U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Sustainable Aviation Fuel (SAF) Grand Challenge: Building Supply Chains

Request for Information (RFI) DE-FOA-0003157

Summary Report

May 2024

Disclaimer

Preface

Since the United States' *SAF Grand Challenge Roadmap* was published in 2022,[1] federal agencies have been advancing toward the 2030 and 2050 goals through a number of collaborative efforts spanning the roadmap's six action areas. These efforts are grounded in the government's commitment to fostering an open dialogue with stakeholders across the sustainable aviation fuel (SAF) supply chain. The roadmap states that it was intended to be the beginning of an evolving, collaborative, and dynamic process that requires regular updates. In September 2023, the U.S. Department of Energy Bioenergy Technologies Office released a request for information (RFI) titled "Sustainable Aviation Fuel (SAF) Grand Challenge: Building Supply Chains"[2] to solicit feedback from stakeholders on issues related to the "Building Supply Chains" action area of the *SAF Grand Challenge Roadmap*. This report is a summary of the RFI inputs received, and it represents just one of many proactive steps being carried out by government agencies to inform these roadmap updates.

The RFI's objective was to gather insights, perspectives, and innovative ideas to help inform future strategy and actions across the agencies. Respondents provided significant feedback to all questions and put forth valuable recommendations that could be implemented to support the development and demonstration of a mature, integrated SAF supply chain. This report reflects a confluence of diverse perspectives from stakeholders and underscores not just the complexity of the SAF supply chain, but also the breadth of the opportunities present in this space. Understanding the ever-changing technology, market, and political factors within the SAF space will enable the government to best leverage its resources to help the industry fully realize the benefits granted by these opportunities.

As the industry moves forward, this report and others can serve as references in the ongoing efforts to catalyze technology innovation, public-private partnerships, policy frameworks, and investments necessary to overcome the barriers to realizing the SAF Grand Challenge goals.

The years leading to 2030 are pivotal in the push toward a sustainable aviation future, and the adaptability of our efforts will enable the industry to overcome challenges as quickly as they appear. Together, we are laying the groundwork for a transformative shift in aviation, one that promises to significantly reduce greenhouse gas emissions, bolster U.S. energy security, stimulate economic growth, and facilitate a just transition to a low-carbon future.

[1] U.S. Department of Energy, U.S. Department of Transportation, U.S. Department of Agriculture, and U.S. Environmental Protection Agency. 2022. *SAF Grand Challenge Roadmap: Flight Plan for Sustainable Aviation Fuel*. Washington, D.C.: U.S. Department of Energy. www.energy.gov/sites/default/files/2022-09/beto-saf-gc-roadmap-report-sept-2022.pdf.

[2] Bioenergy Technologies Office. 2023. "Department of Energy Releases Request for Information on Building Supply Chains to Meet Sustainable Aviation Fuel Grand Challenge Goals." Sept. 21, 2023. www.energy.gov/eere/bioenergy/articles/department-energy-releases-request-information-building-supply-chains-meet.

List of Acronyms

CAPEX	capital expenditure
CI	carbon intensity
CO_2	carbon dioxide
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
DOE	U.S. Department of Energy
GHG	greenhouse gas
GREET	Greenhouse gases, Regulated Emissions, and Energy use in Technologies
HEFA	hydroprocessed esters and fatty acids
IRA	Inflation Reduction Act
IRS	Internal Revenue Service
LCA	life cycle analysis
LCFS	Low Carbon Fuel Standard
PtL	power to liquids
RD	renewable diesel
RFI	request for information
RFS	Renewable Fuel Standard
RIN	renewable identification number
RNG	renewable natural gas
SAF	sustainable aviation fuel
TEA	techno-economic analysis
USDA	U.S. Department of Agriculture

Executive Summary

In September 2023, the U.S. Department of Energy (DOE) released a request for information (RFI) in an effort to understand barriers and opportunities related to the "Building Supply Chains" action area of the *SAF Grand Challenge Roadmap* launched in 2021 by DOE, the U.S. Department of Transportation, and the U.S. Department of Agriculture. The RFI requested feedback from stakeholders across the sustainable aviation fuel (SAF) supply chain—from feedstock production through final end use, and all points in between. Stakeholders were asked to respond to five questions related to:

1. Building regional supply chain coalitions.
2. Modeling and simulation tools needed to enable build-out of the SAF supply chain.
3. Identifying and overcoming critical gaps in the demonstration of SAF supply chain elements.
4. Addressing barriers to scaling and commercial build-out of SAF supply chain elements.
5. The government's role in informing SAF stakeholders about investors and financial structures available in the SAF ecosystem.

Respondents provided significant feedback to all five questions and put forth valuable recommendations that could support the development and demonstration of a mature, integrated SAF supply chain.

Two overarching themes were observed throughout responses:

1. A clear need exists for long-term, stable policy to serve as an indicator of regulatory certainty for the industry, provide incentives that can be distributed across the supply chain, and create market demand for SAF. A consistent and supportive policy framework will be crucial for stakeholders to mitigate financial and technical risk, which will in turn unlock investments spurring technology innovation, supply chain demonstration, and adoption of SAF.
2. Stakeholder coalitions provide a functional platform for collaboration and engagement among a diverse set of supply chain participants. This engagement is critical for developing effective strategies that drive the scalability and sustainability of SAF supply chains. Coalitions foster a collaborative environment that helps stakeholders identify common goals, address financing and investment risks, navigate regulatory hurdles, and overcome infrastructure constraints. Within a coalition, stakeholders can align industry efforts with policy objectives, which helps attract investment, promote growth, and enhance the resiliency of the aviation sector.

Key Takeaways

Accelerating Success of Regional SAF Supply Chain Coalitions

- A wide range of new and existing stakeholder groups exist that can serve as models for the development of coalitions.
- Strong public-private SAF collaborations help mitigate risks for all parties; aid in establishing a secure, stable, and competitive SAF supply chain; and help establish long-term competitiveness of SAF.
- It is critical to both establish clear and consistent communication with constituents and ensure alignment of goals between members.
- Securing the commitment of partners spanning the entirety of the supply chain is imperative.
- The support of state and local officials who are interested in accelerating the uptake of SAF in the region can help overcome barriers that hinder supply chain growth.
- Coalition development requires a cohesive, strategic, and collaborative approach that addresses present challenges and accounts for future considerations.
- The correct SAF enabling policies could provide incentives and opportunities that are sufficient by themselves to drive stakeholders together to form coalitions.

Modeling and Simulation Tools for Enabling the SAF Supply Chain

- Recognizing Argonne National Laboratory’s Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET) model for calculating lifetime greenhouse gas emissions reductions for SAF tax credits would give supply chain developers, feedstock providers, investors, and SAF producers a predictable, durable framework for assessing tax program eligibility.
- It is necessary, but difficult, to develop comprehensive models and simulations for complex supply chain scenarios that account for a wide variety of environmental, economic, social, and technical facets.
- Biofuel and climate modeling tools should incorporate robust assessments of direct and indirect land use change to capture the full scope of life cycle emissions from various systems.
- Supply chain transparency, especially as related to carbon accounting, is extremely important in generating trust and reducing compliance risk.
- The availability of field-verifiable data is necessary to support analyses that will allow stakeholders to make informed decisions. However, collection and dissemination of real-world empirical data to assist modeling verification is

challenging due to the potentially competitive business-sensitive nature of the information.

Critical Gaps in the Demonstration of SAF Supply Chain Elements

- Compound risks stem from challenges such as a lack of funding required to scale SAF supply, limited sustainable feedstock availability, ongoing social debates, low technology readiness, lack of dedicated SAF infrastructure, high capital costs, and absence of stable policy.
- The disallowance of sequestered carbon dioxide (CO_2) and renewable hydrogen for generating tax credits if used in SAF production can hurt the economics for intermediate-scale production.
- Long-term field trials and the training of feedstock producers are necessary to increase farmers' willingness to adopt new feedstocks and low-carbon-intensity (CI) agricultural practices.
- Infrastructure challenges at airports are a barrier to demonstrating the last mile of the supply chain.

Scaling and Commercial Build-Out of SAF Supply Chain Elements

- One of the greatest challenges to scaling and the commercial build-out of SAF supply chain elements remains the difficulty in raising capital.
- The commercial build-out of other SAF supply chain elements is dependent on the commercial viability of announced SAF production facilities.
- Technical risks still associated with biorefinery scale-up and operation means market uncertainty for the feedstock producers contracted with those biorefineries.
- Timelines for permitting/construction required to build commercial-scale SAF projects are excessive and lead to uncertainty in the economics of proposed projects.
- Investors are unsure about the long-term viability of SAF policy in the United States and are deterred from taking on the financial risk associated with commercial-scale projects.
- Airlines have difficulty committing to long-term, binding offtake contracts that require paying even slight premiums.
- Community acceptance of proposed projects is critical for success.
- Risk should be equally distributed among all supply chain participants to enhance early successes.

- Competing incentives and demand for SAF resources (CO_2, hydrogen, and low-CI electricity) or final fuel products such as renewable diesel make the economics of SAF difficult to balance and reduce market pull.

Understanding the Government's Role in Informing Stakeholders

- There is an opportunity to increase the knowledge level and confidence of all SAF supply chain participants, including feedstock producers, biorefineries, SAF users, and other stakeholders, by holding regional SAF workshops throughout the country, holding webinars, and using other forms of outreach and education.
- Stakeholders ask the U.S. government to:
  - Provide information and education regarding the various funding and loan programs within DOE and other government agencies.
  - Continue collaboration and consultation with industry stakeholders to identify near-term opportunities in building out the necessary supply chains to support the large-scale deployment of SAF.
  - Share lessons learned and best practices with the industry to prevent cost overruns and help drive down production costs across the board.
  - Continue strategic cross-agency activities for building the SAF industry.
  - Develop matchmaking tools or interactive maps for stakeholders to identify potential investors or partners and help initiate conversations.

This RFI was for informational and strategic planning purposes only and was not associated with any funding opportunity announcement or solicitation of applications. There is no obligation on the part of the government to provide support for any ideas identified in response to the RFI.

The Bioenergy Technologies Office sincerely appreciates all stakeholders for the time and effort put into developing their responses to this RFI. The passion and wealth of expertise held by our stakeholders is clearly evident in the comprehensive responses that were submitted. The ideas expressed in response to this RFI will assist DOE and its interagency partners in understanding what is needed to develop effective and robust SAF supply chains that will enable the United States to meet the SAF Grand Challenge goals. DOE looks forward to continued engagement with all stakeholders in the ongoing effort to decarbonize the aviation industry and meet the goals of the SAF Grand Challenge.

Table of Contents

List of Figures

Introduction

In September 2023 the U.S. Department of Energy (DOE) Bioenergy Technologies Office released a request for information (RFI) titled "Sustainable Aviation Fuel (SAF) Grand Challenge: Building Supply Chains"[3] to solicit feedback from stakeholders on issues related to the "Building Supply Chains" action area of the *SAF Grand Challenge Roadmap*.

The SAF Grand Challenge is a U.S. governmentwide approach to work with industry to reduce cost, enhance sustainability, and expand production of SAF. The goals of the SAF Grand Challenge are to (1) achieve production of 3 billion gallons per year of domestic SAF with a minimum 50% reduction in life cycle greenhouse gas (GHG) emissions compared to conventional fuel by 2030, and (2) produce sufficient sustainable aviation jet fuel to meet 100% of projected jet fuel use, or 35 billion gallons of annual domestic production, by 2050. An interagency team led by DOE, the U.S. Department of Transportation, and the U.S. Department of Agriculture (USDA) worked with the U.S. Environmental Protection Agency; other government agencies; stakeholders from national laboratories, universities, and nongovernmental organizations; and the aviation, agricultural, and energy industries to develop a *SAF Grand Challenge Roadmap*. This roadmap outlines a whole-of-government approach, with coordinated policies and specific activities that should be undertaken by federal agencies to support achieving both the 2030 and 2050 SAF Grand Challenge goals.

A key action area of the *SAF Grand Challenge Roadmap* is building supply chains to meet the SAF Grand Challenge goals. The purpose of this RFI was to engage with stakeholders on the "Building Supply Chains" action area of the SAF Grand Challenge, understand the challenges facing critical elements within the SAF supply chain, and to identify opportunities to enable the rapid development of effective supply chains capable of meeting future SAF demand. A supply chain is a complete system that produces and delivers a product or service, from raw materials to final delivery to end users. SAF supply chains encompass feedstock production, collection, and distribution to SAF production facilities; conversion of feedstock to fuel; and transport of finished fuel to the infrastructure required to fuel aircraft.

[3] Bioenergy Technologies Office. 2023. "Department of Energy Releases Request for Information on Building Supply Chains to Meet Sustainable Aviation Fuel Grand Challenge Goals."

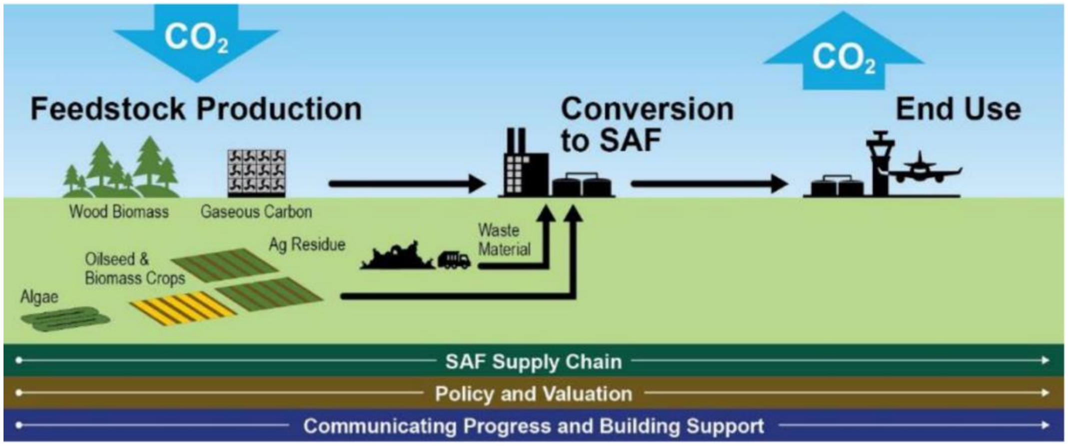

Figure 1. Graphic representation of the SAF supply chain from the *SAF Grand Challenge Roadmap*

The supply chain action area includes four priority workstreams that include activities, deliverables, and desired impacts associated with:

1. Convening regional SAF stakeholder coalitions.
2. Developing and disseminating SAF supply chain simulation and modeling tools.
3. Demonstrating SAF supply chain elements.
4. Investing in commercial-scale SAF production infrastructure and facilities.

These four workstreams were the basis for the five questions asked by the RFI:

1. Are you aware of effective regional supply chain coalitions that have been formed for renewable fuels?
    a. **If yes**, what factors contributed to the successful establishment of those coalitions, what challenges have they faced in their development and operation, and how can SAF stakeholders best apply these learnings to accelerate the development of their own coalitions across the United States?
    b. **If no**, how can effective SAF supply chain coalitions be formed, and what is needed to accelerate their efforts to supply SAF to regions across the United States?
2. What modeling and simulation tools would enable participants along SAF supply chains to be more effective at maturing functional, integrated supply chains?
3. What are the most critical gaps in demonstration (pre-commercial validation) of supply chain elements, and how can these be overcome?
4. What are the most significant barriers to scaling and commercial build-out of SAF supply chain elements, and how should these be addressed?

5. Is there a beneficial role that DOE and other U.S. government agencies could serve in informing potential SAF producers about the wide range of potential investors and financial contractual structures in the SAF ecosystem?

    a. **If yes**, please describe what types of additional resources and activities the DOE and other U.S. government agencies could provide to help advance SAF goals.

Approximately 86 responses totaling more than 600 pages of material were received from a wide range of U.S. and international stakeholders. Responses came from stakeholders across the entire supply chain, including feedstock production, SAF production and distribution, and SAF end users. These submissions recognized the scale of efforts needed to achieve the SAF Grand Challenge goals, but also signaled an overwhelmingly positive sentiment for the future of SAF.

