Sustainable aviation fuel (SAF) on the rise

Sustainable development through a dynamic environment

EY
Building a better working world

BOOM

Sustainable aviation fuel (SAF) has been on a slow rise to replace conventional jet fuel and is widely accepted as the most promising path to achieve net zero air travel in the short to medium term. From governments to airlines, aggressive SAF goals have been implemented, but actions and policies required to meet these goals fall short. An unpredictable geopolitical and economic environment over the next five years further adds to the complexity of widespread SAF adoption. SAF adoption and capacity will likely be impacted as countries shift toward establishing bloc alliances and focus on developing policies that strengthen technologies related to energy independence and national security. It is critical to understand how different geopolitical scenarios shape the future of SAF in order to participate in the SAF economy effectively and capitalize on the promising opportunity it presents.

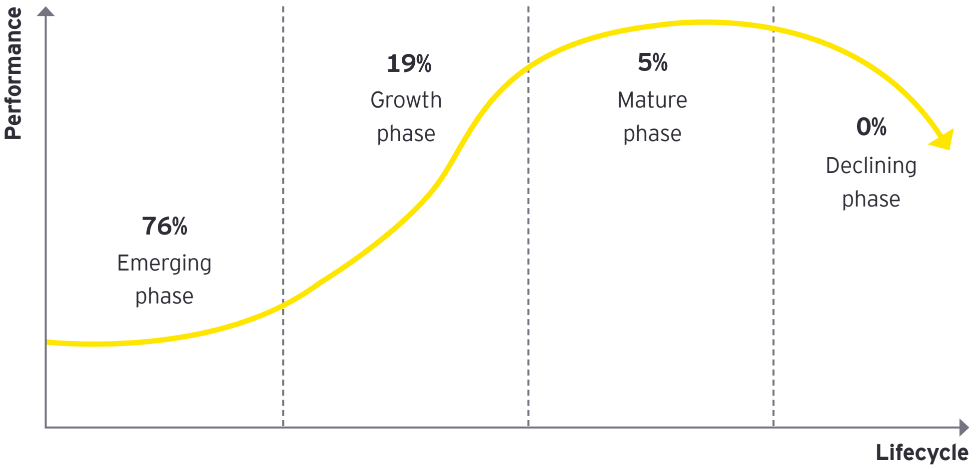
How SAF could be the key to greener skies

Recent advancements in green technology for the aviation sector are dramatically shifting sentiment away from the often-held, but false, view that environmental sustainability and commercial air travel are conflicting concepts.

SAF has the potential to deliver the performance of petroleum-based jet fuel, with up to a 100% reduction in net CO$_2$, giving airlines better footing for decoupling greenhouse gas emissions (GHGs) from air travel. SAF could also be a dynamic investment opportunity for those looking for new ways to tap into the sustainability market.

The EY SAF Survey 2022 explored SAF adoption trends and a five-year market outlook. The survey included responses from industry practitioners, investors, travel industry partners and service providers. Seventy-six percent of the survey respondents consider the SAF industry to be in the emerging phase. Being in the emerging phase means there are new SAF producers entering the market rapidly to test new technology and gain market share.

76% of survey respondents think SAF is in the emerging phase of the technology lifecycle



Source: EY SAF Survey 2022

Emerging: early development and proof of concept stage for a novel technology
Growth: beyond proof of concept and available for use in small capacity
Mature: widely available and utilized as a preferred solution
Declining: losing demand in the market with risk of being replaced by an alternative technology

With the first flight with a SAF blend taking off in 2008, it has since seen a growing interest from energy producers, aircraft original equipment manufacturers (OEMs) and airlines alike. To date, we have seen more than 450,000 commercial flights with more than 50 airlines using SAF. That number is still low, given approximately 38.9 million commercial departures in 2019 alone, but still encouraging as SAF adoption is increasing. Although blended SAF flights are taking off regularly, industry and regulators are now looking to transition to 100% "drop-in" SAF in the near term. Currently available SAF has the potential to reduce carbon emissions by up to 80%, having the potential to reach 100% with future SAF technology in the near future.

Organizations and governments working to promote sustainable air travel see SAF as having the most impact in achieving net zero carbon emission by 2050, while other technologies are being explored. Electric and hydrogen technologies are often presented as alternatives to conventional jet fuel along with SAF, but those technologies are relatively less mature, require major infrastructure changes for both aircraft and airport logistics, and, in the case of electric, are unlikely to have sufficient range for long-haul commercial flights by 2050.

Electric propulsion is in the very early stages of development, and it may take until 2030–35 for short-range commercial aircraft to be technically feasible and viable for short-range travel. The ability for electric aircraft to travel beyond regional/domestic routes is likely even further away. The biggest challenge in electrifying propulsion is the low specific energy (or mass-based energy density) of batteries, which severely limits flight range. Electric aircraft would also require significant infrastructural transformation, including improving the electrical grid at airports to support high-powered charging required for electric aviation.

Hydrogen can play a strong role in the aviation fuel mix. However, there are significant challenges in designing a hydrogen-powered aircraft for commercial aviation. Liquid hydrogen has 2.8 times the specific energy of jet fuel but the extra weight required for fuel storage becomes a major disadvantage for hydrogen. Fuel consumption may decrease, engines will be smaller, engines will make less noise, and there will be no CO_2 emissions but hydrogen powered aircrafts will likely be limited to short-haul flights. Massive investment is needed to boost hydrogen production. New aircraft and engines compatible with hydrogen must be designed and manufactured. Although short haul H_2 powered demonstration flights are in development, a wide adoption of hydrogen powered flights may not be viable until 2040 or 2050.

Given the limitations of electric and hydrogen aircraft, SAF remains the most viable solution to help the commercial aviation industry reach its goal of achieving net zero carbon emission, which is in line with the Federal Aviation Agency (FAA) 2021 Aviation Climate Plan and International Civil Aviation Organization (ICAO) long-term global aspirational goal report.

The case for SAF

SAF can be produced from a number of sources (feedstocks), including waste oil and fats, agriculture and municipal waste, and non-food crops. It can also be produced synthetically via processes that capture carbon directly from the air. SAF feedstock is sustainably sourced since the raw feedstock does not compete with food crops or water supplies and is not responsible for forest degradation. Five million gallons of SAF were produced in the United States in 2021, while targets under the SAF Grand Challenge, proposed by the Biden Administration in 2021, aim to produce 3 billion gallons by 2030. Given the upward trend in current production levels, feedstock availability and demand, this target is likely to be achieved if positive momentum toward SAF development continues.

