



BLACK & VEATCH

Fueling the Future:

Five Steps to Successful Sustainable Fuels Development



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Introduction

As countries and industries move towards decarbonization, there is a growing need for sustainable fuels.

Sustainable fuels – those produced from primary renewable resources – have a lower carbon footprint compared to fossil-based fuels and include fuels such as sustainable aviation fuels (SAF), renewable natural gas (RNG) and drop-in liquid biofuels.

The global biofuels market is expected to grow significantly in the coming years due in part to increasing demand for renewable energy sources and government policies promoting the use of biofuels. According to the International Energy Agency, global demand is projected to grow by 20% from 2022 to 2027¹, but that demand could be even greater if driven by favorable government policies and fuel costs. Similarly, the International Air Transport Association predicts the demand for sustainable aviation fuels could reach 30 billion liters by 2030 with effective government incentives².

While a combination of factors can influence sustainable fuel demand, one thing remains certain – developers must adequately evaluate and plan to achieve a successful project outcome. In this eBook, we'll cover the critical success factors developers should consider to ensure the viability of sustainable fuels projects to meet the continually growing demand.






Securing Feedstock

The success of a sustainable fuels development project depends chiefly on sourcing of optimum feedstock resources in the quantities and qualities needed. Feedstock is the raw carbonaceous material used to produce biofuels and can include agricultural residuals, energy crops, forestry residues, municipal solid waste (MSW) and algae. Each type of feedstock has its own unique characteristics and properties that affect the efficiency, cost and environmental impact of the biofuels production process.

Biomass

Solid biomass is one of humanity's oldest fuels. For centuries, it has been used in the production of renewable energy, predominately in a localized manner. In many cases, biomass fuels are a waste or byproduct of agricultural, industrial or commercial processes; thus, they can be relatively low cost. Compared to fossil-based resources, biomass is often low in sulfur, nitrogen, mercury and other pollutants. Additionally, it is considered a carbon-neutral/renewable fuel throughout much of the world when coupled with sustainable harvesting/management practices or carbon capture, utilization and storage.

Because biomass is often used for other applications such as animal feed, paper production and construction materials, there can be price variability due to competition, especially when there is limited supply. However, biomass can offer long-term cost savings associated with sustainable sourcing and processing.



Hydrogen can be a key feedstock for sustainable fuels or used to increase the capacity and conversion yield of sustainable fuels from other primary feedstocks.



Getting Started: Resource Assessment

Picking the most sustainable and economically viable feedstock for your project starts during the initial stages of development. A resource characterization/assessment clarifies the fuel properties and quantifies the amount of available fuel within a reasonable distance from the plant.

Municipal Solid Waste

Raw municipal solid waste (MSW) and other types of commercial and industrial wastes are also considered to be viable fuel for energy applications. As the waste management industry has evolved across the globe, many nations consider waste-to-energy to be an integral part of the overall waste/resource management strategy, particularly in geographies with heavy population densities and limited landfill capacity. To enhance energy production, waste materials can be processed into either a refuse-derived fuel or solid recovered fuel; the former entails minimal shredding and component separation, and the latter includes a host of processes to yield a product that meets a rigorous specification.

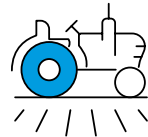
MSW is a readily available and abundant feedstock. Unlike other feedstocks that require significant resources and energy to produce, MSW already is being generated as a byproduct of domestic and commercial activities. This means that MSW can be a cost-effective and sustainable solution for producing renewable energy and reducing waste.

Using MSW reduces the volume of waste sent to landfills or incinerators, which can result in cost savings associated with waste management. Because of this, MSW typically has a negative cost, or tipping fee. Additionally, the production of sustainable fuels from MSW can provide a source of revenue for waste management companies, offsetting some of the costs associated with waste disposal.