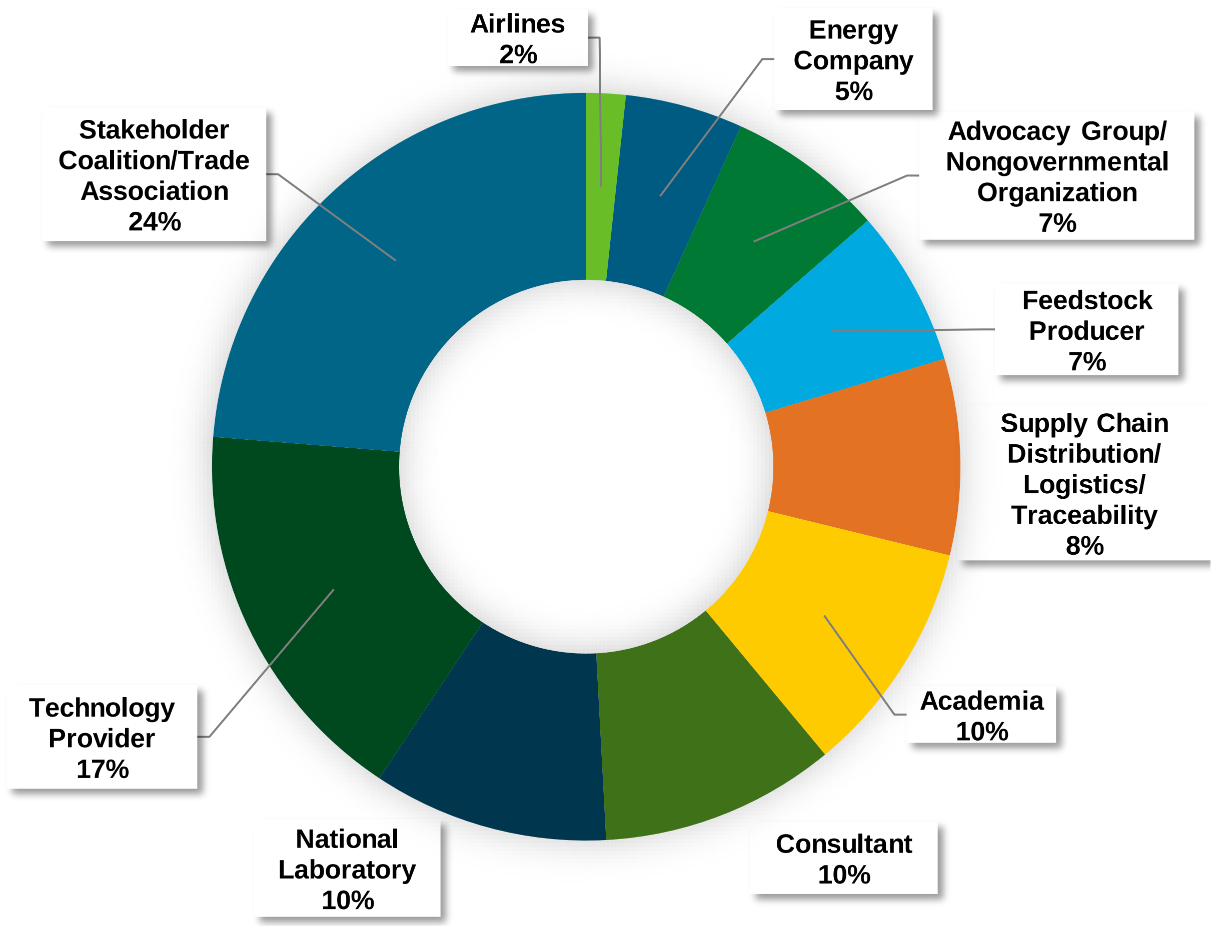

Figure 2. Percentage of responses received from various types of institutions

To minimize barriers to submitting responses, this RFI required responses to be submitted in the form of a single written document emailed to a DOE inbox. There were no requirements to create accounts on a system, and responses were not evaluated against any criteria.

It must be noted that even with significant outreach efforts and a simple submission procedure, the responses to this RFI may not necessarily be representative of the full range of stakeholders. Developing an RFI response requires time and effort that is not possible for all organizations and individuals to spare, and it is likely that outreach efforts did not reach every relevant stakeholder. Therefore, the feedback summarized here may not be representative of the entire community from which DOE sought input. Continued engagement will be essential in the ongoing efforts to achieve the goals of the SAF Grand Challenge.

The following summary report sections are based on each RFI question. The report is intended to provide a high-level overview of key themes identified during the internal review of RFI responses and is not intended to be a comprehensive documentation of all comments received.

Convening Regional Stakeholder Coalitions

*Question 1: Are you aware of effective regional supply chain coalitions that have been formed for renewable fuels? **If yes**, what factors contributed to the successful establishment of those coalitions, what challenges have they faced in their development and operation, and how can SAF stakeholders best apply these learnings to accelerate the development of their own coalitions across the United States? **If no**, how can effective SAF supply chain coalitions be formed, and what is needed to accelerate their efforts to supply SAF to regions across the United States?*

Respondents suggested that newly developed coalitions will be most successful if partners bring representation from across the entire supply chain, including key members of any communities that stand to be impacted by the establishment of a new supply chain. Many responses underlined the importance of involving partners with experience in the existing conventional jet fuel supply chain, securing strong C-suite support within private partners, and engaging with state and local officials that are committed to increasing SAF uptake in the region. In addition to developing a strong foundation of stakeholder membership, coalitions can further increase their impact by leveraging the advantages of regionally unique traits. The geographic location of coalitions may present opportunities in the form of variations in feedstock type and availability, SAF demand from local high-volume end users, proximity to fuel producers, availability of existing infrastructure, existing policy, and other regionally unique attributes that provide compoundable benefits. By utilizing as many of these location-specific benefits as possible, newly formed coalitions can be enabled to manage and reduce risk surrounding policy, capital, and demand, which in turn will accelerate SAF production and use within the region.

Factors Contributing to the Successful Development and Operation of Coalitions

Success of existing stakeholder groups was consistently linked to early establishment of strong foundational members that are aligned around a core set of values and goals. As partnerships are formed and membership increases, clear communication within these groups ensures that members are applying their resources and efforts in a unified way. To further increase the impact of their efforts, successful coalitions can tap into the resources like local knowledge and infrastructure already present within the region.

Success Factors for Existing Coalitions
• Securing key member support • Inclusivity among partners • Collaboration and alignment of goals • Clear communication with members and external parties • Utilization of regional advantages • Understanding limitations • Utilization of existing infrastructure and knowledge.

Securing Key Member Support

- **Establish “anchor partners” early on.** Successful coalitions have partnered with large financial institutions, airlines, energy companies, and public groups early in the coalition’s development. These partnerships can provide significant resources but also display strength and commitment to outside groups, which helps garner additional support from other sector partners as well as state officials.
- **Secure strong C-suite support with private partners.** Backing from executives not only demonstrates commitment to coalition members and reaffirms motivations, but also ensures that resources and staffing will be made available and allocated to coalition activities.

Inclusivity Among Partners

- **Develop partnerships that represent the entire supply chain.** Effective regional coalitions should not only include major partners such as airlines, banks, and fuel producers, but also strive to include:
  - Feedstock producers (e.g., biomass; residues; fats, oils, and greases; municipal solid waste; renewable natural gas [RNG]).
  - Technology developers (e.g., enzymes, catalysts, additives).
  - Regional airports as offtake partners.
  - Elected leaders and community activists.
  - Representatives for enterprise zones, Bioeconomy Development Opportunity Zones, port districts, etc.
  - Regulatory agencies involved in the permitting process (e.g., air, water, transport).
  - Entrepreneurial innovators.
  - Educational institutions.
- **Perform community outreach work and education.** Coalitions should strive to develop positive relationships with local residents. They should educate communities on the potential value of their local or regional feedstock supplies, especially waste feedstocks. Communities should also understand the environmental and health benefits of SAF, as well as the potential economic benefits presented by new SAF projects in the region.
- **Work with other established stakeholder groups.** Successful coalitions do not operate independently in a vacuum and are engaged with trade associations, advocacy groups, and other coalitions to share experiences and grow cooperatively.

- **Strengthen the coalition through extensive and inclusive membership.** Including stakeholders from different geographies and industries helps bring strength and knowledge to the coalition. Ensuring that all voices are heard allows for assertive decision-making.

Collaboration and Alignment of Goals

- **Define clear goals and ensure alignment between coalition members.** With a diverse membership, it is important to ensure that a cohesive strategic plan is established. Coalitions should set specific, measurable targets that give members a clear direction forward. Collaboration is necessary to overcome challenges and achieve the milestones toward a mature supply chain, but if stakeholders are not united in their mission, interfering efforts can impede progress.
    - Goals could include identifying the airports to be supplied with SAF, setting annual regional targets for SAF utilization, quantifying desired reductions in GHG emissions, considering other locally relevant environmental impacts encompassing pollution reduction in rural areas close to SAF production facilities and airports, defining the number of local employment opportunities created, etc.

Clear Communication with Members and External Parties

- **Clearly define roles for coalition members at the outset.** Members should focus on their existing areas of expertise and use their resources to support each other.
- **Communicate frequently with constituents.** Successful coalitions keep an open line of communication with members and provide a collaborative platform to share and exchange data, ideas, business contacts, best practices, etc.
- **Communicate lessons learned and best practices to SAF advocates outside of the coalition.** Knowledge sharing outside of a coalition can accelerate efforts being undertaken by policymakers, financiers, and other supply chain participants.
- **Communicate the environmental and health benefits of SAF to local communities**. Educating the public helps dispel myths and can lead to greater support for SAF among advocacy groups.
- **Share the potential financial benefits and opportunities to local stakeholders.** Transparent communication and demonstration of these benefits increases the likelihood of establishing community support for SAF projects.

Utilization of Regional Advantages

- **Take advantage of the unique benefits within a region.** Successful coalitions have strived to locate in an area that has a variety of regionally unique traits that can be capitalized on to realize compounded benefits. Examples include but are not limited to:
    - Access to multiple feedstocks enabling varied production pathways.
    - Proximity to high-volume demand from a major airport or regional airports.
    - Useful infrastructure already in place.
    - Other supply chain partners already in operation within the region.
    - Willing partners with proven history of civic engagement and collaboration.
    - Engaged and enthusiastic local communities.
    - Supportive state and local policy.

Understanding Limitations

- **Knowing the limits of any coalition**. Successful coalitions and funding agencies understand that information generated by coalition activities cannot always predict the business needs that ultimately determine the siting of SAF facilities and their supply chain. The value proposition of stakeholder groups is that they spur new thinking, but they should not unintentionally limit innovation by railroading toward a fixed outcome.

Utilization of Existing Infrastructure and Knowledge

- **Utilize the existing conventional jet fuel supply chain.** Conventional jet fuel has a fully mature supply chain with established infrastructure and supply chain players that can share knowledge gained from many decades of operation. The knowledge held by these participants is not limited to fuel production, transport, and logistics, but also understanding how to communicate with regulators, navigate policy, ensure consistency in fuel quality, establish safety procedures, and manage relationships with end users.

- **Build off efforts undertaken by organizations supporting conventional jet fuel.** Industry groups identified in comments received from stakeholders include, but are not limited to, the International Air Transport Association, International Civil Aviation Organization, Energy Institute, Joint Inspection Group, American Petroleum Institute, and Airlines for America. These industry groups establish protocols, issue standards, and conduct audits that cover all stages of the conventional jet fuel supply chain and that are implemented on a voluntary basis.

- **Apply learnings from the existing downstream supply chain to enable the new upstream supply chain.** Procedures such as the use of voluntary consensus standards, periodic quality control checks, service bulletins, service experience feedback collection, and quality control audits are equally applicable and effective at the front end of the supply chain as well as the back end.

- **Utilize the supply chains developed for other renewable fuels.** The ethanol, biodiesel, and renewable diesel (RD) supply chains have been well developed over the years and include both established infrastructure and prominent stakeholder groups.

Apply Guidance from Government Agencies

- **Observe the guidance published by federal agencies.** Documents such as *The U.S. National Blueprint for Transportation Decarbonization* and *SAF Grand Challenge Roadmap* are published by federal agencies and outline the actions and activities to be undertaken to achieve federal goals in the coming years. They can serve as guidelines for action for coalitions.
- **Engage with state and local government officials.** Coalitions can secure additional support for their activities by engaging with officials that have demonstrated an interest in promoting economic development in their region. Coalitions should look at state- and local-level legislation and incentives that support SAF production to determine those officials that are likely to support work to further develop the supply chain.

Barriers to the Development and Operation of SAF Coalitions

Common among responses was a reference to the negative impacts stemming from misalignment of goals between coalition members. This misalignment leads to individualized efforts and inefficient use of resources. Just as impactful is the result of partnering with entities that are not sufficiently positioned to make the necessary time, staffing, and funding commitments to support coalition efforts. In addition, coalition strategies that neglect public input or do not include ongoing engagement with local communities are more likely to introduce additional barriers to coalition efforts and SAF uptake in general down the line.

Barriers Facing Coalition Development
• Misalignment of priorities and miscommunication • Lack of strategic partners and cross-industry engagement • Lack of funding and resources • Failure to establish public awareness and acceptance.

Misalignment of Priorities and Miscommunication

- **Diverse membership leads to difficulties in setting common goals.** An extensive and diverse background of companies, from different geographies and industries, helps bring strength and knowledge to coalitions, but it also brings challenges in setting common priorities that work for everyone.

  - Coalitions may find it challenging to balance the desire of advancing public interest goals such as decarbonization while also avoiding harm to incumbent institutions that may have substantial political and market influence.

- **Neglecting to communicate with local communities and advancing their needs.** Concerns from local communities can lead to significant delays for projects. Failure to provide ongoing transparent communication of a project's health, environmental, and economic benefits to communities can impede project progress and even shut it down entirely.

Lack of Strategic Partners and Cross-Industry Engagement

- **Lack of strategic partners in the region.** Coalitions require membership from partners that are not only invested in the success of SAF in the region, but also have the resources and capabilities to engage in activities that support the coalition goals. Supply chain growth is impeded by an inability to connect feedstock production and transportation with SAF production, distribution, and utilization.
- **Failure to include entities across levels of the supply chain**. Unequal representation from stakeholders across the entire supply chain exacerbates the disconnect between upstream and downstream needs. A fully functional, mature supply chain requires continuity and inclusion of a full range of partners.
- **Failure to engage in collaborative efforts across industries**. Working in isolation leaves the cost burden of infrastructure development entirely on the SAF supply chain participants. Exploring broader and more integrated public−private partnerships across other industries is crucial for sharing risk, ensuring demand certainty, and facilitating participating in cost improvement.
- **Limited institutional and nongovernmental organization interest.** Some large actors are still hesitant to dedicate time, staff, and resources to support activities for what they view as early-stage technologies. The uncertain nature of pre-competitive and early commercial collaboration, in addition to a lack of public education in this area, leads to an unwillingness to participate fully.

Lack of Funding and Resources

- **Limited availability and capacity of SAF production facilities.** Fuel production facilities can serve as focal points for coalitions, but there is widespread difficulty in raising funds to design and construct these commercial-scale facilities.

- **Lack of sufficient and sustained funding to improve the infrastructure.** Limited engagement with financing institutions limits the coalition and its partners as they seek to build out supply chain infrastructure. This type of engagement can help enhance credibility and increase attractiveness for private financing.
- **Absence of information or the inability to secure necessary data**. As coalitions engage in activities to develop the supply chain, they require access to specific data that can inform analyses for facility siting, transportation logistics, product marketing, etc. The sensitive nature of some data means that it is unlikely to be shared freely, if at all, which poses a significant challenge.

Failure to Establish Public Awareness and Acceptance

- **Failure to communicate basic awareness of SAF and its relevance to economic development**. Stakeholders should be engaged with key community members early in coalition development to generate awareness and interest in SAF and to clearly articulate any potential health, environmental, and economic impacts that would come from development of SAF in the region. Failure to accurately communicate potential positive and negative impacts of a project can lead to opposition by affected communities and has the potential to stop projects entirely.
- **Lack of involvement from public sector partners**. Coalitions will find it more difficult to make progress in areas such as policy advocacy if they do not engage with public sector groups that already work in that space. Public sector involvement is also critical for generating regulatory support and developing an enabling environment for SAF.

Suggestions for Forming New Coalitions and Accelerating Their Efforts

Stakeholders pointed to existing coalitions as examples of how to quickly establish a new coalition and begin making meaningful progress toward bringing SAF to a region. Responses consistently mentioned the importance of building a wide base of stakeholder membership that spans the entire value chain. Respondents also emphasized the importance of balancing coalition efforts to address SAF policies, develop market demand, and ensure project access to capital.

