute to maintaining the viability of SAF made from soybean oil.

Figure 6

Subsidies for crop-based SAF compared with production cost



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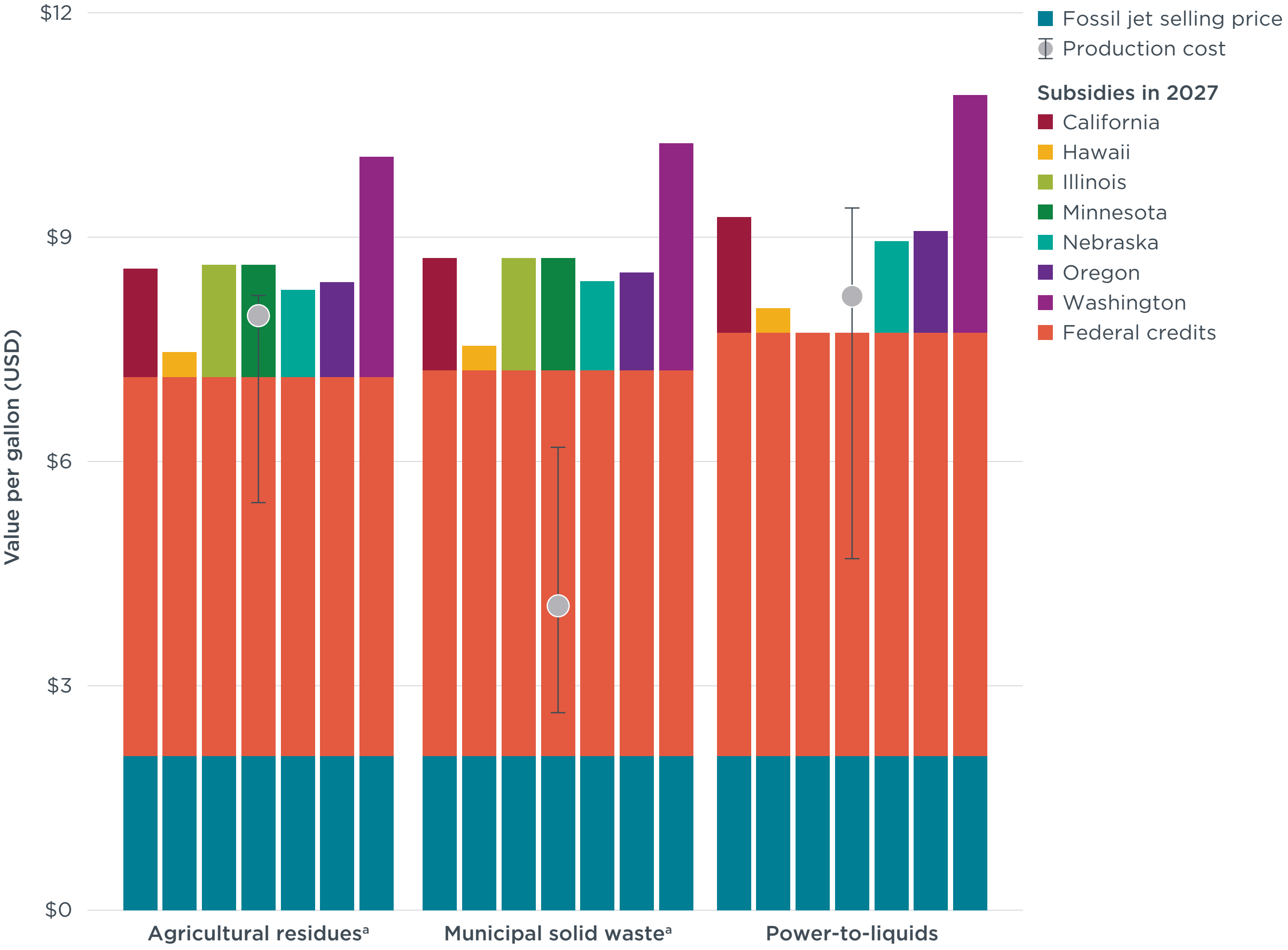
SUBSIDIZED VALUE OF SECOND-GENERATION SAF

