



UNITED ARAB EMIRATES
MINISTRY OF ENERGY & INFRASTRUCTURE



الهيئة العامة للطيران المدني
GENERAL CIVIL AVIATION AUTHORITY

National Sustainable Aviation Fuel Roadmap of the United Arab Emirates

2022-2050



Foreword



H.E. Suhail bin Mohamed Al Mazrouei
Minister of Energy and Infrastructure
United Arab Emirates

The conservation of our environment is a founding principle of the United Arab Emirates, enshrined in the words of our founding father, Sheikh Zayed bin Sultan Al Nahyan: “We have worked, since the establishment of our state, to protect the environment and wildlife. These achievements should be an incentive for us, particularly the Emirati youth, the future generation, to continue taking care of and keeping the environment safe and clean because if we don’t, we shall destroy the resources that Allah blessed us with; these resources are not ours alone, they also belong to our children and their children.”

In these words, Sheikh Zayed bin Sultan Al Nahyan reminds us that the economic development catalyzed by aviation must not come at the cost of the environment; a truth that is brought sharply into focus in the era of climate change. We are equipping ourselves with the means to realize this vision. The strong foundations of international cooperation have built the architecture for action, and the UAE is proud to be undertaking the preparations to host COP28, ensuring we work together for our shared future. Our global efforts are reflected in our national targets, with the UAE leading the MENA region with the first commitment to the Paris Climate Agreement, complimented by the UAE Net Zero by 2050 strategic initiative. Our government, companies, and research institutions are rapidly translating this into action.

In 2019, Etihad operated the world’s first flight using fuel made in the UAE from plants grown in saltwater by the Sustainable Bioenergy Research Consortium (SBRC), a consortium of Khalifa University, Etihad Airways, Boeing, ADNOC, Safran, GE and BAUER Resources. Emirates and GE are collaborating on a program to conduct a test flight using 100% SAF by

using fuel made in the UAE from plants grown in saltwater by the Sustainable Bioenergy Research Consortium (SBRC), a consortium of Khalifa University, Etihad Airways, Boeing, ADNOC, Safran, GE and BAUER Resources. Emirates and GE are collaborating on a program to conduct a test flight using 100% SAF by the end of 2022, eroding the barriers to higher uptake of sustainable fuels. Considerable efforts are delivering further initiatives, including partnerships by ADNOC, BP and Masdar to pioneer clean hydrogen and technology hubs, and several facilities under development to produce clean fuels from sustainable waste feedstocks.

Aviation is a particularly challenging industry to decarbonise and will require the development of novel technologies. Our research institutions are stepping up to the task, building the knowledge and tools to ensure our world can be sustainably connected.

The development of clean aviation fuels represents the dawn of an age where we are able to leverage existing and future resources to become more sustainable. The UAE is endowed with superb advantages to succeed in this future, with access to some of the cheapest renewable electricity from solar generation in the world, adaptable hydrocarbon infrastructure, and the industrial capability and workforce to leverage the opportunities. The sunrise of this new industry will bring jobs, economic growth, and climate benefits to our nation, and we are delighted to present this roadmap for the UAE to become the center of this energy ecosystem.

Contributors

This roadmap was made possible with the contributions of the following organizations: UAE General Civil Aviation Authority (GCAA), UAE Ministry of Energy and Infrastructure (MOEI), Abu Dhabi National Oil Company (ADNOC), Beeah Energy, Boeing, bp, Dubai Airports, Emirates, Etihad Airways, HSBC, International Air Transport Association (IATA), Khalifa University, Masdar, Safran, Shell Aviation, and ICF.

Leading Organizations



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MINISTRY OF ENERGY & INFRASTRUCTURE

The UAE SAF Committee



Knowledge Partner



Contents

Executive Summary.....	vii
Principle 1: Establishing the Ambition.....	viii
Principle 2: Accelerating SAF Technology Deployment and Innovation.....	ix
Principle 3: Developing the National Regulatory Environment for SAF	x
Principle 4: Building Local Capacity to Boost In-Country Value.....	xi
Principle 5: Leading International Collaboration.....	xii
 1 Context and Scope of This Roadmap	 2
1.1 The UAE’s 2050 Vision and Low Carbon Energy Strategies	4
1.2 Importance of Aviation to the UAE.....	7
 2 SAF Technology and Policies.....	 10
2.1 International Aspirations	10
2.2 National Policies.....	13
 3 SAF Outlook in the UAE	 17
3.1 Building the Foundations: Existing SAF Projects in the UAE	17
3.2 SAF Feedstock Opportunities in the UAE	22
3.3 Opportunity Analysis.....	29
 4 The Case for SAF in the UAE	 31
4.1 SAF Scenarios for the UAE.....	31
4.2 The UAE SAF Roadmap.....	35
 5 Delivering the Roadmap.....	 40
5.1 Policy Mechanisms and Regulatory Environment.....	42
5.2 Institutional Roles	45
 6 Closing Remarks for Roadmap	 49
 7 Appendix	 51
 Glossary.....	 64

The UAE SAF Roadmap

Creating a Low Carbon Aviation Energy Hub

The 5 Sustainable Aviation Fuel (SAF) principles are designed to accelerate the decarbonization of the UAE's aviation sector and transform it into a regional hub for low carbon aviation fuels.

1

Establishing the Ambition: 700 million liters SAF by 2030

By 2030, the UAE will develop domestic SAF capacity sufficient to produce 700 million liters of SAF on an annual basis.

2

Accelerating SAF Technology Deployment and Innovation

The UAE will support research, development, and demonstration (RD&D) of SAF technologies through dedicated research efforts focusing on SAF production and deployment of early-stage facilities to produce SAF at a commercial scale by 2025.

3

Developing the National Regulatory Environment for SAF

The UAE will explore and assess potential policies to support the long-term economic operation of SAF facilities in the UAE, and to align with domestic and international SAF ambitions to decarbonize aviation.

4

Building Local Capacity to Boost In-Country Value

The UAE will further mature the governance structure for the national SAF program, developing the local institutions and skills to create In-Country Value (ICV).

5

Leading International Collaboration

Aviation is a global industry, and alongside national efforts, the UAE will seek to accelerate the global transition through leadership at ICAO, and support of projects on renewable fuels and energy in other countries.

Executive Summary

Aviation has a key role in the UAE's continued growth. The International Air Transport Association (IATA) estimated that in 2018, aviation and tourism contributed 13.3% of the country's GDP, equal to 47.4 billion USD. The sector directly and indirectly sustains 777,000 jobs in the UAE, and it is estimated that aviation's GDP contribution will grow by 170% over the next 20 years. To achieve the international and UAE National climate ambitions, the continued growth of the aviation industry must be sustained with low-carbon technologies. SAF will be the key technology to decarbonize the UAE's predominately long-haul aviation industry.

This SAF Roadmap is a result of strong public-private collaboration in the UAE, which will be a key enabler to deliver the roadmap. The Ministry of Energy and Infrastructure is leading the nation's SAF future with supporting partners in the SAF Committee. It is informed by feedback and inputs from industrial stakeholders, and from international and supranational institutional parties. Due to their immediate potential to decarbonize the aviation sector, the Lower Carbon Aviation Fuels (LCAF) opportunities are managed by a dedicated taskforce, falling outside the scope of this report.

The UAE has several advantages to develop a SAF industry that creates economic value, jobs, and reduces emissions. The UAE has considerable existing infrastructure and expertise with hydrocarbon fuels, a vibrant RD&D landscape, and plentiful opportunities to generate cheap renewable energy. SAF technology supports and is supported by the pioneering UAE strategies across Energy, Climate, Industry, Hydrogen, and International Leadership, and aligns with the 'Principles of 50'. This roadmap illustrates how the UAE can take advantage of these opportunities, while mitigating the cost and feedstock challenges, to allow the UAE's airlines to continue their profitable and sustainable growth.

This roadmap establishes 5 principles for the UAE to scale up SAF. These principles will maximize the benefits of SAF, while reducing aviation emissions and providing substantial economic benefits. These principles will serve as building blocks for the UAE's SAF vision, and will be delivered with strong public private collaboration, alongside the SAF committee:

- **Principle 1: Establishing the Ambition**
- **Principle 2: Accelerating SAF Technology Deployment and Innovation**
- **Principle 3: Developing the National Regulatory Environment for SAF**
- **Principle 4: Building Local Capacity to Boost In-Country Value**
- **Principle 5: Leading International Collaboration**



Principle 1: Establishing the Ambition

By 2030, the UAE will develop domestic SAF capacity sufficient to supply 700 million liters SAF on an annual basis. The current development of facilities utilizing halophytes and MSW will kick-start production towards this goal. In the mid-term, biogenic feedstock limits will constraint the scalability of these approaches, while increasingly affordable renewable energy generation, hydrogen production and carbon capture will allow Power to Liquid (PtL) SAF to play an increasingly important role in the UAE's SAF future. Chapter 3 provides a comprehensive assessment of the SAF potential in the UAE with a focus on feedstocks, and Chapter 4 presents the results of the scenario study and buildup of the UAE's SAF target.

The 700 ML SAF target by 2030 will provide substantial environmental and economic benefits. This volume of SAF will reduce an estimated cumulative 4.8 million tonnes of CO₂ by 2030, and create up to 18,000 new jobs across the value chain in the process. The fuel will be produced at up to five SAF facilities, potentially including the expanded SBRC's halophytes to SAF project, construction of Tadweer's MSW to SAF project, and 1-3 additional Power-to-Liquid facilities. Some of this production could be exported to make use of more mature policies regimes, for example in the European Union (EU), and allocating half of this supply for export opportunities could provide a cumulative \$1.7bn of export revenue for the UAE by 2030. This would further diversify the UAE's economy and contribute to the nation's current account surplus. It is estimated that \$7bn to \$9bn of investment will be required in SAF facilities and the supporting value chain to provide 700 million liters of SAF in the UAE by 2030.

With 700 million liters of SAF by 2030 target, the UAE can both boost low carbon growth of its aviation industry, and can unlock export opportunities



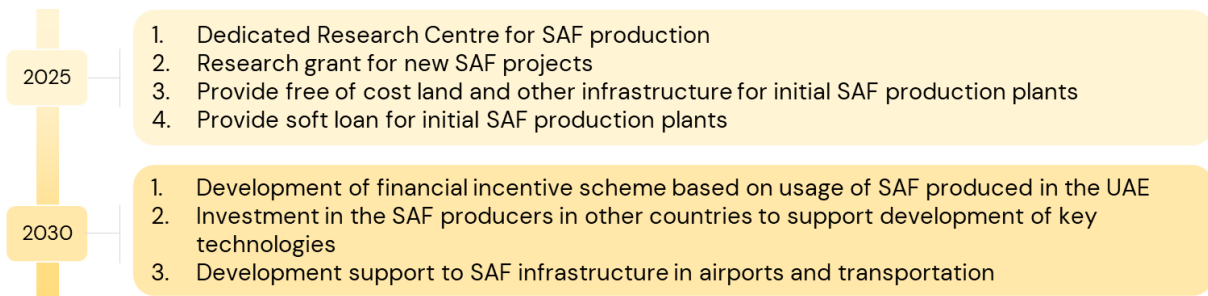
This target would position the UAE as a regional leader for SAF, and cement its role within the global SAF industry by slightly exceeding the EU's 2030 SAF targets of 6%. It would also slightly exceed the IATA estimation that 5.2% SAF (23 billion liters globally) is required in 2030 to set the industry on the path to net zero emissions by 2050.



Principle 2: Accelerating SAF Technology Deployment and Innovation

The UAE will support research, development and demonstration (RD&D) of SAF technologies and deployment of early-stage facilities to produce SAF at a commercial scale by 2025. The need for further RD&D support across SAF technology pathways is crucial, as the most promising SAF production pathways applicable to the UAE are still in the early stages of commercialization (mid - Technology Readiness Levels, TRL). The UAE is seeking to unleash the potential of these emerging technologies through collaborative RD&D support. To achieve this, the UAE could establish a research center focusing on SAF production, bringing together industry and academia under a unified strategic research agenda. Providing financial support for SAF RD&D and production will enable the UAE to create a SAF ecosystem which supports and attracts sustainable research and industrial activity for the purposes of achieving sustainable aviation. Chapter 5 provides details on how to accelerate SAF technology deployment and innovation through financial and regulatory tools, and capital building. Key initiatives to support this principle by 2030 are given below:

Accelerating SAF Technology Deployment and Innovation

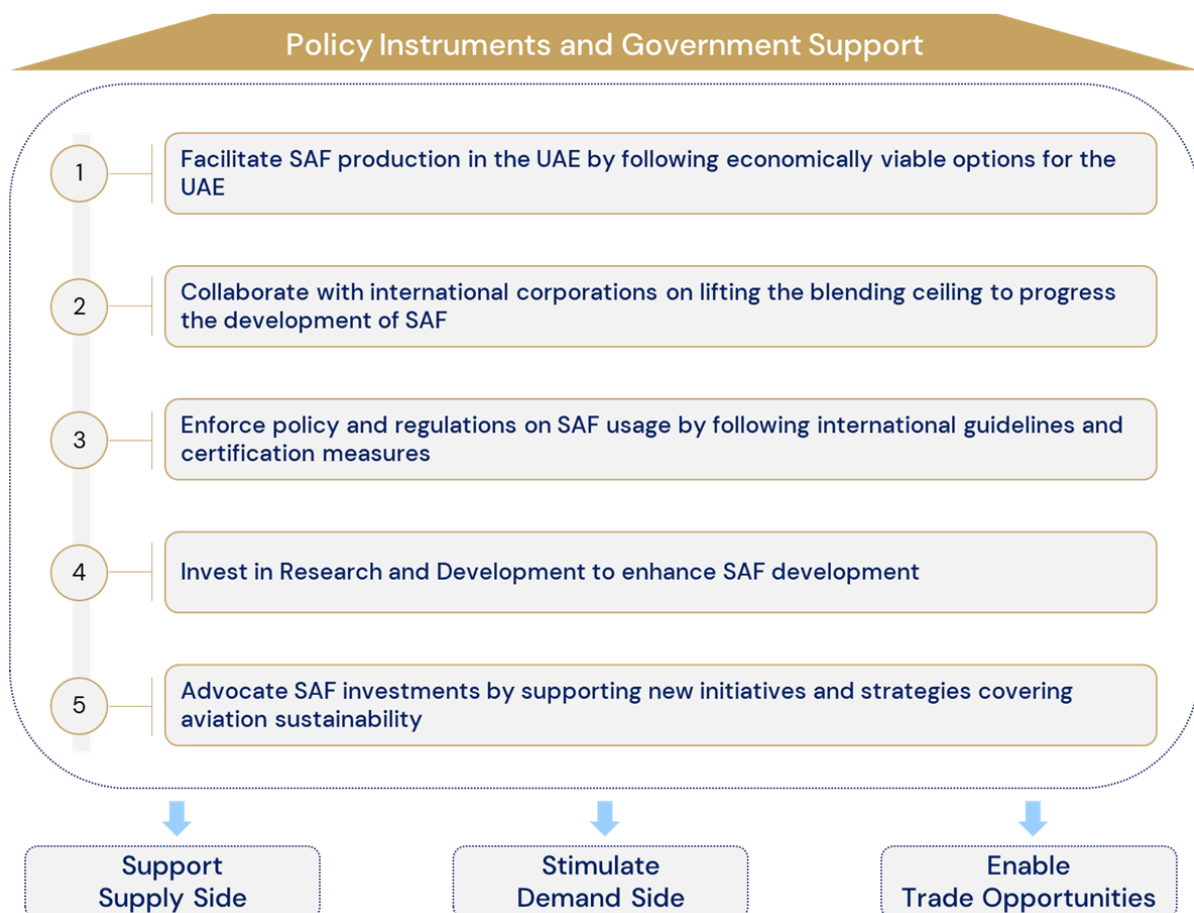




Principle 3: Developing the National Regulatory Environment for SAF

The UAE will explore and assess potential policies to support the long-term economic operation of SAF facilities in the UAE, and achieve the domestic and international ambitions to decarbonize aviation. There is a variety of policy instruments which could be utilized to scale up SAF capacities, which can be broadly categorized into supply-side and demand-side measures. Positive incentives are likely to be the most appropriate tools to scale up early stage SAF facilities in the UAE, given the specific feedstock and technology related opportunities and challenges. This roadmap provides a top-level overview of global SAF policies applicable to the UAE, with a more detailed assessment of policy measures to be conducted subsequently. Chapter 5 provides details on developing the national regulatory environment for SAF through the utilization of policy instruments.

Supply, demand and trade oriented hybrid policies can be used to deliver the UAE's 2030 SAF target





Principle 4: Building Local Capacity to Boost In-Country Value

The UAE will further mature the governance structure for the national SAF program, developing the local institutions and skills to create In-Country Value (ICV). This report highlights the feedstock, technology, economic and employment opportunities for SAF in the UAE. Achieving these opportunities will require a robust governance structure, and skilled workforce. The UAE has a unique head-start with a workforce highly experienced with liquid hydrocarbons, and developing experience producing renewable electricity, low-carbon hydrogen, and carbon capture. Further steps can consolidate and build on these skills and capabilities to ensure the UAE becomes a regional hub for low carbon aviation. Establishing educational courses, engineering specializations, a SAF specific government department as a part of the Assistant Undersecretary for Oil, Gas and Mineral Resources, and SAF conferences are just some of the steps the UAE can take to build its capacity to develop SAF. Chapter 5 provides details on building local capacity to boost ICV. Key initiatives to support this principle by 2030 are given below:

Building Local Capacity to Boost In-Country Value

2025

1. Dedicated SAF department in the MOEI for all the information and required approvals
2. Establishment of SAF implementation task force as a part of the SAF/LCAF council
3. Annual/bi- annual international conference on SAF
4. Establishment of SAF production network locally and globally

2030

1. Development of in country value (ICV) incentive programs
2. Dedicated courses and trainings on SAF in collaboration with universities and international organizations
3. Engineering specialisation courses for SAF for development of talent pools



Principle 5: Leading International Collaboration

Aviation is a global industry, and alongside national efforts, the UAE will seek to accelerate the global transition through leadership at ICAO, and support of projects on renewable fuels and energy in other countries. The UAE's commitment to SAF development will meaningfully support the decarbonization of the UAE's aviation industry, and develop the technologies, skills, and methods required for the global transition to a low-carbon aviation industry. However, this is a transition that no country, industry, or company can achieve alone, and collaboration will be essential to success. Poised to host COP28 in 2023, the UAE is uniquely positioned to lead global discourse on SAF production and utilization as part of wider climate change action. Furthermore, as a developing finance, technological, and industrial hub, the UAE can facilitate the global proliferation of SAF best practice, aid in knowledge transfer, and invest and export RD&D. SAF technology is itself underpinned by several low-carbon technologies, including renewable electricity generation and storage, low-carbon hydrogen, carbon capture, and logistics. The financial support and expertise that the UAE already provides to international projects across these technologies is crucial to the broader transition, which compounds the work the UAE is undertaking for SAF. Chapter 5 provides details on how the UAE can support international SAF ambitions. Key initiatives to support this principle by 2030 are given below:

Leading International Collaboration



“The aviation sector is one of the United Arab Emirates’ success stories and has a central place within the national and the regional economies, helping diversification, tourism and supporting job creation. Growing and protecting the aviation sector will only be possible to the extent that it is decarbonized.”

H. E. Suhail bin Mohamed Al Mazrouei

Minister of Energy and Infrastructure UAE

Dubai

Photo by Max Avants

1 Context and Scope of this Roadmap

The urgency of climate change makes it of vital importance that the United Arab Emirates (UAE) develops and implements a unified national policy strategy that recognizes both the inherent complexities associated with the energy transition in the aviation sector and the unique opportunities and characteristics of the UAE.

The Ministerial Development Council (MDC) under the Cabinet of the UAE is responsible for supporting the Executive Branch of the UAE Federal Government via follow up on the implementation of general policy, development plans, laws and regulations within the framework of its jurisdiction and responsibilities. Among such responsibilities, the MDC issues binding instructions and studies reports and proposals aimed at advancing government activities in national priority areas.

In March 2021, the MDC reviewed a proposal to “form a committee on sustainable fuel and low-carbon fuel for the aviation sector, with the aim of enhancing future investment opportunities in this field and developing an integrated strategy that promotes partnership between public and private sectors”¹. This led to the creation of the Committee on Sustainable and Low Carbon Aviation Fuels (SAF/LCAF Council), chaired by His Excellency Suhail bin Mohammed Al Mazrouei, Minister of Energy and Infrastructure (MOEI), with the membership of the Ministry of Foreign Affairs and International Cooperation, the Ministry of Climate Change and the Environment, the Ministry of Industry and Advanced Technology, the Ministry of Economy, the General Civil Aviation Authority and the Abu Dhabi National Oil Company (ADNOC). As a result of the first meeting of the SAF/LCAF Council in May 2021², the drafting of a national policy strategy on low-carbon fuels in the UAE was prioritized, aiming to:

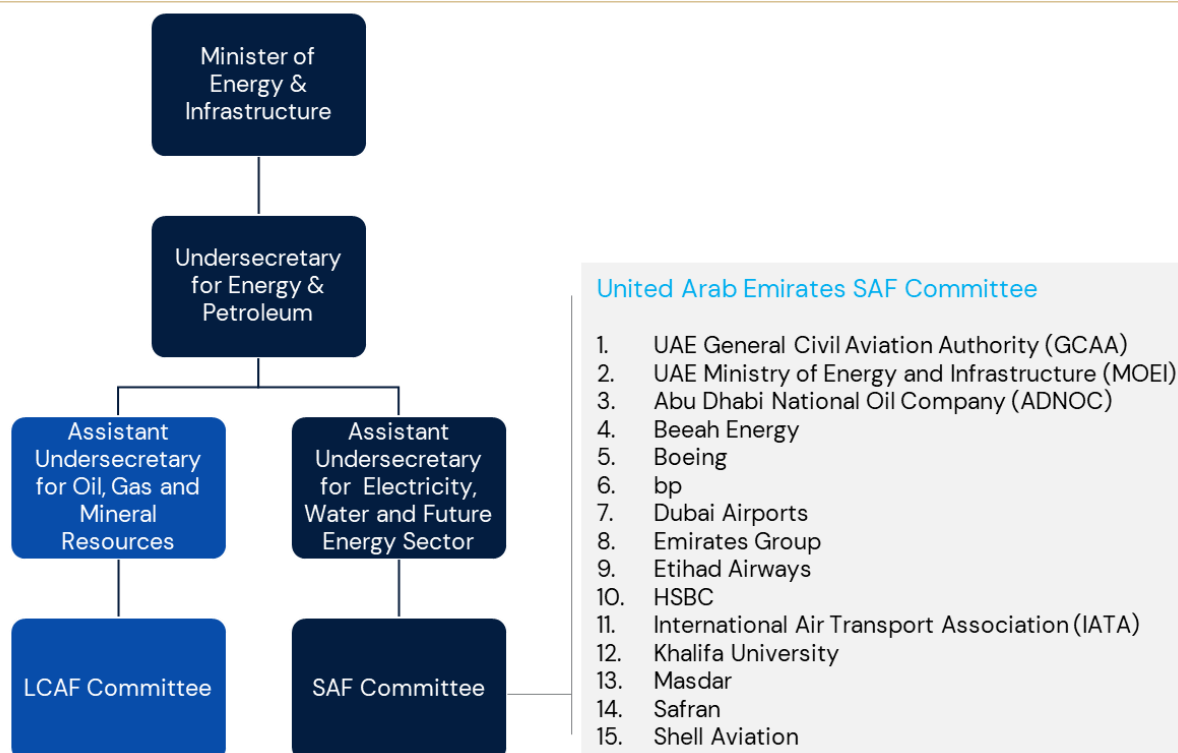
1. Encourage public-private partnerships in the SAF production value chain.
2. Attract foreign and domestic investment in sustainable energy in the aviation sector.
3. Support local development of scientific research in key related areas.
4. Support the General Civil Aviation Authority in regional and international negotiations related to climate change mitigation with a focus on the aviation sector.

The UAE presents multiple opportunities and challenges that must be recognized by the national policy strategy, and this roadmap endeavors to assess and summarize these. This includes the scarcity of biogenic feedstocks, plentiful opportunities to generate cheap renewable energy, existing infrastructure and expertise with hydrocarbon fuels, vibrant RD&D landscape, and the vital importance of aviation and the associated tourism and business to the UAE. Exploiting these opportunities will require targeted policy support, and the level and design of this support will result in the difference between the UAE becoming a pioneer or a follower in the global SAF market. The roadmap aims to clarify targets, tackle the challenges expected on the path to the national policy framework and facilitate the work of the **SAF committee** towards that goal.

¹ <https://uaecabinet.ae/en/details/news/ministerial-development-council-discusses-proposed-legislations-and-initiatives-designed-to-advance-government-work>

² “Suhail Al Mazrouei highlights importance of drafting national strategy on sustainable, low-carbon fuel in aviation” (19 May 2021) <https://wam.ae/en/details/1395302935958>

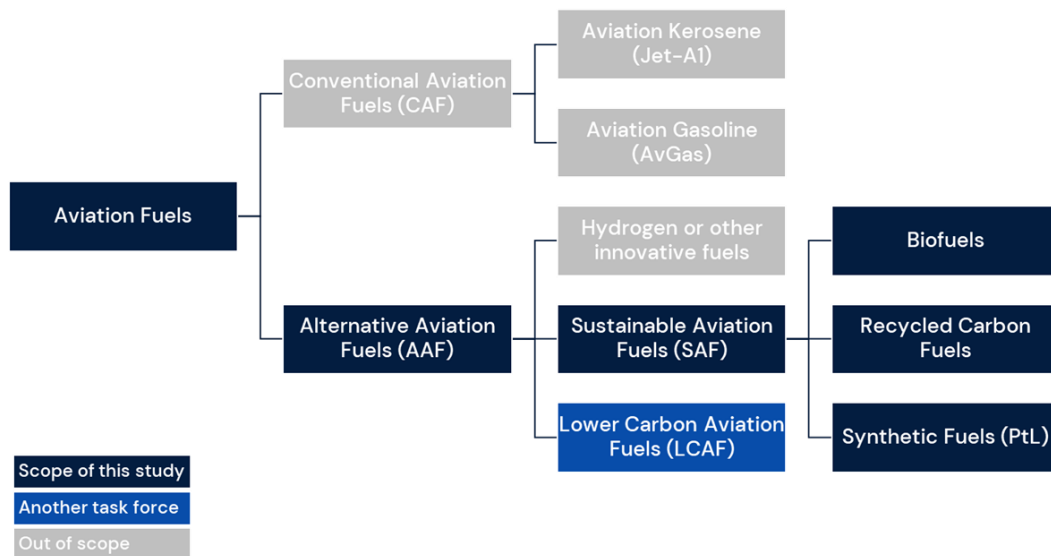
The UAE SAF committee is a public and private collaboration across aviation value chain



The SAF Roadmap is the result of a collaboration of the Ministry of Energy and Infrastructure with supporting partners in the SAF Committee and outside stakeholders. It is informed by feedback and inputs from national and international industrial stakeholders, and from international and supranational institutional parties. This roadmap is supported by the work undertaken by the UAE to develop LCAF, which is defined as a fossil-based aviation fuel that meets the CORSIA Sustainability Criteria under the Annex 16 Volume IV definition³. Due to the considerable near-term opportunities for LCAF, this work is undertaken by a dedicated taskforce, separate to the scope of this report. Aviation technologies may also allow increasing use of alternative fuel types, such as liquid or pressurized hydrogen and batteries. While both electricity and hydrogen are key enablers for the UAE's SAF roadmap, their direct use as fuels is also outside the scope of this report, as illustrated below.