Recommendations for New Coalitions
• Understand the opportunities and challenges with new stakeholders • Understand the available resources • Balance policy, capital, and demand • Build off existing successful coalitions • Align member goals and ambitions • Engage with local communities • Identify success criteria and monitor activities • Branch the reach of the supply chain • Focus on innovation • Broaden the scope • Focus on market development.

Understand the Opportunities and Challenges with New Stakeholders

- **SAF supply chain coalitions need to cover the entire value chain.** This will be a wide range of stakeholders who historically have not known or worked with each other. Supporting regional awareness of the contributions that each entity can contribute across the value chain will help build local ecosystems capable of supporting a fully mature supply chain. **This includes, but is not limited to:**
  - Feedstock suppliers (including municipal waste, forestry and agricultural products and residues, waste cooking oils, industrial carbon dioxide [CO_2] emitters, green hydrogen, renewable electricity, and many more).
  - Technology providers.
  - Engineering, procurement, and construction firms.
  - Project owners/operators.
  - Investors/finance providers.
  - Fuel blenders.
  - Oil refiners/upgraders.
  - Transport infrastructure owners/operators.
  - Airport authorities/cities.
  - Aviation fuel suppliers/airlines to support offtake and use of SAF.
  - Local communities.
  - State and local government officials.

Understand the Available Resources

- **Leverage regionally unique advantages**. Newly formed coalitions should strive to locate in an area where they may take advantage of as many regional benefits as possible. Examples include but are not limited to:
    - Access to multiple feedstocks enabling varied production pathways.
    - Proximity to high-volume demand from a major airport or regional airports.
    - Useful infrastructure already in place.
    - Existence of some supply chain players already in operation within the region.
    - Willing partners with proven history of civic engagement and collaboration.
    - Engaged and enthusiastic local communities.
    - Supportive policy at the state and local levels**.**
- **Take advantage of regional feedstock diversity and availability.** Coalitions will benefit from a broad focus and utilization of the full range of feedstocks that can be produced in a region. By doing so, these coalitions can mitigate risks associated with impacts to various portions of the feedstock supply and therefore establish a more resilient and stable supply chain.
    - National resource assessments may not account for smaller volumes of certain feedstocks in a region if they fall below a certain threshold, but aggregating multiple feedstock types could be sufficient to make an impact on the industry.
- **Accelerate success through matchmaking and access to key players**. Supply chain activities would be bolstered by having access to a centralized platform of businesses, government laboratories, and nongovernmental organizations that are actively pursuing SAF and/or have relevant capabilities in enabling these new supply chains.
- **Develop high-resolution resource and infrastructure analysis for the region.** Coalitions should work with their members or other entities capable of providing higher-resolution resource mapping for their region. The granularity of resource analyses at the national and global levels is too coarse and misses the details necessary for coalitions to plan and execute at the project level. Detailed analyses should account for issues on land and water availability; energy needs; rail, shipping, and trucking logistics; and other supply chain logistics. Understanding these regional factors will help accelerate coalition activities.

- **Utilize existing tools and knowledge to optimize supply chain operations.** Doing so leads to cost reduction, technology risk mitigation, and improved feedstock processes and logistics.

Balance Policy, Demand, and Capital

- **Cohesively address policy, demand, and capital.** Efforts to secure product offtake should be made in conjunction with policy incentives and other credits such that enough risk is mitigated that financiers are willing to provide the capital to build supply and facility infrastructure. A strategy focused only on securing SAF demand through memorandums of understanding or offtake agreements will fail if the need for capital and policy incentives is not addressed.

Build Off Existing Successful Coalitions

- **Understand the challenges faced by other coalitions.** Future coalitions should not only be aware of potential barriers to their development, but also actively work to address them before they pose an issue. This includes enthusiastically learning about the interests and motivations of its members and considering how their needs and interests align or differ from those of the coalition as a whole. Different coalitions must address the inherent similarities or differences to other stakeholder groups that stem from variables including their sector, location, partners, etc.

- **Successful coalitions should strive to enable success of new coalitions.** Materials can be developed and shared with entities like policymakers and financiers so they may better understand how support for efforts like new R&D, policy, and incentive programs lead to numerous benefits that follow SAF commercialization. This type of education can in turn lead to greater support for the development and advancement of new coalitions by these entities.

Align Member Goals and Ambitions

- **Define clear, achievable, regional goals.** As coalitions are first being established, they should strive to work with partners to develop a list of specific and measurable targets that can serve as indicators of success. Clear regional goals provide a shared purpose and direction for newly formed coalitions.

- **Share a central ambition among core coalition members.** Regional coalitions should be seeking to enable the production of significant volumes of SAF to airports at a manageable cost to the end user. If the coalition anchor companies are aligned around this common goal and committed over the long term to improve the sustainability and reduce the cost of SAF, the coalition’s probability of success is far greater.

Engage with Local Communities

- **Engage with local communities.** Community support is integral to the success of SAF supply chains, and establishing positive relationships and transparent communication channels with local residents is crucial. Coalitions should recognize the importance of addressing concerns and actively engaging with communities located not only near SAF production facilities and airports, but also along all major portions of the supply chain.

Identify Success Criteria and Monitor Activities

- **Develop transparent monitoring and evaluation frameworks**: Implement a transparent and accountable system for consistently assessing the coalition's progress in achieving its defined goals. This framework should also enable the measurement and reporting of the environmental and economic impacts resulting from the coalition's actions.

Branch the Reach of the Supply Chain

- **Collaborate with other pathway-specific coalitions.** While different stakeholder groups may be developed around various biogenic and synthetic SAF pathways, there will still be significant overlap in the supply chain, and collaboration between these groups will be important. Meeting the SAF Grand Challenge volumes will require SAF produced from multiple feedstocks and conversion technologies.

- **Coordinate with green hydrogen and CO_2 supply chains.** SAF coalitions will find greater success if they can coordinate activities with and enable integration with the supply chains for green hydrogen and CO_2. SAF facilities will be large users of low-carbon hydrogen and CO_2, and by engaging with the groups that are building out the hydrogen hubs and CO_2 supply chain infrastructure, SAF coalitions position themselves to integrate with those supply chains and use those resources as they become available.

Focus on Innovation

- **Include a focus on innovation as part of coalition objectives.** Coalitions should participate in advancing the state of SAF through various means of support for their partners. By creating initiative programs or providing funding to their partners, these coalitions can help support innovation in activities like feedstock production, de-risking of conversion technologies, new market assessments, supply chain logistics, etc.

Broaden the Scope

- **Broaden the focus on feedstocks and conversion technology options.** In the short term, a narrow focus to support higher-probability pathways can help the industry meet the 2030 goal, but in the long term, coalitions should be as technology neutral and performance based as permitted given any geographic or policy restrictions. An inclusive view of pathway options is needed to encourage innovation.

- **Consider distributed processing of feedstocks and intermediates.** The localized nature of many feedstocks limits the scale of the SAF refinery, if directly tied to the feedstock source. Distributed hub-and-spoke-type models can help offset the cost impacts presented by feedstock challenges and provide a focal point for a coalition to build out other elements of the supply chain.

Focus on Market Development

- **Work with stakeholders to secure offtake and drive market development**. Coalitions can work with members to pursue aggressive long-term offtake targets that provide a guaranteed market for fuel, which in turn reduces risk for financiers. The de-risking of fuel production also reduces risk for feedstock producers and downstream supply chain partners, which can promote investment in infrastructure and operations to accelerate overall supply chain development.

Modeling and Simulation Tools to Enable the Supply Chain

Question 2: What modeling and simulation tools would enable participants along SAF supply chains to be more effective at maturing functional, integrated supply chains?

Responses emphasized that it is necessary, yet extremely difficult, to develop comprehensive models and simulations for complex supply chain scenarios that incorporate a wide variety of environmental, economic, social, and technical facets. A holistic network optimization approach will enable the most efficient production and distribution of SAF by allowing stakeholders to make data-driven decisions based on regionally specific inputs, understand the effects of variable constraints including incentives and policies, and manage risk across the supply chain. Stakeholders recognized that the collection and dissemination of potentially competitive business data for use in these models is an added complication, but stressed that the availability of such data is necessary to support the development of these and other tools for supply chain optimization.

Tools Needed to Develop a Functional, Integrated Supply Chain

It was common for responses to outline a need for models and simulations specific to individual elements of the supply chain such as feedstock production, biorefinery siting, and fuel transportation logistics, but many responses also called for complex holistic models that would allow users to account for an extensive set of dynamic variables to see the evolution of the supply chain over time.

Tools Needed by Industry
• Comprehensive supply chain models and simulations • Tools for updated techno-economic analysis (TEA) • Life cycle analysis (LCA) modeling • Policy analysis tools • Secure data sharing and availability • Feedstock production models • Biorefinery siting tools • Transportation network modeling • Resource management tools • Pathway-specific modeling tools • Supply chain transparency and carbon tracking • Supply chain resiliency models • Workforce analysis and social science tools • Financial analysis.

Comprehensive Supply Chain Models and Simulations

- **Holistic models for tracking variability of critical metrics across time.** Regional-scale studies present a perspective of supply chains that can be directly related to day-to-day operations, and these models would allow projects to track variables, identify bottlenecks, and minimize impacts. Models would need to consider:
    - Heterogeneity of feedstock quality, supply, cost, and availability.
    - Surplus land availability, quality, and suitability.
    - Transportation and distribution logistics.
    - Technology development.
    - Infrastructure availability, limitations, and competitiveness.
    - Fuel and coproduct markets.
    - Socioeconomic impacts on communities.
- **State-level simulations for a variety of feedstocks.** State-specific simulations for feedstocks could help de-risk project planning for owners and investors. Factoring in local cost and availability of energy, transport routes and connections, and infrastructure access would provide the data necessary to drive decision-making for projects and their investors.
- **Systemic models capable of simultaneous operations.** Stakeholders would benefit greatly from models that allow for simultaneous implementation of considerations such as availability of products and services, investment competition, and path dependency for short-, medium-, and long-term investments. Such models allow stakeholders to view a dynamic evolution of the value chains and any competition with other value chains.
- **Accurate tools and models for rapid identification of ideal SAF development regions.** The critical elements of feedstock availability, quality, supply chain risk, logistics and infrastructure strength, workforce, and socioeconomic impacts necessary to accurately evaluate regional readiness for SAF manufacturing are not available at spatial resolutions for large-scale assessment of multiple combinations of feedstock, region, and technology. Layered geospatial regional models could highlight feedstock availability by type, physical properties, current use, seasonality and forecasting, land utilization, land use change (direct and indirect), biomass supply, logistics assessment, and existing infrastructure.

    - Similar geospatial models could also highlight elements like SAF demand, technology suppliers, technologies employed, projects announced, phase of construction, estimated commissioning dates, etc.

- **Models to assess and compare multiple production pathways**. This type of model would aid in the selection of suitable feedstocks, strategic production locations, and optimal distribution channels that would minimize environmental impacts and costs while considering and addressing local socio-environmental needs.
    - These models should be constructed using reliable, real-world field data or accurate simulations to evaluate the environmental, economic, and social impacts associated with the transition to SAF across multiple levels.
    - Regional case studies can be combined with data-driven models to facilitate future projections of production scale-up and prediction of impacts from broader SAF adoption across the United States.
- **Tools that consider the end use markets of byproducts and coproducts of the SAF supply chain.** These types of tools would also enable more effective supply chains by accounting for the operational efficiencies and potential cash flows of the various supply chain stakeholders.
- **Tools specifically developed to drive decision-making at key points.** Some respondents felt that the timeline to develop holistic models is too long and that efforts should focus on tools that specifically inform key decision points for SAF projects such as facility siting, permitting, air and water emissions, transportation impacts, etc.

Tools for Updated TEA

- **Updated TEA modeling and simulation tools.** Updated modeling for existing and emerging SAF pathways and associated potential feedstocks should incorporate detailed information on process specifics to most accurately model costs. New innovations such as artificial intelligence tools should be incorporated into updated tools to facilitate the types of complex optimization necessary for SAF supply chain modeling.

LCA Modeling

- **Updated LCA models for various existing and emerging SAF pathways.** LCA tools facilitate a comprehensive evaluation of the environmental impacts associated with SAF production and utilization throughout the entire supply chain. These models include assessments of GHG emissions, energy consumption, water usage, and other environmental effects, but updates to existing models should account for additional factors such as climate-smart agricultural techniques, low-carbon power generation, indirect land use change, and coproduct production. Like with TEA models, LCA simulation tools could be bolstered by including artificial intelligence tools.

Policy Analysis Tools

- **Tools to model existing policy and simulate potential policy shifts.** The current policy environment for U.S.-based SAF includes multiple tax credits and incentives between the Inflation Reduction Act (IRA) (carbon oxide sequestration credit [45Q], Clean Fuel Production Credit [45Z], and clean hydrogen production credit [45V]), the Renewable Fuel Standard (RFS) renewable identification numbers (RINs), and state-level policies such as the Low Carbon Fuel Standard (LCFS). Evolving policies can result in shifts in both demand centers and SAF supply. As federal policy changes and additional states begin to implement LCFS and SAF incentives, stakeholders will benefit from the ability to simulate how these shifts in policy will affect the techno-economics of various SAF production pathways and to predict how demand for SAF will shift within the region. These tools can also help legislators understand how new policy can affect the SAF industry within a geographic region. Simulations will also need to model how policy changes for other industries being decarbonized may affect the availability of resources needed for SAF. These tools should be able to navigate policy changes that affect multiple sectors and identify synergies that can bring benefits to SAF and these other industries.
- **Detailed policy simulation tools to inform effective policy design.** Federal and state policy around SAF has been evolving rapidly, making it increasingly difficult for stakeholders to navigate utilization of various incentives and credits to maximize value. There is a continued need for tools that allow both stakeholders and lawmakers to evaluate a complex set of policy strategies and can account for impacts from existing and proposed legislation.
- **Tools for determining policy compliance.** As demand for SAF increases and a more diverse set of feedstocks are used to produce SAF, models to assess GHG emissions will need to be developed for the specific feedstocks to ensure their qualification for the standard. The criteria for Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)-eligible fuels have been updated to include an increased set of criteria that will extend beyond GHG reductions to include maintaining carbon stocks, carbon permanence, water quality and availability, soil health, air quality, conservation, waste management, and human and labor rights. With these additional requirements, new tools will need to be developed to allow stakeholders throughout the supply chain to track their individual impact on each of the qualification requirements. These tools should also allow stakeholders to examine the downstream impacts of decisions at various points of the supply chain.

Secure Data Sharing and Availability

- **SAF registry to enable the efficient and confidential sharing of key fuel documentation and attributes.** This type of tool could not only alleviate barriers in the carbon tracing and accounting process due to hesitations from stakeholders to share data, but could also help capture global SAF usage data. Usage data could provide stakeholders with insight into regional supply and demand, market trends, and other key performance indicators that can be used to optimize the supply chain.
- **Secure data collection methods to enable carbon tracking.** For renewable fuel producers to obtain feedstock origination data, the original collector must be willing to share data that are tied to competitive business information. The sharing of these data is crucial to provide transparency across the supply chain and to enable the level of carbon tracing required to claim SAF incentives. Platforms that enable secure sharing of sensitive information would further enable a transparent supply chain with verifiable tracking from feedstock production through end use.
- **Availability of data is key for analysis and data-driven decision-making.** Whether it be data on optimization of economic costs, the reduction of carbon intensity (CI), or the exploration of new investment opportunities, having access to the necessary data will help stakeholders make informed decisions and will reduce the potential for unforeseen issues down the line.

Feedstock Production Models

- **Support and expansion of tools for feedstock tracking and supply.** Accurate documentation and reporting of data for a wide variety of feedstocks is not only useful for project development and siting purposes, but can also be used to enable economically distressed communities to find more immediate markets for their biomass assets. Transparent data presented publicly can be used by biomass producers, biointermediate and biofuel project developers, capital financing, and risk and offtake insurance providers to engage in building out this new supply chain for SAF production faster and with less risk. Feedstock models could integrate with downstream distribution and logistics models to further enable the supply chain.
- **Analysis on feedstock storage and preprocessing.** Numerous factors can influence the availability of SAF feedstocks. Seasonal fluctuations and market dynamics can have a notable impact on the supply of feedstock to biorefineries, so it is crucial to have analysis tools that consider the existing network of storage facilities, the connectivity of delivery systems, both established and emerging infrastructure developments, and the trade-offs between feedstock density and transportation costs.