Cellulosic feedstocks, including agricultural and forest residues, as well as energy crops such as miscanthus, represent by far the most abundant potential source of biomass-derived SAF. These second-generation biofuels have a low CI, but the high capital costs and technological challenges of converting the feedstocks to liquid fuel have so far prevented significant production (Figure 1). State SAF policies could play an important role in ensuring the viability of fuels from agricultural residues and incentivize construction of production facilities. Based on our analysis, SAF from agricultural residues would be viable in six states (Figure 7). Washington's combined clean fuel standard and SAF tax credits, along with the federal 45Z and RFS credits, would add just over $8 per gallon of total support to the selling price of jet fuel. Based on the analysis shown in Figure 7, we find that producing SAF using municipal solid waste should be viable; state policies may help incentivize the high level of capital investment required. The PtL pathway may also be economically viable after combining IRA credits with state policy support in California, Nebraska, Oregon, and Washington.

Figure 7

Subsidies for second-generation SAF compared with production cost



[a]Gasification followed by conversion to SAF through the Fischer–Tropsch process

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DISCUSSION

Meeting SAF Grand Challenge 2050 targets while also reducing aviation GHG emissions in the United States to levels consistent with the Paris Agreement will require rapid expansion of production capacity. However, with the expiration of federal tax credits in 2028, the prospect for this growth is uncertain. While the history of federal alternative fuels credits would suggest that these credits will likely be extended in some form (Kotrba, 2019), uncertainty disfavors long-term investments in additional production. Effective statewide SAF policies could help fill this gap by providing a stable supplement to federal policy, thereby reducing GHG emissions from a sector that is challenging to decarbonize and supporting local economies. Conversely, policies which result in the shuffling of SAF to states with the most generous subsidies, or in a reallocation of feedstock that was already destined for use in fuel production, will have a very low GHG reduction return on investment. This risk is most evident with state support for HEFA fuels that rely on the limited supply of feedstocks currently used in large part for bio-based diesel production (Calderon et al., 2024). A summary of SAF policy risks and policy solutions can be found in Table 3.

Table 3
SAF policy risks and recommendations

Policy risk	Policy solution
Subsidies go to lower cost fuels offering marginal GHG reductions	Make subsidy values proportional to GHG reductions
Subsidies fail to spur new investment because of uncertainty about future support levels	Enact durable policies that provide certainty to investors well in advance of fuel production
Policy support for crop-based SAF causes ILUC emissions	Use consequential LCA with rigorous ILUC penalties
Shuffling of fuels or feedstocks based on subsidies, waste-oil fraud	Cap HEFA fuels derived from lipids
Non-GHG environmental impacts from fuel production	Require fuels to meet CORSIA sustainability standards
Incentives prioritize reductions in aviation emissions without regard to lower-cost GHG reductions or local benefit	Prioritize locally produced SAF
Policies use general or road-sector funding to support aviation decarbonization	Penalize fossil jet consumption through payments to offset emissions

THE ROLE OF HEFA SAF IN STATE POLICIES

More than 90% of SAF today is produced via HEFA treatment of vegetable or waste oil feedstocks (Washington, 2023). As seen in figure in Figure 5, we project that combined RFS and 45Z tax credits are already sufficient to make waste oil HEFA SAF commercially viable without further state support. Nevertheless, HEFA SAF supplies are limited relative to overall jet fuel consumption. In 2022, 1.1 billion gallons of jet fuel were consumed in Illinois alone compared with a total volume of 24.5 million gallons of SAF produced in the entire United States in 2023 (U.S. EPA, n.d.). Considering that SAF policies in five states will likely provide a dollar or more per gallon of additional support for these fuels, a near-term consequence of these policies is likely to be the shuffling of HEFA SAF to states with the strongest incentives. An example of policy-driven shuffling of lipid-based fuels can be found in the road sector: Bio-based diesel consumption supported by the LCFS in California has grown at the expense of consumption in other states (Martin, 2024). As with renewable diesel, shuffling of HEFA SAF to states with the most supportive policies does not create additional GHG reductions.

