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The Chinese characters "德勤" (Deloitte) are located in the top right corner. They are rendered in a white, sans-serif font.

德勤

The text "OUR POINT OF VIEW" is located in the middle left section of the page. It is written in a white, all-caps, sans-serif font.

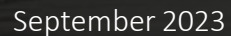
OUR POINT OF VIEW

The text "Sustainable Aviation Fuels (SAF) in China" is located in the middle left section of the page, below the "OUR POINT OF VIEW" text. It is written in a green, sans-serif font.

Sustainable Aviation Fuels (SAF) in China

The main title "Checking for Take-off" is located in the bottom left section of the page. It is written in a large, white, sans-serif font.

Checking for Take-off

The date "September 2023" is located in the bottom left corner of the page. It is written in a small, white, sans-serif font.

September 2023

# Aviation's pathway to carbon neutrality

For the aviation industry to keep growing, it is critical that it reach net zero emissions, but there are key challenges that must be overcome. Aviation is recognized as a “hard-to-abate” sector and SAF is the only commercially viable, near-term mechanism able to reduce the carbon intensity of air travel.

AT A GLANCE

## Aviation and SAF

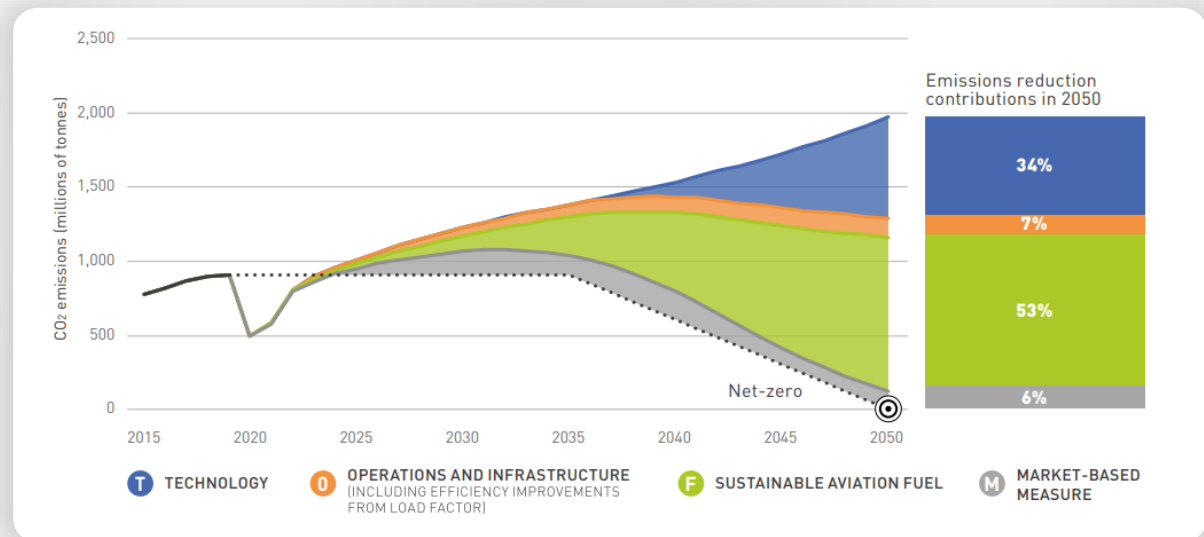
Aviation supports \$3.5 trillion (4.1%) of the world's GDP and accounts for 3% of all global CO<sub>2</sub> emissions, but as other sectors decarbonize its contribution could reach 22% of global emissions by 2050.

IATA forecasts the biggest growth in passenger numbers will be in Asia Pacific. In 2021, the Chinese domestic passenger market made up 18.9% of global passengers

**SAF will be aviation's primary means of decarbonization – as a drop-in fuel there is no need to redesign aircraft or airport infrastructure – but action must focus on scaling production and lowering cost.**

## 2050 Net Zero Pathway for Aviation

Sectoral scenarios anticipate that SAF will bring between 50 and 75% of carbon reductions required by aviation in 2050.<sup>1</sup>



1. ATAG Waypoint 2050 ([Link](#))

# Relying on business as usual and waiting for new clean technologies to emerge is an inadequate strategy

The aviation sector needs to explore and leverage multiple strategies to ensure a timely and successful transition

## Aviation’s decarbonization goals

The industry, through the International Air Transport Association (IATA)<sup>1</sup> and the Air Transport Action Group (ATAG), has committed to Net Zero by 2050.<sup>2</sup>







The International Civil Aviation Organization (ICAO) formally recognized that technology and market-based measures will be needed for industry decarbonization. This will be achieved through **multiple levers**, including:

- Efficiency gains
- Sustainable aviation fuels (SAF)
- Carbon offsetting
- New propulsion systems such as electric batteries and hybrid aircraft
- The use of hydrogen

However, the successful development and deployment of SAF will be critical to reducing emissions by 2050.