Biorefinery Siting Tools

- **Updated site selection tools.** Existing siting tools should be updated with publicly available data to more effectively identify optimal sites for new facilities. These new tools should provide clearer insight on where to locate feedstock aggregation plants and should include a focus on feedstock transportation infrastructure allowing site selection in proximity to cost-effective transportation alternatives such as rail and barge. Tools should identify ideal transportation corridors between the feedstock production locations and the fuel producer to ensure sufficient and affordable transportation of materials to the fuel producers and then to markets. Additionally, these tools could include the locations and owners of existing transport infrastructure (e.g., rail, pipelines), clean hydrogen production sites, CO_2 point-source emissions sites, CO_2 pipeline and sequestration locations, and electrical transmission line locations. Additionally, DOE could provide geospatial analysis of renewable energy levelized costs of energy production. For SAF produced from biological feedstocks, DOE could provide geospatial mapping of feedstock availability and CIs using satellite data to assess regenerative agriculture practices (e.g., cover crops, no-till farming).

Transportation Network Modeling

- **Develop transportation network optimization models**. These models are important to connect feedstock supply points, hubs, biorefineries, and airports in the most efficient manner. Effective transportation models would be capable of interlinking various transportation methods for diverse volumes of feedstocks and SAF. Future SAF transport will require significant use of pipeline systems, and being able to model pipeline use from terminals to airports will also be critical to the efficient distribution of SAF.

- **Comprehensive transport infrastructure analyses.** Building out the optimization models necessary to enable effective feedstock and SAF transport throughout the supply chain will also require comprehensive analyses of SAF demand, transportation mode capacity, and existing transport and storage infrastructure, as well as understanding competition for resources with the conventional fuel supply chain. Employing advanced forecasting tools will be necessary for rapid response to dynamic changes in demand. Distribution logistics tools must also accurately account for the CI of all modes of transport under various scenarios to understand the effect on the final CI score of the fuel delivered to the end user.

Resource Management Tools

- **Feedstock resource management and planning modeling tools.** Feedstock resource tools and modeling could provide stakeholders with useful predictions for regional feedstock availability throughout the year, which can be incorporated into management and planning scenarios. Feedstock resource management and planning modeling offers several advantages and opportunities, including the ability to include regional climate, soils, and agronomic insights to enable more complex and realistic forecasting.

- **Tools to identify resources and determine availability.** Stakeholders could benefit greatly from the development of a simulation tool that allows them to understand the full range of resources available to them. Such tools would identify existing feedstock suppliers, SAF producers, fuel blenders, quality control options, and delivery/logistics routes, with the ability to visualize the data and simulate different scenarios. Understanding demand and ideal SAF distribution to major airports would also help participants strategically select future facility locations, enabling more mature and integrated supply chains. Facility siting efforts would be further supported by mapping process resources like deionized water, cooling water, renewable electricity, and even existing jet fuel blenders in the region.

Pathway-Specific Modeling Tools

- **Pathway-specific modeling tools.** Detailed modeling for SAF production pathways would bring enormous benefits to fuel producers and supply chain partners. For example, the power-to-liquids (PtL) pathway would benefit significantly from modeling tools that integrate detailed data about gaseous feedstock sources (e.g., point sources of CO_2 and biogas) with high-resolution electricity cost models. Databases with substantial information on CO_2 point sources exist already; further process information such as flue gas composition, temperature, and pressure would help PtL producers better identify sources that are good matches for their unique processes. For example, high-temperature processes such as reverse water-gas shift or solid oxide co-electrolysis might need to identify CO_2 sources that produce hot flue gas, from which thermal energy may be easily recovered for the process.

- **Methodologies and tools to explore alternative pathways.** Tools that identify techno-economic opportunities, constraints, choke points, and risks for alternatives outside of traditional SAF production pathways could support industry growth and build out SAF production in areas where it was previously not feasible. These tools should be supported by a data layer that organizes knowledge and data related to the techno-economic aspects of processes, resources, and alternative products. This analysis should be conducted with a global perspective, taking into account impacts on international feedstock production and considering potential national security implications. The study of the effects of the introduction of policies to realign incentives along the supply chain, the incentivization of economic activities that need expansion, and the identification of potential unintended consequences should be supported by the tools. Simultaneously, a rigorous emissions accounting framework must be integrated in the tool to guide and constrain the techno-economic exploration of alternative supply chain pathways.

Supply Chain Transparency and Carbon Tracking

- **Supply chain complexity necessitates accurate and transparent carbon tracking methods.** Transport of biomass feedstocks may require multiple transfers between entities before final handoff to a fuel producer, which requires documentation by all parties who may use different record-keeping methods. Tracking tools should incentivize traceability across SAF supply chains. Such traceability would ensure federal and state compliance, assist with enforcement, allow for the market to take advantage of dynamic CI scoring, and help identify optimizations and improvements across supply chains.
- **Integration of data collection into traceability models and tools**. Carbon tracking tools and systems should integrate data collection technology at multiple points along the chain. For example, system components for upstream data collection may include a field dispatch tool, harvest-equipment-mounted data capture, a data analytics visibility tool, a work order visualization tool, and an inventory management tool.
- **Robust accounting tools for separable attributes.** Both air transport end users and aircraft operators who want to purchase SAF credits to meet their climate goals will need verifiable volumes of fuel. SAF and its low-carbon and renewable fuel attributes can be sold separately from each other, which necessitates the development of digital platforms that can reliably track these independent of each other.
- **Tools for tracking feedstock CIs across the value chain.** Because regenerative agriculture practices are a key lever for reducing SAF CI scores, easy-to-use tools that link farming practices to the Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET) model and CI calculations will be needed to support farmer adoption and enable tracking of low-CI feedstocks across the value chain. Because SAF incentives are dependent on CI score, the value of the feedstock will be dependent on the CI score, creating the need for these tracking and calculation tools.

Supply Chain Resiliency Models

- **Tools to assess and improve supply chain resilience.** Tools that assist in assessing the resilience of supply chains and identifying and mitigating vulnerabilities are necessary to ensure the continuity of the SAF supply. Resilience models and tools should be as dynamic as the supply chain itself and should be responsive to new risks and vulnerabilities that emerge over time. Resilience tools should use mathematical and computational models of the supply chain to identify vulnerabilities and develop strategies to make the supply chain more robust and responsive to unexpected disruptions. Supply chain resilience models provide four essential functions:

1. Identification of vulnerabilities, including single points of failure, bottlenecks, and external threats.
2. Assessment of the risks associated with likelihood of the disruptions happening.
3. Evaluation of resilience strategies to mitigate disruption events.
4. Cost/benefit analysis of the impact of implementing the resilience strategies.

Workforce Analysis and Social Science Tools

- **Workforce requirement analyses.** The ability to estimate human capital requirements during the planning, construction, commissioning, and operating phase of infrastructure build-out will be helpful for resource allocation, as well for calculating indirect economic benefits to the state.
- **Integration of community acceptance models.** Social science tools like the Community Assets and Attributes Model were referenced by stakeholders and could be integrated into holistic models to allow for comprehensive analyses of regions. This could enable site selection based on technical criteria while also accounting for factors that could affect the likelihood of community acceptance.

Financial Analysis

- **Datasets that aggregate and anonymize industry capital expenditures (CAPEX) and operational expenditures.** Tools that give industry stakeholders access to aggregated, anonymized CAPEX and operational expenditures would enable modeling of project economics across the value chain. A similar effort is being undertaken within the Office of Energy Efficiency and Renewable Energy to benchmark hydrogen electrolyzer costs.

Development and Dissemination of SAF Supply Chain Tools

Respondents supported the development and dissemination of these modeling and simulation tools by industry and government. Respondents suggested that industry and government should not only support additional R&D and analyses to aid in the development of these models and tools, but also enable stakeholders to develop and employ data infrastructures that enable the curation and use of multidomain data for the development, verification, and validation of the models.

For government-funded development of these tools, stakeholders proposed a number of approaches to distribution:

- **Make tools available on a centralized platform.** Supply chain modeling and simulation tools could be presented as a specific category within a centralized platform for SAF-enabling business.
- **Make tools available as part of government-furnished equipment on future contracts.** If purchased or developed by the government, these tools could be provided to recipients of government funding.
- **Direct utilization to develop public data packages.** The government or government-sponsored entity could use enhanced modeling and simulation tools directly and makes data packages available to SAF stakeholders.

Demonstration of Supply Chain Elements

Question 3: What are the most critical gaps in demonstration (pre-commercial validation) of supply chain elements, and how can these be overcome?

A significant number of responses emphasized the need for long-term, stable policies at all levels of government. The policy uncertainty present in the SAF space is compounded with other risks such as lack of funding, limited sustainable feedstock availability, ongoing social debates, technology risks, lack of dedicated SAF infrastructure, and high capital costs. This uncertainty becomes an integral component of the pricing model to deliver SAF to the airport, making the total cost substantially higher than that of conventional jet fuel. These compounded risks make it extremely difficult for stakeholders to demonstrate many elements of the supply chain, including not just the production of feedstocks and fuel, but also distribution and transport logistics and integration with existing infrastructure.

Critical Gaps in Demonstration of Supply Chain Elements

While stakeholders pointed to individual barriers facing intermediate-scale demonstration of various pieces of the supply chain, these barriers were commonly tied back to a lack of financial support, which itself stems from uncertainty in policy, technology readiness, and market demand.

Demonstration Gaps
• Investment risks and funding availability • Policy barriers and regulatory barriers • Technology integration and demonstration risks • Market uncertainty • Incentive programs causing competition between fuels and resources • Unbalanced risks along the supply chain • Premiums and fees for intermediate-scale demonstration • Integration with existing infrastructure and other supply chains or technologies • Social debates and community concerns • High capital costs • Availability and sourcing of low-cost, low-CI feedstocks • Permitting timelines and difficulties • Transparency in tracking • Transport and distribution • High costs for associated pre-commercial technologies • Operating margins for supply chain stakeholders.

Investment Risks and Funding Availability

- **Lack of funding required to demonstrate SAF technologies**. Ongoing issues such as limited sustainable feedstock availability, ongoing social debates, low technology readiness, lack of dedicated SAF infrastructure, and high capital costs increase investment risk and reduce the likelihood of securing funding through traditional financing entities.

Policy Barriers and Regulatory Barriers

- **Short-term policy timelines.** Current federal SAF incentives do not provide certainty for the industry, as they will sunset before many SAF facilities are constructed and have begun operation. The short-term nature of these policies makes it difficult for projects to demonstrate long-term economic viability of their projects to potential financing entities.
- **Competition between state incentives.** Some state-level incentives are helpful to promote SAF production and use, yet leave significant portions of the United States without supply. Lack of significant volumes of SAF makes it difficult to demonstrate various supply chain elements such as pipeline distribution or large-scale blending and storage. Exploration of different types of policy instruments that could support SAF supply chain development in other states could identify state- and local-level policy approaches that would support supply chain development. Such policy instruments could include incentives for facility location or additions to existing facilities.
- **Inconsistent definitions of renewable biomass within legislation.** For example, differences between the RFS program's definition of renewable biomass and the U.S. Forest Service's wildfire crisis 10-year strategy means a difference of tens of millions of tons of biomass per year available for SAF production. An updated definition would include underutilized woody biomass materials from federal and nonfederal forestland, mill waste, standing dead trees, and wildfire mitigation measures.
- **Lack of a standardized methodology to calculate the life cycle emissions of SAF**. Current legislation and incentive programs do not agree on the allowable methodologies for determining life cycle GHG emissions. Standardized methods should allow producers to account for climate-smart agricultural practices and indirect land use change in determining the final CI score of fuels.

Technology Integration and Demonstration Risks

- **Complexities in ensuring compatibility among technologies, equipment, and processes**. To bridge integration gaps, thorough testing, piloting, and simulation studies are essential. Collaborative R&D efforts are also crucial for identifying and resolving these issues.

- **Technology integration difficulties.** Integrating unit operations presents challenges in all SAF pathways. For example, syngas cleanup following gasification of biomass presents significant difficulties and increases the complexity of seamless integration between gasification and Fischer-Tropsch technologies. For PtL processes, hydrogen electrolyzers must be deployed in coordination with carbon capture technology and the Fischer-Tropsch process, which all together present numerous challenges. Continuous feeding of biomass into pressurized reactors remains a difficult challenge for producers.
- **Significant delays in equipment procurement.** Supply chain delays for key equipment such as electrolyzers can then lead to significant project delays. A hydrogen electrolyzer, for example, can take up to 18–24 months to procure.
- **Immature technologies for feedstock conversion and SAF production.** Low energy conversion efficiencies continue to drive high costs. Responses support continued investment in R&D to advance technology readiness levels. Collaborations among research institutions and the private sector to accelerate technological innovations should be encouraged.
- **Complexity of pilot- and pre-commercial-scale operation of integrated, low-cost processes for SAF production.** The pre-commercial demonstration of these technologies requires the demonstration of novel catalysts, reactors, and process configurations optimized for the smaller commercial scales suitable for sustainable carbon feedstocks. Not only is the demonstration of these complex integrated processes an extremely challenging undertaking, but these must also be carried out in different geographic locations to validate opportunities from diversified feedstock sources, which introduce entirely new challenges. Further, the demonstration of coproducts is critical to validate the TEA and LCA, which requires additional technology development.

Market Uncertainty

- **Uncertainty in market signals to invest in SAF.** It is difficult to secure project financing for demonstration-scale facilities without a stable market. Projects need to be able to point to stable policy as a driver for SAF demand, or they need to secure long-term SAF offtake agreements from airlines. Airlines are unlikely to commit to these long-term agreements unless SAF is cost-competitive with conventional jet fuel or unless they are mandated to.
- **Market favors production of RD over SAF.** The current incentive environment at the federal and state levels makes it more economically advantageous for refiners to produce RD rather than hydroprocessed esters and fatty acids (HEFA) SAF. Additionally, in some cases, HEFA yields may be lower for SAF than RD, which would further decrease the attractiveness of SAF for HEFA producers.

Incentive Programs Causing Competition Between Fuels and Resources

- **Disallowance of sequestered CO_2 and renewable hydrogen for generating tax credits if used in SAF production.** Current incentive language disqualifies sequestered CO_2 and renewable hydrogen from receiving IRA tax credits if the CO_2 and hydrogen are then used in SAF that generates tax credits. This creates competition between necessary resources for economic SAF production.
- **Unbalanced costs to produce RD versus SAF.** HEFA-based SAF competes with RD due to shared feedstocks and refining infrastructure but is further disadvantaged because the HEFA process yields lower volumes when making SAF than RD. Current incentives are also higher for RD, making it a clear economic choice for producers at this time.
- **Potential value of E-RINs from RNG.** Production of RINs from renewable electricity generation via RNG could significantly reduce or entirely consume the biogas available from anaerobic digesters and landfills. This could result in insufficient volumes of biogas available to demonstrate SAF production.

Unbalanced Risks Along the Supply Chain

- **Increased risks for farmers that are adopting new practices or purchasing equipment to enable low-CI feedstock production.** As farmers are tasked with growing unfamiliar crops or incorporating new agricultural techniques, they take on significant risk because the market for these feedstocks is directly tied to offtake by the fuel producer. If the biorefinery fails, these farmers are left with a product that has little to no market, while investors can offset some losses through sale of the facility or equipment. Incentive sharing, along with support through long-term field trials and training of feedstock producers, is necessary to increase farmers' willingness to adopt new feedstocks in their planting decisions. Farmers also need funding and risk management tools to help overcome the challenges in introducing a new cropping system into their rotation.

Premiums and Fees for Intermediate-Scale Demonstration

- **Limited grain storage on farms and at grain elevators.** For new intermediate crops and oilseeds, farmers must either have sufficient on-farm grain storage capacity or rely on elevators to store the harvest. Elevators have limited capacity and may not be willing to dedicate storage to intermediate volumes of these new crops. As a result, growers are given a very small window of time in which to deliver their crop and must time delivery to coincide with the arrival of rail cars to the elevator and the elevator's ability to load rail cars. This is not always feasible for farmers and may result in late fees or even demurrage charges from the elevators holding the grain for longer durations due to late rail cars, which are due to the railroads deprioritizing delivery of the cars due to low volumes.