State SAF policies can also drive an expansion of HEFA SAF production capacity, but GHG savings are likely to be limited. Because increasing HEFA SAF capacity requires only a moderate investment in reconfiguring renewable diesel facilities (Schroeder, 2024; Robertson, 2024), the primary barrier to producing greater volumes is feedstock limitations. If growth does occur, options for expanding the supply of waste oil feedstocks are limited and entail significant drawbacks. Diversion of domestic supplies from the road sector is possible but, as described earlier, this does not lead to net GHG reductions. An increase in UCO imports from Asia is also possible, but the risk of fraud (European Commission, 2022) may be difficult to mitigate even with more rigorous certification requirements (International Sustainability and Carbon Certification, n.d.);

the supply is also fundamentally limited (Kristiana et al., 2022). In the absence of state incentives, UCO collected in Asia would also likely be used to make fuels supported by other international policies (Giuntoli, 2018; "Japan to require," 2023; U.K. DfT, 2012), which means that diverting these feedstocks to SAF production within the United States will again lead to minimal additional GHG reductions. Furthermore, as greater percentages of waste and byproduct feedstocks are used to produce fuels, alternative uses such as soap production or livestock feed will be increasingly forced to instead rely on less sustainable inputs (O'Malley et al., 2021).

Finally, despite higher CI values and therefore lower incentives, producers may also turn to soybean and other vegetable oils as feedstocks. Incentives for soybean oil SAF are highest in Minnesota and Illinois (Figure 6): Fuels meeting the 50% reduction threshold receive a fixed $1.50 per gallon credit and the use of 40BSAF-GREET to calculate CI allows the 50% reduction threshold to be met (Figure 3). Increased soybean oil supply could be accomplished by either redirecting vegetable oil from food to fuel within the United States or by increasing the domestic crushing of soybeans for greater oil extraction. In either case, the loss of vegetable oil from the total global supply will likely lead to the expansion of oilseed cultivation in areas with a high risk of deforestation (Bukowski & Swearingen, 2023; Santeramo & Searle, 2019), thus offsetting a major portion of the GHG savings from use of soybean oil based fuel (U.S. EPA, 2023a). As incentivizing soybean oil SAF results in minimal GHG savings, the 10-million-gallon annual cap on subsidized SAF from soybean oil in Illinois is a significant step in the right direction. Caps on lipid SAF as proposed in the United Kingdom (U.K. DfT, 2024) and recommended by ICCT for the California LCFS (O'Malley et al., 2022) could help guard against further subsidizing competition for a limited pool of feedstock.

SUPPORT FOR SECOND-GENERATION FUEL PATHWAYS

Compared with HEFA fuels, low carbon second-generation pathways have much higher capital costs and carry the risk of implementing less mature technologies (Brown et al., 2020). Overcoming these barriers to investment will likely require extra incentives for higher reductions in GHG coupled with high overall levels of support or a mandate to use second-generation fuels. Washington state's combined tax credit and clean fuel standard, which provide about $3 per gallon for low-carbon fuels, could create such an environment (Figure 6). Washington's SAF policies do not have an expiration date, which offers the longevity needed to incentivize investment.

In contrast, Minnesota provides an example of an SAF policy unlikely to meaningfully impact long-term aviation decarbonization. As with Illinois (Figure 3), the credit structure in Minnesota provides no incentive to produce fuels with GHG savings beyond 50%. Furthermore, the capped value of Minnesota's tax credit means that it can be used to support a maximum of 7.7 million gallons of fuel over an approximately 7-year period; this is equivalent to 0.4% of in state demand, based on 2022 consumption (U.S. Energy Information Administration, 2023). This level of policy ambition is unlikely to incentivize producers to take action beyond transporting SAF that would have been produced elsewhere to Minnesota.