1. IATA Net Zero Commitment ([Link](#))  
 2. ATAG Global Aviation Emissions ([Link](#))

## Decarbonization levers

Decarbonization levers	Description	Role and Challenge
 Sustainable aviation fuel (SAF)	Fuels from sustainable resources to substitute fossil-based kerosene	<b>Main decarbonisation option in the next 30 years; ability to use with existing aircraft</b>
 Efficiency gains	Design and operational improvements to reduce fuel burn	Important option but impact diminishes over time
 Offsets	Investment in out-of-sector emission reductions or removal	Important as other long-term options are scaled up
 Hydrogen	Combustion of green hydrogen and/or conversion to electricity through fuel cells	Requires storage and new airframe designs. Long time to develop, ensure safety, certify and deploy at scale
 Battery	Electric propulsion with zero emissions if charged with green electricity	Battery weight and size limits applicability to short-haul routes
 Behavioral change	Reduction of demand resulting from modal shift	Behavioural change may be outpaced by population and economic growth



# What is Sustainable Aviation Fuel (SAF)?

SAF is an alternative jet fuel that represents the most viable near-term solution to decarbonize the aviation industry

## Sustainable Aviation Fuel

SAF is a biofuel used to power aircrafts that has similar properties to conventional jet fuel, but with a smaller carbon footprint

When used to power aircraft, SAF can reduce the carbon intensity of flying by up to 85%, depending feedstock selection and technological pathway

### What is SAF?

SAF is a drop-in liquid fuel alternative that can reduce carbon emissions by up to 85% when compared to traditional jet fuel, depending on the feedstock selection and production pathway. SAF is currently produced from several sources (feedstocks) including forestry residue, agricultural waste, used cooking oils, and municipal solid waste. SAF producers are also exploring synthetic production pathways via a process that captures carbon directly from the air.

In addition, SAF is considered 'sustainable' when:

- Feedstock does not compete with food crops or water supplies
- SAF does not contribute to forest degradation or soil depletion
- SAF recycles carbon stored in the biomass of feedstock



#### Immediate Action:

SAF is a 'drop-in' fuel compatible with existing aircraft and airport infrastructure, which does not require significant changes to aircraft and airports and delay deployment.



#### Scalability:

Global SAF production is estimated to grow to cover 10% of total jet fuel sales by 2030, based on sustainable feedstock availability and capital investment.



#### Accounting:

SAF is not recognized (officially) by the GHG Protocol for Scope 3 emissions reductions. In lieu of official guidance, the market is working to develop guidance and demand signals in support of SAF certificate inclusion in GHG inventories.



#### Commercial Viability:

At this time, SAF is the only near-term climate solution, as hydrogen and electric propulsion will develop over the next decade and may not be viable for long haul air travel (which is the largest contributor to sector emissions).

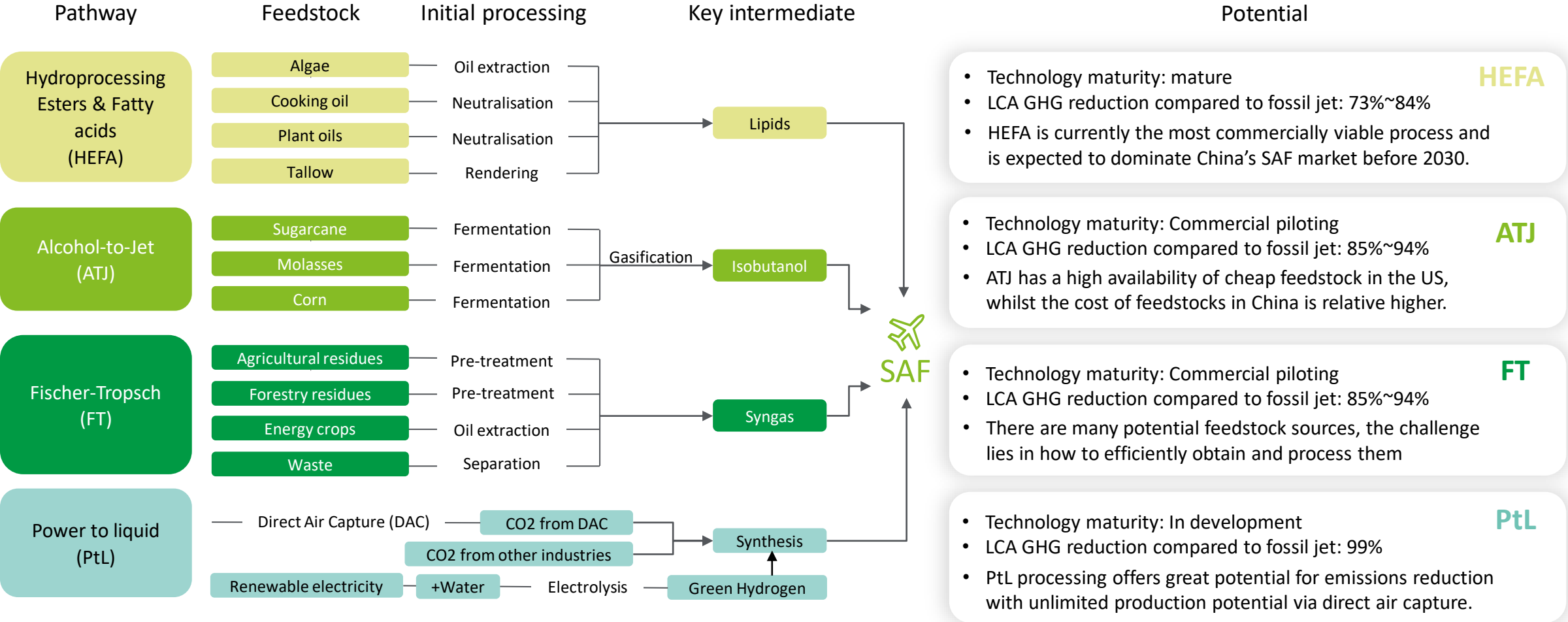


#### Co-Benefits:

SAF has several co-benefits beyond reducing carbon emissions, including improved air quality, job creation and investment renewable energy, and increased energy security.