- **Transport of intermediate volumes via railroad.** Feedstock producers without enough volume to warrant unit trains or shuttle trains must rely on single train cars to move their product. Delivery of single cars is frequently behind schedule, which leads to compound issues and fees from the grain elevator, increased burden on the farmer, and higher costs of delivered feedstock for the fuel producer. For biointermediate producers, the railroads rarely offer single oil tankers, and most shipping companies require a long-term lease to move oil in rail tankers. As a result, moving oil from crush to refining can be a challenge when the volumes get too large to use trucks, but not large enough to justify a long-term lease for tanker rail cars.

Integration with Existing Infrastructure and Other Supply Chains or Technologies

- **Immaturity of technologies and resources necessary for production of SAF at scale.** Access to low-CI CO_2, hydrogen, and electricity at scale will be necessary to decrease costs for future SAF production and enable volumes meeting the SAF Grand Challenge goals. The future integration of supply chains for these low-CI resources should be considered in the build-out of present-day SAF supply chains. For CO_2 this includes not just pipeline integration, but also support for R&D to advance emerging direct air capture projects and carbon capture and sequestration projects of the highly pure stream of CO_2 produced during the fermentation of ethanol. For hydrogen production, producers require stable access to clean electricity to power electrolyzer processes at relevant scale.
- **Infrastructure challenges at airports.** Demonstrating the last mile of the supply chain is difficult due to a lack of appropriate infrastructure to store SAF blending components and final blended fuels. To ensure traceability along the supply chain, individual tanks are needed for SAF blending components, the blending itself, and storage of the final blended fuel. It is likely that investment by the airports, blenders, or other stakeholders will be needed to construct the additional storage and blending facilities to resolve this.
- **Lack of integration of the SAF supply chain with existing jet fuel infrastructure.** Many SAF supply chain efforts focus on the front end of the supply chain, from the feedstock source through fuel production, because it is unique to SAF production and introduces new challenges and complexities not present in the conventional jet fuel supply chain. However, the back end of the SAF supply chain, from fuel production up through end use, requires some unique handling and storage requirements to accommodate SAF.
    - ASTM D7566 requires blending SAF components with conventional jet fuel and retesting after blending before the final fuel can be certified as jet fuel. Blended fuel must meet certain physical property requirements, such as

minimum aromatics concentration, minimum and maximum density, distillation slope, and lubricity. These properties are driven by the composition and properties of both the SAF and conventional jet fuel blending components. Therefore, a suitable conventional jet fuel batch must be matched with the SAF synthetic blending component to meet the specification property requirements. This, in turn, limits the supply of suitable conventional jet fuel batches that can be used to produce the fuel product. Conversely, the composition and the physical properties of the SAF synthetic blending component will dictate the size of the population of suitable conventional jet fuel blending components.

- **Gaps in data availability related to siting and cost requirements of blending facilities.** Stakeholders recognize the importance of blending facility capacity for the SAF supply chain but note a lack of information related to costs and requirements for constructing stand-alone blending facilities. Stakeholders suggest that cost sensitivity analyses should be developed to understand the trade-off between SAF composition and blending facility scale and scope requirements.
- **Approval of neat and blended SAF from multiple pathways**. Being able to approve SAF from multiple sources at the airport is critical to the efficient movement of SAF at scale. Pipeline transportation is the most cost-effective way for SAF to be transported at scale; it is critical that the pipeline operators approve SAF in neat and blended form. Like terminal storage capacity, many pipelines are also constrained for capacity. Additionally, the batch sizes are significant and will be a challenge for many smaller-scale SAF producers. To solve this problem, there must be a consistent process to approve SAF by various feedstocks to the ASTM D1655 specifications for synthetic paraffinic kerosene. This will allow for SAF producers to develop projects at scale knowing that they will be able to utilize the lowest cost of transportation. This will also allow for the future aggregation of SAF for distribution on the pipeline systems.

Social Debates and Community Concerns

- **Public hesitation due to the food vs. fuel debate.** Public perception of biofuels in general is still influenced by the belief that the food supply is substantially affected by the use of farmland for growing feedstocks for biofuel production.
- **Community acceptance of new SAF facilities is not guaranteed.** The health and economic benefits that a new SAF production facility can bring to a local community are not always well known by the public. Without public outreach and education to make the benefits known, new projects may face significant pushback, which can delay or even stop the project entirely.

High Capital Costs

- **High capital costs of SAF biorefineries**. Capital costs continue to rise since the COVID-19 pandemic, and funding is already limited for demonstration-scale projects, so CAPEX reduction is critical. Reducing capital cost will require process intensification, optimized unit operations, and reduced costs for common processes such as separations. Additional R&D to help advance separation technologies, reduce the number of passes required for conversions, or increase catalyst selectivity can help reduce capital costs.

Availability and Sourcing of Low-Cost, Low-CI Feedstocks

- **Difficulty sourcing sufficient volumes of consistent, low-CI biomass feedstocks**. A stable supply of low-CI feedstock available within an affordable distribution range of biorefineries is extremely limited. Feedstock pricing is a dominant factor contributing to high SAF costs and a critical bottleneck for financial investment in first-of-a-kind and other early SAF facilities. A broad portfolio of low-cost, abundant feedstocks is needed to meet the SAF Grand Challenge due to constraints on the availability of low-cost lipids, which are being relied on in current SAF production. Access to the necessary volumes of a consistent feedstock reduces project risk, creates regional stability, and increases bankable project financing.
- **Limited soft seed crush capacity.** For SAF pathways utilizing oilseeds and intermediate crop feedstocks, greater crush capacity is required to produce volumes of oils necessary to demonstrate technologies and at reasonable scale.
- **Lack of feedback from the biorefinery regarding feedstock specifications.** This lack of feedback from biorefineries leads to feedstock producers optimizing bales for cost reduction rather than to meet a specification that would result in optimized biorefinery performance. This, coupled with a lack of rapid analytical tools for attributes like moisture and ash content, leads to issues at the biorefinery that result in technical issues and cost increases for handling and processing the bales.
- **Disallowance of cover crop harvest under federal programs.** Under traditional scenarios, USDA does not allow farmers to harvest cover crops as part of federal conservation programs. Farmers that implement a harvestable winter oilseed crop cannot utilize USDA conservation programs to support that effort. Stakeholders submit that new winter oilseeds provide the same conservation and soil benefits as an unharvested cover crop and should be allowed to participate under these programs.

Permitting Timelines and Difficulties

- **Lack of data needed for environmental permitting of facilities**. The timelines for applying for and obtaining the permits necessary for construction and operation of biomass feedstock preprocessing facilities and biorefineries are prohibitive. Delays are extremely costly, and demonstration projects are already facing difficulties in securing funding.

Transparency in Tracking

- **Difficulties defensibly tracking carbon from the feedstock producer to end user.** SAF necessitates a new and complex chain of custody models. Current methods include physical segregation, mass balance, and book-and-claim models, but disparity in carbon accounting practices across jurisdictions and programs leads to uncertainty across the supply chain. As the supply chain becomes increasingly complex through the incorporation of new feedstocks, use of different carbon life cycle models, and various approaches to fuel production, there is a new and important need to track carbon and fuel characteristics more effectively throughout the entire value chain. Tracking challenges prevent broader buy-in and reduce trust in the system due to fears of double counting and noncompliance.
- **Difficulty claiming fuel use against multiple regulatory schemes**. Airlines will gain the greatest economic benefit if they can claim their fuel use against various end-user regulatory schemes, such as CORSIA and the European Union Emissions Trading System, but to do so they need to have detailed information on the SAF purchased. It is difficult for airlines to collect this documentation, as fuel may come from multiple upstream suppliers who may subdivide fuel and whose documentation requirements may differ from that of the producers. Upstream, the same tracking is needed for producers and suppliers to take advantage of credits coming from the IRA and RFS. If upstream stakeholders are unable to claim these credits, the industry will not be able to drive down SAF premiums.

Transport and Distribution

- **Inability to utilize the most efficient distribution methods.** Depending on the location of the SAF production facility and the directional flow of the pipeline systems, there will be production facilities that have to utilize other methods of transportation outside of the pipeline systems. If a pipeline is not viable for the movement of SAF, a producer must use rail or Jones Act vessels to transport the fuel. These methods are 5 to 6 times the cost of transporting on a pipeline. For demonstration-scale operations, this cost increase can entirely change the economics of the facility. Infrastructure for loading and unloading of marine and rail vessels would need to be established at the blending terminals.

High Costs for Associated Pre-Commercial Technologies

- **Low-CI hydrogen, electricity, and CO_2.** These resources are especially important for commercializing the PtL pathway but can also provide significant benefits for other SAF pathways. Current levels of commercialization for these resources are not sufficient to support production of the volumes of SAF needed to meet the SAF Grand Challenge goals. Further advancements in technology and infrastructure are necessary to achieve a stable, affordable supply of low-CI hydrogen, electricity, and CO_2.

Operating Margins for Supply Chain Stakeholders

- **Tight operational margins at both ends of the supply chain.** Feedstock producers operating within tight margins are less likely to take on risks associated with adopting new agricultural practices or purchase new equipment that may enable them to produce lower-CI feedstocks that will ultimately allow fuel producers to take advantage of the full benefits of federal and state incentive programs. At the other end of the spectrum, airlines also operate within tight margins and are not as willing to sign long-term offtake agreements that require them to pay even a slight premium for SAF. Without long-term agreements, the fuel producers have a more difficult time demonstrating a market for their product, which makes securing project financing more difficult.

Recommendations for Overcoming Gaps in the Demonstration of SAF Supply Chain Elements

Many of the actions recommended for overcoming barriers to pre-commercial activities can be effective in their own right, but when enacted together could help further accelerate demonstration of the supply chain. The implementation of new policies is one of the greatest opportunities in this area. Supportive policies can reduce the burden on stakeholders across the supply chain, giving them the opportunity to engage with and collaborate with others to increase overall efficiency of operations and help bring each element of the supply chain closer to commercial viability.

Overcoming Demonstration Barriers
• Policy recommendations • Leverage existing supply chains and infrastructure • Invest in development of a wide range of feedstocks • Strategically target deployment of funding • Enable partnering/matchmaking and education • Optimize SAF production with critical products.

Policy Recommendations

- **Limit fees and penalties that are common to intermediate-scale feedstock production**. Policy limiting the amount of demurrage charged when railroads deliver cars late would help alleviate the burden placed on farmers seeking to deliver lower volumes of new feedstocks to fuel producers.
- **Allow sale of biointermediates from a single hub to multiple fuel producers**. Current rules from the Environmental Protection Agency limit transfers from one biointermediate producer to a single renewable fuel producer. Revising this rule would quickly incentivize economies of scale and remove a limiting factor to building out feedstock diversity for SAF producers.
- **Recognize the need for a wide variety feedstocks and production pathways.** Development of the SAF industry would be accelerated by approval of new RFS pathways in response to the continued innovation in the biofuels space. Stakeholders highlighted the need for new approval of RFS pathways, including biofuels produced in conjunction with carbon capture utilization and storage, corn oil produced at bioethanol wet mills, and bioethanol pathways from kernel fiber. New pathways can help clear the way for further decarbonization and commercialization of SAF.
- **Alleviate barriers for biomass access from federally owned lands.** Various categories of forestry biomass, including residues remaining after harvest, fuelwood, residues from processing mills, and residues from silvicultural treatments, represent an additional source of feedstock for SAF production. Existing regulations inhibit forest biomass removal from public land, but revising these rules could aid in establishing an effective supply chain by increasing the volume of available biomass while reducing potential fire risk.

Leverage Existing Supply Chains and Infrastructure

- **Optimize transportation routes and expand storage facilities and blending facilities along the supply chain.** Supply chain participants should leverage the existing vast network of pipelines, petroleum product terminals, and distribution sites for conventional jet fuel. Expanding petroleum product terminals to accommodate SAF and other biofuels represents a minor effort compared to building entirely new infrastructure, enabling rapid growth in SAF availability.
- **Utilize the efficiency of the existing ethanol supply chain**. The production, storage, and transportation of corn has evolved over decades and is highly efficient. Ethanol is transported nationwide and blended with gasoline downstream at terminals for distribution to retail stations, which requires immense coordination across the entire supply chain.

- **Utilize existing infrastructure from the pulp and paper industry.** The government should incentivize lignocellulosic production hub project financing for the retrofit of existing fuel refineries and pulp and paper mills. These projects could significantly increase the capacity for production of meaningful volumes of biointermediates and biofuels derived from woody biomass.
- **Utilize small, independent refiners**. These refiners may be more agile in their operations and could enable demonstration of technologies at an intermediate scale that larger refiners may not be able to accommodate.
- **Utilize the U.S. Department of Defense for large-scale demonstrations.** The Department of Defense is the federal government’s largest consumer of jet fuel and represents an opportunity area for demonstrating multiple supply chain elements including fuel production, distribution, blending, and use.

Invest in Development of a Wide Range of Feedstocks

- **Support long-term field trials and the training of feedstock producers**. De-risking the adoption of new crops and practices is necessary to increase farmers’ willingness to participate in production of new feedstocks for SAF production. The information on feedstock yield, equipment requirement and investment, and impacts on the soil quality is critical in farmers' decisions and requires further efforts in both research and extension services. Extension activities should ensure that farmers receive up-to-date information to guide their decisions and support them as they transition from traditional cash crops to SAF crops in future efforts. It is particularly crucial in the short term for winter oilseeds that are not commonly adopted by farmers but play a critical role in the feedstock supply for SAF production from the HEFA pathway.
    - In the medium to long term, improving farmers’ perceptions and willingness to adopt new purpose-grown SAF feedstocks will also be critical and require sustained funding in research, education, and extension targeted at this group. To this end, long-term feedstock research trials strategically located across regions would be critical to collecting data that will inform education and extension outreach to farmers.
- **Support distributed feedstock processing.** As limited local feedstock availability and the size of individual biorefineries remain gaps, considering hub-and-spoke models allows for larger, centralized processing. The capital intensity (capital per throughput) remains high for biorefineries operating at smaller scales. Hub-and-spoke systems are one means to balance distributed processing by allowing large, centralized plants for a portion of the SAF production process.
- **Support allowance of cover crop harvest under federal programs.** Stakeholders emphasize that the same public programs farmers would typically

explore to implement a new conservation-oriented cropping program cannot be used for winter oilseed and other intermediate crops. Without access to federal programs, the uncertainty associated with beginning a new cropping program remains a barrier to farmers developing the low-CI feedstocks needed to support the SAF supply chain.

- **Support a diverse range of feedstocks that enable SAF production and a wide range of coproducts.** Portfolio diversification can help cushion the overall SAF market against price fluctuations in markets by reducing reliance on revenue from any single coproduct stream.
- **Support the role of climate-smart agriculture in SAF production**. Feedstock production can account for up to a third of the CI of SAF, but sustainable agriculture production practices can significantly reduce CI, sequester carbon, and improve soil health and water quality. Coupled with today's agriculture yield increases driven by technology and production efficiency, these climate-smart agriculture practices result in additional sustainable feedstock from less land and fewer inputs and resources. Monetary incentives for sustainable feedstocks still lie largely in the realm of the voluntary market, and the volatility of this market prevents not only companies but also farmers from securing and producing more sustainable feedstock.
    - Lack of harmonization on everything from basic definitions and standards to measuring and reporting protocols for climate-smart agricultural commodities has also created uncertainties around integrating sustainable feedstock into SAF supply chains. Formal guidance and recognition of standards and protocols from a federal agency would reduce this uncertainty and help push sustainable feedstock production from voluntary markets to compliance markets.
- **Institute financial support mechanisms for biomass feedstock producers**. Feedstock collectors, growers, and producers commonly encounter a profitability gap up to 5 years while establishing feedstock production and the corresponding supply chain infrastructure to connect with processing facilities or offtakers. Conventional agricultural financial institutions often lack a comprehensive understanding of risk management during this transitional period.

Strategically Target Deployment of Funding

- **Analyses to support strategic deployment of efforts and funding.** Undertake efforts to identify areas in which funding may have the greatest impact. For example, identify areas in which there may be existing infrastructure and facilities that are not equipped to handle and convert the feedstocks that are most readily available in the region. Targeted funding to adapt existing facilities and develop the local workforce could bring greater benefits for a lower cost than developing new facilities.