³ <https://www.icao.int/environmental-protection/CORSIA/Pages/SARPs-Annex-16-Volume-IV.aspx>

This roadmap only explores SAF pathways for the UAE, therefore LCAF utilization will be a part of another study

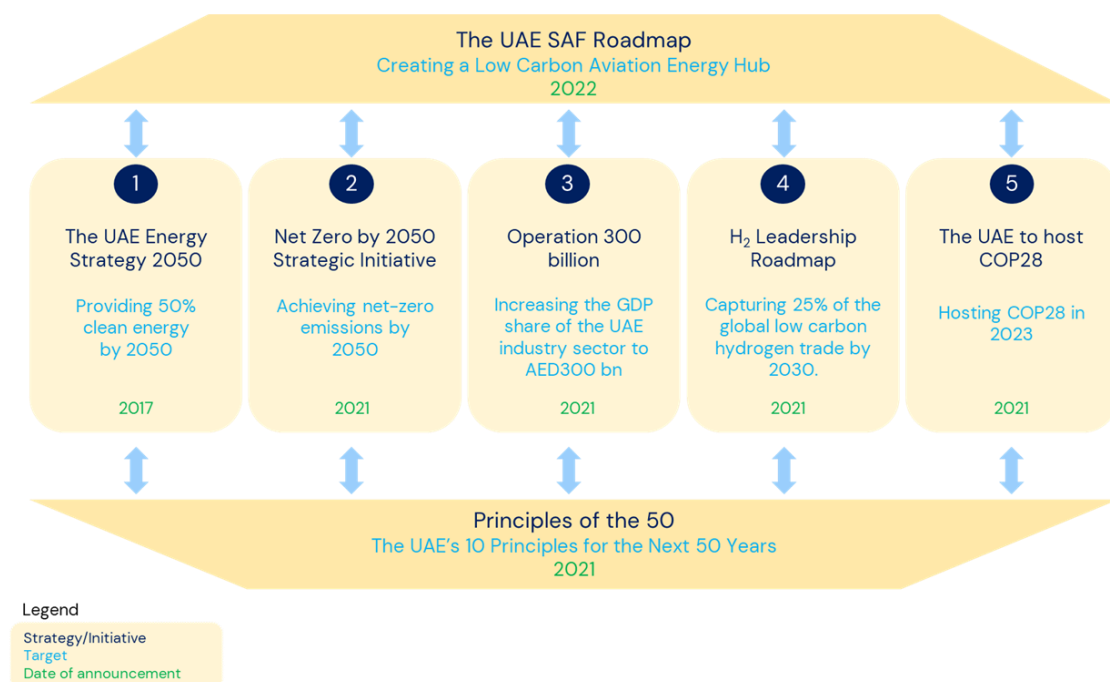


Source: Adapted from Chiamonti et al., 2021: <https://www.mdpi.com/1996-1073/14/19/6430>

1.1 The UAE's 2050 Vision and Low Carbon Energy Strategies

Guided by the 'Principles of 50', the UAE has been actively building a vibrant low carbon economy, with key strategies in five areas: Energy, Climate, Industry, Hydrogen, and International Leadership. This framework provides a strong platform that the UAE SAF Roadmap consolidates and accelerates. This section describes how the interactions between each strategy serve to facilitate the development of the UAE's SAF industry.

Underpinned by Principles of 50, the UAE SAF Roadmap will both benefit from and support the UAE's existing 5 strategies to boost low carbon economy transition



The UAE Energy Strategy 2050

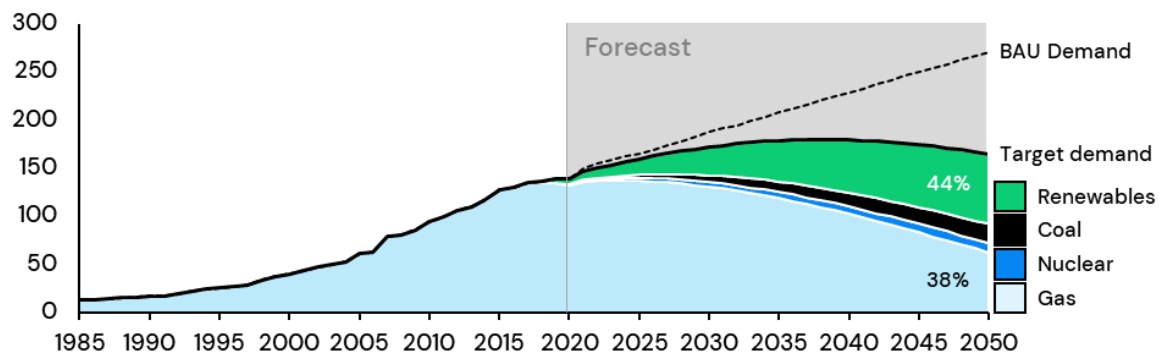
Launched in 2017, the ‘Energy Strategy 2050’, provides a unified energy strategy to achieve three major objectives⁴:

1. Increase the contribution of clean energy in the total energy mix to 50% by 2050.
2. Reduce the carbon footprint of power generation by 70% based on 2017 baseline.
3. Increase the consumption efficiency of end-users by 40%.

With over 600 billion AED committed by 2050, the strategy targets an energy mix that combines renewable and nuclear as clean energy sources to meet the UAE’s economic requirements and environmental goals. This strategy is currently being updated through the development of an Integrated Energy Model (IEM) in partnership with Khalifa University and the International Renewable Energy Agency (IRENA).

The UAE energy strategy aims 50% clean energy share in the UAE’s 2050 energy mix with 40% reduction in business as usual demand

Historical and forecast electricity consumption by generation type, in TWh



The UAE Net Zero by 2050 Strategic Initiative

Announced in October 2021, the “Net Zero by 2050 Strategic Initiative”, made the UAE the first in the Middle East and North Africa (MENA) region to commit to national economy-wide net-zero emissions. This initiative aligns with current national development plans laid out in the “Principles of the 50” roadmap⁵, which aims to accelerate economic transition and growth along a clean and sustainable paradigm.

Operation 300 billion

Operation 300 billion is the UAE’s industrial strategic initiative, which aims to increase the GDP contribution of the UAE’s industrial sector to 300Bn Dirham by 2031. This includes specific provisions to accelerate research and development, which could include the emerging SAF technologies.

Additional roadmaps include the “National Climate Change Plan of the UAE 2017–2050”, as well as emirate-specific ones, such as the “Abu Dhabi Economic Vision 2030”. Together, these initiatives are expected to support the development of 14GW of low-carbon energy production by 2030, with 31% emissions reduction being targeted over the same period⁶. This target was originally 23.5% and has

⁴ <https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/federal-governments-strategies-and-plans/uae-energy-strategy-2050>

⁵ <https://u.ae/en/about-the-uae/initiatives-of-the-next-50/the-principles-of-the-50>

⁶ <https://www.wam.ae/en/details/1395302978138>

been updated in September 2022 to reflect the UAE's increasing ambition to mitigating the impacts of the climate change⁷.

The UAE Hydrogen Leadership Roadmap

In November 2021, the UAE announced the "Hydrogen Leadership Roadmap"⁸, a comprehensive blueprint aimed at establishing/developing/expanding the nation's hydrogen production capabilities in line with its net-zero ambitions. Building upon previous commitments, the Hydrogen Roadmap serves to reinforce and strengthen the UAE's position within the international hydrogen economy. Chief among its ambitions, the roadmap highlights the UAE's intent to possess 25% of the global low carbon hydrogen trade by 2030. This Roadmap promotes a sustainable economic growth trajectory that leverages research, development, innovation, and clean technology and firmly establishes the country as a competitive exporter of low carbon hydrogen.

The UAE formed the Abu Dhabi Hydrogen Alliance and the National Hydrogen Technical Committee have already announced over 7 projects and more to come. The Hydrogen Leadership Roadmap comprises three core objectives: unlocking new sources of value creation through exports of low carbon hydrogen, derivatives and products to key importing regions, fostering new hydrogen derivative opportunities through low-carbon steel, sustainable aviation fuel (specifically PtL SAF) as well as other priority UAE industries and contributing to the UAE's 2050 net zero commitments.

As outlined in the Roadmap, the UAE aims to support the low-carbon hydrogen business through five critical enablers: a clear regulatory framework backed by policies, incentives, standards, and certifications; best-in-class technology through value-add partnerships and the vibrant and robust UAE domestic research and development structure; access to existing and new Government-to-Government relationships to accelerate growth of a domestic ecosystem; readily available land and infrastructure resources to support domestic production; and green financing within the UAE and in international capital markets. The UAE is well on its way to meet its ambition to be a global leader in low carbon hydrogen with more than seven projects already underway which will target 25 percent market share in the key export markets, including Japan, South Korea, Germany, and India initially along with additional high-potential markets in Europe and East Asia.

This governmental effort is reflected in the realignment and strategic movements by national energy and development companies to also pursue a unified vision in the hydrogen economy, as demonstrated by the partnerships between ADNOC, Abu Dhabi National Energy Company (TAQA), Mubadala and Masdar towards project development and investments in clean and renewable energy, Carbon Capture, Utilization and Storage (CCUS) technologies and other enablers of low-carbon hydrogen production and use. Since the announcement of the roadmap, strategic partnerships have rapidly evolved from the former Abu Dhabi Hydrogen Alliance into the new joint ownership structure

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<http://wam.ae/en/details/1395303082685#:~:text=In%20its%20updated%20second%20NDC%2C%20the%20UAE%20has%20increased%20its%20greenhouse%20gas%20emission%20reduction%20target%20from%2023.5%20percent%20to%2031%20percent%20by%202030.%20To%20achieve%20this%20goal%2C%20the%20country%20aims%20to%20involve%20five%20priority%20sectors%20%E2%80%93%20electricity%2C%20transport%2C%20industry%2C%20waste%20management%2C%20and%20CCUS.>

⁸ <https://www.wam.ae/en/details/1395302988986>

of Masdar⁹, which will focus the development efforts of these companies in the renewable energy and green hydrogen market, aiming to increase production capacity targets from 23 GW to well over 50 GW by 2030.

Hydrogen is a key input for both biogenic and PtL SAF production. Therefore, the UAE's target of substantially increasing affordable hydrogen production will create a competitive advantage for initiatives looking to scale-up SAF capacity. The UAE is currently working on a National Hydrogen Strategy, which will be launched at the end of 2022, and is expected to further accelerate the UAE's leadership in the hydrogen industry.

UAE to Host COP28

In 2021, the UN Framework on Climate Change announced that the UAE will host the 28th Conference of Parties (COP28) in 2023.¹⁰ This opportunity shows the unwavering commitment of the UAE to mitigate the effects of global warming and will provide further opportunities for the UAE to lead and accelerate the development of a national SAF industry.

1.2 Importance of Aviation to the UAE

Aviation is one of the most successful industrial sectors in the UAE. The International Air Transport Association (IATA)¹¹ estimated that in 2018, air transport industry and foreign tourists arriving by air contributed 13.3% of the country's GDP, equating to 47.4 billion USD. The sector, directly and indirectly sustains 777,000 jobs in the UAE, and it is estimated that the GDP contribution will grow by 170% in the next 20 years.¹¹

The decarbonization of the domestic aviation sector is addressed under the Nationally Determined Contributions (NDCs) through the Paris Agreement. The International Civil Aviation Organization (ICAO), a specialized UN agency, addresses all matters related to international aviation, including environmental protection and GHG emissions.

The UAE's two flag carrier airlines have been actively building strategies and initiatives to decarbonize by 2050:

- Etihad committed to achieving net zero emissions by 2050, with milestones including a 20% emissions reduction intensity by 2025, and a 50% reduction by 2035 compared to 2019.
- Emirates supports the IATA's collective industry commitment to reach net zero emissions by 2050 and is constantly reviewing the opportunities that will help to achieve this goal, which include operational fuel efficiency, SAF, LCAF and renewable energy.

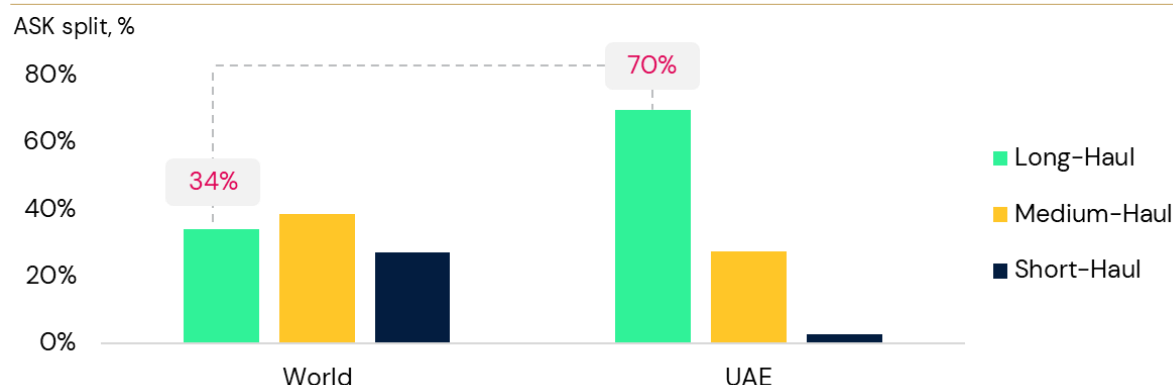
⁹ <https://www.spglobal.com/commodity-insights/en/market-insights/latest-news/energy-transition/120121-uaes-adnoc-to-combine-its-renewables-with-taqva-mubadala>

¹⁰ UAE to Host COP28 in 2023. Retrieved from <https://wam.ae/en/details/1395302991666>

¹¹ The importance of Air Transport to the United Arab Emirates. Retrieved from <https://www.iata.org/en/iata-repository/publications/economic-reports/united-arab-emirates--value-of-aviation/>

These airlines have pursued a highly successful interconnection model, establishing the UAE as a transport hub between the global east and west. The success of this model has led to a high share of long-haul flights in the UAE, with long-haul flights representing 70% of UAE Available Seat Kilometers (ASK) in 2019, compared to the global average of 34%¹².