But all waste isn't equal when it comes to sustainability. Biomass is a relatively sustainable component of MSW; it can be composted, providing nutrients for soil and reducing the amount of waste sent to landfills. On the other hand, plastics are less sustainable as they are not biodegradable and require a significant amount of energy to produce, resulting in net positive carbon emissions when used as a feedstock for sustainable fuels.

Types of Waste

Agricultural



- Crop residues
- Food and crop processing residue
- Animal manure

Urban



- Food waste
- Fats, oils and greases
- Green waste
- Urban forestry residues

Forest



- Timber harvest residuals
- Line clearing activities
- Forest thinning activities



Getting Started: Feedstock Assessment and Logistics Study

Ensure consistent and reliable supply of your feedstocks with a feedstock assessment and logistics study. This study can help identify optimal delivery routes and transportation methods while providing insights into the availability and quality of feedstock. As previously mentioned, feedstock availability can be impacted by market dynamics or other industries, so feedstock assessments typically have a period of validity. Additionally, these studies can identify the optimal onsite storage and handling procedures for the feedstock, which can reduce waste and minimize costs associated with feedstock management.

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Choosing a Conversion Technology

When selecting a conversion technology for a sustainable fuels project, a developer must consider several factors, including feedstock availability, efficiency/yield and scalability.

Reforming

Fuel reforming is the process of converting liquid or gaseous feedstocks into synthesis gas (syngas), which can then be used to produce a myriad of sustainable fuels. This is achieved via the use of high-temperature processes and catalysts. Scalability is a key advantage of this technology, making it suitable for numerous production capacities. However, depending on the carbon intensity of the feedstock, reforming can produce significant greenhouse gas (GHG) emissions that are typically mitigated by implementing carbon capture and sequestration (CCS).

Gasification

For gasification, a wide variety of solid feedstocks can be used to produce syngas, which can be upgraded to sustainable fuels, like reforming. While gasification can be efficient in producing syngas, there can be additional energy penalties and yield constraints as a result of associated fuel synthesis technologies (e.g., Fischer Tropsch). However, gasification can produce emissions such as carbon monoxide and nitrogen oxides, which can have negative environmental impacts if not managed properly. There are also difficulties in feedstock handling prior to the gasifier; gasifiers require a specific shape and size, along with dryness. Reaching full production levels takes significant troubleshooting with downtime before reaching full design capacity.