# Four key technical pathways to SAF

As of April 2023, ASTM International has approved nine technical routes based on HEFA, ATJ, and FT. The PtL pathway is still awaiting approval.



Sources: ICAO, EASA, World Economic Forum, Airbus  
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# The SAF Ecosystem

Stakeholders within the aviation industry are aiming for decarbonization, but more action is needed to reach this goal

## Feedstock suppliers

- Investment in feedstock collection and segregation processes

## SAF Producers

- Technologies for using feedstock to produce bio SAF is mature; the challenge lies in how to efficiently obtain and process feedstocks
- Further technological development is needed to reduce production costs and expand production

## Fuel suppliers

- SAF procurement, sales and into-plane services
- Comply and promote standards, certification and reporting to ensure SAF and offset quality

## Airlines

- Motivate passengers to pay for carbon offsets and SAF
- Raise the decarbonization ambition and encourage other players in the ecosystem to act



## Logistics services

- Large corporate travelers and cargo owners are encouraged to take the lead and utilize SAF to fulfill their climate commitments
- Internal cost control and investment

## Investors and financial institutions

- Provide financing support

## Regulators

- Regulations, incentives and policy guidance are needed to help accelerate the production and use of SAF

## Aircraft manufacturers

- Invest in R&D to address technological challenges
- Seek to establish partnerships with other ecosystem players that want to accelerate SAF and decarbonization
- Improve aircraft efficiency and accelerate fleet updates

## Airports

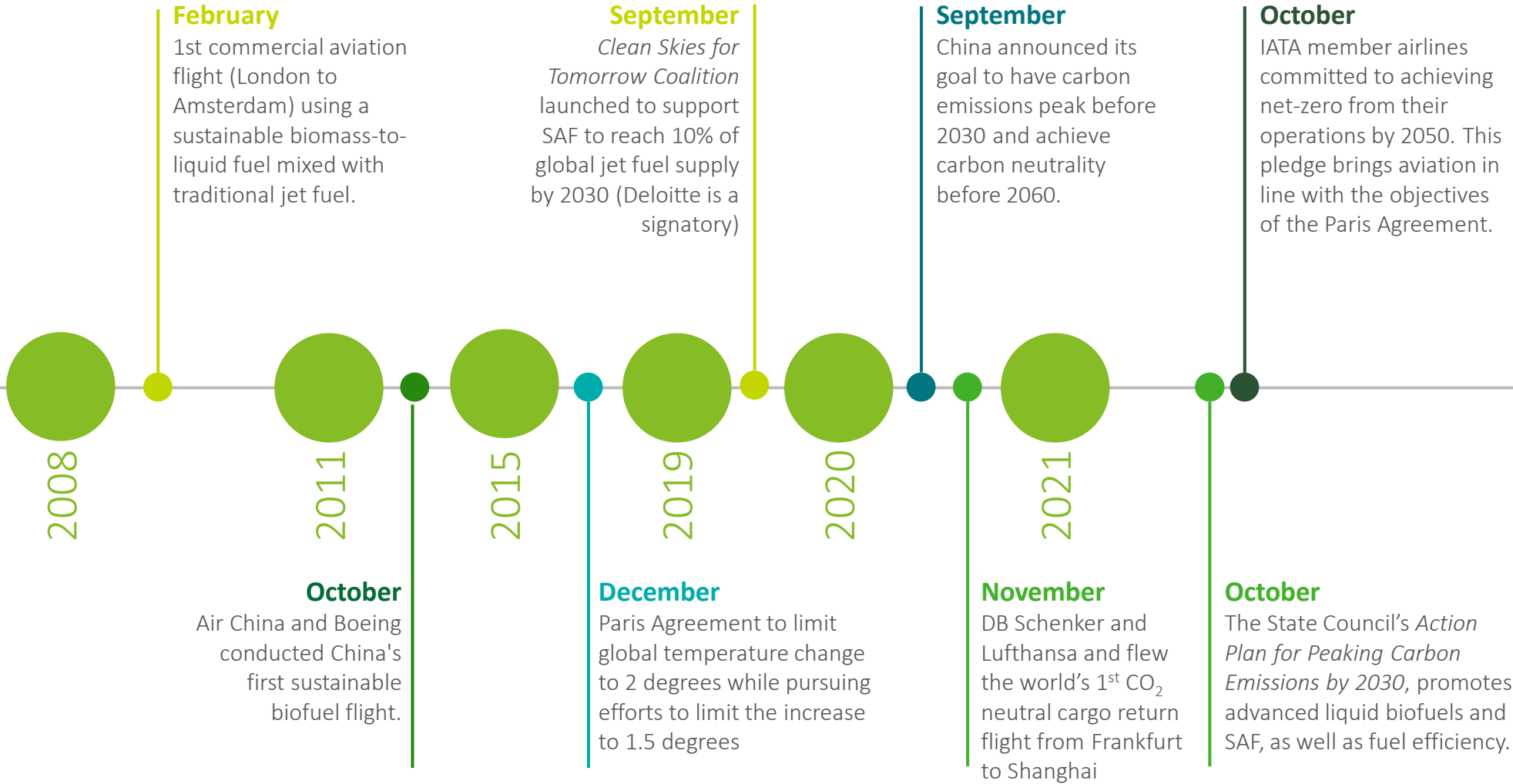
- Promote SAF use and fleet upgrading
- Strengthen infrastructure and the allocation of specialist personnel