An ecosystem of both specialized and diversified players is involved in SAF development. Diversified producers are defined as conventional fuel companies that have been producing traditional fuel and have been expanding into SAF, while specialized producers are defined as fuel companies focusing primarily on producing sustainable and renewable fuels.

While there are still concerns about supply for this new energy source, SAF technology continues moving forward. In line with characteristics of an industry in the emerging phase, 62% of experts we surveyed predict specialized SAF producers will be more successful in gaining market share in the next five to seven years, while diversified producers will be successful in seven or more years due to market consolidation and acquisition in the SAF industry. SAF is also growing as an investment opportunity. For example, specialized players are witnessing increases in both the number and value of private investments, up from three transactions valued at $31m in 2008 to 11 transactions and $651m in the first half of 2022. The combination of historical underinvestment and rising demand has created an imbalance, thus creating a potential market for new entrants. Venture capital firms, corporates, and government grants and loans are the major sources of capital for these specialized entrants into the SAF market. Increasing SAF demand has also driven M&A activity toward renewable fuel, primarily in the oil and gas sector. The focus has been on integration and market share expansion, as well as raw material procurement, supply chain integration and technology evolution.

In addition to increased investment activity, commercial aerospace companies and airlines are entering into partnership agreements with SAF manufacturers to meet their net zero targets. Companies that rely on heavy business travel are entering "book-and-claim" agreements with airlines to help offset their carbon footprint. Book-and-claim agreements enable corporations to participate in SAF economy especially when SAF is not physically available for their business travels. These agreements are on the rise across industries and will likely benefit the overall adoption of SAF by creating positive demand signals. Current global SAF production capacity, including plants coming live before 2024, is estimated to be at 0.8 billion gallons. The overall global SAF production capacity is expected to reach 2 billion gallons by 2027 as specialized producers aggressively add to their production capacity and new producers enter the SAF market.

The technology of SAF

By 2030, the SAF industry is projected to have 3,815 megatons (Mt) per year of biomass feedstock available. This should yield approximately 120% of the projected 2030 global jet fuel demand of 108 billion gallons per year. Notably, these figures don't account for technologies not reliant on biomass feedstock, such as Power-to-Liquid (PtL) pathway which relies on carbon capture technology, to produce SAF. In order to meet SAF goals of 2030, feedstock availability is least likely to be a constraint but will depend on the supply chain and geopolitical risk.

As sustainability and technology continue to become intertwined with the acceleration of decarbonization efforts, those working toward bringing SAF into everyday use have an opportunity to lead the transformation of the aviation industry. Work continues to accelerate to develop new feedstocks and new methods of making SAF a reality. Nine SAF technologies have received American Society for Testing and Materials (ASTM) approval, meaning that they can be used for commercial flight. In our report, we included four SAF technologies that are most likely to scale and attract industry attention:

Technology	**Description**	**Feedstocks**	**2030 Feedstock availability**	**Conversion rate[1]**	**ASTM approval**	**Maturity**
Hydrotreated Esters and Fatty Acids (HEFA)	Hydro-processing of oils and fats to produce diesel fuel	Waste and residue lipids, vegetable oils, palm, camelina, jatropha, and used cooking oil	195 Mt/year	90%	2011	◕
Classification/ Fischer Tropsch (FT)	Conversion of carbon materials into synthesis gas, then fuel	Municipal solid waste, coal, ash, and sawdust	2,290 Mt/year	13%	2009	◑
Alcohol-to-Jet (AtJ)	Conversion of alcohol using catalytic steps to produce jet fuel	Sugarcane, sugar beet, sawdust, plant dry matter (biomass)	1,330 Mt/year	20%	2016	◔
Power-to-Liquid (PtL)	Synthetic fuel production through combining electricity with CO_2 and water to produce hydrogen	CO_2, water, renewable electricity	N/A	17%	Methanol and other pathways under consideration	◔

Source: World Economic Forum, ASTM, EY analysis

1. Yield of total output (including aviation and road fuel) relative to feedstock

The current conversion rates, which are defined as a percentage of SAF yield from the feedstock, will improve with maturity in technology and enhancement in production capacity, further promoting SAF adoption. Based on current maturity levels, HEFA will drive a majority of SAF production in the short term, with other technologies such as PtL rising in their contribution to SAF supply in the coming years as they mature. PtL supply depends on carbon capture and hydrogen supply, both of which are forecast to far exceed demand scenarios for PtL. In particular, the projected scalability, long-term cost decline, and feedstock availability of PtL will likely make this technology the primary pathway for SAF production in the long term. The industry is executing strategic investments today in hydrogen and renewables to achieve this goal beyond 2030.

Policy can also fuel adoption

A strong government push, in terms of mandates and incentives, is expected to have a significant impact on SAF production and adoption. Based on our survey, 50% of respondents believe that increased policy incentives would be the highest impact driver of adoption, while 35% believe that imposing tax burdens on traditional energy producers and users would have the highest impact. Many countries are in the initial stages of framing policies for SAF adoption, with the US and EU leading the way with tangible policies and goals to promote SAF production. Even though 135 member countries have submitted their state action plans to reduce aviation-related carbon emissions to the ICAO to support its long-term aspirational goal of net zero emissions by 2050, a majority of them lack targeted policies and tangible incentives for a widespread SAF adoption.

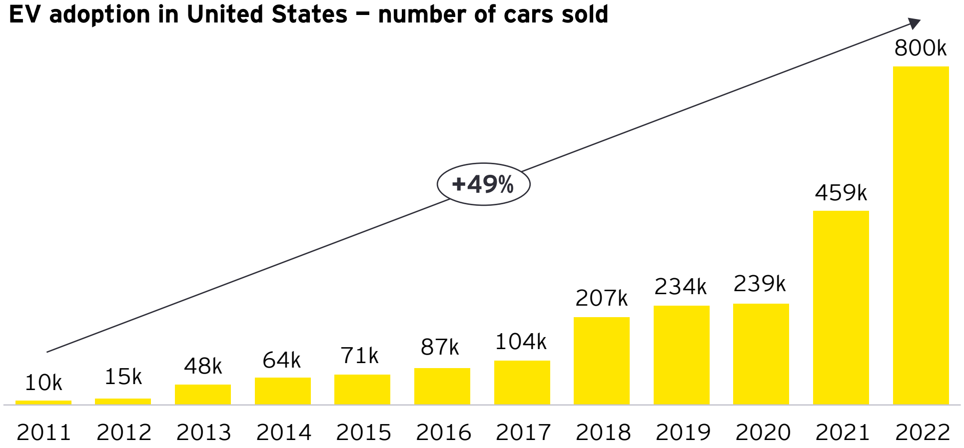
Strong policy measures have had a major impact on similar technologies in other sectors. Electric vehicles (EVs) and residential solar power adoption have increased dramatically over the last 10 years. Major incentives and mandates have been introduced in the United States that positively impacted production and affordability of these alternative technologies.