Enable Partnering/Matchmaking and Education

- **Provide information on existing capabilities and fuel producers that are willing to partner.** Identifying collaboration opportunities between producers with related capabilities would help advance the state of technology and allow demonstration of integrated operations along the supply chain. Existing facilities may already have space and capabilities to support smaller-scale SAF storage, blending, and distribution—for example, at the drum, tote, and ISO tank volume levels.
- **Utilize data and tools that are presently available to make the best decisions.** Successfully deploying the right technology at the optimal location and capacity is key to influencing other elements in the supply chain.
- **Provide the resources to assemble high-talent, entrepreneurial teams.** Provide support to either startups or those within established industry who are focused on pre-commercial validation of novel low-CI feedstocks, associated value chains, refining, resulting fuels, and regulatory pathway verification (e.g. CI scoring).

Optimize SAF Production with Critical Products

- **Incorporate coproduct production and distribution logistics into demonstration activities.** Coproducts have the potential to link SAF with other synergistic industries and contribute significantly to a pathway's TEA. Integrating the coproduct supply chain with the SAF supply chain could bring additional benefits to both industries.

Commercial Build-Out of Supply Chain Infrastructure and Facilities

Question 4: What are the most significant barriers to scaling and commercial build-out of SAF supply chain elements, and how should these be addressed?

Barriers to Scaling and Commercial Build-Out of SAF Supply Chain Elements

Stakeholders suggested that the most significant barriers to scaling and commercial build-out of SAF supply chain elements are driven by difficulties in securing funding due to the nascent stage of the industry and the overall uncertainty of commercializing projects. The successful build-out of many SAF supply chain elements is dependent on the success of other interconnected projects. Planning and executing these commercial SAF projects encounters uncertainty surrounding federal and state tax incentives, permitting processes and timelines, feedstock quality and availability, community acceptance, and upstream and downstream transportation and distribution, as well as a multitude of technical and market risks that all have the potential to shift pathway economics outside of the range of viability. Success of these projects is dependent on overcoming a wide range of challenges within separate yet connected domains, which will require coordinated efforts between the government and SAF supply chain partners.

Commercial-Scale Barriers
Financing risks and difficulty in raising capital
Policy uncertainty and incentive program barriers
Technical risks
Feedstock quality, availability, and cost
Access to low-CI resources
Unequal distribution of risk along the supply chain
Lack of coordinated efforts by stakeholders
Competition for shared resources
Dependency on success of other supply chain elements
Difficulties in permitting and construction
Community acceptance
Supply chain logistics: transportation and distribution
Competing incentives and programs affect viability and market pull
Capacity to judge success
Fuel quality validation and certification.

Financing Risks and Difficulty in Raising Capital

- **Uncertainty presents a significant barrier to securing funding.** Investors are hesitant to fund projects due to uncertainty around the short-term nature of SAF policy in the United States. Airlines are risk averse to committing to long-term offtake contracts that are binding due to this policy uncertainty, and there are limited financial programs to assist in enabling this new industry to grow and reduce these perceived risks.

- **Interlinked risks contribute additional uncertainty for investors**. Steps toward commercialization like the deployment of risk-sharing frameworks, the inception of public-private partnerships, and the exhibition of successful pilot/demonstration projects are significant undertakings that present their own individual challenges yet play an interconnected role in reducing risks and attracting investments. Projects that can navigate the complexity of these systems will play a pivotal role in mitigating risks and catalyzing investment.
- **Gaps in funding for demonstration- and commercial-scale facilities.** Private equity is not always accessible for new technologies until they have been proven at scale, but loan guarantee programs are also unlikely to fund projects that propose first-of-a-kind technologies, instead requiring the proposed process flow to have already been proven at a demonstration scale.
- **Lack of long-term, transparent feedstock contracts and sustained SAF offtake commitments.** At both ends of the supply chain, de-risking SAF production requires long-term contracts to demonstrate a stable supply of feedstock and a guaranteed market for the final product. Investors are wary of providing the necessary capital for large-scale projects with significant sources of uncertainty.
- **High interest rates and concern over rates of return deter third-party investment in new energy infrastructure.** Of particular concern is financing for commercial-scale facilities using production pathways that have not yet been demonstrated at commercial scale. Due to technology, execution, and/or market risk, these projects are particularly challenged to obtain debt or equity financing to proceed to the construction phase. Once proven at commercial scale, these pathways can more easily access capital, enabling more rapid deployment of SAF in the marketplace.

Policy Uncertainty and Incentive Program Barriers

- **Uncertainty surrounding the allowance of the GREET model as an acceptable methodology for calculating lifetime GHG emissions.** The CI of various feedstocks is calculated differently based on which GHG model is used, which makes it difficult for SAF producers to have confidence in structuring feedstock agreements for their projects.
- **Widespread effects of policy uncertainty.** Investors are unsure about the long-term viability of SAF policy in the United States and unwilling to take on the

financial risk. Airlines are then risk averse to committing to long-term offtake contracts that are binding due to this uncertainty.

- **Current policy landscape presents a limited timeline for action**. The SAF credit is set to expire at the end of 2024, and the Clean Fuel Production Credit is scheduled to conclude at the end of 2027. Most SAF projects will not benefit from these credits by the time they achieve commercial production volume. This requires SAF producers to pass that cost onto customers. This compressed time frame leaves investors with mounting uncertainty regarding the expected return on their investments.
  - Stakeholders expect that an increase in fuel CI reductions in the California LCFS rescope will cause a further tightening of lipid supplies favoring RD over SAF. Finally, the federal government must make a final decision on the model to be used for GHG accounting, and this decision must be for GREET.
- **Exclusionary requirements of certain regulations.** The Environmental Protection Agency's biointermediates rule requires the physical segregation of feedstocks from different facilities. Requirements like this make it difficult or impossible to utilize existing fuel transportation and transfer infrastructure assets that exist today. The requirement for keeping intermediates separated through the transportation process results in significant logistical challenges that will increase delivered costs to SAF producers.
- **Policy gaps regarding feedstock allowability remain**. The RFS does not recognize industrial waste gases or solids, CO_2 (including biogenic CO_2), and even most sustainably sourced forestry residues as allowable feedstocks for production of advanced biofuels, which excludes them from RFS RIN generation.
- **Uncertainty of carbon accounting requirements.** Pipeline-injected RNG tracked via book-and-claim accounting methods could contribute to SAF production, but there is uncertainty regarding its allowance as a feedstock for SAF production under various incentive programs. Clearly articulating that book-and-claim accounting of RNG is allowed under the Clean Fuel Production Credit and the SAF credit for production of SAF would give producers and investors the necessary certainty to make large-scale investments.
- **Lack of support for plastic-to-fuel technologies.** In comparison to the European Union, where jet fuel produced from waste gases and waste plastics is considered sustainable, stakeholders find that the United States does not adequately consider the benefits of plastic waste as a feedstock for SAF.

Technical Risks

- **Low technology readiness level for many process operations**. Technical risks remain for many SAF technologies that are still in the developmental or prepilot stages, which deters investment. New technologies that have not yet been demonstrated at scale create the risk of cost overruns and underperformance (e.g., lower production volumes, higher CI). Continued R&D leading to demonstration-scale activities with proven large-scale models is crucial. Establishing pilot projects and fostering partnerships among academia, industry, and government can significantly contribute to maturing the necessary technologies.

- **Lack of sustainable aromatics to allow for 100% SAF usage.** SAF produced via many pathways does not have sufficient aromatic content to provide fuel properties that meet ASTM specifications for 100% use in commercial planes. Current ASTM approvals limit SAF blending to 50%. Supplemental production of aromatics to be blended with SAF would be necessary under many SAF pathways, which would introduce additional technical risks in the development and scale-up of those processes.
- **Innovative processes requiring nonstandard process conditions.** Some SAF pathways require new reactor configurations or operate under nonstandard process conditions, which introduces operational and scale-up risks. Mitigating these risks requires validation at pilot and demonstration scale, which requires some level of investor confidence to raise capital.

Feedstock Quality, Availability, and Cost

- **Exclusion of feedstocks from federal crop insurance products.** Winter oilseeds' low CI scores stem from the fact that they are grown on the same acreage, and in the same year, as the primary crop. Federal crop insurance products for those primary crops have not yet been broadly amended to allow prior oilseed harvest. Farmers are not willing to risk an uninsured crop for a potential benefit granted by planting intermediate crops.
- **Inconsistent feedstock availability and quality.** SAF pathways rely on a consistent stream of in-spec feedstocks to optimize process efficiencies. Inconsistent quality or interrupted supply of feedstocks can disrupt the entire supply chain. Crop- or waste-based feedstock supplies may vary in availability due to extreme weather events.
- **Poor economics due to low-energy-density feedstocks.** Transporting SAF feedstocks is relatively less economical than crude oil and drives creation of processing facilities close to available feedstocks.
- **Finite supply of HEFA feedstocks.** The current supply of fats, oils, and greases used for HEFA-based SAF and RD is limited, which requires either production of new significant volumes of lipids or advancements in feedstocks and technologies for other SAF pathways.

- **Lack of data surrounding underutilized biomass and infrastructure.** SAF producers do not have the information necessary to form a complete understanding of the location, available quantity, quality, cost, and supply chain risks of underutilized biomass.

Access to Low-CI Resources

- **Lack of low-CI electricity and hydrogen.** The production of the green hydrogen needed for many SAF pathways requires low-cost, reliable, and abundant carbon-free electricity, which is currently not available at the levels necessary for growth of the industry.
- **Prioritization of low-CI hydrogen for other end uses.** The hydrogen hubs being developed within the United States do not all include SAF as a priority end use, which limits the future volumes that will be available for use in SAF production.

Unequal Distribution of Risk Along the Supply Chain

- **Risk is still not equally distributed among feedstock producers.** The risks associated with the connection between feedstock producers and biorefineries are complex and circular. Feedstock producers are not certain about the market of the feedstock if the biorefinery fails, and are thus hesitant to grow it at their own risk. The biorefinery and its investors do not know from where their feedstock will be sourced and find it difficult to set up contracts with individual feedstock producers.
- **The loan guarantee system and incentive programs focus on biorefineries**. Other supply chain participants upstream and downstream of the biorefinery must finance equipment and facilities entirely at their own risk. Investors in the biorefinery can recover capital if something happens to the biorefinery, but others along the supply chain are then left with unusable infrastructure.

Lack of Coordinated Efforts by Stakeholders

- **Limited collaboration among supply chain stakeholders**. Individualized and distributed efforts by stakeholders spread resources thinly in a growing industry. Stakeholder efforts could be multiplied by establishing regional partnerships and engaging in cross-industry coalitions.

Competition for Shared Resources

- **Increased investment in national infrastructure demands significant resources**. Government funding through the IRA and Bipartisan Infrastructure Law has led to supply chain challenges for SAF projects and often results in longer lead times for key equipment. Build-out of the SAF supply chain requires much of the same workforce and resources as other infrastructure projects.

Dependency on Success of Other Supply Chain Elements

- **Commercial viability of SAF projects influences bankability for other infrastructure.** The barriers facing individual SAF facilities flow down to other SAF supply chain elements because success of the biorefinery demonstrates to financiers that build-out of other supply chain infrastructure is a worthwhile investment.
- **Reliance on supply chain success in other industries.** The CO_2 supply chain is considered critical to the future of SAF, yet there are various transportation, infrastructure, and technical challenges associated with its build-out that will impact the availability of low-CI CO_2 for SAF production in the future. The growth of CO_2 pipeline and storage infrastructure is considered essential to unlock large-scale deployment of carbon capture projects that will further enable the growth of the SAF industry.

Difficulties in Permitting and Construction

- **Lengthy timelines for permitting and construction for commercial-scale SAF projects.** Projects are currently experiencing delays in permitting, pushing project timelines out past the sunsetting dates for the SAF credit and Clean Fuel Production Credit, which means that these projects will not be able to benefit from the credits. This also applies to the brownfield expansion of existing infrastructure and conversion of refinery assets to produce SAF.
- **Difficulties in obtaining permitting for CO_2 pipelines and wells**. Inefficiencies in the permitting process to approve and build CO_2 pipelines and wells impede the progress of CO_2 distribution and sequestration efforts. Stakeholders recognize the importance of permits for environmental, health, and safety reasons, but ensuring greater efficiencies to reduce paperwork and other process redundancies would shorten project timelines and encourage greater investment.
- **Compromising on key decisions to avoid delays.** Making site selection decisions based on the ability to quickly obtain permits for construction may mean that projects make concessions in other areas that lead to operational issues down the line.

Community Acceptance

- **Lack of community acceptance can stop projects entirely.** Some major population centers are resisting industrial development, so SAF projects must be developed in areas that may have limited workforces and resources. Lack of support from these communities can further delay a project or completely stop progress.

Supply Chain Logistics: Transportation and Distribution

- **Difficulties in distribution via pipeline.** Pipeline operators may not allow SAF and other biofuels to share existing petroleum product infrastructure.
- **Overall immaturity of multiple supply chain elements.** Interconnected elements along the supply chain rely on each other for demonstration at scale, but in this case the industry is tasked with maturing a supply chain that does not yet exist.

Competing Incentives and Programs Affect Viability and Market Pull

- **More attractive economics for RD production.** Many suppliers who have the capability to produce SAF are choosing instead to produce RD because the process to make RD is simpler, the yields are higher, and RD production and use claim higher incentives.
- **Reduced market pull for SAF resources**. Incentives for other utilization of SAF resources like CO_2 impacts the economics of SAF and reduces market pull. Companies providing direct air capture and biogenic sources of CO_2 have strong incentives to sequester their emissions under the carbon oxide sequestration credit (45Q) and voluntary markets. SAF utilization pathways may not satisfy permanence criteria imposed by voluntary buyers.

Capacity to Judge Success

- **Lack of performance measures to monitor, evaluate, and report progress**. Without performance measures, it is difficult to evaluate the effectiveness of federal government actions to meet the SAF Grand Challenge goals.

Fuel Quality Validation and Certification

- **Validation and certification of SAF**. Certification testing related to CORSIA's International Standards and Recommended Practices requires large volumes of fuel, which is difficult and costly for technologies that are still in development.
- **Lack of experience working with rigorous requirements for production and transport.** Conventional jet fuel regulations are stringent to ensure that fuel quality is maintained throughout the supply chain, and many prospective SAF producers do not yet have experience with these rules and processes.

Addressing Barriers to Commercialization

Stakeholders provided useful recommendations for how the government, along with other supply chain participants, could most effectively address the long list of barriers facing commercial build-out of the SAF supply chain.

Suggestions for Overcoming Commercial-Scale Barriers

- Support efforts to balance costs and offset premiums
- Support production of low-CI feedstocks
- Reduce or distribute risks along the supply chain
- Policy recommendations and considerations
- Support production of a wide variety of high-quality, low-carbon feedstocks
- Support manufacturing and infrastructure development and integration
- Support R&D to overcome technology barriers
- De-risk financing
- Support stakeholder collaborations and coalition development
- Support transparent carbon tracking across the supply chain
- Support fuel qualification testing and certification.

Support Efforts to Balance Costs and Offset Premiums

- **SAF buyer coalitions can help manage the SAF green premium.** Creating coalitions of corporate buyers can help share the price premium with airlines based on corporate environmental, social, and governance commitments and these corporations' internal prices on carbon. Existing coalitions include the Sustainable Aviation Buyers Alliance and Sustainable Freight Buyers Alliance, as well as partnerships between large corporations and major airlines.
- **Stabilize feedstock pricing via public price mechanisms.** To ensure the economic viability of feedstock sourcing, the California Forest Residual Aggregation for Market Enhancement has applied a formula rate contract with a collar. This contract ensures stable pricing and includes an indemnification clause to protect against market volatility and business interruptions.

Support Production of Low-CI Feedstocks

- **Crop insurance programs should incentivize relay- or double-cropping systems.** These systems produce low-CI feedstocks such as winter camelina and pennycress. Additionally, the Risk Management Agency pilot insurance program for camelina should be expanded to support winter varieties in appropriate regions, particularly the Upper Midwest and Great Plains, and a similar pilot program should be launched to de-risk planting of pennycress.
- **Mitigate the effects of inconsistent feedstock availability and price volatility.** Secure reliable sources of feedstocks and diversify supply channels to manage risk. In the case of HEFA SAF, which relies on finite and price-volatile waste fats, oils, and greases, it is crucial to develop feedstock management and storage solutions.