Source: Shell, Institute of Energy, Peking University

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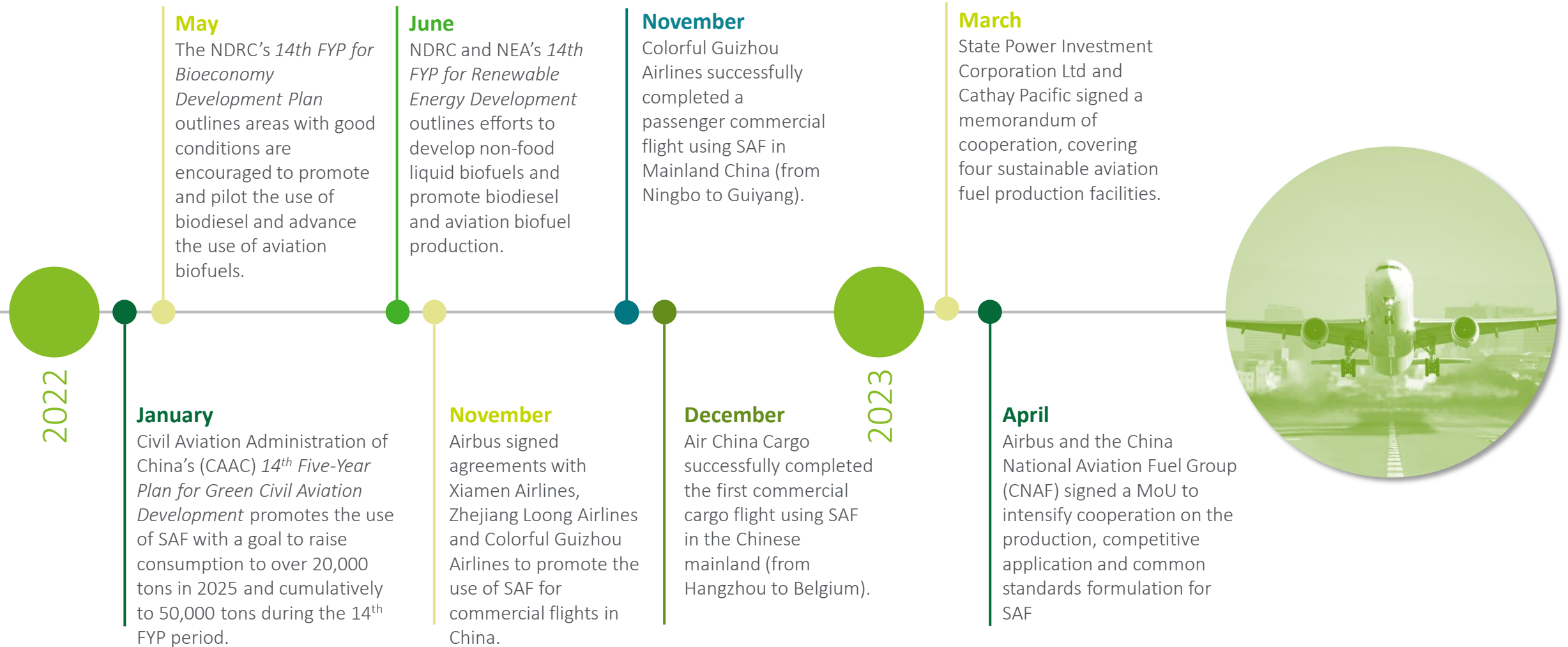
# Aviation's carbon neutral journey in China