For example, EVs have been growing at the annualized rate of 46% over that period, with 2021 seeing the biggest jump. EV-friendly policies and tax incentives introduced by the US government, both at the federal and state level, played a major role in kick-starting the industry during 2009 and 2010. A study* published in 2016 found that more than 30% of EV sales were attributed to the federal tax credit, with the impact going up to 49% for some vehicles. We continue to see a government push toward EVs, with the government allocating billions of dollars toward EV manufacturing in the US as recently as 2022.

---

*Tal, G., & Nicholas, M. (2016). "Exploring the Impact of the Federal Tax Credit on the Plug-In Vehicle Market." *Transportation Research Record*, 2572(1), 95-102. https://doi.org/10.3141/2572-11.

EV adoption in United States – number of cars sold



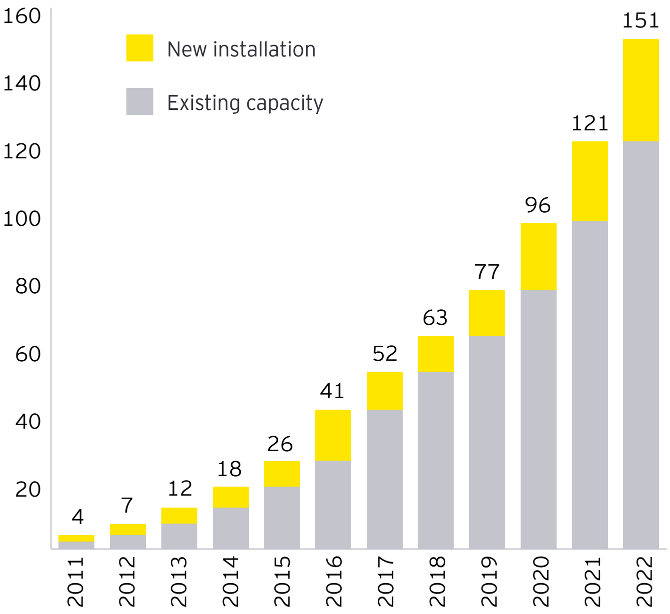
Electric vehicles		Impact		
		Production	Adoption	Price
2009	US government pledged $2.48b in federal grants to support the development of next-generation EVs and batteries, with the goal of becoming the first country to have 1 million EVs on the road by 2015	⏫	⏫	↗
2010	Federal Income Tax Credit up to $7,500 on all newly purchased all electric and plug-in hybrid vehicles			
2016	Paris Agreement established and Zero Emission Vehicle Alliance partners commit to sustainable transport electrification, including at least 20% of all road transportation to be powered by electric power by 2030			

Source: International Energy Agency (IEA), Alternative Fuels Data Center (AFDC) Energy, EY analysis

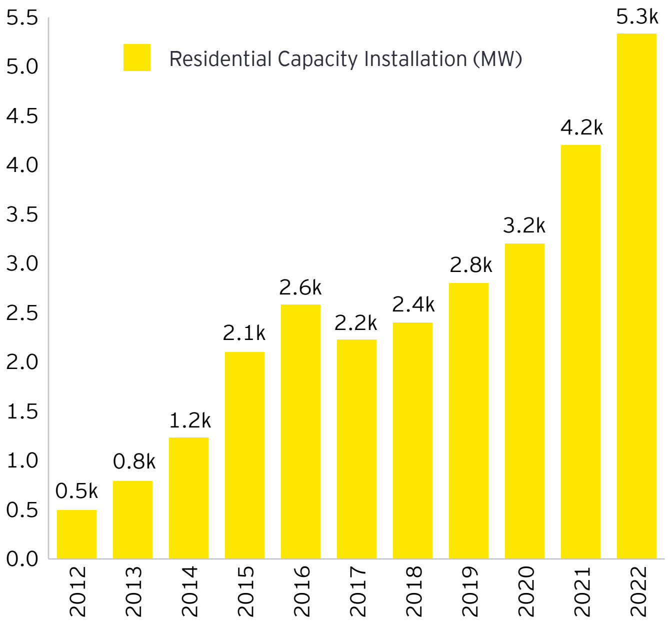
⏫ ↗ »
High positive → Moderate

Solar power follows a similar trend as EVs, with the US government introducing tax credits and collaborative measures with industry partners to develop solar capacity within the US. These actions played a key role in lowering prices and improving mainstream adoption. The combination of grants, tax credits and direct investments led to an annualized growth rate of 47% of installed residential solar power in the from 2012 to 2019.

Solar Power Production in United States (GWp)



Installed Residential Solar Power Capacity in US



Solar energy		Impact		
		Production	Adoption	Price
2010	Per the Recovery and Reinvestment Act, the federal government funded 104,733 projects totaling $24.9b	⇈	↱	⇈
2016	Federal tax credit for solar per the financial bailout bill is extended till 2016 to generate 28 gigawatts of solar power			
2016	SunShot Initiative to reduce the cost of solar power by 75% from 2010-20; the levelized cost of energy generated by large solar plants reduced by 82%			

Source: Solar Energy Industries Association (SEIA), U.S. Department of Energy (DOE)

⇈ ↱ »