- **Balance the production of biomass feedstocks as other pathways advance.** As pathways to produce SAF from waste feedstocks and CO_2 advance, the production of agricultural biomass for SAF can be reduced to decrease land use impacts.
- **Support agricultural practices that can lower the CI of feedstocks.** On-farm practices such as the use of biological productions, cover crops, tillage management, fertilizer management, precision agriculture tools, and others can contribute to CI score reductions that can increase incentives and further enable the economics of the final SAF product.
- **Provide and share data that can help connect feedstock producers with aggregators, densifiers, upgraders, and infrastructure.** Access to these resources can help address uncertainties for feedstock producers and allow them to handle and distribute their product in the most effective manner, reducing delivered costs to the SAF production facility.

Reduce or Distribute Risks Along the Supply Chain

- **Develop supply chain models where assumption of risk falls upon all supply chain partners.** Either through incentive sharing or other financial support, the success of the SAF supply chain should be shared among those that take on risks to enable that success.
- **Create or modify insurance products to de-risk biomass supply chains**. In this new industry, it may be necessary to develop innovative insurance strategies and products to mitigate risks related to a complex supply chain.
- **Support the implementation of streamlined permitting processes to reduce risks.** The producer bears excessive risk due to uncertainty in the permitting and construction timeline. Coordination among agencies when more than one set of approvals is required for a project can help expedite the process. Transparent permitting requirements and timelines would also decrease financing risks for the project and mitigate uncertainty for stakeholders upstream and downstream of the facility.
- **Encourage the development of comprehensive risk mitigation plans for projects**. Risk mitigation strategies should be a part of every project, but working with knowledgeable parties that are experienced in the design, construction, and operation of SAF facilities would help address risks in SAF-specific areas and reduce potential for project delays or facility issues.
- **Encourage the use of models to increase the likelihood of community acceptance**. Risks associated with delays from community pushback can be

avoided from the start by utilizing tools to inform project siting based on social science and community attributes.

Policy Recommendations and Considerations

The RFI summarized within this report was closed prior to the Dec. 15, 2023, release of Notice 2024-6 from the U.S. Department of Treasury and Internal Revenue Service (IRS) Notice 2024-6 (the Notice).[4] The Notice states that the existing GREET model from Argonne National Laboratory (ANL-GREET model) does not satisfy the requirements to calculate the emissions reduction percentage for SAF under § 40B(e)(2) of the Internal Revenue Code. The Notice also announced that DOE is collaborating with other federal agencies to develop a modified version of the ANL-GREET model that would satisfy the requirements of § 40B(e)(2) and anticipates the release of this model (the § 40B(e)(2) GREET model) in early 2024. Additionally, the notice creates a "safe harbor" for SAF blending components that generate RINs under the federal RFS, and the resulting SAF qualified mixture will be deemed to have 50% or 60% emissions reductions depending on the RIN code generated for the SAF blending component.

A significant number of responses to the RFI included observations, recommendations, or general commentary related to subject matter that might be affected by Notice 2024-6. The content within this report has been developed based on the responses as they were originally submitted and does not attempt to draw conclusions as to how the new IRS guidance or the § 40B(e)(2) GREET model might impact the statements made by stakeholders in their responses.

- **Recognize the GREET model as an allowable methodology for determining life cycle GHG emissions under federal and state incentive programs.** This allowance would simplify implementation for all stakeholders by providing a consistent compliance tool that satisfies each of the clean fuel provisions of the IRA, the RFS, and multiple state fuel programs. It would further bring life cycle emission calculations under a common verification regime and help improve industry coordination of biointermediate feedstocks, allow parity across fuels, and reduce risk during scale-up and operations. This would give supply chain developers, feedstock providers, investors, and SAF producers a predictable, durable framework for assessing program eligibility.
- **Extend the life span of incentive programs.** Current production costs for SAF are significantly higher than those of traditional jet fuel. Current tax incentives are encouraging to the emerging SAF industry, but there remain concerns about the durability of policy and financial incentives and the need for an investment framework to support scale-up of SAF production. Long-term incentives are

[4] Internal Revenue Service. 2023. "Sustainable Aviation Fuel Credit; Lifecycle Greenhouse Gas Emissions Reduction Percentage and Certification of Sustainability Requirements Related to the Clean Air Act; Safe Harbors." Notice 2024-6. www.irs.gov/pub/irs-drop/n-24-06.pdf.

needed for the supply chain and fuel producers until the cost of production is in line with and comparable to that of fossil fuels. Long-term incentives will also provide certainty to investors and fuel producers who are considering committing to the large financial obligations necessary to produce SAF at scale. Stakeholders suggest that a 10-year credit would better align with project investment and construction timelines and the length of other clean energy incentives.

- **Support use of biogenic CO_2 as a critical feedstock for SAF**. The carbon oxide sequestration credit (45Q) is structured to incentivize biogenic CO_2 producers to capture and store/sequester their CO_2 rather than sell it as a feedstock for utilization in SAF production processes. Expanding federal programs such as the RFS program to include biogenic CO_2-based fuels so that these fuels can generate RINs would enable such fuel producers to gain additional value for their products and share that throughout the supply chain.
- **Expand existing state LCFS and adopt clean fuel standards in new states.** State-level policies should build on the success of existing legislation and seek to address aspects of those programs that have proven difficult to manage or introduce complexities in disclosures or reporting that could be avoided.
- **Implement local incentives or programs from state legislators or regional planners.** These local incentives and programs should be capable of stacking with federal and state policies to further increase attractiveness for locally sited SAF projects and reduce risks for financing such projects.
- **Include testing requirements for biogenic carbon to align with other regulations.** Biogenic content testing requirements following the ASTM D6866 Method B standard should be required for any SAF produced by coprocessing and for any SAF blended with petroleum for end use. This method can be integrated with book-and-claim systems for logistical ease for producers and airlines. Book-and-claim inputs should be required to perform biogenic testing to properly account for the renewable content, which can be assigned and retired at the point of use.
- **Provide explicit guidance regarding key SAF feedstocks.** Stakeholders request that the U.S. Department of Treasury be explicit in forthcoming guidance that SAF produced from RNG on a book-and-claim basis is eligible for the Clean Fuel Production Credit and SAF credit, so long as such SAF meets the GHG emissions threshold and other criteria outlined in 26 U.S.C. § 45Z and § 40B, respectively.
- **Continue to base incentives and potential future mandates on CI score.** Policies should reward fuels that deliver greater life cycle GHG reductions over

time. Stakeholders noted that the SAF credit provides a tangibly greater incentive for 50% GHG reduction compared to that offered by the Clean Fuel Production Credit for the same 50% GHG reduction beginning in 2025. Providing additional credit for SAF that achieves negative CI would incentivize even further CI reduction.

- **Enable growth in unison with decarbonization efforts of other sectors.** Feedstocks and technologies to produce SAF have inherent overlap with decarbonization solutions for other sectors, including heavy-duty on-road, marine, rail, and off-road applications. Future policy should not create competition between sectors but seek to enable areas for collaborative growth.
- **Consider the desired effects of SAF incentives in comparison to existing incentives.** On a dollar-for-dollar basis, tax credits under the Clean Fuel Production Credit will not provide a greater demand for low-CI ethanol for SAF production than for gasoline blending. This means that any significant SAF from alcohol-to-jet synthetic paraffinic kerosene will have to cover the cost premium of fuel production and facility construction.
- **Adapt policy based on projections for future use.** As technologies advance and renewable fuel production increases, policies should support redirecting biofuels such as ethanol toward markets like aviation, where alternatives are not viable, and away from markets like light-duty vehicles, where demand is projected to decrease due to increased adoption of electric vehicles.

Support Production of a Wide Variety of High-Quality, Low-Carbon Feedstocks

- **Remove barriers facing intermediate crops like winter oilseeds.** These feedstocks can be used to produce SAF without the need for additional acreage. Currently, winter annual oilseeds such as CoverCress, carinata, and camelina are not eligible to participate in USDA conservation programs that promote the use of cover crops and therefore are not eligible for funding due to the fact they are harvested. Current USDA conservation programs do provide assistance to growers that plant cover crops or implement other conservation practices, but winter annual oilseeds are currently ineligible. To increase feedstocks available for SAF, climate-smart agriculture practices, including planting cover crops and harvesting winter annual oilseeds, should be eligible for these programs.
- **Continue updates of the Argonne GREET model to reflect new low-CI agricultural practices.** For example, including optionality for autothermal-reforming-based ammonia production with carbon capture and storage will allow more accurate assessment of lifetime GHG emissions for feedstock production. Farm-specific utilization of low-carbon fertilizers can be demonstrated and

verified with available commercial documents (e.g., purchase orders, receipts), which do not rely on proprietary systems or tools.

- **Seek methods to overcome the inherently low energy density of biomass feedstocks.** Funding should support efforts to collect and process geographically dispersed low-energy-density feedstocks and process them to produce an intermediate that can be economically transported to a conversion facility. Similarly, stakeholders should support funding for technology advancements to enable local conversion of feedstocks to an intermediate that can be transported to a central facility for conversion to a finished fuel.

Support Manufacturing and Infrastructure Development and Integration

- **Support development of new infrastructure, as well as integration into existing infrastructure.** Nationally, available tankage to store, certify, and blend SAF presents a major hurdle along the supply chain. Scaled distribution of SAF will require investments in new infrastructure. SAF producers should also work with refineries, pipelines, terminals, and airports to account for the potential effects of SAF integration on existing, optimized operation with other refined products. Additionally, while some SAF is likely to be produced in existing refining/terminal hub locations with pipeline access, some production may be remote and require new marine, rail, or truck infrastructure to get to market.

- **Support manufacturing of auxiliary components and related equipment**. As SAF production is expected to scale, the manufacturing of the required equipment and components for these facilities must also scale. The government should continue to support domestic clean energy equipment manufacturing to avoid future supply chain constraints and bottlenecks. This includes novel equipment like electrolyzers that may have limited options domestically.

- **Enable ease of integration with renewable energy sources.** Not all SAF production locations will be well suited for wind, solar, or anaerobic digestion solutions that will be critical for the rapid decarbonization of SAF production processes. Ensuring that renewable energy can be connected to the project via the commercial electric grid and natural gas pipelines through book and claim, instead of requiring a dedicated connection, will reduce costs and remove significant barriers to siting these projects.

- **Provide supplemental support to activities bolstered by the IRA.** Large-scale infrastructure needed to scale SAF—including blending facilities, carbon capture and storage infrastructure, hydrogen infrastructure, and electrical grid development—is supported by the IRA, but federal support for PtL processes, hydrogen transport, and build-out of additional electrical transmission lines and pipeline capacity will be required.

- **Conduct studies to determine the best ways to aggregate, blend, and test SAF.** The current aviation fuel infrastructure is not set up to handle multiple fuel types from various sources that require blending to a final product. Studies should determine the process or entity needed to aggregate potential fuels, blend them to the necessary specifications, and provide testing and certification prior to delivery to the airport.
- **Airports can play a role through infrastructure investment and as a facilitator.** Airports should allocate funds and develop supply chain infrastructure for SAF, including blending facilities to enable SAF use at major airports. Airports can also facilitate negotiations between infrastructure owners like airlines, service providers, and energy suppliers, leveraging their key role within the industry.
- **Low-CI CO_2, hydrogen, and electricity are key for growth of multiple SAF pathways.** Producing SAF cost effectively and at large scale also requires carbon-free and low-cost electricity that can be easily procured across the United States. This translates into the need for electrical grid expansion, interconnection of renewable energy projects, and de-bottlenecking supply and demand as part of the grid connection process.
    - Flexible electricity procurement mechanisms such as power purchase agreements can support the development and growth of the clean hydrogen industry. These mechanisms offer SAF producers more cost options, help to de-risk projects, support project bankability, and avoid lengthy procurement timelines.
    - Existing renewable electricity certificate registries should be leveraged to accommodate carbon-free power and clean hydrogen production.

Support R&D to Overcome Technology Barriers

- **Continue R&D support for SAF production technologies.** Efficiency improvements and process optimizations in preprocessing, pretreatment, catalyst development, separations technologies, etc. will all play into the overall TEA for a SAF pathway and bring it closer to commercial viability.
- **Integrate current technologies in a new manner to solve challenges**. For example, use conversion of bio-oil to syngas rather than hydroprocessing to solve challenges of solid handling in gasifiers and provide an input into multiple conversion pathways, including gas fermentation.
- **Invest in pilot projects and demonstration facilities**. Validation of technology performance at these scales helps de-risk the process before large-scale construction begins. Performing changes to address issues at commercial scale is far more expensive from a CAPEX and revenue standpoint.

- **Coordinate funding opportunities and incentives**. Federal, state, and regional programs could work together to increase the impacts of available funding by coordinating on focus areas and enable stacking across programs.

De-Risk Financing

- **Continue and expand loan guarantee programs.** To encourage more lenders to underwrite projects in the SAF supply chain, DOE's Loan Programs Office could expand its 100% loan guarantee to include financing with commercial and private capital providers, in addition to financing with the Federal Financing Bank. The loan guarantee program guidelines/criteria should explicitly indicate these direct lenders' underwriting risks that may be unique to the SAF supply chain industry. Finally, having the Loan Programs Office also provides full or partial guarantee of the back leverage financing of equity investors in SAF supply chain projects and should also help attract more investments.

- **Support demonstration projects to help de-risk pathways and attract financing**. While construction of demonstration-scale facilities is underway, support for scale-up of other elements along the rest of the supply chain such as development of hydrogen hubs will help demonstrate financial viability of these technologies at scale.

- **Demonstrate market demand through long-term offtake agreements**. Corporate commitments of 10 years or longer for purchase of significant SAF volumes can demonstrate revenue certainty, improving producers' ability to attract financing.

- **Unify demand-side efforts for SAF and related industries.** SAF's reliance on access to low-CI resources like CO_2, hydrogen, and electricity can be used to bring benefits to the markets for these resources. If demand-side efforts for these resources were considered within a single marketplace, a large buyer of SAF could also backstop procurement of large amounts of low-CI hydrogen, CO_2, and electricity, bringing additional stability to those markets.

Support Stakeholder Collaborations and Coalition Development

- **Promote knowledge sharing and collaboration within the SAF industry.** Established SAF producers can share their experience and best practices with new projects to help them avoid common pitfalls and challenges.

- **Convene stakeholder teams to address barriers in policy, demand, and capital.** Teams can work on alignment with ongoing efforts, leverage R&D programs, and work with various government agencies to identify opportunity areas that can be addressed with available resources. Private industry should collaborate across the value chain to solve supply bottlenecks and scale up SAF in parallel to expected government actions. Stakeholders, including airlines, can engage in lobbying efforts to push the SAF agenda, leveraging airlines' national relevance and influence.

- **Stakeholder groups can encourage corporate change**. Encouraging corporate partners to include SAF in their sustainability agenda and Scope 3 strategy can help accelerate SAF efforts. Corporate partners can demonstrate commitment with short- and long-term emissions reduction targets tied to SAF use.
- **Airports should leverage their resources and influence in the space to enable SAF.** Airlines can develop partnerships with SAF producers and other stakeholders to contribute to development cost, technical knowledge sharing, and/or CAPEX co-investment.

Support Transparent Carbon Tracking Across the Supply Chain

- **Establish book and claim as a valid chain of custody for sustainable feedstocks.** This tracking methodology would allow more farmers to participate in the SAF value chain and make it easier for companies to integrate sustainable feedstocks into their supply chain. CORSIA policy requires independent certification of each piece of the supply chain, including grain elevators, which increases the complexity of tracking feedstocks and expands the scope of certification beyond both the fuel and feedstock producers.
- **Open data sharing enables transparency.** Provide relevant key performance indicators on SAF to the end user including feedstock types and sustainability practices, technology pathway, production location, and total carbon footprint (including transport).

Support Fuel Qualification Testing and Certification

- **Support expedited approval of the 100% drop-in SAF annex at ASTM.** This is a critical barrier needed to overcome some of the infrastructure issues associated with partial SAF blends such as dedicated storage and blending tanks. Efforts should also work toward certification of new aircraft use of 100% SAF and address certification of legacy aircraft that require ASTM D1655 jet fuel.
- **Provide support to advance SAF testing to gain ASTM approval.** The costs associated with producing fuel volumes and conducting the testing required for the ASTM approval process can be overwhelming to early-stage companies advancing new technologies. As more technologies come to market and the demands for testing increase, providing support and incentives for engine manufacturers to advance this testing will be critical. The Federal Aviation Administration has previously provided financial support to pay for testing and provided grants to offset the costs of producing the initial fuel at volumes sufficient for testing requirements.

- **Support is needed to narrow the cost differential between RD and SAF.** Areas for cost reduction include SAF certification costs for production, cost of recertification of SAF before blending with ASTM D1655 jet, and cost of certification of final blend of semi-synthetic jet fuel.