## Past



# Aviation's carbon neutral journey in China

## Today / Future

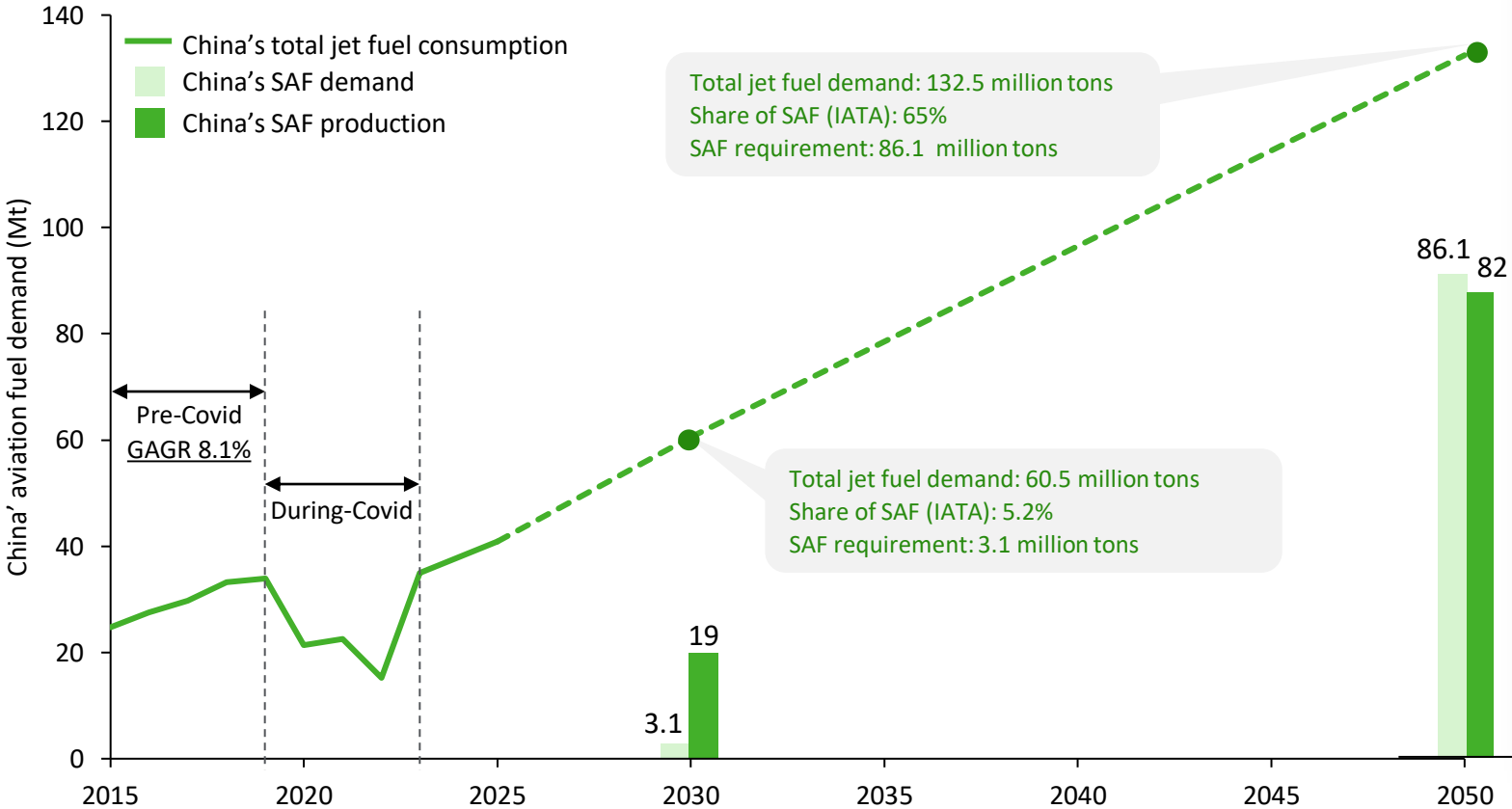




# Potential SAF supply and demand

With such a large theoretical availability of feedstock, China could become a significant global supplier.

China's potential SAF supply and demand



Total jet fuel demand: 132.5 million tons  
Share of SAF (IATA): 65%  
SAF requirement: 86.1 million tons

Total jet fuel demand: 60.5 million tons  
Share of SAF (IATA): 5.2%  
SAF requirement: 3.1 million tons

### 2030

- China's total jet fuel consumption is estimated to reach 60.5 million tons (Mt) by 2030, with a CAGR of 8% from 2023 to 2030
- SAF demand in China may reach **3 Mt/year** by 2030 if China's aviation sector aligns with IATA's 5.2% SAF target
- If theoretical feedstock is fully converted to SAF, potential supply in China could exceed **19 Mt/year** by 2030 – far exceeding potential domestic demand
- To facilitate such growth, action need to be taken to reduce production costs as well as consolidate domestic and international demand for SAF

### 2050

- China's projected jet fuel demand is estimated to reach 132.5 Mt by 2050, with a CAGR of 4% from 2031 to 2050
- With advancement in technology and China's goal to reach carbon neutrality, domestic SAF demand is expected to reach **86 Mt/year** by 2050
- China's SAF production capacity could reach **82 Mt/year** by 2050, facilitated by improved efficiency of feedstock processing and scaling green hydrogen production

Source: IATA, Deloitte Research

# Supply side | China has the potential to produce enough SAF to meet domestic demand

The potential supply of feedstock for SAF in China is positive, but it requires innovative approaches to establish technical routes and production capacity

## Potential availability of SAF feedstocks

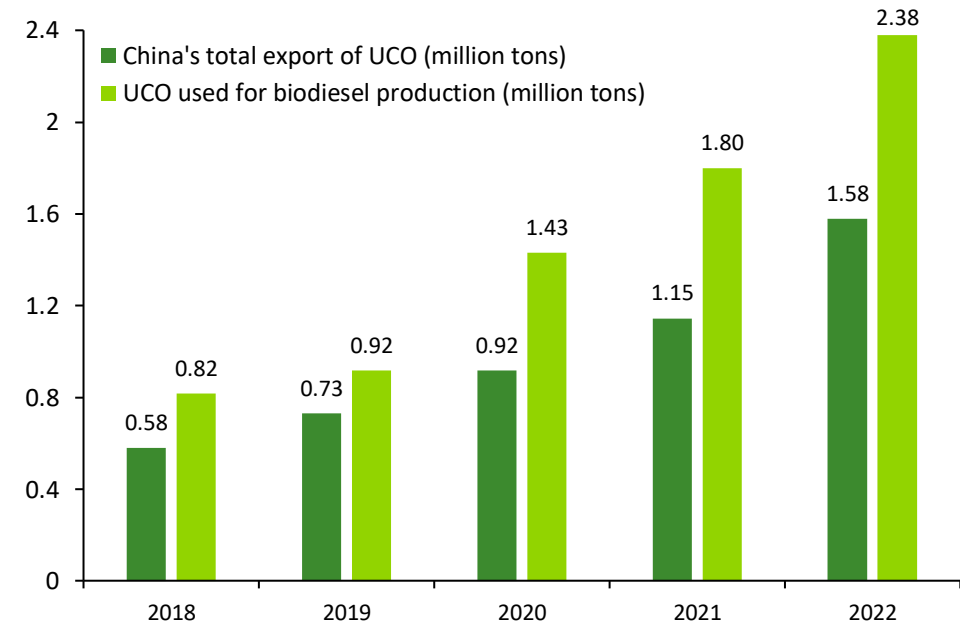
Feedstock	Availability (million tons/year)	SAF output ratio (%)	SAF production capacity upper limit (million tons/year)
Used cooking oil	3.4	40	1.36
Agricultural waste	207.0	10	20.70
Forestry waste	195.0	10	19.50
Municipal organic solid waste	23.5	10	2.35
Industrial waste gas-based ethanol	5.0	50	2.50
<b>Total</b>			<b>46.41</b>

- China has significant potential to develop SAF sustainably as feedstocks are not expected to compete with food supplies, although infrastructure will be needed to develop rural supply chains.
- Used cooking oil (UCO) is a major source of feedstock for biodiesel in China and is expected to be the major feedstock for SAF at least in the next decade.