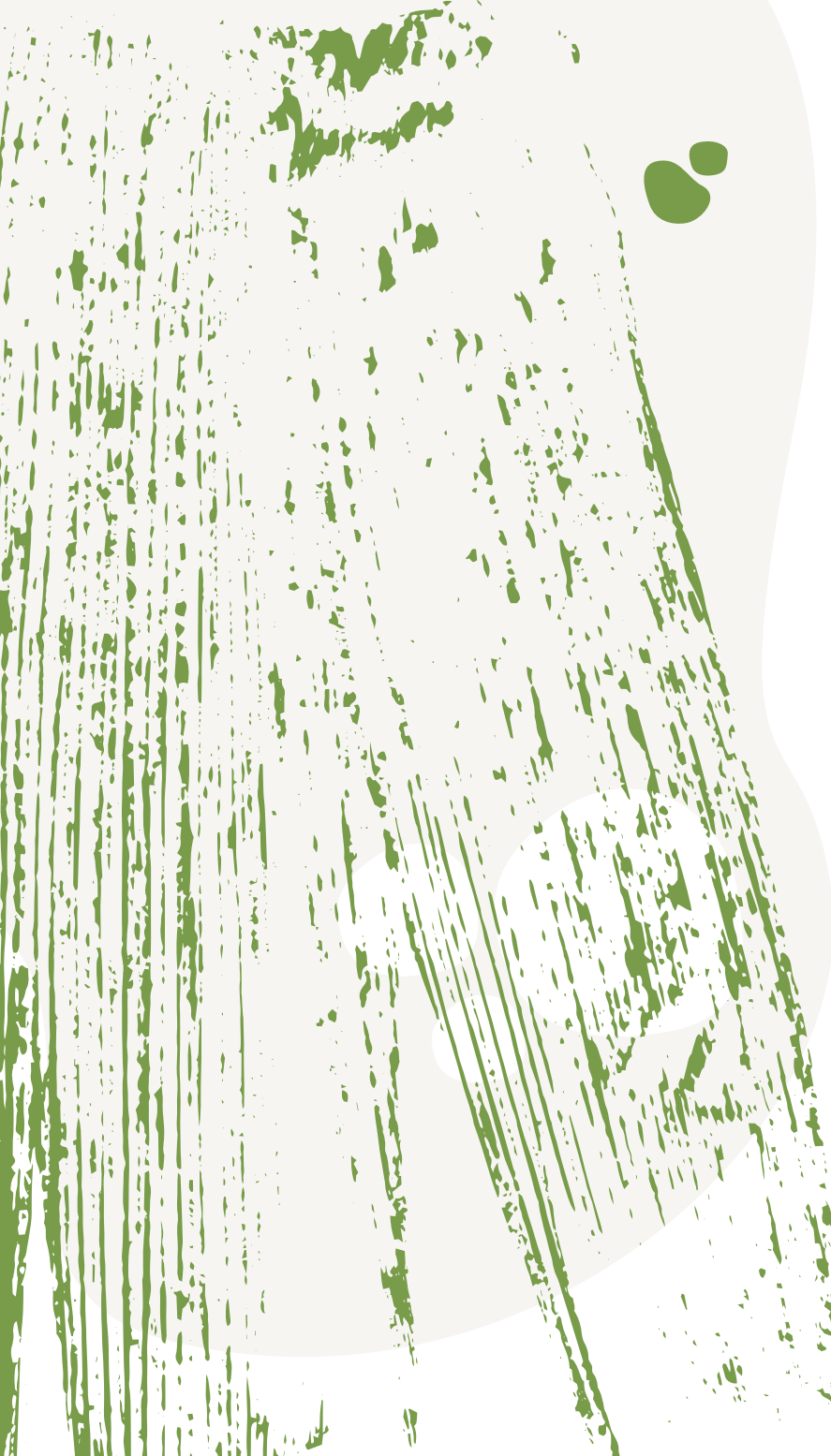
Pyrolysis

Similar to gasification, pyrolysis can use various feedstocks, but due to milder operating conditions, it typically requires greater feedstock homogeneity. However, pyrolysis tends to be more efficient in converting feedstock into a liquid fuel with higher yields compared with gasification in combination with syngas fuel synthesis unit operations. Pyrolysis has comparable scalability attributes and similar criteria air pollutant concerns as gasification but can also result in the production of greater amounts of air pollutants and residual char/ash that needs to either be sold as co-product or disposed of as waste.

Anaerobic Digestion

Anaerobic digestion (AD) is a biochemical conversion technology that uses bacteria to decompose wet organic wastes, including agricultural waste, livestock manure and food waste, into biogas composed primarily of methane and carbon dioxide. AD is particularly efficient in the conversion of high-moisture feedstocks, whereas thermochemical conversion technologies would require significant pre-processing and drying. The scalability of AD is typically limited solely by the quantity of feedstock available within a reasonable distance of the plant, or sometimes locally at a given farm or food processing operation. The utilization of biogas for power generation or RNG production can result in hazardous air pollutants, but frequently it results in significant GHG emissions relative to the emission of methane from untreated organic waste materials.