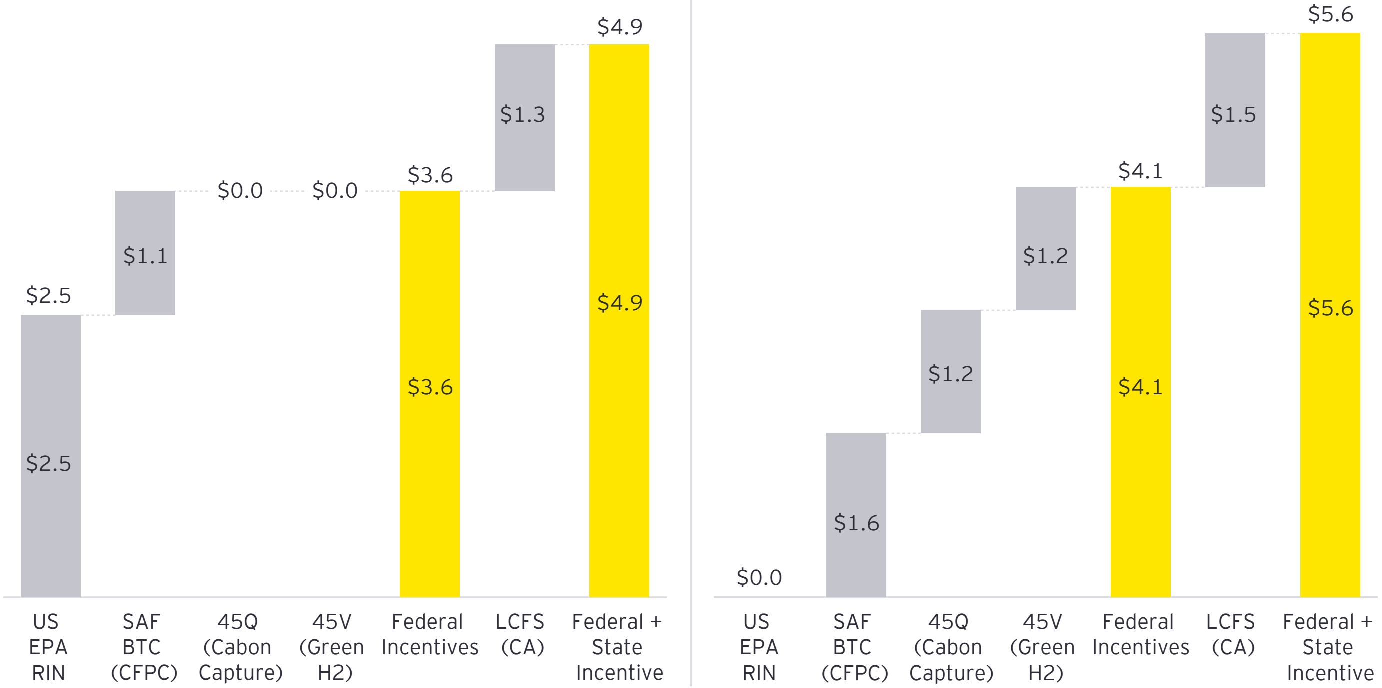
High positive → Moderate

Although SAF policies are still in development globally, the US and EU have been ramping up formal support and incentives for SAF. For example, the Inflation Reduction Act passed in 2022 offers tax credits up to $1.75 a gallon for SAF production and $297 million in grants projects related to production, transportation, blending or storage of SAF. In total, the US has announced more than $5 billion in grants and incentives, including tax credits, to SAF producers and consumers. Similar grants and targets have been launched in the EU along with a proposed SAF mandate, with global policy activity expected to ramp up in the next five to seven years.

One of the challenges in gaining acceptance of new technology is that it is usually more expensive than the technology it is trying to replace. As technological improvements are made and strategic investments come into play, the price gradually becomes less prohibitive. Incentives and policies can have a significant impact on the success of the technology. Depending on the feedstock and pathways, these incentives can be stacked to have a favorable impact on SAF adoption. SAF produced using bio-mass based feedstock qualifies for Renewable Identification Numbers (RINs) under the Renewable Fuel Standard (RFS2) which incentivizes purchase of SAF. This is in addition the blenders tax credit introduced by the Inflation Reduction Act (IRA) in 2022 which provides the producers a range of tax credit from $1.25 to $1.75 per gallon based on lifecycle GHG emissions of the SAF pathway. Additionally, the IRA has introduced and improved tax benefits to incentivize production of clean hydrogen (45V) and carbon capture (45Q) in the United States which is particularly helpful for technologies such as Power-to-Liquid (PtL). There are additional incentives at a state level such as California's Low Carbon Fuel Standard (LCSF) that can utilized for SAF production in the state.

We provide a comparison scenario of potential tax benefits of SAF produced using FT and PtL pathways below. Tax incentives introduced in the United States provide a tremendous benefit for fuel producers and is expected to accelerate SAF adoption in the near term.

SAF Inventive Stack – Typical Scenario



Federal and State Incentive Stack – Fischer-Tropsch (FT)
US Dollars per gallon; Feedstock: MSW, Ag, Forest Residue

Federal and State Incentive Stack – Power-to-Liquid (PtL)
US Dollars per gallon; Feedstock: Direct Air Capture (DAC)

Source: ASCENT, International Energy Agency, EY Analysis

Federal regulations and incentives, along with improvements in technology readiness, will likely be more effective at driving SAF adoption than mandates. While both solar and EVs continue to see billions of dollars' worth of investment from the government to accelerate production and adoption, SAF has yet to see incentives and programs of that magnitude specifically targeted to increase SAF production. Aggressive SAF goals, set by governments and organizations, that are accompanied by major incentives, will be required to accelerate the supply of SAF in the United States, since there is no shortage of SAF demand. The number of commercial SAF offtake agreements has risen globally in an effort to decarbonize the industry. In terms of intake agreements, 59 have been signed in 2021–22, compared to only nine in 2019–20. For SAF adoption to take off, governments across the world will need to align their incentives and programs to the ambitious goals they have set to reach net zero travel through SAF.

However, there are still challenges to be overcome before SAF becomes the standard fuel for the aviation industry.