Source: Institute of Energy, Peking University

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## Used cooking oil potential



- According to ICCT's estimate, China has abundant UCO potential (over five million tons per year)
- Currently most UCO in China is exported or used for biodiesel production, which is also driven by overseas demand.
- Availability of SAF feedstocks in China related to domestic SAF demand.

Source: China Customs, The US Department of Agriculture

# Supply side | However, production capacity development is still in an early stage

As of May 2023, the combined operational and announced SAF production capacity in China is 1.6~1.8 Mt/year

## Current SAF production capacity

Developers	Technology provider	Pathway	Annual capacity (tons)	Location	Announced	Planned operational start
Sinopec	Sinopec	HEFA	100,000	Zhenhai, Zhejiang	June 2021	June 2022
Oriental Energy	Honeywell	HEFA	1,000,000	Maoming, Guangdong	February 2022	Not available
Jiaao Enprotech	Honeywell	HEFA	Not available	Lianyungang, Jiangsu	September 2022	Not available
Sichuan Jinshang	Honeywell	HEFA	300,000	Suining, Sichuan	May 2023	Not available
SPIC & Cathay Pacific	Not available	Similar to PtL	4 * 50,000-100,000	N/A	April 2023	2024 ~ 2026

Companies that produce HVO biodiesel can shift their production to SAF with retrofitting. According to Peking University's estimate, if producers repurpose their existing HVO capacity for SAF, this could bring an **additional 1.9 million tons of annual capacity online**.

Source: China Daily, Honeywell, Cathay Pacific

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## Key issues



China's SAF supply is still in its early stage.



Sinopec Zhenhai Refinery obtained airworthiness certification for China's first large-scale production of SAF from the Civil Aviation Administration of China (CAAC) in 2022, and more market players are emerging.



The HEFA pathway dominates the current and announced production capacities in China, while SPIC and Cathay Pacific plan to use a pathway similar to PtL to generate SAF.



China has huge capacity for renewable electricity generation - this could help drive the commercialization and scaling of PtL.



China's green hydrogen development is driven by provincial plans. Over ten provinces, including Shandong, Qinghai and Sichuan, have developed explicit plans for hydrogen development. Several projects will be deployed around the country to produce synthetic fuels.



China's overall decarbonization goals support the emergence of incentives. With the right financial allocation, China could become global leader in SAF production.

# Demand side | Early market actions

Commercial utilization of SAF is still at an early-stage, but we found that Chinese airlines are engaged in SAF flight tests

Airlines	SAF Target	Flights using SAF	Ecosystem collaboration	Key actions
China Southern	N/A	Two flights with SAF (February 2019 and October 2022)	N/A	Used first batch of domestic SAF fuel provided by Sinopec
China Eastern	N/A	Test flight with SAF in 2013 and flight with 5% SAF in 2022	N/A	Plans a series of flights powered by SAF in 2023
AirChina	N/A	Test flight with SAF in 2011 and a flight with SAF in 2022 First commercial cargo flight using SAF in 2022	Joined SAFUG (Sustainable Aviation Fuel Users Group) in 2011 Air China Cargo cooperated CNAF and Cainiao, for its first commercial cargo flight using SAF	Early user of SAF on the Chinese Mainland First commercial cargo flight using SAF on the Chinese Mainland
Cathay Pacific	Committed to use SAF for 10% of its total fuel consumption by 2030	38 flights with Airbus aircraft with SAF since 2016	Signed a MoU with SPIC for four SAF plants Launched pilot Corporate SAF Programme (“Book and Claim”) with eight corporate customers	Launched Asia’s first major Corporate SAF Programme Invested in Fulcrum BioEnergy, a US-based sustainable biofuel developer
Hainan Airlines	N/A	Commercial passenger flight with 50% SAF in 2015 and an intercontinental SAF passenger flight in 2017	N/A	First commercial passenger flight using SAF on the Chinese Mainland
Colorful Guizhou Airlines	N/A	Commercial passenger flight with 10% SAF in 2015	Signed agreements with Airbus to promote the use of SAF in commercial flights in China in 2022	Received a grant of RMB50 million from the Ministry of Industry and Information Technology (MIIT) to support its SAF program in 2021