Hydrogenation/Isomerization

This pathway typically uses high-quality, lipid-rich feedstocks such as vegetable oils and animal fats. Hydrogenation/isomerization uses hydro-processing to convert these materials into a mix of hydrocarbons that meets the applicable fuel specification (e.g., ASTM 975 for diesel fuel). As with AD, the availability of viable feedstock is frequently the limiting factor for these projects, rather than the inherent scalability of the technology. The carbon intensity of sustainable fuels produced from these processes is highly dependent on that of the hydrogen needed; thus, there is often a cost-benefit analysis that needs to be performed to discern the relative benefits and disadvantages of using low-carbon hydrogen via water electrolysis or fuel reforming with carbon capture. These pathways also are able to utilize existing refineries, making the projects attractive from a technology and economics standpoint, if feedstock is secured.

Gas Fermentation and Alcohol Upgrading

Gas fermentation is a newer technology that converts carbon-containing gaseous feedstock (i.e., syngas, carbon monoxide, and/or carbon dioxide from carbon capture and storage (CCS) via fermentation by various microorganisms into alcohols (e.g., methanol and ethanol). These alcohols can subsequently be upgraded to drop-in hydrocarbon fuels via dehydration, oligomerization and hydrogenation in comparable manner to other upgrading processes discussed. Given the wide availability of these feedstock types, gas fermentation's scalability is thought to be limited based on the operational constraints of the microorganisms. Although gas fermentation and alcohol upgrading can have efficiency and yield benefits, the process kinetics can be slow relative to other methods and is the subject of current research and development efforts.



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Understanding Risk Factors

Sustainable fuels projects come with several risk factors that can impact their success – from feedstock supply and quality to technical viability and regulatory requirements.

Feedstock Risks

Feedstock risks can significantly impact sustainable fuels development projects, leading to project issues that can delay or derail the project.

The feedstock market can be volatile and subject to change due to weather conditions, crop yields and competing uses for the feedstocks, which can impact availability and price and, in turn, impact project feasibility and profitability.

Developers must carefully evaluate feedstock risks, such as:

- Lack of onsite pre-processing equipment to handle unanticipated contaminants (i.e., use of urban wood waste rather than forestry waste)
- Incorrect assumptions around feedstock moisture content and insufficient drying onsite to enable proper conversion
- Collection and transportation infrastructure limitations, which may impact feedstock procurement
- Elevated contaminant content and impacts on conversion/refining equipment due to suboptimal operating conditions or other sources of contamination such as water supply



First-of-a-Kind Technology Risks

First-of-a-kind (FOAK) projects are often based on new or untested technologies that have not been proven on a commercial scale. This means there is a higher degree of uncertainty about the feasibility and cost-effectiveness of the technology, as well as its performance and environmental impact.

FOAK sustainable fuels projects may face regulatory challenges due to the lack of established regulations and standards for the technology. This can result in delays and increased costs as developers work to obtain the necessary permits and approvals. Additionally, the supply chain for sustainable fuels is often not as well established as for traditional fossil fuels, which can lead to supply chain risks such as feedstock availability and transportation challenges, depending on similarities and differences in fuel product quality.

To appropriately manage risk and successfully advance a FOAK project, it is important for stakeholders to have responsibility for the risk/benefit that they have control over. If project developers seek to wrap technologies into a singular engineering, procurement and construction (EPC) contract, it can put the entire project at greater risk should the technology provider face financial troubles and not be able to meet their commercial agreements. When this happens, it signals to the industry that sustainable fuels projects are too challenging or risky to execute. That's why it's important for project developers to work with a reputable EPC company that can develop a risk management strategy that is palatable to all stakeholders.



Getting Started: Technical and Commercial Risk Management

Sustainable fuel infrastructure developers must manage a host of technical and commercial risks throughout the project lifecycle. This entails having a sophisticated understanding of the feedstock, structuring commercial agreements in a manner that properly allocates risks to the parties best suited to manage them, and allowing sufficient flexibility in the schedule/budget to mitigate those risks according to the plan.

A front-end loading engineering process must be completed to properly design the facility and evaluate the risks. This process has a higher upfront cost, but it reduces the overall project costs and significantly increases project success from a performance, budget and schedule standpoint. It also allows technology providers to have more stringent reviews of their technology, and support project execution with the development of engineering and permitting drawings required to complete the project.