To further improve the utility of tax credits for promoting low-carbon SAF in the United States, the IRA's 45Z credits for and 45Q credits for carbon sequestration are instructive. As shown in Figure 3, 45Z credits increase linearly for additional GHG savings so that fuels with 90% or greater reductions receive significantly greater support than those just exceeding the 50% eligibility threshold. This creates strong incentives to pursue pathways with maximum GHG reductions. Section 45Q credits are long-lived; facilities to sequester carbon are guaranteed 12 years of production credits once entering operation. Providing a similar guaranteed credit period of 12 to 15 years for state or federal SAF credits could help establish the revenue certainty needed for investment in second-generation SAF facilities.

Well-designed SAF policies can simultaneously lower GHG emissions and enable technology advancements without burdening outside sectors with the cost of decarbonizing aviation. Accomplishing this requires careful policy development. Making SAF eligible for subsidies through existing clean fuel standards—but only on an opt-in basis, as seen in California, Oregon, and Washington—is good for establishing long-term certainty but is not without drawbacks. In particular, the absence of a penalty for the use of fossil jet fuel makes it harder for more expensive, less advanced pathways to compete. Furthermore, credits given to HEFA fuels produced as a byproduct of renewable diesel do little to promote investment in facilities employing the advanced technology necessary for long-term decarbonization. Finally, as the road sector decarbonizes and SAF volumes increase, the burden of supporting SAF opt-in credits will increasingly fall on drivers of older vehicles. Meanwhile, air travelers remain unpenalized, creating a significant equity issue (Pavlenko & Mukhopadhaya, 2023).

Indeed, ICCT research suggests that the mandatory inclusion of jet fuel in clean fuel policies, combined with a cap on oil-based HEFA SAF, would be most effective at driving the deployment of second-generation SAF (Pavlenko & Zheng, 2024). Local producer-focused tax credits could boost development of new SAF facilities, but a long horizon is needed. The current 5-year limit on eligibility for tax credits in Nebraska may not be sufficient to encourage construction of facilities. Bonds can support facility construction, but it is difficult for states to do proper diligence on emerging technologies, as evidenced by the failure of bond-backed biofuel projects in Nevada and Oregon (Wallace, 2023; Sickinger, 2023). In contrast, policies which guarantee a return for the successful production of low-carbon SAF over a 10- to 15-year period, either through a mandate or locked-in credits, are likely to be most successful in advancing development of second-generation fuels. Policies designed specifically to help smaller facilities may be particularly effective at allowing advanced technologies to establish a track record, thus enabling financing of subsequent larger facilities while making efficient use of limited state support.

RECOMMENDATIONS

Based on the considerations outlined in this paper we recommend that the following principles be considered for state SAF policies:

» **Prioritize second-generation pathways**
A key conclusion of our analysis is that state SAF policies as currently implemented will, in some cases, incentivize the reallocation of existing fuel production to take advantage of state support without a net reduction in GHG emissions. To ensure that state policies achieve the intended outcome of growing a domestic SAF industry, policies should focus on enabling the viability of second-generation low-carbon pathways. This can be partly accomplished by designing policies that make

the value of SAF support directly proportional to GHG reductions, as in the IRA's 45Z credits (Figure 7). A cap on the volume of lipid-based HEFA fuels eligible for support would reflect the reality that this pathway is constrained by the availability of sustainable feedstock. Finally, state policies that provide guaranteed support for smaller but technologically advanced local facilities could be especially effective at accelerating the eventual scale-up of these pathways.