70% of the UAE flights are long haul, therefore SAF has a key role in the UAE's aviation decarbonization



The UAE aviation market is overwhelmingly international, with very limited domestic operations. The majority of short haul flights are to neighboring counties, and these short flights constitute only 3% of the UAE's aviation activity, and correspond to a negligible amount of jet fuel consumption. By comparison, long-haul flights account for 70% of the UAE's aviation activity and will commensurately result in the majority of emissions created by the countries aviation sector. Decarbonizing long-haul aviation is particularly challenging, as long-distance flights must be powered by fuel with a high energy density, low weight, and small volume. In the short to medium term, emerging clean aviation technologies such as electricity and hydrogen will be limited in their ability to meet these demands, while drop-in SAF can be used today to decarbonize existing and future aircraft¹³. SAF will therefore be critical to decarbonize the UAE's aviation sector.

In addition to Emirates and Etihad, the UAE has two low-cost carriers, Flydubai (since 2009), and Sharjah-based Air Arabia (since 2003). There are three domestic and seven international airports in the country, including Dubai International Airport (DXB), one of the world's largest international airports, and Abu Dhabi International Airport (AUH). The nation also has a large air cargo industry, with busy cargo routes to India, Germany, UK, Turkey, and Saudi Arabia¹⁴.

¹² Long haul is defined as routes over 4,800 Km, Medium haul as 1,500-4,800 Km, and short haul below 1,500 Km. Global Air Transport Management and Reshaping Business Models for the New Era. United States: IGI Global, 2022. This analysis is based on EK and EY flights.

¹³ The volume of hydrogen will make it unsuitable for extra-haul long flights, but studies have shown that a 10,000 km range aircraft could be built with hydrogen, though arguably this may be available in the long term

¹⁴ <https://www.iata.org/en/iata-repository/publications/economic-reports/united-arab-emirates--value-of-aviation/>

"Climate change is not a temporary concern, but a global challenge that is here to stay. We must unite our efforts to safeguard the planet for future generations or risk paying heavier costs in the future."

H.H. Sheikh Mohammed bin Rashid Al Maktoum

Vice President and Prime Minister of the UAE and Ruler of Dubai



Hatta Lake

Photo by Lina Kivaka

2 SAF Technology and Policies

SAF can be classified based on feedstocks, blending limits and conversion pathways. The below table lays out what the available conversion pathway for certain feedstocks, blending ratios by volume and commercial projects in relation to every process¹⁵. To be used in commercial flights, a sustainable aviation fuel must comply with the American Society for Testing and Materials (ASTM) standard D4054¹⁶. As of June 2020, co-processing and seven conversion processes have been approved for SAF production.

There are 9 ASTM approved pathways for SAF production

Pathway	Feedstock	Max. Blending Limit
FT-SPK	Biomass (e.g. trash/rubbish, forestry residues, grasses)	 50%
HEFA-SPK	Waste lipids & fats (e.g. UCO, tallow, DCO)	 50%
HFS-SIP	Sugars to hydrocarbon (e.g. molasses, sugar beet, corn dextrose)	 50%
FT-SPK / A	Same feedstock as FT-SPK, but slightly different process	 10%
ATJ-SPK	Agricultural waste (e.g. forestry slash, crop straws)	 50%
CH-HK	Plant and animal fats, oils and greases (FOGs)	 50%
HC-HEFA-SPK	Bio-derived hydrocarbons, fatty acid esters	 10%
Co-processed HEFA*	Fats, oils, and greases (FOG) co-processed with petroleum	 5%
Co-processed FT*	Fischer-Tropsch hydrocarbons co-processed with petroleum	 5%

* Approved under ASTM D1655 Annex A1
Source: <https://www.icao.int/environmental-protection/GFAAF/Pages/Conversion-processes.aspx>

Out of the seven approved pathways, HEFA is currently used to produce most commercially available SAF. Other pathways are in various stages of development, with commercial scale facilities under construction that will utilize the FT-SPK and AtJ technologies, among others. While the HEFA pathway is currently the most mature and affordable, it is increasingly constrained by the availability of feedstock. Some additional feedstocks for the HEFA process can be manufactured, via approaches such as Halophyte growth, but other SAF production technologies, such as Power-to-Liquid, possess greater scalability potential. The main obstacles to scaling these technologies are the high cost and risk, which are both a result of their early stage of technical development¹⁷.

2.1 International Aspirations

There have been extensive efforts to develop global aviation decarbonization targets and policies. ICAO has been at the forefront of these efforts alongside the IATA. ICAO is funded and directed by 193 national governments to support their diplomacy and cooperation in air transport, therefore its role

¹⁵ Please visit Appendix for more details on SAF blending

¹⁶ [https://www.icao.int/environmental-protection/GFAAF/Pages/Conversion-processes.aspx#:~:text=In%20order%20to%20be%20used%20in%20A0commercial%20flights%2C%20a%20sustainable%20aviation%20fuel%20\(SAF\)%20has%20to%20comply%20with%20A0ASTM%20A0%20D4054.](https://www.icao.int/environmental-protection/GFAAF/Pages/Conversion-processes.aspx#:~:text=In%20order%20to%20be%20used%20in%20A0commercial%20flights%2C%20a%20sustainable%20aviation%20fuel%20(SAF)%20has%20to%20comply%20with%20A0ASTM%20A0%20D4054.)

¹⁷ <https://www.easa.europa.eu/eaer/topics/sustainable-aviation-fuels/figures-and-tables>

in designing the global SAF future through policies is critical. Representing 290 airlines that carry 83% of total air traffic, IATA is another key international player in developing the future of SAF.

ICAO Aspirational Goals

With a view to minimize the adverse effects of international civil aviation on the global climate, ICAO formulates policies, develops, and updates Standards and Recommended Practices (SARPs) on aircraft emissions, and conducts outreach activities. These activities are conducted by the Secretariat and the Committee on Aviation Environmental Protection (CAEP). In pursuing its activities, ICAO also cooperates with other United Nations bodies and international organizations.

The ICAO Assembly at its 40th Session in 2019 adopted “Resolution A40-18: Consolidated statement of continuing ICAO policies and practices related to environmental protection — Climate change”¹⁸. It reiterated the two global aspirational goals for the international aviation sector of 2% annual fuel efficiency improvement through 2050 and carbon neutral growth from 2020 onwards, as established at the 37th Assembly in 2010.

To achieve the global aspirational goals, ICAO is pursuing a **basket of measures** including (i) aircraft technology improvements, (ii) operational improvements, (iii) use of sustainable aviation fuels, and (iv) market-based measures (MBM) aimed at emissions reduction¹⁹. This basket of measures is commonly described as the four pillars of ICAO’s environmental protection plan, with additional work dedicated to other dimensions such as aircraft noise and local air quality. A global MBM scheme is considered to be preferable to a “patchwork” of local and regional measures with disparate compliance regimes.

The MBM scheme developed by ICAO to achieve carbon-neutral growth from 2020 onwards is the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). CORSIA relies on carbon offsets to address CO₂ emissions that cannot be reduced through the use of technological and operational improvements, and SAF. To ensure environmental integrity, both carbon offset programs and the emissions units themselves must be approved by ICAO as part of an ongoing process for eligibility²⁰. The volume of emissions that must be addressed is based on a comparison of the total CO₂ emissions for the year against a baseline level of CO₂ emissions. Any international aviation CO₂ emissions covered by the CORSIA that exceed the baseline level represent the sector’s offsetting requirements for that year.

The definition of the CORSIA baseline values for implementation during the pilot phase of the program has changed from its initial inception to acknowledge the effects of the global COVID-19 pandemic. While originally the sectoral baseline was defined as the average of total CO₂ emissions for 2019 and 2020, accounted on all routes covered by and connecting airports between CORSIA pilot phase voluntary participant countries, it was later amended in June 2020 by the ICAO Council to refer to emissions in the year 2019 only for the pilot phase, in order to avoid placing an undue economic

¹⁸ https://www.icao.int/environmental-protection/Documents/Assembly/Resolution_A40-18_Climate_Change.pdf

¹⁹ <https://www.icao.int/environmental-protection/pages/climate-change.aspx>

²⁰ In accordance with two ICAO Documents, namely the “CORSIA Emissions Unit Eligibility Criteria” and “CORSIA Eligible Emissions Units”

burden on aircraft operators impacted by a sharp decline in international aviation activity²¹. The impact on the COVID-19 pandemic in the aviation sector and the potential pathways for recovery in the near future are also a key element of the 2022 CORSIA Periodic Review, which is the first periodic review incorporated in the CORSIA framework to reassess the program performance every three years.

The CORSIA implementation plan is still expected to follow three phases, starting with participation of States in the CORSIA offsetting on a voluntary basis (during ongoing pilot phase and upcoming first phase), followed by participation of all States except the States exempted from offsetting requirements, as follows:

- Pilot phase: from 2021 to 2023.
- First phase: from 2024 to 2026.
- Second phase: from 2027 to 2035.

The UAE announced in 2016 its commitment to participate in CORSIA starting from the Pilot Phase (1st Jan 2021 onwards) and has since actively participated along ICAO efforts to ensure that all reporting aircraft operators in the country (nine in total) were able to reach CORSIA compliance and readiness status²².

Alongside CORSIA eligible emissions units, the UAE's plan to meet offsetting requirements will rely on deployment of CORSIA eligible fuels. Understanding how different SAF may be able to meet CORSIA eligible fuel status is a key consideration in the development of the UAE SAF Roadmap²³.

Since the second ICAO Conference on Aviation Alternative Fuels (CAAF/2) in March 2018, efforts to promote SAF have been undertaken by specialized working groups, such as the ICAO Long-Term Aspirational Goal (LTAG). ICAO, calling on its private and public sector partners/members, maintains that by 2050, a significant proportion of CAF must be replaced by SAF as a means of significantly reducing carbon emissions of the industry. Information gathered at the first "ICAO Stocktaking Seminar toward the ICAO 2050 Vision for Sustainable Aviation Fuels (SAF)" ²⁴ in April 2019 shows that commercial production of SAF increased from an average of 0.29 million liters per year (2013-2015) to 6.45 million liters per year (2016-2018).

The ICAO Council is in the process of establishing concrete targets for SAF adoption to facilitate a conventional aviation fuel (CAF) replacement by the year 2050. Such targets are expected in line with the 2050 Vision for Sustainable Aviation Fuels, to be defined no later than 2025, when the third ICAO Conference on Aviation Alternative Fuels (CAAF/3) is expected to take place.

The latest high-level meeting on the feasibility of a long-term aspirational goal for international aviation CO₂ emissions reductions conducted between 19-22 July 2022 in Montreal was a strong step

²¹ <https://www.icao.int/environmental-protection/CORSIA/Pages/CORSIA-and-Covid-19.aspx>

²² <https://www.icao.int/Meetings/ENVSymposium/Presentations/Eng%20Majed%20Session%209.pdf>

²³ Please visit Appendix for more details on CORSIA eligible fuels

²⁴ <https://www.icao.int/Meetings/SAFStocktaking/Pages/default.aspx>

towards achieving global aviation decarbonization targets. The meeting concluded with many recommendations focusing on SAF, including the following²⁵:

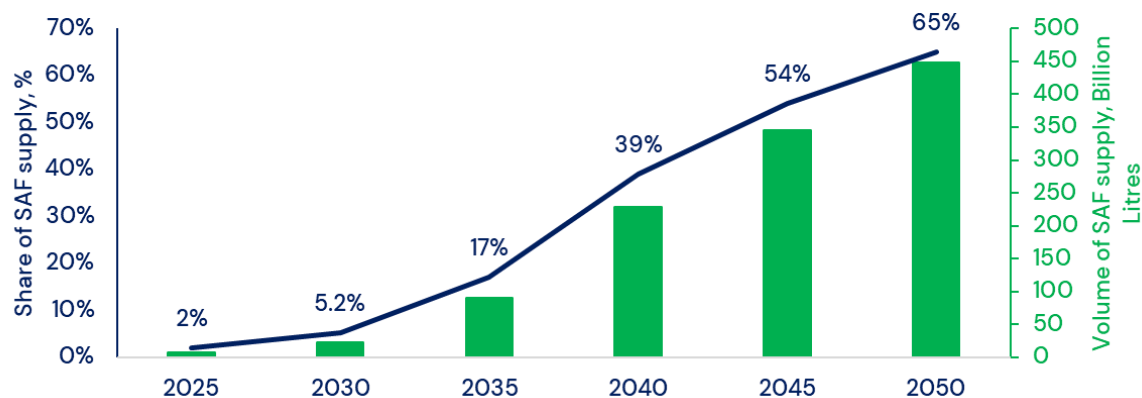
“ICAO Member States are invited to incentivize, through policies and policy tools, the research, development and deployment of Sustainable Aviation Fuels (SAF), Lower Carbon Aviation Fuels (LCAF) and other cleaner energy sources for aviation”

IATA Aspirational Goals

The IATA represents aircraft operators across 290 airlines engaged in commercial aviation from 117 countries. Publishing its environmental ambitions within the “IATA Sustainable Alternative Jet Fuels Strategy”²⁶, the association originally targeted a 50% emission reduction by 2050 compared to 2005 levels. This target was updated in 2021, when at the 77th IATA General Assembly, a resolution to achieve net-zero carbon emissions by 2050 was approved²⁷. The newer and more ambitious commitment puts the aviation sector’s emission reduction target in line with the Paris Agreement²⁸.