SAF policy development timeline

United States

2005

- Energy Policy Act – US Renewable Fuel Standard (RFS) created updates through Energy Independence Act 2007

2021

- SAF Grand Challenge – 3b gallons of SAF and aviation emissions reduced 20% by 2030
- $4.3b for SAF opportunities, including $3b loan guarantee
- $175m in research funding for technologies to reduce SAF carbon emission
- >$61m to advance biofuels and support low-cost SAF pathways by the FAA

2022

- Inflation Reduction Act – Incentives to use SAF up to $1.75 per gallon. Infrastructure grant of $245m
- Sustainable Aviation Tax Credit – Build Back Better Agenda with tax credit for 50% or more lifecycle GHG reduction
- Renewable Diesel and Sustainable Aviation Fuel Parity Act – EIA to report production and import of renewable diesel and SAF
- New sustainable aviation goal

European Union

2009

- Renewable Energy Directive (RED) – EU countries to source at least 10% of their transportation energy from renewable source by 2020

2016

- EC 2016 – EU energy and climate goals for 2030, renewable energy target of at least 27% of total EU energy consumption by 2030
- Initiative Towards Sustainable Kerosene For Aviation (ITAKA) – collaborative project for a large-scale European drop-in HEFA SAF supply chain
- Aviation Initiative for Renewable Energy in Germany (AIREG) 2016 – support the production and use of SAF, with a bio jet target of 10% of jet fuel consumption by 2025 in Germany

2019

- Dutch Sustainable Aviation Agreement – zero CO_2 emission from domestic aviation by 2050

2021

- ReFuelEU Aviation – Fit for 55 package. Proposal to provide 2% SAF by 2025, 63% SAF by 2050
- The UK government launched £15m "Green Fuels, Green Skies" competition to provide funding to early-stage development of UK SAF plants

Source: ICAO report, IATA report, EY secondary research, EIA: Energy Information Administration, FAA, S&P Global

Impact of geopolitical environment on SAF adoption

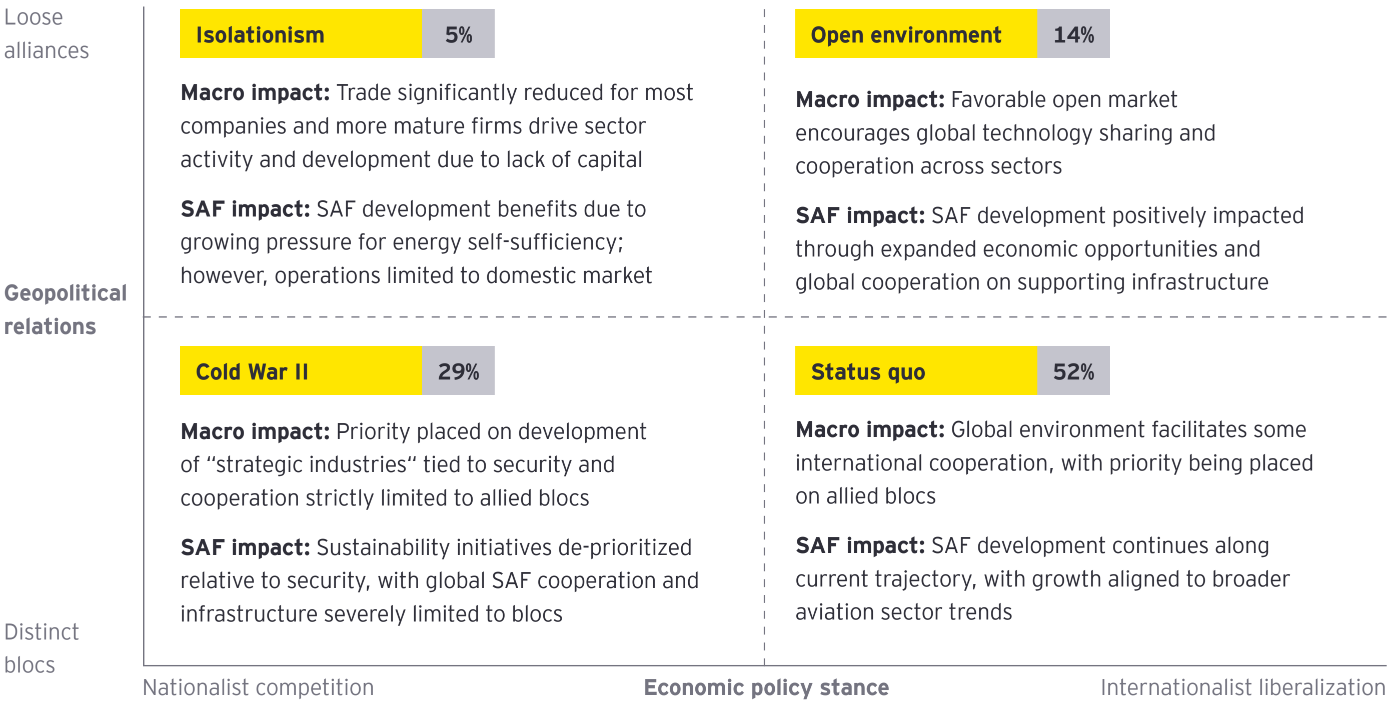
The global political environment continues to be unpredictable, and emerging technologies like SAF are not immune to this. It is critical to look at SAF through the dynamic geopolitical lens, since adoption of new technologies like SAF depends heavily on these factors. Factors such as government policies, production capacity and demand, and price parity with traditional jet fuel are all variables that react heavily to the geopolitical environment. The added pressure of energy independence and supply chain resiliency further add to this dynamic and complex environment. Understanding how SAF outlook changes based on the events of the world prepares us to participate in SAF adoption in a variety of geopolitical scenarios.

Global scenario analysis reveals diverging paths for geopolitics, economic policies and company strategies. The trajectory of geopolitics will shape these trends and the global business environment across aerospace and defense (A&D), and SAF in the next five years is uncertain.

We highlight four geopolitical scenarios, the economic outcome and their impact on SAF adoption:

Geopolitical scenario outlooks

Probability of outcome (%) based on EY SAF Survey 2022



Isolationism 5%

Macro impact: Trade significantly reduced for most companies and more mature firms drive sector activity and development due to lack of capital

SAF impact: SAF development benefits due to growing pressure for energy self-sufficiency; however, operations limited to domestic market

Open environment 14%

Macro impact: Favorable open market encourages global technology sharing and cooperation across sectors

SAF impact: SAF development positively impacted through expanded economic opportunities and global cooperation on supporting infrastructure

Cold War II 29%

Macro impact: Priority placed on development of "strategic industries" tied to security and cooperation strictly limited to allied blocs

SAF impact: Sustainability initiatives de-prioritized relative to security, with global SAF cooperation and infrastructure severely limited to blocs

Status quo 52%

Macro impact: Global environment facilitates some international cooperation, with priority being placed on allied blocs

SAF impact: SAF development continues along current trajectory, with growth aligned to broader aviation sector trends

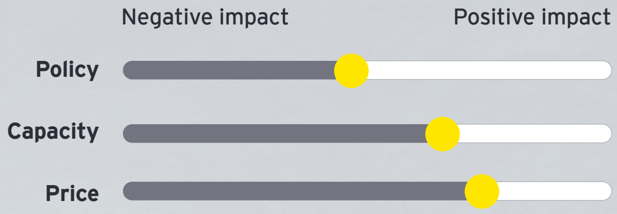
Source: EY analysis

While recent shocks have created momentum toward a Cold War II scenario, events in the near and medium term could shift the trajectory toward another scenario. Open environment scenario, with a lower probability of occurrence, would be the most preferable for SAF development.