Role of Government in Educating Producers on Financial Partners and Resources

*Question 5: Is there a beneficial role that DOE and other U.S. government agencies could serve in informing potential SAF producers about the wide range of potential investors and financial contractual structures in the SAF ecosystem? If **yes**, please describe what types of additional resources and activities DOE and other U.S. government agencies could provide to help advance SAF goals.*

While this question was intended to solicit recommendations for how the government could better inform stakeholders specifically concerning financial aspects of the SAF industry, many stakeholders provided suggestions for how the government should also use its position to educate the public and introduce stakeholders to the wide range of SAF resources that are available. Responses recommended that the government use its reach and influence to provide a platform for connecting stakeholders across the SAF supply chain. Outreach efforts to inform and educate stakeholders and the public as to the environmental, social, health, and economics benefits of SAF uptake would help minimize opposition to new projects, generate interest in the SAF industry, and provide opportunities for introductions between stakeholders.

Recommendations for Beneficial Government Actions
• Inform and educate the public • Provide platforms to convene stakeholders • Provide guidance to stakeholders • Encourage innovation and progress • Coordinate government efforts.

Inform and Educate the Public

- **Highlight funding options across the government.** Inform and educate SAF stakeholders as to the various funding and loan programs within DOE and other government agencies.
- **Educate feedstock producers on the benefits of SAF.** One group that would significantly help communicate the potential of SAF is state departments of agriculture. Incorporating these departments in communication and outreach efforts would serve two benefits. First, they are another mechanism for reaching feedstock producers and developing state-level programs for increased sustainability. Second, they could be in-state experts working with legislators as they craft state incentives. Federal dollars targeted to state outreach efforts would increase the likelihood of incorporating these agencies in advancing SAF to broader audiences.

- **Provide resources or databases to share lessons learned.** Lessons could be related to project management, technology development, process integration, scale-up, operating within various regulatory environments, licensing, offtake agreements, etc. Stakeholders would benefit from the opportunity to securely share information and learn from others in the industry.
    - Provide avenues for government-funded projects to provide nonproprietary learnings and best practices with the industry to prevent cost overruns and help drive down production costs across the board.
- **Information and training.** Provide educational resources and training programs for SAF producers to better understand financial contractual structures, investment strategies, and access to capital markets.

Provide Platforms to Convene Stakeholders

- **Develop matchmaking platforms for investors.** Provide a platform that connects investors with SAF stakeholders. Provide opportunities for feedstock producers, fuel producers, infrastructure developers, etc. to present their resources, capabilities, and focus areas publicly to allow interested investors to find them and initiate conversations.
- **Develop matchmaking platforms and interactive tools.** Provide a platform that connects investors with SAF producers. Provide opportunities for stakeholders to present their resources, capabilities, and research areas publicly to identify potential partners and initiate conversations. Provide interactive maps or tables that allow stakeholders to filter and search based on a variety of considerations. These tools should be connected to similar existing tools from other DOE offices like the H2 Matchmaker map.
- **Support regional coalition development.** Like bridging the “valley of death” for technology development, sufficiently mature stakeholder coalitions could eventually take over responsibilities within the SAF industry that had previously fallen to the government to manage.
- **Provide regular forums to bring together stakeholders.** Events that convene industry, academia, and government can keep stakeholders informed and connected, as well as allow them to exchange ideas and best practices.
- **Encourage and reward collaborative models.** Bring together stakeholders along the entire SAF value chain in formal settings and forums via funding opportunity announcements and using DOE’s platform to communicate the transportation and environmental benefits of SAF and the need for policy certainty to encourage future growth of this technology.

- **Investor matchmaking.** Facilitate connections between SAF producers and potential investors. Establish platforms or events where producers can pitch their projects to investors, venture capitalists, and private equity firms.
- **Networking opportunities.** Organize industry events, conferences, and forums where SAF producers, investors, and financial experts can connect, share ideas, and explore potential collaborations.

Provide Guidance to Stakeholders

- **Help stakeholders navigate the financial landscapes within the SAF ecosystem**. Developing financial tools that assist in evaluating the financial feasibility, risks, and returns associated with SAF production can be invaluable for producers. These tools can provide insights into the financial dynamics of different contractual and investment structures.
    - The government can also organize forums and conferences that facilitate interactions between SAF producers, investors, and other stakeholders. These networking platforms can foster partnerships and investor engagement crucial for advancing SAF production.
- **Serve as third-party validators for critical technologies and infrastructure.** Stakeholders need federal agencies to serve as third-party validators of SAF, decarbonization technologies, and associated policies to demonstrate to potential investors that risks have been sufficiently addressed.
- **Increase the availability of access to governmental agencies**. Help enable fast turnarounds for any necessary approvals and permitting (including renewable energy interconnections), timely issuance of guidance, and interpretation and implementation of tax credits under the IRS to reduce legislative risk and remove investment barriers to SAF.
- **Intergovernmental education and outreach efforts.** Educating other areas of government to the benefits of SAF could open new avenues for advancing the industry. SAF pathways have the potential to reduce waste biomass in forests, utilize organic waste streams across multiple industries, and capture and utilize CO_2 emissions from a variety of sources, among other benefits. Educating government offices and lawmakers could help them recognize the opportunity presented by SAF production and drive them to take action.
- **Facilitate conversations to understand and adapt to government agency rulings.** Additional efforts could be undertaken to work with regulatory agencies to demonstrate the opportunities and barriers presented by decisions to include or exclude certain feedstocks from the RFS. The majority of byproducts from the forest products industry (e.g., lumber mills) do not currently qualify as feedstocks.

Expanding the definition of feedstocks to include these mill residuals would significantly increase the availability of feedstock for producers and the utilization of an existing, sustainable byproduct.

- **Financial advisory services.** Offer financial advisory services to SAF producers, helping them navigate the complexities of financing and structuring deals. These services can include guidance on project financing, risk mitigation, and capital allocation.
- **Risk mitigation.** Assist in identifying and mitigating financial risks associated with SAF projects. Government agencies can provide tools and expertise to assess and address risks that may deter investors.
- **Offer technical support and resources.** Government support can help validate SAF production technologies and demonstrate their readiness to investors.

Encourage Innovation and Progress

- **Provide funding support for early-stage projects.** Particularly for new production technologies, investors are waiting to see at-scale commercial demonstrations and final CAPEX costs before investing in subsequent projects. As a result, public sector loans and loan guarantees will likely be needed to support new SAF production technologies. DOE's Loan Programs Office can also act as a facilitator of funding consortia for early projects by connecting investors with companies constructing early projects.
- **Encourage and reward collaborative models.** Both within and between regions, collaborations between stakeholders will pave the way for optimal cost solutions in scaled SAF production globally. The government's participation in industry initiatives enhances credibility and signals stability and trust to the financial sector.

Coordinate Government Efforts

- **Continue strategic cross-agency partnerships.** DOE coordination with other agencies and SAF supply chain stakeholders helps clarify and bring certainty to actions being undertaken in the SAF space.
- **Help establish consistent performance metrics.** The industry would benefit greatly from establishing key performance metrics and benchmarks to track the financial and environmental performance of SAF projects.
- **Support for siting and permitting new projects.** Industry players have consistently highlighted that permitting reform is required to accelerate project construction, creating the need for the U.S. government to streamline and simplify permitting processes.

Conclusion

Responses to the RFI underscored the importance of both long-term stable policies and collaborative actions by stakeholders to drive the development and deployment of SAF supply chains. Consistent and supportive policies at the federal and state level will be essential for providing the industry with regulatory certainty, incentives, and market demand. These policies can help mitigate risks, unlock investment, and foster innovation within the aviation industry. Furthermore, stakeholder coalitions play a significant role in industry efforts to build a functional and integrated SAF supply chain, and their actions can be magnified by the right policies. By working together to identify common goals, leverage policy, address financing and investment risks, and overcome infrastructure constraints, stakeholder coalitions can drive the scalability and sustainability of SAF within the aviation sector. This collaborative approach can not only foster industry resilience and innovation, but also pave the way for a more sustainable and environmentally friendly aviation industry.

As new policies are implemented and industry actions progress, technical and financial risks can be mitigated, which will unlock greater investment from private finance. Private investment will accelerate efforts to demonstrate, scale up, and integrate all elements of the supply chain, enabling the industry to produce, distribute, and consume the volumes of SAF necessary to meet the SAF Grand Challenge goals for 2030 and 2050.

As we move toward the future, DOE and its interagency partners will look to stakeholder recommendations to understand industry perspectives, adapt current approaches, and align future initiatives to best support the development of the SAF supply chain. We look forward to continued collaboration with all stakeholders as we work toward a greener and more sustainable future for aviation. Thank you all for your dedication and commitment to advancing the SAF industry.

Appendix: Stakeholder Groups Listed in RFI Responses

The following table includes stakeholder groups identified by stakeholders in response to RFI Question #1: *Are you aware of effective regional supply chain coalitions that have been formed for renewable fuels?*

Reference herein to any specific entity does not constitute or imply its endorsement, recommendation, or favoring by the U.S. government or any agency thereof or its contractors or subcontractors.

Name	Description
Advanced Bioeconomy Leadership Bold Goals Action Working Group	Multinational effort by bioeconomy stakeholders to define specific actions that must be accomplished by industry, financiers, and government in order to reach ambitious net-zero defossilization goals set by governments and corporations in recent years.
Advanced Biofuels Association	A national trade association whose members produce, blend, and distribute advanced biofuels.
Agriculture, Auto, Ethanol Alliance (AAE)	Formed to work through technical issues around higher ethanol blends in fuels. Auto participation is conducted under the auspices of USCAR, which allows technical coordination, including fuel issues, to be discussed without antitrust concerns.
Airlines for America (A4A)	Advocates on behalf of its members to shape crucial policies and measures that promote safety, security, and a healthy U.S. airline industry.
American Fats and Oils Association (AFOA)	Seeks to foster trade and commerce within the United States and throughout the world for animal, fish, and vegetable fats, oils, and proteins.
Americans for Clean Aviation Fuels (ACAF)	Diverse coalition of the largest industrial sectors in America, from farmers to fuel producers and aviation to agribusiness. Focused on promoting the economic benefits of building a robust U.S. market for clean aviation fuels.
Aviation Climate Taskforce (ACT)	ACT's purpose is to accelerate breakthroughs in critical emerging technologies by 10 years by bringing together stakeholders from the aviation ecosystem to support rapid scale-up and adoption.
Aviation Sustainability Center (ASCENT)	A cooperative aviation research organization co-led by Washington State University and the Massachusetts Institute of Technology that works to create science-based solutions for the aviation industry's biggest

Name	Description
	challenges. Funded by the FAA, NASA, the Department of Defense, Transport Canada, and the Environmental Protection Agency
Biofuture Campaign	The mission of the Biofuture Campaign is to enable the reduction of GHG emissions and foster a circular economy by showcasing pathways by which countries, companies, and consumers can substitute sustainable bio- and waste-based fuels, chemicals, and materials for their fossil equivalents.
Brazilian National Corn Ethanol Union (UNEM)	Represents more than 90% of Brazil's corn ethanol producers and works to promote growth and sustainability of corn-based biofuels.
Business Aviation Coalition for Sustainable Aviation Fuel	Created to address a "knowledge gap" on the availability and safety of SAF and advance the proliferation of alternative jet fuels at all logical touchpoints.
Commercial Aviation Alternative Fuels Initiative (CAAFI)	CAAFI's goal is to promote the development of alternative jet fuel options that offer equivalent safety and favorable costs compared with petroleum-based jet fuel, while offering environmental improvement and energy supply security for aviation.
Clean Fuels Alliance America	Representing biodiesel, renewable diesel, and sustainable aviation fuel, Clean Fuels Alliance America seeks to advance the interests of its members by supporting sustainable biodiesel, renewable diesel, and sustainable aviation fuel industry growth.
Clean Fuels NY Coalition	Led by the New York League of Conservation Voters and formed to demonstrate the broad and diverse support for New York state to create a clean fuel standard to reduce greenhouse gas emissions from the transportation sector.
Airports of Tomorrow	Airports of Tomorrow Initiative consolidates the aviation decarbonization work previously done by the World Economic Forum through its Clean Skies for Tomorrow and Target True Zero initiatives under one umbrella.
Coalition of Renewable Natural Gas	Nonprofit association of members advocating for the sustainable development, deployment, and utilization of renewable natural gas so that present and future generations have access to domestic, renewable, clean fuel and energy.

Name	Description
Council on Sustainable Aviation Fuels Accountability (CoSAFA)	The group aims to provide clarity, transparency, and accuracy to the accounting practices documenting the use of SAF in multiparty transactions.
FARM to Fly Initiative	The FARM to Fly initiative's purpose is to "accelerate the availability of a commercially viable and sustainable aviation biofuel industry in the United States, increase domestic energy security, establish regional supply chains, and support rural development."
First Movers Coalition	Advances the most critical, emerging climate technologies by leveraging members' collective purchasing power. By translating member commitments into the world's largest, credible demand signal, the First Movers Coalition accelerates the adoption of emerging climate technologies to decarbonize the world's heavy-emitting sector.
Forever Green Partnership	Unites members from private, public, and advocacy sectors around a common interest in increasing Continuous Living Cover in agriculture to capitalize on its many economic and environmental benefits. Works to diversify and strengthen Midwestern agriculture by adding crops that can grow in fall, spring, and summer and can thrive on slopes and other locations where row crops struggle.
Global Biofuel Alliance	An initiative by India as the G20 Chair. The Alliance intends to expedite the global uptake of biofuels through facilitating technology advancements, intensifying utilization of sustainable biofuels, and shaping robust standard setting and certification through the participation of a wide spectrum of stakeholders.
ICAO Global Coalition for Sustainable Aviation Fuel	Forum of stakeholders that aims at facilitating the development of new ideas and accelerating the implementation of innovative solutions that will further reduce greenhouse gas emissions at the source, on the ground, or in the sky.
Kentucky SAF Coalition	Regional coalition interested in increasing the production, distribution, and use of SAF in Kentucky.
Midwest Aviation Sustainable Biofuels Initiative (MASBI)	Brings together representatives from across the biofuels value chain to address ways to best leverage regional assets and achieve the potential economic, environmental, and energy security benefits that can be delivered from a robust advanced biofuels industry.

Name	Description
Minnesota Sustainable Aviation Fuel Hub	Coalition with a multiyear strategy that aims to create an integrated value chain across multiple SAF technology pathways capable of producing affordable, low-carbon SAF at scale, leveraging Minnesota's unique assets, and in alignment with the Department of Energy's SAF Grand Challenge.
Northwest Advanced Renewables Alliance (NARA)	NARA takes a holistic approach to building a supply chain within Washington, Oregon, Idaho, and Montana based on using forest harvest residuals to make aviation biofuel and coproducts. The alliance is tasked with empowering rural economies, increasing America's energy security, and reducing aviation's environmental impact.
Qantas SAF	Australia's first coalition program to support decarbonizing aviation through SAF. Offers corporate partners the opportunity to help contribute to the use of SAF and to minimize the impact of flying on the environment by aiding the transition to low-emission technologies.
Renewable and Low-Carbon Fuels Value Chain Industrial Alliance	Initiative dedicated to advancing the production and supply of renewable and low-carbon fuels in the aviation and waterborne sectors.
Renewable Fuels Association	Trade association for America's ethanol industry, driving growth in sustainable renewable fuels and bioproducts for a better future.
San Francisco International Airport – SAF Working Group	150-member SAF Stakeholder Working Group implements actions that achieve the airport's SAF targets. This includes sharing knowledge and best practices regarding SAF and advances in the industry and global market (e.g., policy, technology, infrastructure, feedstocks, financing alternatives).
Sustainable Aviation Buyers Alliance (SABA)	SABA is accelerating the path to net-zero aviation by driving investment in, and adoption of, high-integrity SAF and supporting companies, airlines, and freight customers in achieving their climate goals.
WSU – Pacific Northwest National Laboratory Bioproducts Institute (Bio-In)	Joint research collaboration of Washington State University and the U.S. Department of Energy's Pacific Northwest National Laboratory. Seeks to leverage cutting-edge science, engineering, and analysis to transform engineered plants and industrial, agricultural, and municipal waste into valuable materials and chemicals, and develop a pipeline of talent to meet future workforce needs.

U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

For more information, visit: energy.gov/eere/bioenergy

DOE/EE-2843 • May 2024