Achieving this ambitious goal will require that both industrial stakeholders and governmental institutions accelerate the development of SAF production in a scalable, timely, and affordable manner. Policy support will be critical to achieve the proliferation of affordable and accessible SAF in line with the vision. The following base case scenario is the current focus of IATA efforts:

Required SAF volume to achieve IATA’s 2050 net zero target is 23 billion liters



2.2 National Policies

Major global aviation markets are also being supported in their decarbonization goals by national initiatives. In the United States (US), the federal government launched the “Sustainable Aviation Fuel Grand Challenge”, which aims to reach at least 3 billion gallons (approximately 11 billion liters) of SAF

²⁵ https://www.icao.int/Meetings/HLM-LTAG/Documents/ICAO_Doc_10178-HLM_LTAG_Report.pdf

²⁶ “IATA Sustainable Alternative Jet Fuels Strategy”

https://www.iata.org/contentassets/d13875e9ed784f75bac90f000760e998/sustainable_alternative_jet_fuels_strategy.pdf

²⁷ <https://airlines.iata.org/news/net-zero-carbon-emissions-by-2050>

²⁸ Please visit Appendix for detailed notes on Paris Agreement and the UAE’s NDCs

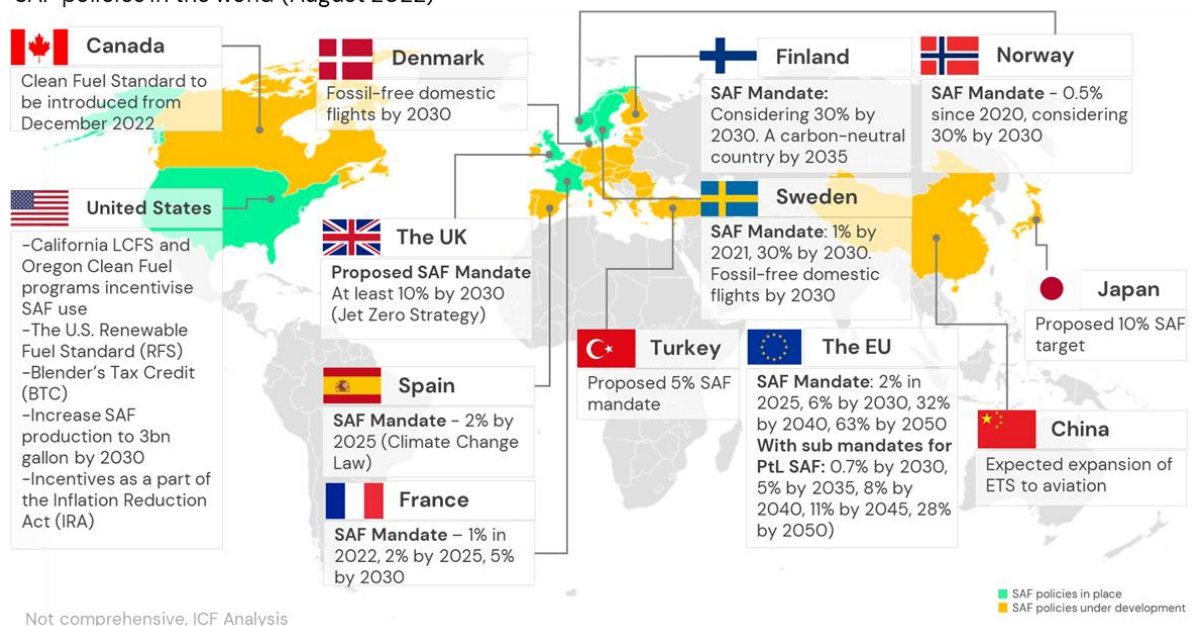
production in the country by 2030²⁹. This initiative is spearheaded by federal agencies³⁰ and others to develop a comprehensive strategy for the scale-up of the SAF production at commercial scale levels³¹. It follows two specific goals, namely the reduction of overall GHG lifecycle emissions of SAF produced in the US by at least 50%, while achieving production scale sufficient to meet 100% of aviation fuel demand in the US by 2050, estimated at over 35 billion gallons (over 132 billion liters).

A comparable effort in target setting is seen across the Atlantic in the European aviation sector, where aviation sector associations representing aircraft manufacturers, airlines, airports and air navigation service providers³² have published the “Destination 2050” action plan, aiming to identify the main levers, drivers and barriers relevant to reaching net zero emissions in European aviation sector by 2050, and to provide a unified vision for collective action across the sectoral ecosystem³³.

The European Union (EU) has recently increased its SAF mandate by 2030 proposal to 6% (from 5%), which also includes a 0.7% sub mandate for PtL SAF. This PtL target will linearly increase to 5% by 2035, and eventually reach 28% by 2050. Considering the strong demand signal for the PtL SAF in the EU, and the UAE’s potential to produce it through cheap renewable energy, this can be a significant export opportunity for the UAE.

Many countries are introducing SAF policies to enable rapid scale of SAF by 2030

SAF policies in the world (August 2022)



The governmental efforts are being supported by other stakeholders and non-governmental actors. For instance, the World Economic Forum (WEF) established the “Clean Skies for Tomorrow (CST)” Coalition³⁴. This coalition aims to align both SAF producers and consumers with relevant actors along the SAF technology value chain and support first-mover efforts and initiatives for large-scale,

²⁹ <https://www.whitehouse.gov/briefing-room/statements-releases/2021/09/09/fact-sheet-biden-administration-advances-the-future-of-sustainable-fuels-in-american-aviation/>

³⁰ Such as US DOE, US DOT, USDA

³¹ <https://www.energy.gov/eere/bioenergy/sustainable-aviation-fuel-grand-challenge>

³² Namely A4E, ACI, ASD, ERA, and CANSO

³³ Please visit Appendix for detailed information on Destination 2050

³⁴ <https://www.weforum.org/projects/clean-skies-for-tomorrow-coalition>

commercial SAF production projects. Among its published reports, the “Sustainable Aviation Fuel Policy Toolkit”³⁵ describes the need for targeted, geography-specific technology developments, project implementations and policy measures that leverage specific feedstock resources found in each country to the most appropriate SAF production pathway. These actions must also align potential cross-sectoral opportunities for de-risking project investments or manage market demands, in such a way that the harder-to-decarbonize industrial sectors are afforded strategic importance during the allocation of decarbonized fuels within a portfolio of lower-carbon energy system options. The importance of a systems-oriented approach to energy policy development is a view endorsed by the UAE MOEI, which actively supported the development of the policy toolkit document. The UAE MOEI also supported development of a PtL Roadmap for the UAE in collaboration with WEF and ICF.

³⁵ https://www3.weforum.org/docs/WEF_Clean_Skies_for_Tomorrow_Sustainable_Aviation_Fuel_Policy_Toolkit_2021.pdf



" We are an oil producing nation, but we are today focusing on renewable energy. Though there are many questions raised, the answer is very clear. We want to build the future like we build our present."

H.H. Sheikh Abdullah bin Zayed Al Nahyan

Minister of Foreign Affairs and International Cooperation UAE

Dubai Expo

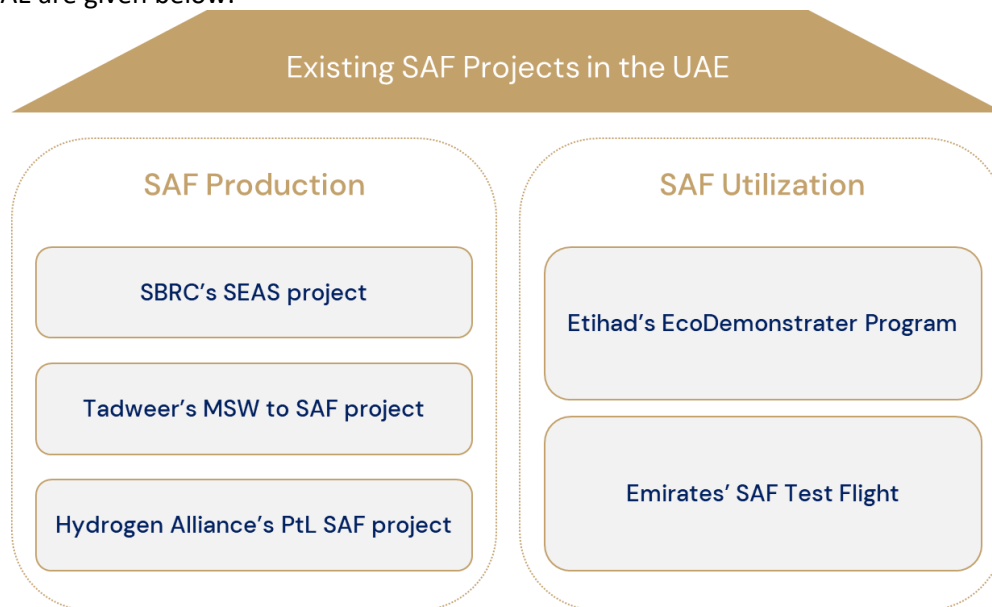
Photo by Diego F. Parra

3 SAF Outlook in the UAE

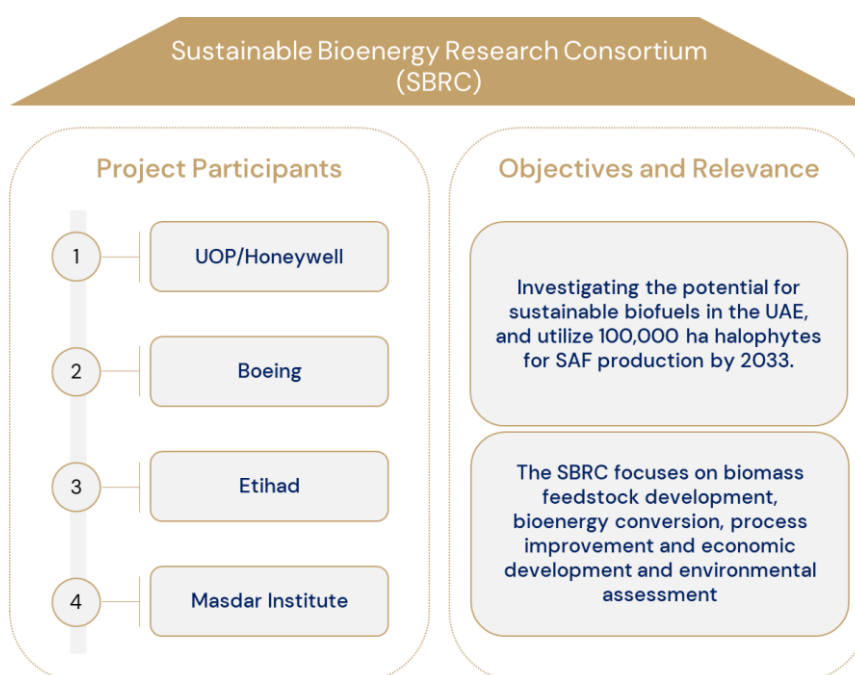
The UAE has been actively working on projects which build the foundations for SAF deployment in the country. This section will explore the existing SAF projects and feedstock potential in the UAE, consolidating them into a brief strengths, weaknesses, opportunities, and threats (SWOT) analysis of the current UAE SAF landscape.

3.1 Building the Foundations: Existing SAF Projects in the UAE

Through several strategies and initiatives, the UAE is striving to reduce the carbon footprint of its aviation sector. Several projects are being developed which promote SAF production and use in the UAE in the hopes of achieving its long-term goal of reducing emissions by 50% come 2050. The UAE aims to achieve its ambition through an increased share of hydrogen use throughout its economy, and by continuing to support initiatives which contribute to the development of SAF. Existing SAF projects in the UAE are given below:



SAF Production: Sustainable Bioenergy Research Consortium (SBRC)

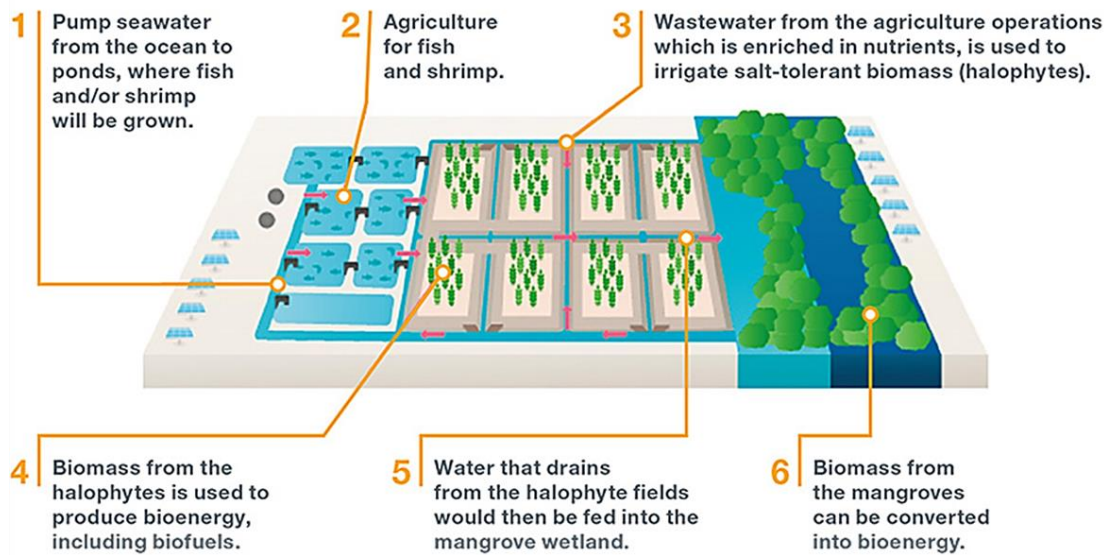


The Sustainable Bioenergy Research Consortium (SBRC) was established in Abu Dhabi in 2011 as a not-for-profit research consortium to advance the aviation industry's commitment to sustainable business practices by developing technology with the promise of producing a clean, alternative fuel supply. The SBRC was founded by Masdar Institute (now part of Khalifa University of Science and Technology), Etihad Airways, The Boeing Company, and Honeywell-UOP. Since then, Safran, GE, ADNOC Refining, and Bauer Resources have joined. A crucial part of its research activity has been developing a large-scale research program on alternative fuels derived from halophytic (saltwater tolerant) plants, called the Seawater Energy and Agriculture System (SEAS).