Navigating Policies & Regulations

Governments across the globe have been implementing policies and regulations to promote the development of renewable energy sources, including sustainable fuels. These policies can include financial incentives, regulatory frameworks, and support for research and development, which can help to reduce the costs of sustainable fuels and make them more competitive with traditional fossil fuels.

Feed-in tariffs (FITs) have been implemented in several countries, including Germany, China and Japan, and have been successful in promoting the deployment of renewable energy sources. FITs offer long-term contracts to renewable energy producers, guaranteeing a fixed price for their energy for a certain period, which can make renewable energy more attractive to investors. Additionally, renewable portfolio standards (RPS) require a certain percentage of energy to come from renewable sources, which can create a market for sustainable fuels. In the United States, many states have implemented RPS policies, which have helped to promote the development of renewable energy sources, including sustainable fuels.

In addition to RPS policies, there is also the renewable fuel standard (RFS) in the United States that mandates that refiners and distributors of transportation fuels utilize certain types of renewable fuels and provides volumetric

blending targets through 2022³. And California's Low Carbon Fuel Standard (LCFS)⁴ which requires oil producers, importers and other fuel providers to gradually reduce the carbon intensity of their transportation fuel mix. This is typically accomplished through alternative fuels blending and transport technologies.

Carbon pricing policies such as carbon taxes or emissions trading schemes can increase the cost of traditional fossil fuels, making sustainable fuels more competitive. Carbon pricing policies have been implemented in several countries, including the European Union, China and Canada, and can be an effective tool for promoting the transition to a low-carbon energy system.

Incentive programs for sustainable fuels projects have been created to encourage the development of renewable energy sources, reduce greenhouse gas emissions and promote energy independence. Incentive programs can benefit sustainable fuels developers by providing financial support that can offset the high costs associated with sustainable fuels projects. This can include grants, tax credits, loan guarantees and other forms of financial support. Incentives can vary depending on the country or region and can be influenced by political, economic and environmental factors.

Many countries have incentive programs and/or taxation initiatives for clean energy projects, including sustainable fuels. For example, the United States offers several

incentive programs, such as the RFS and the Advanced Biofuel Payment Program⁵. In Europe, the European Union (EU) has established several incentive programs, including the Renewable Energy Directive⁶ and the European Fund for Strategic Investments⁷. In 2021, the EU revised its Energy Taxation Directive⁸ to promote clean technologies and remove outdated reduced rates that encouraged use of fossil fuels. In China, the Renewable Energy Law⁹ provides incentives for renewable energy projects, including sustainable fuels.



Getting Started: Strategic Roadmap

When it comes to sustainable fuels projects there's a lot to navigate. Strategic advisory partners can help developers analyze feedstocks, technological/commercial risks and regulatory frameworks to set sustainable fuels projects up for success from the beginning. A strategic roadmap identifies and manages risks from beginning to end.



Preparing a Plan



From feedstock considerations to regulatory guidelines, it's clear there are a lot of sensitivities that come into play when developing a successful sustainable fuels project. Strategic planning, when completed up front and in a comprehensive manner, can identify potential challenges, optimize project design, streamline the project schedule and benefit the bottom line.

A strategic advisor can provide project-specific recommendations; however, common planning protocols may include:

Feasibility Studies

Feasibility studies can help determine whether a sustainable fuels project is technically and economically feasible. These studies can evaluate factors such as the availability and quality of feedstocks, the technical feasibility of the conversion process, and the potential market demand for the final product. By conducting a feasibility study, developers can assess the viability of the project and identify potential risks and challenges before investing significant resources.

Feasibility studies should then continue into a front-end engineering design (FEED) process to identify and mitigate risk in the most economical way for the overall project prior to EPC execution.