- **Develop policies that provide certainty to investors**
  Because of the high upfront cost and long lifetime of SAF facilities, policies with long-term uncertainty or short duration are unlikely to induce new investment; instead, they are likely to either support existing production or do nothing at all. For state SAF policies to have a positive influence on investment decisions, producers need a guarantee of credit values before securing financing for construction. This means a multiyear lead time. Dependable credit values and the perception of a stable, long-term market for advanced fuels are key enablers of investment in SAF production.
- **Establish binding policies to drive long-term SAF deployment**
  SAF currently constitutes just 0.1% of jet fuel used domestically. A complete transition to SAF, as envisioned by the Biden administration's SAF Grand Challenge, will almost certainly require some form of disincentive for the use of fossil jet fuel; it is difficult to imagine a scenario where tax credits alone enable the entire 2050 SAF target of 35 billion gallons. Tax credits are also no guarantee of a reliable customer for the decades of SAF production anticipated from a newly constructed facility. Using state clean fuel standards to obligate fossil jet—so that prices reflect payments made to offset GHG emissions—could be a critical step in the creation of a durable SAF market in the United States, self-supported within the aviation sector. Nevertheless, mandates focused on technological progress, as originally intended in the federal Renewable Fuel Standard and proposed in the United Kingdom, might also be needed over the long term to ensure the widespread development of second-generation fuels. Such policies recognize the reality that the SAF label encompasses a collection of pathways and that the design of public support mechanisms can influence which pathways are most likely to be deployed.

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APPENDIX

Table A1

Enacted state tax credits

State	Title	Statute or code	Date enacted	Credit value	Duration	Years of taxpayer eligibility	Eligible SAF	LCA methodology	Feedstock limitations	Eligible for tax refunds	Payout limits	Other
Hawaii	Renewable Fuels Production Tax Credit	HRS §235-110.32	June 27, 2022	$0.20 per 76,000 Btu	No expiration	10 years	Life-cycle emissions below that of fossil fuels, sold in Hawaii	Hawaiʻi State Energy Office determination	None	Yes, at a 30% discount	$3.5 million per year for individuals, $20 million per year in total	Eligible taxpayers must produce at least 2.5 billion BTUs of renewable fuel per year to establish eligibility
Illinois	Sustainable Aviation Fuel Purchase Credit	Ill. Admin. Code tit. 86 § 130.333	February 3, 2023	$1.50 per gallon	Expires December 31, 2032	No limit	50% GHG reduction SAF purchased in Illinois	ICAO or most recent version of GREET	Cap < 10 million gallons of soybean oil feedstock per year; cannot be derived from palm oil; biogenic domestic feedstocks only after June 1, 2028	No	None	Credits go to fuel purchaser
Minnesota	Sustainable Aviation Fuel Credit	Minn. Stat. § 41A.30	July 1, 2023	$1.50 per gallon	June 30, 2024, to December 31, 2030	No limit	50% GHG reduction SAF produced in Minnesota or sold for use in Minnesota	ICAO or most recent version of GREET	Derived from biomass but not from palm oil	Yes	$7.4 million total for 2025, $2.1 million total for 2026 and 2027; unused funds roll over	Credits go to fuel producer or blender
Nebraska	Sustainable Aviation Fuel Tax Credit Act	LB937 Sections 50-55	April 25, 2024	$0.75 per gallon plus $0.01 for each % reduction beyond 50%	January 1, 2027, to January 1, 2035	5 years	50% GHG reduction SAF	ICAO or most recent version of GREET	No palm oil and no co-processing of fatty acids	No	$500,000 per year in total	Credits go to fuel producer
Washington	Alternative Jet Fuel Tax Incentives	Senate Bill 5447 Part 2	April 10, 2023	$1.00 per gallon plus $0.02 for each % reduction beyond 50%	No expiration, to be reviewed in 10 years	10 years	50% GHG reduction SAF produced in Washington or purchased for flights departing Washington	Washington State GREET	None; co-processing is allowed	No	None	Credit goes into effect only after in- state production capacity of 20 million gallons is reached