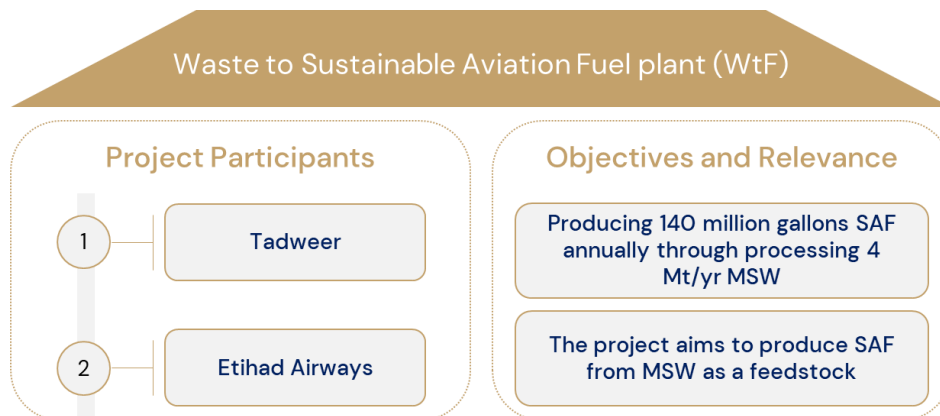
The SEAS platform is conceived as a multidisciplinary and holistic approach to the food-water-energy nexus. It manages to leverage the harsh environmental conditions and resources of arid-desert locations, (i.e., "conventionally" non-arable land, seawater, and sunlight) to produce socio-economic relevant outputs: seafood, bioenergy, biomaterials, and ecosystem services. It does so through each of its integrated subsystems, namely aquaculture, halophyte agriculture, and halophyte agroforestry.

The first ten years of the SBRC were dedicated to conducting extensive research in the field of halophyte agriculture. In addition, two significant milestones were achieved: 1) In March 2016, the pilot facility of the SEAS was inaugurated and has been operating for over six years; 2) On January 15th of 2019, the first commercial airplane flight, partially fueled with jet fuel derived from oilseeds produced at the pilot facility and refined at the ADNOC Refining Research Center, departed from Abu Dhabi to Amsterdam, acting not only as a proof-of-concept for the SEAS but also for the establishment of an entirely local UAE SAF supply chain. This SAF was refined at the ADNOC Refining Research Center starting from Salicornia oil extracted from seeds produced at the SEAS pilot facility. Equipped with this experience, due diligence is underway to design, build and operate a SEAS demonstration-scale facility of up to 200 hectares (ha) within the next 3-5 years in the western region of Abu Dhabi, where the aquaculture subsystem would be a commercial operation while the halophyte agriculture and agroforestry subsystems would continue to be dedicated to Research & Development.

SBRC's SEAS project has potential to deliver up to 152 kton/yr SAF by 2033 through biogenic feedstock (halophytes)



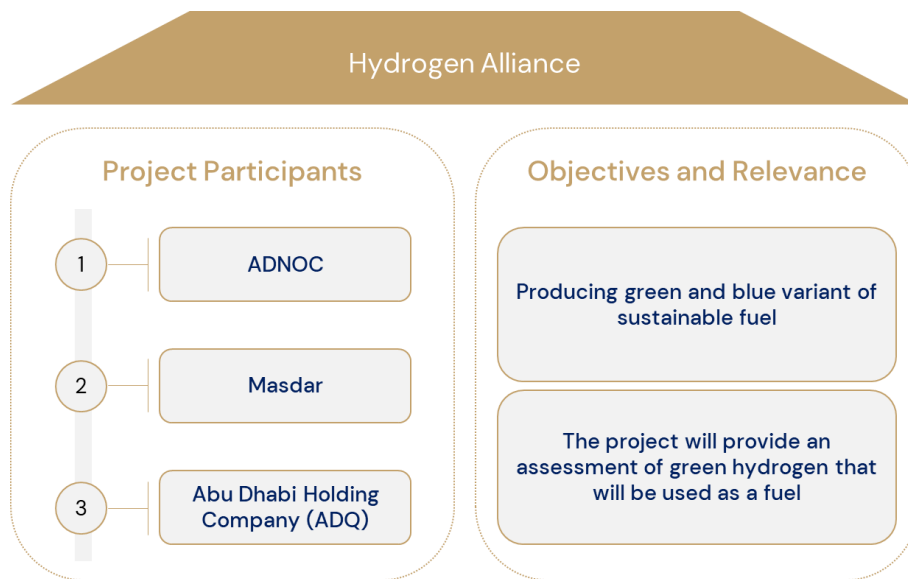
SAF Production Initiative: Waste to Sustainable Aviation Fuel Plant (WtF)



In November 2021, the Abu Dhabi Waste Management Center (Tadweer) signed a Joint Project Development Agreement (JPDA) with Etihad Airways to facilitate the development of the first Waste-to-Sustainable Aviation Fuel (WtF) plant in the Middle East³⁶. The plant is expected to process 4 million tons of MSW to produce 140 million gallons (0.42 Mt) of SAF annually. CO₂ emissions are expected to be reduced by 1 million tons annually, which reinforces the UAE's commitment to net-zero.

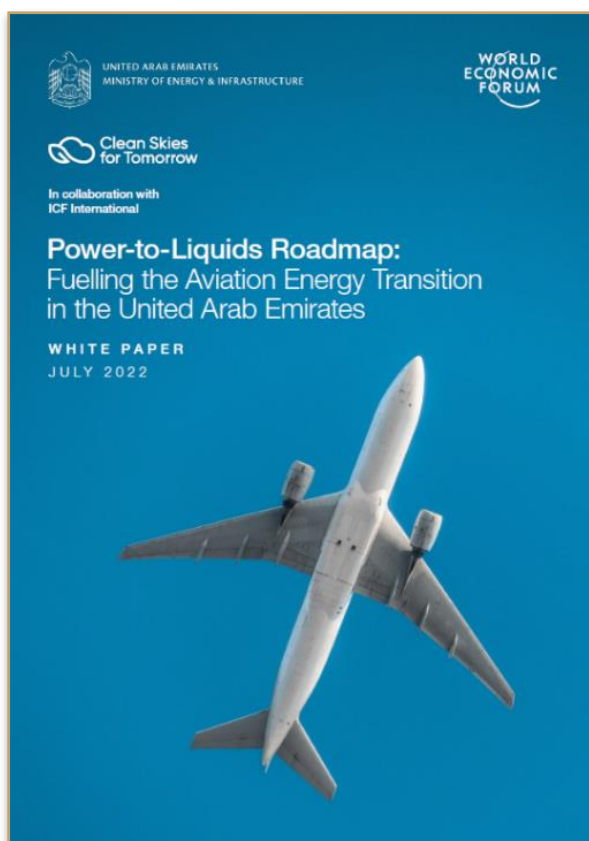
SAF Production Initiative: Power-to-Liquids (PtL)

³⁶ Abu Dhabi to establish first Waste-to-Sustainable Aviation Fuel plant in Middle East Retrieved from <https://www.wam.ae/en/details/1395302992893>



In 2021, Masdar's parent company Mubadala, alongside the ADNOC and Abu Dhabi Developmental Holding Company (ADQ), agreed to form a "hydrogen alliance" with the objective of producing green and blue variants of the fuel. The project will provide an assessment of green hydrogen uses in the carbon neutral Masdar City, as well as in aviation fuel to be used by Etihad and Lufthansa. Green hydrogen refers to hydrogen gas produced from renewable sources of energy such as wind and solar. Conversely, blue hydrogen, which is being produced by ADNOC, is manufactured through steam methane reforming pair with Carbon Capture. The construction of the demonstrator project is likely to be completed with a two-year timeframe.

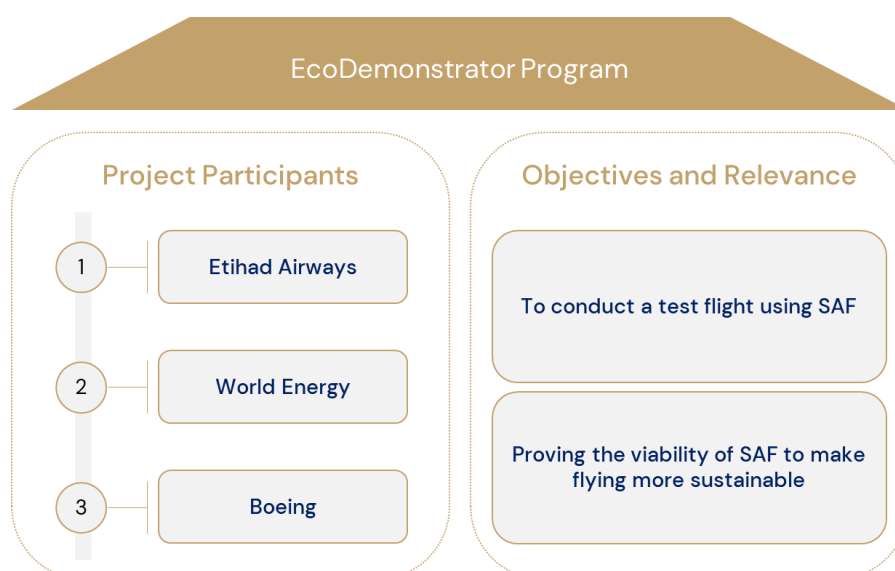
Masdar's project is backed by Germany's Siemens Energy, Japan's Marubeni, Etihad Airways, the Lufthansa Group, the UAE's Khalifa University of Science and Technology and the Abu Dhabi Department of Energy. The main infrastructure for the green hydrogen project is being developed by Siemens Energy and Marubeni. The German company is also developing one of the first solar-powered electrolyzer projects to produce hydrogen for fuel cells at Dubai's Expo 2020. Masdar will trial manufacturing hydrogen using solar photovoltaic power and will look at opportunities in the future to export such fuel to meet growing demand globally, particularly in Europe.



MOEI supported a PtL Roadmap study for the UAE in collaboration with the WEF and ICF³⁷. This study was published by the WEF in July 2022 and was led by the UAE SAF committee. Given the limited availability of biogenic feedstock in the UAE, this roadmap provides a comprehensive analysis on how to scale up PtL in the UAE by 2050, through leveraging affordable renewable energy, existing hydrocarbon experience and infrastructure. The report also considers industrial waste CO₂ for PtL SAF production, which can be supplied from the UAE's increasing number of MSW to energy facilities and growing industrial sector. With the right support of policy measures and strong public-private collaboration, this report concludes that the UAE has the potential to produce up to 11.2 Mt PtL SAF by 2050 while creating and sustaining up to 1.4 million jobs across the industry value chain. The report serves to both shape the future of PtL in the UAE, and also serves as a key study for supporting global PtL SAF ambitions. This shows the UAE's commitment and vision for delivering a low carbon future in collaboration with global

stakeholders.

SAF Test Flight Initiative: Etihad EcoDemonstrator Program



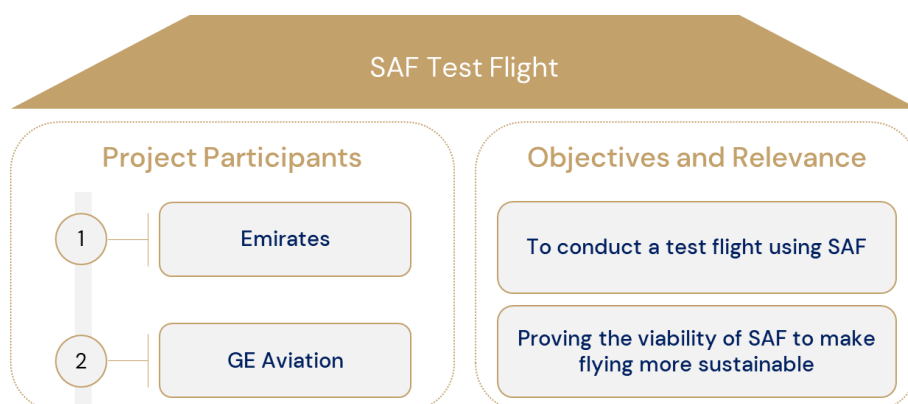
In 2020, Boeing, Etihad Airways and World Energy conducted an in-country flight using a 50/50 blend of sustainable and traditional jet fuel as part of the EcoDemonstrator program³⁸. The fuel used from

³⁷ <https://www.weforum.org/whitepapers/power-to-liquids-roadmap-fuelling-the-aviation-energy-transition-in-the-united-arab-emirates/>

³⁸ (2020). Retrieved 2 March 2022, from <https://www.etihad.com/en-ae/news/boeing-etihad-airways-and-world-energy-lift-sustainable-aviation-fuel-to-the-next-level-on-ecodemonstrator-programme>

World Energy which was supplied to Boeing was certified by the Roundtable on Sustainable Biomaterials to have reduced carbon emissions by more than 75% over the fuel's life cycle.

SAF Test Flight Initiative: Emirates SAF Test Flight



In November 2021, Emirates and GE Aviation signed a Memorandum of Understanding to conduct a test flight using 100% SAF on an Emirates Boeing 777-300ER to be powered by GE90 engines³⁹. This collaboration aims to demonstrate how jet fuel produced by alternative sources can lower lifecycle CO₂ emissions in contrast to petroleum-based fuels. At present, SAF is constrained by a maximum 50% blending limit. Meanwhile, an international task force chaired by one of GE's fuel experts is working to develop standardized industry specifications to support the adoption of 100% SAF. This test flight supports the efforts of both companies in combating CO₂ emissions in the aviation industry and will serve as a significant milestone to scaling up SAF usage in the UAE.

3.2 SAF Feedstock Opportunities in the UAE

Feedstock availability is one of the key considerations for the future SAF industry, as it directly impacts the volume and specifications for SAF technology opportunities in each region. The availability assessment in this roadmap considers three stages: technical availability, sustainable availability, and allocation to the aviation industry (or net availability for SAF production):

- **Technical availability** of a feedstock refers to total amount of potential feedstock available in a region. This includes availability for SAF production, as well as other potential uses, such as biodiesel or energy. Depending on the environmental dynamics of the region, technically available feedstock amounts vary widely. Due to its hot and dry climate, the UAE has very limited biogenic feedstock availability compared to some other countries⁴⁰.
- **Sustainable availability** reduces the total possible feedstock supply by the portion that would be unsustainable to collect or produce. For example, some agricultural wastes must be left in the field to protect soil quality, and the fossil portion of MSW should be avoided. Deducting the unsustainable quantity from the technically available feedstock gives the sustainably available feedstock quantity.

³⁹ Emirates and GE Aviation commit to test flight program using 100% Sustainable Aviation Fuel to reduce CO₂ emissions. (2021). Retrieved from <https://www.emirates.com/media-centre/emirates-and-ge-aviation-commit-to-test-flight-programme-using-100-sustainable-aviation-fuel-to-reduce-co2-emissions/>

⁴⁰ RSB & Agroicone (2021). Feedstock Availability for Sustainable Aviation Fuel in Brazil: Challenges and Opportunities. Roundtable on Sustainable Biomaterials, Switzerland.