# Demand side | Stimulating customer interest by bringing corporate customers to SAF

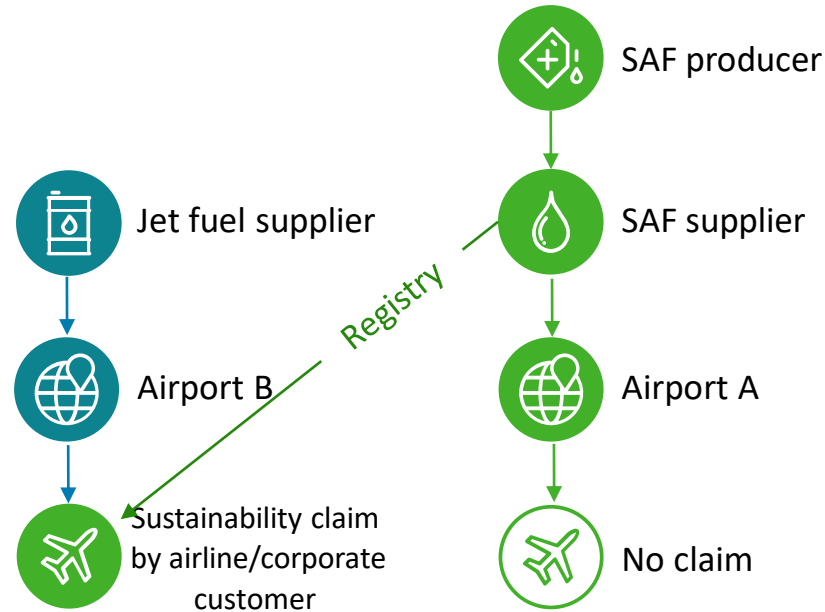
The book-and-claim model allows airlines to buy SAF certificates – and offer those certificates to their passengers – without being tied to physical supply

As the production of SAF is still limited, there is no guarantee that airlines can access SAF through the existing supply chain network.

The book-and-claim model creates environmental attributes that are tracked as SAF certificates.

It enables airlines to purchase SAF without receiving physical delivery and to transfer its environmental attributes to corporate customers.

## Book and claim model



- The SAF producer ‘books’ their SAF into a registry
- A robust chain of custody certification that guarantees full transparency and avoids the risk of fraud
- SAF used in Airport A is claimed by airlines and their corporate customer located in Airport B

## Certification system

There is currently no global certification system for SAF.

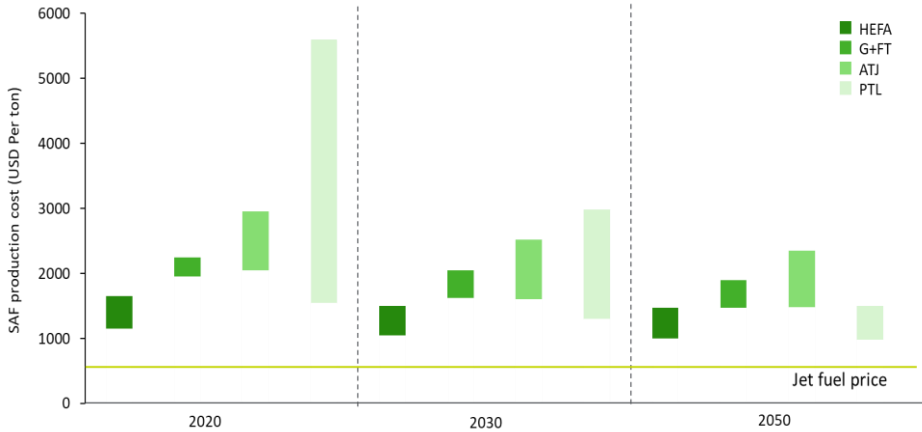
**The SAFc framework** developed through the World Economic Forum’s *Clean Skies for Tomorrow* initiative marks a critical step in developing a standardized approach.

The SAFc framework is expected to be recognized by the Science Based Target initiative and GHG Protocol as a viable method for organizations to realize targets for Scope 3.

# Current SAF Costs and Future Trends

Currently, global SAF costs are approximately \$8.67/gal for unblended fuel, which equates to ~\$1,000 to \$1,200/MT carbon avoided.<sup>1</sup>

## SAF Production Costs



Source: World Economic Forum

SAF is currently 2x to 5x higher than fossil-based jet fuel, cost savings are expected as production scales.

SAF production costs can vary significantly by technological routes. HEFA process is currently the most cost competitive option, while PTL process presents significant cost reduction potential

## Possible impacts to prices

### DRIVING REDUCTIONS

<b>Government Subsidies and Incentives</b>	Government can provide support to help reduce the costs of production
<b>Production Capacity</b>	As production increases, the costs per unit of fuel tend to decrease due to economies of scale
<b>Clear Reporting Standards</b>	Reporting standards that recognize SAF as a value chain carbon reduction will likely result in increased investment
<b>Pass on Cost Savings</b>	Fuel producers and airlines are facing increased pressures to pass cost savings to customers to protect aviation accessibility
<b>Feedstock Availability</b>	Greater availability of feedstocks and their lower costs can contribute to lower prices
<b>Value Chain Development</b>	Value chain efficiencies such as supply chain logistics and transportation, are expected to help reduce costs

### DRIVING INCREASES

<b>Growing Regulations</b>	Production and distribution of SAF is subject to environmental regulations, which can increase costs
<b>Voluntary demand</b>	Despite projected increases in production capacity, corporate commitments exceed projected supply. Supply and demand tensions will result in increased costs
<b>Delays in Reporting Standards</b>	Absence of reporting standards (or SAF is not recognized as an in-value chain carbon reduction) will likely stunt investments
<b>Customer Willingness to Pay</b>	Airlines raised airfares during the post-covid boom to offset rising fuel prices and losses incurred during the pandemic. Thus, increased SAF costs may be passed to end customers
<b>Feedstock Availability</b>	Availability of sustainable feedstocks is currently limited which can increase costs
<b>Feedstock Volatility</b>	Prices of sustainable feedstocks can fluctuate, which can lead to increases in SAF prices