Here, we take a closer look at the four scenarios and their impact on SAF through a variety of prisms. What is the investor viewpoint on SAF? How does SAF influence sustainability if countries choose isolationism? What effect does SAF have on jobs and how does the outcome shift in open environment versus Cold War II? Here's our analysis of how things could play out.

Scenario 1

Open environment



SAF adoption benefits from growing commercial air travel and the open global economic environment, with the private and commercial players pushing forward development.

"Open environment" would be a relatively liberalized and globalized operating environment with lower geopolitical tensions. The open environment scenario presents a partial return to the 1990s and early 2000s. Low levels of geopolitical tensions create a more stable and predictable global operating environment for companies. Ideological blocs fade in significance as trade-driven partnerships become more important.

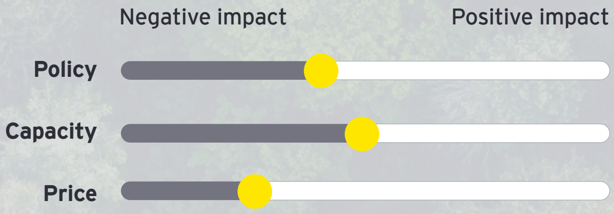
Policy: US and EU policy efforts to support SAF production and adoption continue to expand and grow to support industry trends, but market forces and competition are the major drivers for pushing SAF forward. Consumer awareness and sentiment around SAF continues to improve, further contributing to increased adoption. The favorable economic and political environment expands collaboration, and the formation of ecosystems across borders accelerates innovation. Aerospace and energy companies allocate higher R&D budgets to sustainable aviation fuels, hydrogen and electric flight technology to increase range and reduce costs. Availability of jet fuels and traditional energy sources is not impacted, which also gives government less reason to intervene through policies or mandates as a way to find alternate energy sources and encourage energy independence. Voluntary cooperation on green initiatives, private technology development, as well as positive consumer sentiment, become the driving forces behind SAF adoption.

Capacity: In this scenario, the post-pandemic recovery continues, driven by healthy leisure travel, as well as improving business and international travel volume. Fuel and operating costs decrease, and greater demand for commercial air travel encourages SAF consumption through sustainable aviation and airline alliances. Feedstock required for major SAF pathways is readily available domestically and internationally, resulting in stable pricing and minimizing logistical challenges. Commercial aerospace companies attract high-quality engineering and skilled manufacturing talent from around the world given improved growth prospects. The political landscape enables markets to operate efficiently, resulting in relatively balanced supply and demand with low price inflation. Global alliances and partnerships form to improve SAF logistics and use on international routes.

Price: Investor appetite for emerging growth sectors in commercial aviation, such as SAF, increases in a high-growth, peacetime economy. Companies generally have a strong appetite to invest in capex, technology, R&D and M&A as growth and financial performance improve. The broad investment is expected to accelerate SAF technology, driving costs and prices down. Market forces, production efficiency and scale continue to drive SAF price down to reach parity with conventional jet fuel since policy intervention is minimal in this scenario.

Scenario 2

Status quo



SAF development continues along a positive trajectory. However, cooperation is limited to friendly blocs and alliances.

"Status quo" would also be characterized by strong geopolitical alliances, but trade and capital flow relatively freely among allies, leading to companies "friendshoring," a practice of relocating production and supply chain to countries where political risk is low. The status quo scenario is a less-familiar geostrategic environment, somewhat reminiscent of the early 1900s. Despite these divisions, geopolitical tensions are at manageable levels as governments focus on supporting domestic economic growth.

Policy: Sustainability is a high priority for both the commercial sector and governments, though reduced international coordination increases variability of regulations and policies, increasing cost and complexity for companies. Policy efforts to support SAF continue; however, they are aligned to blocs and take a backseat when tensions rise in other areas. Focus on supply chain resiliency emphasizes adding suppliers rather than severing relationships. Key input access is more limited, as friendly nations prioritize each other for trade, particularly for strategic parts and technologies relevant to commercial aviation. In this environment, SAF production and adoption is still reliant on collaboration and market forces and less dependent on policies and mandates set by governments. SAF collaboration and partnerships are limited to friendly nations, and potential operational constraints for SAF usage emerge on non-allied country travel routes. Collaboration and ecosystem formation is lower than in open environment, but modestly improved given general bloc stability. Energy independence is a lower priority and jet fuel availability is efficiently managed and coordinated through alliances.

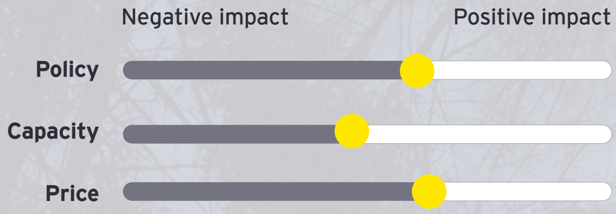
Capacity: The post-pandemic recovery isn't as strong in this scenario, and rival blocs temper economic growth. Fuel and operating costs are relatively stable, leisure travel is moderate, but business and international travel continue to struggle. Global freight and cargo business growth continues as e-commerce trends continue. Demand for air travel continues to grow, albeit at a more moderate pace, leading to increased demand for SAF. Domestic sources are relied upon for feedstock required for SAF, and a network is established with allied blocs to cultivate critical feedstock. Still, while customer awareness of SAF usage and initiatives continues to improve, it has yet to become a priority.

Price: The commercial aviation sector's appetite to invest in capex, technology, innovation and M&A is moderate as growth and performance are tempered against a moderate economic growth backdrop.

Capital flow between countries in different blocs diminishes, with smaller, earlier-stage companies disproportionately affected (e.g., SAF specialized producers). There is a stronger investor appetite for bloc champions with access to higher-growth middle powers, potentially benefiting more mature energy producers (e.g., SAF diversified producers). Pressure to switch to renewable energy and feedstocks accelerates as commodity costs increase. Favorable policies, like those being implemented in the US, may lead to price parity in some blocs, but price parity will be highly dependent on economies of scale due to increased international trade and operational efficiency.