- **Allocation to aviation industry** refers to utilization of feedstock by competing industries. For most feedstocks, SAF production represents just one of its uses, as feedstocks can be used in alternative fuel production (biodiesel), in the chemicals industry (naphtha), in energy production, or in other sectors. Only a portion of the sustainably available feedstocks are typically allocated to the aviation industry.

The two broad categories of feedstocks are biological and non-biological. Many countries in the Gulf Cooperation Council (GCC) region can only access a limited volume of biological feedstock, due to climate conditions, and limited agricultural activity. Examples of biological feedstocks that are available in the GCC are biological MSW and Halophytes. Non-biological feedstocks, especially PtL SAF from low-carbon renewable electricity, are likely to offer greater potential to scale-up.

3.2.1 Assessment of Feedstock Availability

The availability of feedstocks for SAF production in the UAE was assessed. This assessment concluded that halophytes, agricultural residues (AgW), MSW and PtL feedstocks (renewable energy, H₂ and CO₂) would be the most promising feedstocks for the UAE to produce SAF. While there is some availability of used cooking oil (UCO) and tallow in the UAE, both feedstocks are already widely collected and used by other industries, constraining their availability for SAF production. There may be some future biogenic sources with potential, such as microalgae-derived feedstocks, but due to their considerable uncertainty and near-term challenges, these were not considered in this assessment.

This analysis builds on and validates research conducted in 2019 by SBRC on biogenic feedstock availability, i.e., halophytes, AgW and MSW⁴¹. The values given in this report include updates to reflect improved data and the reduced availability for some feedstocks due to newly announced facilities (e.g., MSW incineration) that will utilize some of the feedstock considered in the 2019 study.

⁴¹ <https://www.icao.int/Meetings/SAFStocktaking/Documents/ICAO%20SAF%20Stocktaking%202019%20-%20AI2-5%20Alejandro%20Rios%20Galvan.pdf>

Feedstock assessment showed that halophytes, MSW and non-biogenic feedstocks (CO₂ and Hydrogen) have the highest potential for the UAE to produce SAF

Category	Feedstock	Environmental Criteria		Availability Criteria			Potential
		GHG saving	Sustainability	Technical	Sustainable	Allocation to Aviation	
Crop based	Edible oil crops – Palm	●	●	●	●	●	●
	Edible oil crops – Soyabean	●	●	●	●	●	●
	Edible oil crops – Others	●	●	●	●	●	●
	Edible Sugar – Sugar cane	●	●	●	●	●	●
	Edible Sugar – Maize	●	●	●	●	●	●
	Edible Sugar – Other	●	●	●	●	●	●
	Specific crops – Halophytes	●	●	●	●	●	●
Waste fat, oil and grease (FOG)	Industrial waste cooking oil (Kitchens, eatery)	●	●	●	●	●	●
	Industrial waste cooking oil (household)	●	●	●	●	●	●
	Animal Waste fat (tallow)	●	●	●	●	●	●
Lignocellulosic and biowaste	Biogenic waste from all agriculture production	●	●	●	●	●	●
	Renewable biomass portion of MSW	●	●	●	●	●	●
	Waste from forest	●	●	●	●	●	●
Power-to-liquids	CO ₂ from industry/Direct air capture + Green/blue H ₂ + Renewable Power	●	●	●	●	●	●

● Good
 ● Medium
 ● Low

Crop based feedstocks

Apart from salt-tolerant halophyte plants, other crop-based feedstocks with a high water requirement are not suitable for the UAE⁴². As glycophytes (i.e., freshwater-irrigated plants) remain the primary focus of dedicated fuel crop operations elsewhere, adapting such production systems to the environmental and geographical conditions of the UAE would represent an added burden. Both energy requirements and embodied emissions due to the need for desalination in the UAE would penalize such glycophyte-based systems, when a complete life-cycle based assessment of environmental impacts is taken into consideration. Further, expansion of such crop farming in the country can exacerbate the risk to the limited freshwater resources found in the UAE, such as groundwater

⁴² <https://www.umweltbundesamt.de/en/publikationen/power-to-liquids>

aquifers. Such geological systems are already stressed, and appropriate water management schemes are fundamental to prevent accelerated depletion of such resources⁴³.

The SBRC-led SEAS project is focusing on salt-tolerant biomass and halophytes to build capacity for SAF production in the UAE. Its first two-hectare pilot facility has been operating for six years with excellent results, and the aim of the project is to scale up to 100,000-hectare. This capacity is expected to provide 80 kton - 152 kton SAF by 2033.

Waste fats, oils, and greases (FOG)

Due to competing uses and low technical availability, the UAE has limited potential to utilize UCO and tallow for SAF production. Technical availability of the industrial based UCO is estimated to be around 88 kton/year⁴⁴, yet considering current utilization of UCO in biodiesel production, less than 30 kton/year is expected to be available for SAF production.

Currently McDonald's sends around 0.3 million liters of UCO to Neutral Fuels monthly⁴⁵, which is subsequently used in biodiesel production to fuel McDonald's supply trucks. Another major player in the UAE's biodiesel production scene, Lootah Biofuels, also collects industrial UCO in collaboration with the Dubai Municipality, to produce 60 million liters of biodiesel annually. In addition to these large biodiesel production facilities, new UCO collection initiatives, such as Sharjah's Bee'ah Tandeef's effort to deploy UCO collection machines across the city are beginning to emerge. Although increasing population and collection rates (especially in domestic usage) is expected to increase the technical availability of the UCO, its allocation to the aviation industry is expected to remain limited, as the result of competing usage from the established biodiesel industry. However, UCO can still support the decarbonization of the aviation industry indirectly, through utilization of biodiesel fueled trucks and ground support vehicles across the aviation value chain.

While tallow (animal waste) could serve as another potential SAF feedstock, the size of the meat production industry in the UAE is too small to provide a meaningful contribution to SAF production⁴⁶. It is estimated that 1.4 kton to 2.6 kton tallow would be available in the UAE on an annual basis⁴⁷. Currently the UAE is importing meat from 186 accredited slaughterhouses located in foreign countries. This substantially reduces the technical availability of the tallow in the country. However, as a part of its long-term food security initiatives, the country may consider increasing its domestic capacity for meat production which would increase the technical availability of tallow in the country. However, even doubling the current technical availability would only enable up to 2.5 kton SAF on an annual basis. It is also important to note that this does not take competing use for tallow into consideration, which could further reduce the allocation to aviation industry due to utilization of tallow in production

⁴³ <https://doi.org/10.3390/w8090415>

⁴⁴ <http://www.ieomsociety.org/ieom2020/papers/753.pdf>

⁴⁵ <https://www.thenationalnews.com/uae/environment/uae-recycling-dubai-plant-takes-used-cooking-oil-and-turns-it-into-fuel-1.611857>

⁴⁶ <https://knoema.com/atlas/United-Arab-Emirates/topics/Agriculture/Live-Stock-Production-Producing-AnimalsSlaughtered/Number-of-slaughtered-cattle-and-buffaloes-for-meat#:~:text=Number%20of%20slaughtered%20cattle%20and%20buffaloes%20for%20meat%20of%20United,72%2C345%20thousand%20heads%20in%202020.>

⁴⁷ https://www.scad.gov.ae/Release%20Documents/SYB_2018_EN_9Sep%20_Chart%20Correction.pdf

http://www.safmaps.com/dbms-app/pdfs/SAF_Beef_Tallow_Final.pdf

<https://www.vice.com/en/article/dp3eyq/a-very-precise-calculation-of-exactly-how-many-cows-are-being-murdered-for-the-new-fivers>

of detergents and other beauty products. Low technical availability of tallow and limited allocation of UCO for the aviation industry make it difficult to justify investing in a HEFA plant in the UAE. Therefore, UCO and tallow should not be considered as suitable feedstocks for SAF production in the UAE.

Lignocellulosic and biogenic waste

The UAE has the potential to utilize lignocellulosic and biowaste based feedstocks for SAF production, derived from agricultural residues and municipal solid waste, due to their higher technical availabilities.

The nation's strategic approach of increasing food security through growing its domestic agricultural capacity can serve to facilitate SAF production by increasing the technical availability of AgW⁴⁸. Khalifa University has been exploring ways in which to capitalize on increasing amounts of AgW waste⁴⁹. Based on AgW inventory studies and comprehensive software modelling, SBRC estimates that 39 kton to 97 kton of SAF could be produced through AgW on an annual basis in the UAE by 2033⁵⁰.

The amount of municipal waste has been increasing in the UAE over the last decade due to the growing population and economy. However, the country's well developed waste management system provides high quality service to keep the increasing capacities under control. Based on World Bank data, the UAE's waste generation rate was almost twice the global average with 1.6 kg/capita/day in 2018⁵¹. Considering the UAE's population, this would suggest that over 5.5 Mt MSW is technically available in the country⁵². However, a portion of this MSW would not be suitable for fuel production, while another portion would be allocated to energy production. The SBRC's flagship 2019 research estimated that through utilizing MSW, 80 kton to 520 kton SAF could be produced in the UAE by 2033⁵³. Varying collection and fuel conversion rates, as well as biogenic content availability in the collected MSW are some of the parameters effecting availability.

However, since the publication of that study, two new MSW to energy projects have been announced, thereby decreasing the allocation to aviation industry. Sharjah Waste-to-Energy Project aims to process 0.3 Mt/yr MSW to produce 30 MW energy⁵⁴, while The Dubai Centre for Waste Processing will process 1.9 Mt/yr MSW to produce 200 MW energy⁵⁵, which makes it one of the largest waste-to-energy plants in the world. These two facilities are estimated to utilize 40% of the available MSW in the UAE, decreasing the allocation to aviation industry. On the other hand, Tadweer already announced its plans to produce 140-million-gallon (0.42 Mt) SAF on an annual basis, through utilization of SAF, which is currently the highest capacity SAF project in the UAE.

⁴⁸ <https://www.ku.ac.ae/how-agricultural-waste-can-contribute-to-the-uae-s-food-water-and-energy-security>

⁴⁹ <https://www.ku.ac.ae/masdar-institute-how-abu-dhabi-s-waste-can-help-energy-and-farming>

⁵⁰ <https://www.icao.int/Meetings/SAFStocktaking/Documents/ICAO%20SAF%20Stocktaking%202019%20-%20AI2-5%20Alejandro%20Rios%20Galvan.pdf>

⁵¹ <https://datatopics.worldbank.org/what-a-waste/>

⁵² <https://datacatalog.worldbank.org/search/dataset/0039597>

⁵³ <https://www.icao.int/Meetings/SAFStocktaking/Documents/ICAO%20SAF%20Stocktaking%202019%20-%20AI2-5%20Alejandro%20Rios%20Galvan.pdf>

⁵⁴ <https://masdar.ae/Masdar-Clean-Energy/Projects/Sharjah-Waste-to-Energy-Project>

⁵⁵ <https://wam.ae/en/details/1395302922560>

Power to Liquids (PtL)

The PtL pathway uses CO₂, H₂ and renewable energy to produce liquid hydrocarbons, including SAF. The FT-SPK and AtJ ASTM approved processes can be used to produce synthetic SAF, and the methanol-to-jet route is undergoing certification. This pathway may present some advantages, as the methanol can be more easily stored than hydrogen, mitigating the challenge intrinsic to the pairing of a facility that must run continuously with intermittent renewable electricity production. As an example, the FT-SPK approach converts syngas (CO and H₂) into a mix of long chain hydrocarbons (syncrude), which is then upgraded into final products, including renewable fuels. The Methanol-to-jet route converts the syngas into liquid methanol through catalytic reactions. The syncrude produced by both the methanol-to-jet and FT-SPK processes requires further upgrading, which can be done with existing infrastructure; the UAE has a further advantage here due to the potential to re-use the considerable national fossil fuel infrastructure and expertise.

The UAE's high solar irradiation, experienced construction sectors, and access to capital allow renewable energy to be produced in the UAE at an extremely affordable price, and with very limited use of land and water. Compared to other approaches, the PtL pathway is the least water intensive way to produce SAF⁵⁶, further matching the advantages of this pathway with the constraints of the UAE.

The 2022 WEF report on the PtL opportunities in the UAE developed three scenarios⁵⁷:

1. **Low SAF demand and slow technology penetration (LLT Scenario):** PtL SAF demand is below global ambitions, and penetration of green hydrogen and DAC technologies will start to make significant contribution by 2040
2. **Medium SAF demand and balanced technology penetration (MBT):** PtL SAF demand is in-line with global ambitions, and penetration of green hydrogen and DAC technologies will start to make significant contribution by early 2030s
3. **High SAF demand and rapid technology deployment (HRT):** PtL SAF demand is substantially higher than global ambitions, and penetration of green hydrogen and DAC technologies will start to make significant contribution by 2030

Assessment of these scenarios showed that 11.2 Mt to 2.3 Mt PtL SAF could be produced in the UAE by 2050, with substantial job opportunities and emissions reduction. The PtL scenarios in this SAF roadmap will be built on the findings of the WEF report.