<sup>1</sup>SAF prices are dependent on the emissions factor of the fuel (calculated in g CO<sub>2</sub>e/MJ) which vary by fuel producer (e.g., Neste, WorldEnergy) and are often specific to a given batch of fuel; emissions factors of 14.0 and 25.0 g CO<sub>2</sub>e/MJ were used to calculate the provided range (\$/MT)

# Global progress

Actions taken around the world can impact the development of SAF in China

## The US is increasing incentives for SAF as part of the Inflation Reduction Act (IRA)

**Sustainable Aviation Fuel Credit (2023-2024):** The Inflation Reduction Act (IRA) extended the Blenders Tax Credit, but establishes a new SAF-specific credit for SAF as part of a qualified fuel mixture sold or used in the US<sup>1</sup>

**Clean Fuel Production Credit (2025 – 2027):** The IRA also established the CFPC in which SAF will be eligible for a credit of up to \$1.75/gal for fuels with a 100% GHG reduction, with reduced credits for fuels demonstrating lower GHG reductions<sup>1</sup>

**SAF Grand Challenge:** Targets US SAF production of 3+ billion gallons by 2030, enough SAF production to meet 100% of demand in 2050 (a projected 35 billion gallons) and \$4.3 billion in funding for SAF projects<sup>2</sup>

## The EU Green Deal includes proposed legislation mandating minimum SAF usage and GHG emissions reductions of 55% by 2030

**ReFuelEU Aviation:** The 'Fit For 55' package includes proposed obligations on fuel suppliers to distribute an increasing share of SAF; minimum shares of sustainable fuels must ramp up from 5% of SAF by 2030 to 63% of SAF by 2050<sup>3</sup>

**European Emission Trading System:** Includes 'polluter pays' provisions that increase the responsibility for the industry to pay for its carbon footprint and new allowances for SAF totaling €1.6 billion<sup>4</sup>

**Renewable Energy Directive III:** Increased the 2030 renewable energy target to 45%, SAF likely to exceed ReFuel targets due to low greenhouse gas intensity compared to jet kerosene<sup>4</sup>

## Key Challenges

The comprehensive nature of the US Inflation Reduction Act (IRA) has influenced the industry landscape, potentially impacting foreign investment in SAF projects in China until 2030.

Government is actively promoting the usage of SAF, but explicit strategies and further incentives or mandates for SAF production and utilization will be necessary to guide the industry and attract investments.

Delayed recovery affected the profitability of the aviation industry in China. As traditional fuel prices rise, the incentives of airlines and customers to pay SAF green premiums need to be encouraged.

# Call for action

In order to ensure commercial viability, it is crucial to establish a supportive policy framework that stimulates demand and explores innovative financing mechanisms.

## Ambition



The aviation industry needs to set a more ambitious goal for SAF utilization to meet the aviation industry's Net Zero commitment

## Alliances



New collaborations across the value chain will be key to unlock SAF's future

## Customers



Creating a value proposition that encourages passengers to contribute to sustainable flying will help drive demand

## Feedstock



Improve the feedstock collection system and evaluate its distribution and availability to facilitate better allocation of resources for the industry

## Infrastructure



While blended SAF can use existing infrastructure, the industry still needs to strengthen infrastructure to cope with future demand

## Innovation



Further innovation is needed to achieve production cost reduction or new technologies that run on less constrained feedstocks

## Investment



Investors and financial institutions need to develop an innovative financing blueprint to mobilize capital for SAF

## Leadership



Airlines and the fuel industry can lead by promoting SAF through different pilot projects and investment in the supply chain

## Policy incentives



On both demand and supply side policy is needed to encourage investment and accelerate the adoption of SAF

SAF plays a vital role in the aviation industry's journey towards decarbonization. However, achieving an industry-wide transition within the target date necessitates collaboration across the value chain, supportive policies, substantial investments, with a limited amount of time.



# Deloitte Thought Leadership

Deloitte is committed to sharing its perspective on SAF and aviation decarbonization to support our clients



## [Pioneering Early SAF Transactions](#)

Deloitte US entered agreements with airlines to purchase sustainable aviation fuels and has detailed our early experiences and insights, as well as considerations for other companies entering the SAF market.



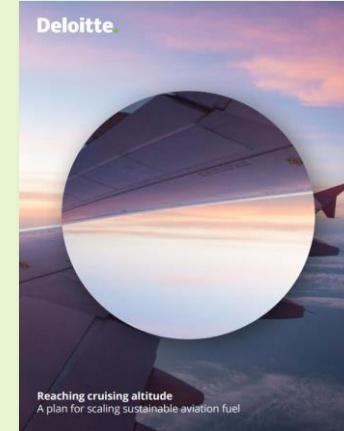
## [Decarbonizing Aviation – Cleared for Take-Off](#)

Deloitte and Shell prepared a report outlining how in the complex ecosystem of decarbonizing aviation, collaboration will be needed between players in the sector and across sectors to scale up demand and production of SAF.



## [Decarbonizing Aerospace – a Road Map for the Industry's Lower-Emissions Future](#)

Deloitte studied the challenge of decarbonizing aerospace, the threat to current industry revenue models, and how SAF and electric propulsion represent the best possible solutions.



## [Reaching cruising altitude, A Plan for Scaling Sustainable Aviation Fuel](#)

Although SAF is not the only possible solution to decarbonizing the aviation industry, Deloitte analyzes how it is a critical stage in achieving near-term emissions reductions.



## [Deloitte Global Impact Report – 2022](#)

Deloitte publishes its Global Impact report annually, which includes reporting on the inclusion of SAF in our full life-cycle assessment (LCA) of air travel emissions.

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