Table A2
Proposed state tax credits

State	Title	Bill	Status	Credit Value	Duration	Years of Taxpayer Eligibility	Eligible SAF	LCA Methodology	Feedstock Limitations	Refundable	Payout Limits	Other
Indiana	Sustainable Aviation Fuel Tax Credit	House Bill No. 1539	Referred to House Committee on Ways and Means January 19, 2023	$3 per bushel of SAF feedstock grown in Indiana	January 1, 2026, to December 31, 2040	No limit	50% GHG reduction SAF produced in Indiana with at least 50% of feedstock produced in Indiana	None	SAF cannot contain palm oil	No	$5 million per year	Credits are for feedstock producers, are transferable
Kentucky	An Act relating to tax credits for sustainable aviation fuel	Senate Bill 313	To Senate Appropriations and Revenue Committee February 29, 2024	$2.50 per gallon	January 1, 2025, to January 1, 2035	No limit	50% GHG reduction SAF purchased in Kentucky	ICAO or most recent version of GREET	No palm oil	No	$10 million per year	Credits are for fuel users in Kentucky
Michigan	Credits for the use of sustainable aviation fuel	Senate Bill No. 447	Referred to Senate Energy and Environ-ment Committee June 28, 2023	$1.00 per gallon plus $0.02 for each % reduction beyond 50%	Unspecified	No limit	50% GHG reduction SAF purchased for use in flights departing in Michigan	ICAO or most recent version of GREET	Derived from biomass but not palm oil	Yes	None	Credits are for fuel users in Michigan

Table A3
Enacted clean fuel standards

State	Title	Website	Enacted	SAF credits	Fossil jet obligation	SAF eligibility requirement	Feedstock limitations	LCA methodology
California	Low Carbon Fuel Standard (LCFS)	https://ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard	2006	Yes, opt-in	None currently, obligation on intrastate flights proposed	Fuel pathways certified by California Air Resource Board (CARB)	Excludes palm oil	CA-GREET
New Mexico	Clean Transportation Fuel Standard	https://www.env.nm.gov/climate-change-bureau/clean-fuel-standard/	2024	Rulemaking process underway				
Oregon	Oregon Clean Fuels Program	https://www.oregon.gov/deq/ghgp/cfp/pages/default.aspx	2009	Yes, opt-in	No	Fuel pathways certified by CARB or Oregon Department of Environmental Quality	Excludes palm oil	OR-GREET
Washington	Washington Clean Fuel Standard	https://ecology.wa.gov/air-climate/reducing-greenhouse-gas-emissions/clean-fuel-standard	2021	Yes, opt-in	No	Fuel pathways certified by Washington State Department of Ecology	Excludes palm oil	WA-GREET

Table A4

Proposed clean fuel standards

State	Bill(s)	Introduced
Hawaii	SB 2768, HB 2297	2024
Illinois	SB 1556	2024
Massachusetts	S 2286, H 3859	2024
Michigan	SB 275 of 2023	2023
Minnesota	SF 2584, HF 2602	2023
New Jersey	S 2425	2024
Pennsylvania	2023 Memorandum	—
New York	S 1292, A 964	2023
Vermont	S24	2023

Table A5

State SAF facility support

State	Statute or Code	Description
Colorado	Colo. Rev. Stat. § 39-22-556	Tax credit for SAF facility construction. Between January 1, 2024, and January 1, 2027, the credit is equal to 30% of "actual cost paid to construct, reconstruct, or erect a sustainable aviation fuel production facility," declining to 24% in 2027, 18% in 2028, and 12% from 2029 to 2033 based on date placed in service.
Montana	SB0510 of 2023	Establishes SAF facilities as a class fourteen property taxed at 3% of market value
Nevada	NRS 349.400 to 349.670	State revenue bonds issued for support of Fulcrum SAF facility
North Dakota	Senate Bill NO. 2006 of 2023	Provides sales tax exemption for materials used in SAF facility construction
Oregon	Internal Revenue Code of 1986 Section 142(a)(6)	Issued exempt facility bonds to support Red Rock Biofuels facility construction