Resource Assessments

Resource assessments can help developers evaluate the availability and suitability of feedstocks for sustainable fuels projects. These assessments can evaluate factors such as feedstock quantity, quality and cost, as well as environmental impact and sustainability considerations. With a resource assessment, developers can identify the most suitable feedstocks for their project and develop a feedstock procurement strategy that is economically viable and environmentally sustainable.

Strategic Roadmaps

Strategic roadmaps can help developers prepare a comprehensive plan for their sustainable fuels project. These roadmaps can include a detailed project timeline, milestones and targets, as well as a comprehensive strategy for feedstock procurement, technology development and market development. By developing a strategic roadmap, developers can ensure that their project is aligned with their long-term goals and has a clear path to success.

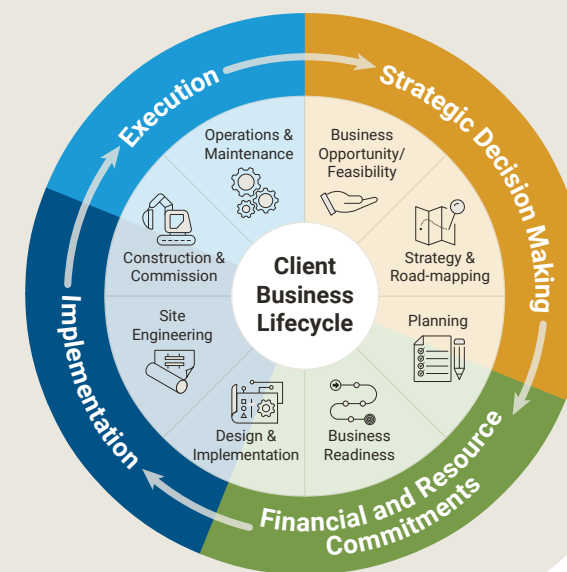


Getting Started: Select an Experienced EPC Provider

Given the complex nature of sustainable fuel infrastructure projects, developers typically seek out an experienced EPC expert to guide them through the project development process.

At Black & Veatch, we apply engineering to strategy, with the unique ability to develop and execute the solutions that align with new or emerging technologies.

From initial design through commissioning, we have the resources and expertise to help plan and execute highly complex technologies, including first-of-a-kind projects across multiple industries.