Scenario 3

Cold War II



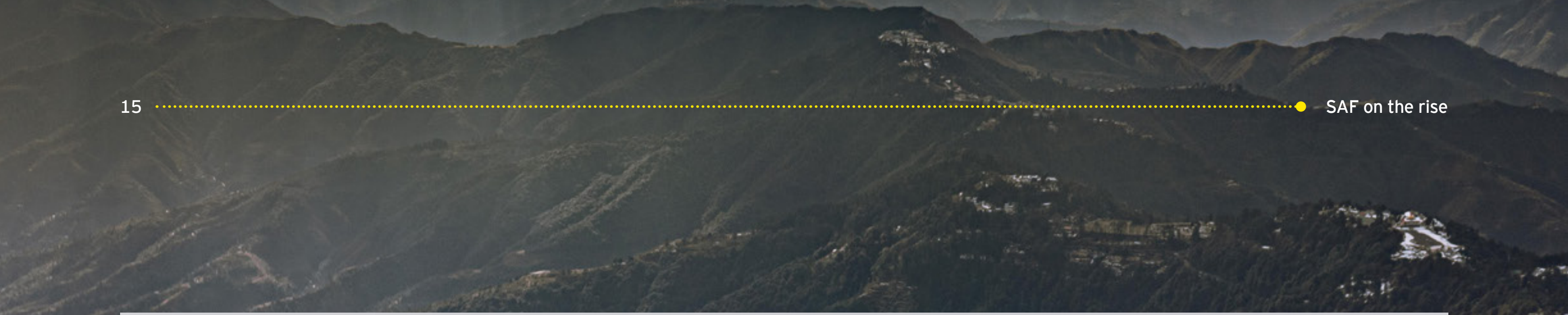
SAF is deprioritized, but may benefit from a greater focus on defense and energy security, which could mitigate weaker investment momentum due to market uncertainty.

"Cold War II," in contrast, would arise from a hardening of alliances and ideological competition combined with nationalist and statist economic policies. The Cold War II scenario matches many of the characteristics of the first Cold War. The hardening of alliances and ideological competition creates a world order defined by two distinct blocs. But in this scenario, based on current trends, one bloc is likely to be comprised of the US, the EU and their allies, and the other led by China and its allies. There is also a third, volatile bloc of largely non-aligned countries that are under pressure to choose a side.

Policy: Strategic industries expand dramatically, guaranteeing the defense sector access to critical production inputs, but imposing greater cost and scarcity risk on sectors not directly supporting national security programs, including commercial aerospace players, particularly airlines. High risk emerges from potential wide-reaching government interventions, including production mandates and nationalization. There is even greater risk around business continuity, particularly from the elevated geopolitical threat environment as cyber attacks and intellectual property theft across blocs rise. Sustainability becomes a lower priority for both firms and governments unless the potential for some advantage over a rival bloc is identified. The fact that the US Department of Defense (DoD) has said sustainability provides it with more mission autonomy could be that advantage. Military adoption of SAF and energy independence as a national security priority would be a game-changer and a major driver for SAF adoption in an unfavorable and risk-averse economic environment.

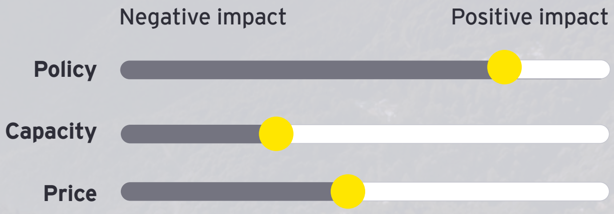
Capacity: Ecosystem formation is dampened, though certain sectors (e.g., defense) may see greater government-backed collaboration. In commercial aviation, diminished capital flows benefit mature firms with greater resiliency and liquidity, hampering startups and commercial innovation, more broadly. Increased spending creates opportunities for startups with differentiated technologies to grow, but access to capital may slow down technology maturity. Companies will look to utilize feedstock available domestically, which may limit the SAF pathways that can be used for SAF production. In this scenario, capacity growth will be moderate and highly dependent on domestic production and usage.

Price: The main impetus for sustainability initiatives stems from renewable energy and feedstock transition pressures, which may vary depending on which countries are aligned with a particular bloc. There is limited to no international partnership or sales opportunities for SAF outside of an alliance bloc. But within that bloc, SAF takes a big step forward when commercial airlines and defense departments look for solutions for fuel autonomy. The increased support for SAF under energy independence initiatives likely leads to price parity within allied blocs. There is less opportunity to reduce production cost by scaling up operations since the demand will be dampened, which will need to be offset by government incentives and tax credits.



Scenario 4

Isolationism



SAF development becomes isolated to domestic markets, and fragmentation in infrastructure and policy reigns.

"Isolationism" would result from decaying alliances and weak economic growth pushing countries to promote domestic production and seek greater self-sufficiency. Policymakers are motivated by achieving domestic self-sufficiency and economic security, despite the high costs involved. Isolationist policies result in increased trade volatility, creating a subdued and unstable economic growth outlook. Nationalist policies, including trade barriers, price controls and other restrictive measures, further fuel inflation. Isolationism, weaker technological progress and increased conflict risks limit business investment and productivity growth.

Policy: The persistence of China's zero-COVID policy isolates it from the world and drives the emergence of new travel and maintenance hubs elsewhere in Asia. Prices rise as competition and supply lessen, greatly encouraging SAF adoption. Inward-oriented economies and diminished international trade significantly reduce growth for a majority of companies. Those less dependent on international reach and aligned with strategic industries and "strategic autonomy" policies benefit. Access to key inputs and traditional logistics hubs/routes becomes increasingly unpredictable and subject to unilateral government action. Global SAF cooperation and infrastructure is unlikely to develop. Self- reliance, security and resiliency become top policy priorities, benefiting domestic SAF production, while broader sustainability slips on the global agenda. Energy independence becomes a national strategic priority leading to ramp-up in SAF production through government incentives and awards. SAF also gets an extra boost from defense programs adopting SAF as their fuel choice.

Capacity: Technological collaboration and trade flow are low, and investment required by the A&D sector is huge. Few countries, such as the US and China, emerge as world leaders. There is an increase in investments in sustainable aviation, especially SAF (driven by shortage of fuel) for long-term self-reliance. Ecosystem formation in strategic sectors, such as aviation, is limited to in-country partners, and the broadly nationalistic political climate dampens non-strategic sector collaboration. In commercial aviation, greatly diminished capital flow benefits mature firms with greater resources and curtails startups. Large diversified SAF producers benefit, while small specialized SAF producers struggle to compete. A lack of cross-border mobility for workers in strategic industries, such as commercial aerospace and defense, as well as weak economic growth, partially offsets upward wage pressures.