Table A6

Proposed SAF facility support

State	Title	Bill	Status	Description
Kentucky	An act relating to tax credits for sustainable aviation fuel	Senate Bill 313	To Senate Appropriations and Revenue Committee February 29, 2024	$1 million annual tax credit for facilities or operations producing various SAF feedstocks

Table A7

Letter grading scheme

Grade	Score (points earned/total points possible)
A+	0.9
A	0.85
A-	0.8
B+	0.75
B	0.7
B-	0.65
C+	0.6
C	0.55
C-	0.5
D+	0.45
D	0.4
D-	0.35
F	0

Table A8

Life-cycle analysis methodologies used to calculate state credit values

State	Waste oil HEFA	Soybean oil HEFA	Municipal solid waste gasification	Agricultural residues gasification	Corn grain alcohol-to-jet	Power-to-liquid
California	CA-GREET	CA-GREET	CORSIA	CORSIA	CORSIA	2022 R+D GREET
Hawaii[a]	—	—	—	—	—	—
Illinois	40BSAF-GREET	40BSAF-GREET	CORSIA	CORSIA	40BSAF-GREET	2022 R+D GREET
Minnesota	40BSAF-GREET	40BSAF-GREET	CORSIA	CORSIA	40BSAF-GREET	2022 R+D GREET
Nebraska	40BSAF-GREET	40BSAF-GREET	CORSIA	CORSIA	40BSAF-GREET	2022 R+D GREET
Oregon	CA-GREET	CA-GREET	CORSIA	CORSIA	CORSIA	2022 R+D GREET
Washington	CA-GREET	CA-GREET	CORSIA	CORSIA	CORSIA	2022 R+D GREET

[a] Hawaii producers submit an LCA which is then evaluated by the State Energy Office on a case-by-case basis.

Table A9

Comparison of induced land-use change values

SAF ILUC assessments	U.S. soybean oil ($g\ CO_2e/MJ$)	U.S. corn grain ($g\ CO_2e/MJ$)
ICAO CORSIA default	24.5	25.1[a]
U.S. EPA Renewable Fuel Standard (2010)	31.8	26.3
California Low Carbon Fuel Standard CA-GREET	29.1	19.8
Washington Clean Fuel Standard WA-GREET	29.1	19.8
Oregon Clean Fuel Program OR-GREET	29.1	7.6
40BSAF-GREET	16.2	11.1

[a] Value for ethanol alcohol-to-jet

Table A10

Carbon intensity values

Pathway and life-cycle analysis method	$g\ CO_2e/MJ$	GHG reduction
CORSIA/40B fossil jet baseline	89	0%
Soy HEFA		
CORSIA	64.9	27%
RFS	40.0	55%
CA-GREET	61.9	30%
40BSAF-GREET sample data	39.9	55%
Corn oil HEFA		
CORSIA	17.2	81%
RFS (diesel)	36.2	59%
CA-GREET	34.1	62%
40BSAF-GREET sample data	12.6	86%
Used cooking oil HEFA		
CORSIA	13.9	84%
CA-GREET	23.5	74%
40BSAF-GREET sample data	17.4	80%
Tallow HEFA		
CORSIA	22.5	75%
CA-GREET	32.0	64%
40BSAF-GREET sample data	18.0	80%
Agricultural residues (gasification-FT)		
CORSIA	7.7	91%
Municipal solid waste (gasification-FT)		
CORSIA	5.2	94%
Corn grain alcohol-to-jet		
CORSIA (iso-butanol)	77.9	12%
40BSAF-GREET sample data	73.5	17%
Power-to-liquid		
R+D GREET 2022	2.4	97%

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