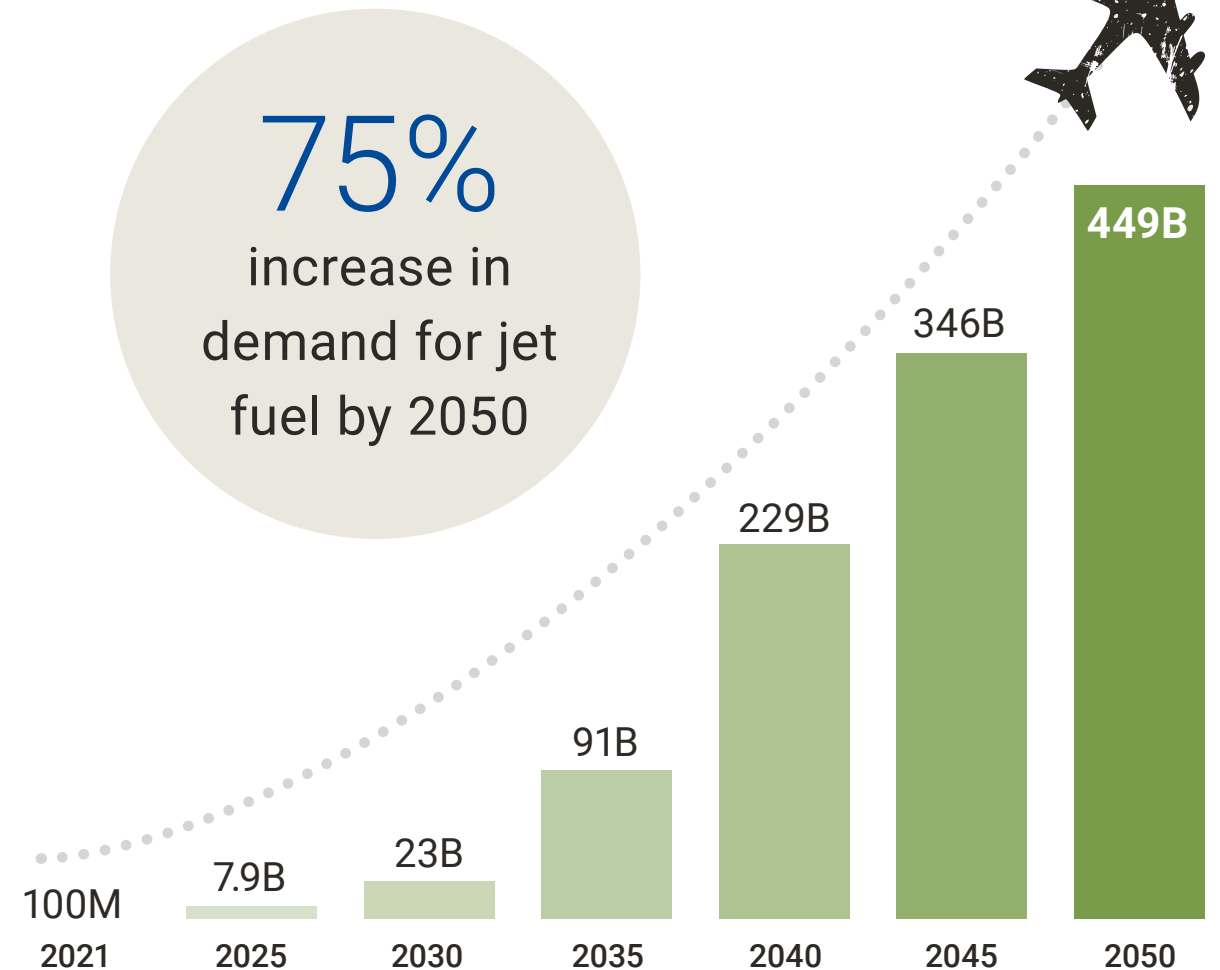



Case Study: DG Fuels Sustainable Aviation Fuel Complex

Sustainable aviation fuels (SAF) is gaining rapid commercial traction and interest as a viable biofuels product. With much public and regulatory pressure ahead to decarbonization air travel, SAF production is forecast to experience exponential capacity growth by 2050. Black & Veatch is advancing a number of projects, including a front-end loading (FEL-3) engineering report for DG Fuels. Such plans could see a production center for sustainable, carbon-reducing aviation fuel in Louisiana based on an innovative design system that would use renewable energy sources such as agricultural and timber waste feedstock. The new fuel's carbon intensity score is projected to be reduced by 140 percent when compared to industry standards.



Global Demand for Sustainable Aviation Fuel





At Black & Veatch, our mission is to build a world of difference through innovation in sustainable infrastructure. We help organizations integrate a range of technologies to cost-effectively achieve resilience, sustainability, and growth.

Sources

- ¹ [International Energy Agency Renewables 2022](#)
- ² [International Air Transport Association](#)
- ³ [United States Environmental Protection Agency Renewable Fuel Standard Program](#)
- ⁴ [California Air Resources Board Low Carbon Fuel Standard](#)
- ⁵ [United States Department of Agriculture Advanced Biofuel Repayment Program](#)
- ⁶ [European Commission Renewable Energy Directive](#)
- ⁷ [The European Fund for Strategic Investments](#)
- ⁸ [Revision of the Energy Taxation Directive](#)
- ⁹ [Renewable Energy Law of the People's Republic of China](#)

**How can we
help you develop
sustainable fuels?**

Contact us 