Price: Pressure to transition to independent energy sources and feedstocks accelerates as commodity costs increase, leading to moderate price improvements. In general, fuel prices would rise, and price parity would become a more realistic goal due to the fact that there would be a lower supply of traditional energy sources, which would drive up prices in that sector. Price parity will ultimately be achieved by traditional fuel prices going up rather than the price of SAF going down. There is little to no price optimization opportunities through operational improvements or producing SAF at scale with demand limited to domestic markets.

Key findings and takeaways

Each scenario presents a unique outcome and set of opportunities for stakeholders in the SAF market. The open environment scenario paints an optimistic picture for the price and capacity of SAF, with commercial players driving the overall adoption and development efforts. If the status quo remains, SAF development will continue pushing ahead, although at a more moderate pace and with unclear impacts on price and policy. A shift toward Cold War II, although not an optimistic outlook for the geopolitical environment, could push SAF development forward through strengthening bloc alliances and cooperation. And finally, in the isolationism scenario, the US would become more inward-focused, and momentum would build toward energy self-sufficiency, which could ultimately benefit SAF production in certain blocs.

The more optimistic scenarios for status quo and open environment lend themselves to commercial activity and investment by the private sector. The consistent and open global trade, partnerships and technology sharing would lend themselves to higher commercial opportunities for investors and companies. On the other hand, the more pessimistic scenarios for Cold War II and isolationism lend themselves to large domestic players, heavy government involvement, and restricted international coordination on SAF and related sustainability goals. In these cases, SAF can still thrive, but the trajectory will be driven by government entities, large companies and the defense sector. The tensions brought about in these two scenarios likely lend themselves to greater DoD involvement and increased crossover of commercial and defense applications for SAF.

SAF is going to drive a significant amount of change in the aerospace industry over the next five years, with the geopolitical and economic environment influencing how the market will evolve and who will be driving the change. The surge in investment, new entrants and agreements around SAF in the present day underscores the importance of tracking market dynamics and developments. It is not a matter of *if* SAF will be adopted as a fuel source for aircraft, but rather *when* adoption will scale up and *where* it will be used.

Call to action

SAF is going to continue evolving as a key part of the aerospace industry regardless of which scenario plays out over the next five years. Depending on where you sit and how you think the global environment will change in the coming years, there is a way to get involved in the development and adoption of SAF. The commercial aerospace industry is committed to sustainability, and SAF is a core part of that solution in both the near and long term. It is time to start thinking about what you can do to be a part of this change, and how you can capitalize on the promising opportunity SAF presents. Regardless of the geopolitical scenarios, for SAF to become a viable path to achieve net zero aviation, the following actions will be critical in the near term:

1. A push for more tangible grants and policies in the US, UK and EU. The UK and EU are significantly behind in introducing meaningful incentives to accelerate SAF production and help the industry reach price parity with conventional jet fuel.
2. Energy producers and investors should continue to pursue less feedstock-dependent technologies, such as PtL, to de-risk from political challenges and supply chain issues.
3. Opportunities exist for both specialized and diversified energy producers to push forward with more mature technologies and allocate capital to build capacity to capture increasing demand from the airline industry.
4. As specialized energy producers continue to mature technology and operations, the diversified players looking to enter the market should pursue partnerships and acquisitions to add to their alternative energy portfolios.
5. Corporations and airlines' partnerships will be important to keep ESG goals front and center by increasing book-and-claim activity and offsetting the carbon footprint of corporate travel.

Contact us

Rosco Newsom
Principal, Aerospace &
Defense Practice, EY-Parthenon
Ernst & Young LLP
rosco.newsom@parthenon.ey.com

Ben Murphy
VP of Sustainability
Boom Supersonic
ben@boom.aero

Raman Ram
Principal, Americas Aerospace &
Defense Leader
Ernst & Young LLP
raman.ramanathan@ey.com

Additional contributors

Erika Solem-Ruckert

Haider Ali

Article references

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

"Net zero 2050: sustainable aviation fuels," IATA website, https://www.iata.org/en/iata-repository/pressroom/fact-sheets/fact-sheet---alternative-fuels/.

"Clean Skies for Tomorrow: Sustainable Aviation Fuels as a Pathway to Net-Zero Aviation," World Economic Forum, https://www3.weforum.org/docs/WEF_Clean_Skies_Tomorrow_SAF_Analytics_2020.pdf, November 2020.

"Sustainable Aviation Fuel – Industry Primer and Outlook," JP Morgan, April 2022.

"Report on the Feasibility of a Long-Term Aspirational Goal (LTAG) for International Civil Aviation CO2 Emission Reductions," International Civil Aviation Organization, https://www.icao.int/environmental-protection/LTAG/Documents/REPORT%20ON%20THE%20FEASIBILITY%20OF%20A%20LONG-TERM%20ASPIRATIONAL%20GOAL_en.pdf, March 2022.

"Aviation Climate Action Plan," Federal Aviation Administration, https://www.faa.gov/sustainability/aviation-climate-action-plan, 9 November 2021.

EY | Building a better working world

EY exists to build a better working world, helping to create long-term value for clients, people and society and build trust in the capital markets.

Enabled by data and technology, diverse EY teams in over 150 countries provide trust through assurance and help clients grow, transform and operate.

Working across assurance, consulting, law, strategy, tax and transactions, EY teams ask better questions to find new answers for the complex issues facing our world today.

EY refers to the global organization, and may refer to one or more, of the member firms of Ernst & Young Global Limited, each of which is a separate legal entity. Ernst & Young Global Limited, a UK company limited by guarantee, does not provide services to clients. Information about how EY collects and uses personal data and a description of the rights individuals have under data protection legislation are available via ey.com/privacy. EY member firms do not practice law where prohibited by local laws. For more information about our organization, please visit ey.com.

Ernst & Young LLP is a client-serving member firm of
Ernst & Young Global Limited operating in the US.

© 2023 Ernst & Young LLP.
All Rights Reserved.

US SCORE no. 19152-231US_2

2210-4108031
ED None

This material has been prepared for general informational purposes only and is not intended to be relied upon as accounting, tax, legal or other professional advice. Please refer to your advisors for specific advice.

ey.com