Other opportunities: Existing infrastructure and co-processing

Co-processing allows existing fossil fuel infrastructure to be used for renewable fuel production. This approach allows renewable feedstocks to be blended into refineries, leading to the final product

⁵⁶ <https://www.weforum.org/whitepapers/power-to-liquids-roadmap-fuelling-the-aviation-energy-transition-in-the-united-arab-emirates/>

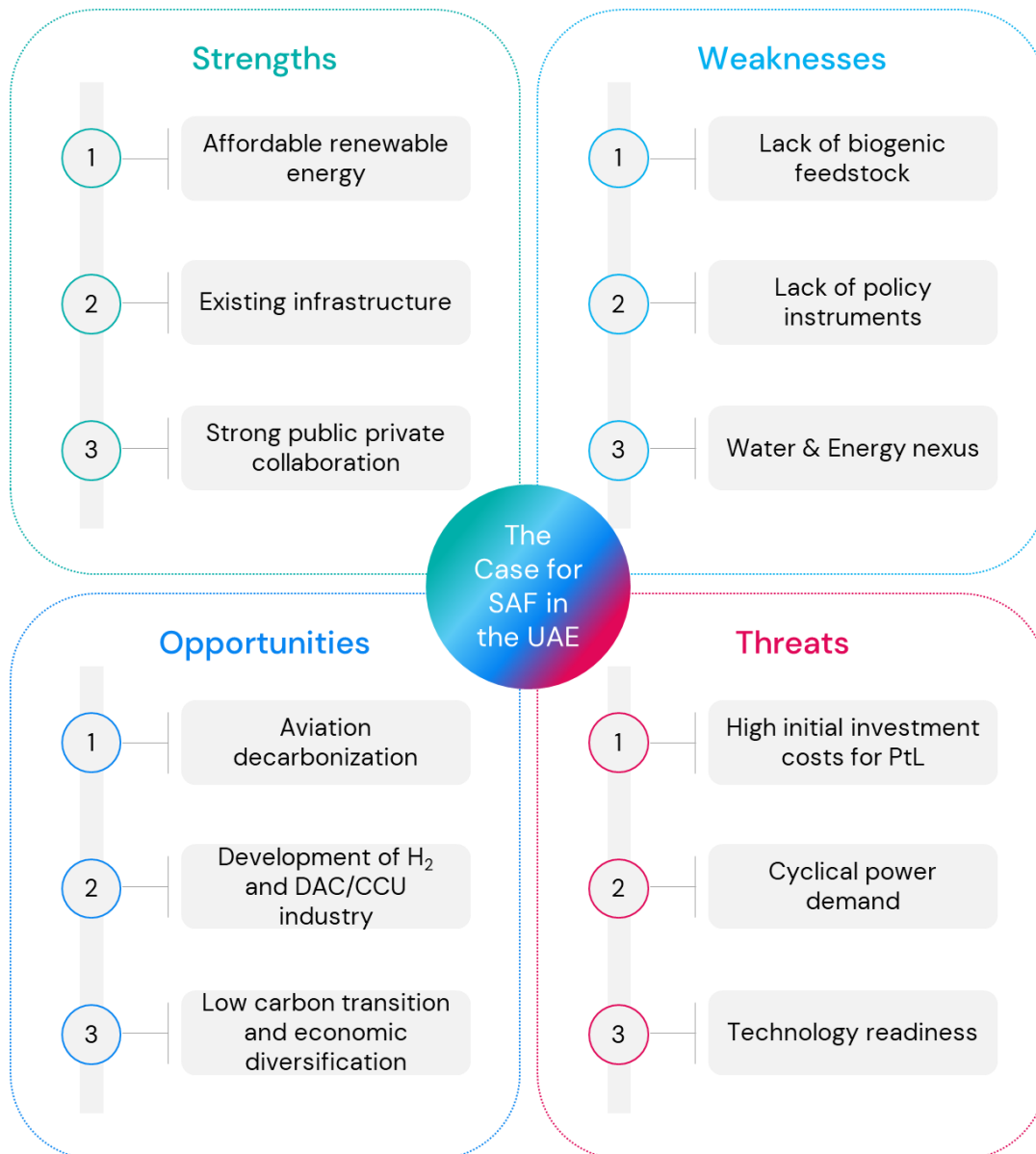
⁵⁷ <https://www.weforum.org/whitepapers/power-to-liquids-roadmap-fuelling-the-aviation-energy-transition-in-the-united-arab-emirates/>

including a blend of fossil and renewable fuel. The ASTM has approved co-processing of up to 5% renewable feedstock, which is limited on a consignment basis, but would represent a significant volume given the large scale of existing refining. The renewable feedstocks that have been tested by other producers includes various organic oils, which means that while the UAE has considerable appropriate infrastructure, the feedstock constraints would need to be overcome. ADNOC Refinery has two plants in Ruwais and Abu Dhabi, which produce and supply jet fuel, and may be able to investigate this approach. Furthermore, it has a research and development center, which has requisite experience in other types of jet fuels, including SAF. Since the SAF approval process is extensive and time consuming, few companies globally are producing SAF that is approved for airline operations. Thus, it is an advantage for the UAE to have this established refining capability.

Safety is the top priority of the aviation industry. Given the specific requirements of any fuels used in aircraft, the process for testing potential new fuels is particularly rigorous. Through testing in laboratories, in equipment on the ground, and under the extreme conditions of in-flight operations, an exhaustive process determines the suitability of SAF. In general, fuel properties required in SAF must meet performance guidelines, operability, and drop-in compatibility to ensure safety, provide general usage and execution in commercial airlines.

3.3 Opportunity Analysis

The UAE has several advantages to support the development of a domestic SAF industry. Building upon some of the most affordable solar in the world and existing hydrocarbon experience and infrastructure, the UAE can become a regional hub and a key player in the global SAF market. Considering the constituent technologies involved in the PtL value chain, the UAE can also leverage its emerging low carbon hydrogen and carbon capture capabilities. Currently, the policy landscape does not constitute any instruments which support the SAF industry and investment costs for early stage PtL facilities are still high. There are also issues related to readiness levels of large-scale DAC and reverse water gas shift (RWGS) deployment in the region. However, the SAF case for the UAE is still promising as it can build upon the nation's strengths and opportunities, while mitigating its weaknesses and threats.





"Net-zero, for us, is about new industries, new skills, and new jobs. For us, the business of tackling climate change is simply good business."

H.E. Sultan Ahmed Al Jaber
UAE Special Envoy for Climate Change

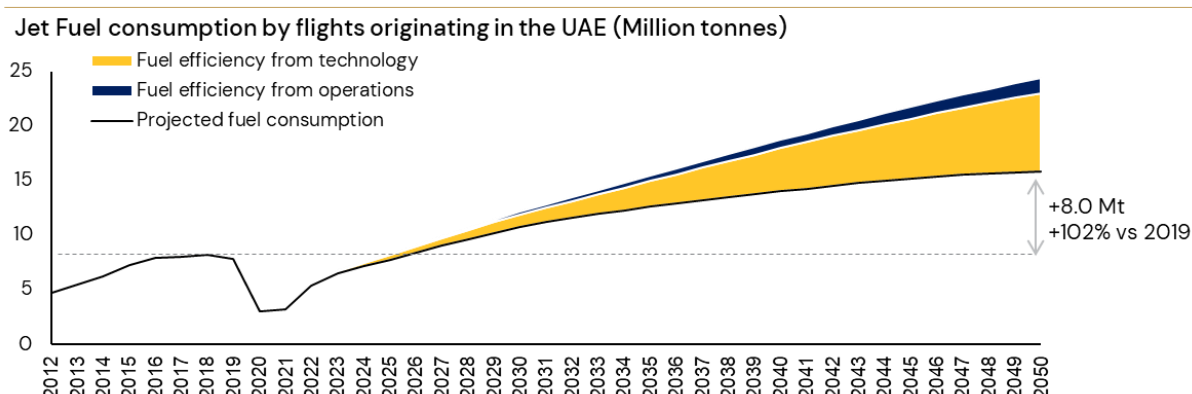


Abu Dhabi
Photo by Jônatas Tinoco

4 The Case for SAF in the UAE

Travel and tourism have become a meaningful percentage of the UAE's economic over the past decade. The UAE has become one of the leading travel, tourism, and logistics hub in the region, which is underpinned by the aviation industry. As a result of the increasing aviation activity in the country, jet fuel consumption is expected to double by 2050, increasing the importance for airlines to decarbonize^{58, 59}. SAF utilization can serve to reduce aviation emissions, while ensuring sustainable growth.

Jet fuel consumption in the UAE is projected to double by 2050



The Minister of Energy and Infrastructure of the UAE emphasized that green initiatives such as SAF production will play a critical role in the future of the UAE, asserting that, “The government of the UAE believes in the importance of sustainable energy, investing in the future and strengthening international collaboration to address the challenge of climate change in all sectors, including aviation.”

4.1 SAF Scenarios for the UAE

There are several SAF deployment scenarios for the UAE to consider, ranging from low to high SAF capacities. Considering the UAE's 2050 net-zero target, and the key role of the aviation industry within the country, low SAF deployment will not be considered as a part of this study. The medium and high production capacity scenarios will be explored reflecting following global aspirational targets with some export opportunities (baseline scenario) and becoming a hub with substantial export opportunities (ambitious scenario). Based on the previously presented feedstock availabilities and PtL scenarios developed⁶⁰, it is estimated that by 2030, 700 million liters (ML) to 1,200 ML SAF can be produced in the UAE.

The baseline scenario follows the global SAF targets and is based on the current SAF projects in the country, with a focus on SBRC's SEAS project (80 kton/yr SAF by 2033) and Tadweer's project to

⁵⁸ https://www3.weforum.org/docs/WEF_UAE_Power_to_Liquid_Roadmap_2022.pdf

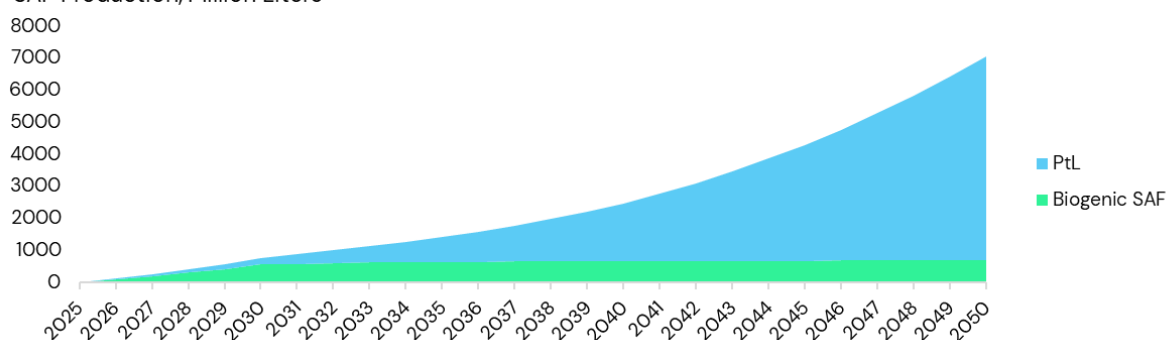
⁵⁹ Please visit Appendix for the jet fuel and emissions forecasting methodology

⁶⁰ *ibid*

produce 431 kton/yr SAF from MSW. Reflecting the impact of population growth and halophyte yields (currently 1,000 L SAF per hectare), a 0.5%/yr increase in SAF output was assumed. This would reflect an 8% increase in the production capacity between 2033 and 2050. Additionally, MSW collection rates are expected to increase over the time due to increasing population. However, current MSW generation rates (2 kg/person/day) are also expected to decrease in the long term, as the UAE increasingly adopts a circular economy⁶¹. For PtL SAF estimations, MBT scenario was taken from the UAE PtL Roadmap developed by the WEF and ICF, which requires 0.18 Mt PtL SAF supply by 2030, and up to 5.08 Mt by 2050. In total, the baseline scenario estimates up to 630 kton (790 ML) SAF production by 2030, with the majority from Tadweer's MSW to SAF project. Given this scenario adopts a pragmatic approach, potential downtimes and large capacity of the facility was taken into consideration as limiting factors. To reflect these potential limitations, supply capacity was calibrated to 700 ML annual SAF production by 2030. This value corresponds to 7.6% of the UAE's 2019 jet fuel consumption.

Baseline scenario concludes that 700 ML SAF production by 2030 is a pragmatic target for the UAE

SAF Production, Million Liters

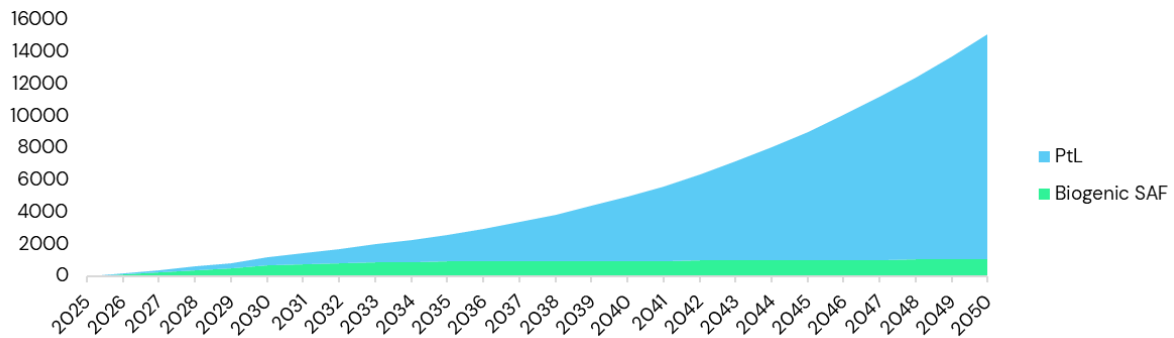


The ambitious scenario positions the UAE as a regional hub as well as a global leader for SAF as it maximizes its biogenic feedstock availability and PtL SAF potential. This scenario was built upon the higher end of the feedstock availabilities. It assumes an increased halophyte yield from the SBRC's SEAS project, delivering 152 kton/yr SAF by 2033, with an additional 44 kton/yr SAF from UCO utilization within the same HEFA plant (196 kton/yr SAF in total). Adding to Tadweer's MSW to SAF project, with its maximum capacity of 0.43 Mt, utilization of AgW was also taken into consideration to supply an additional 88kton/yr SAF by 2030. This scenario also assumes a 1% increase in biogenic SAF output, which corresponds to 17% increase in capacity by 2050, compared to 2033 levels. For PtL SAF estimations, the ambitious high demand and rapid technology deployment (HRT) scenario was taken from the UAE PtL Roadmap developed by the WEF and ICF, which requires 0.39 Mt PtL SAF supply by 2030, and up to 11.24 Mt by 2050. In total, the ambitious scenario estimates up to 950 kton (1,190 ML) SAF production by 2030. This value corresponds to 12.9% of the UAE's 2019 jet fuel consumption.

⁶¹ <https://datatopics.worldbank.org/what-a-waste/>

Ambitious scenario estimates 1,190 ML SAF production by 2030

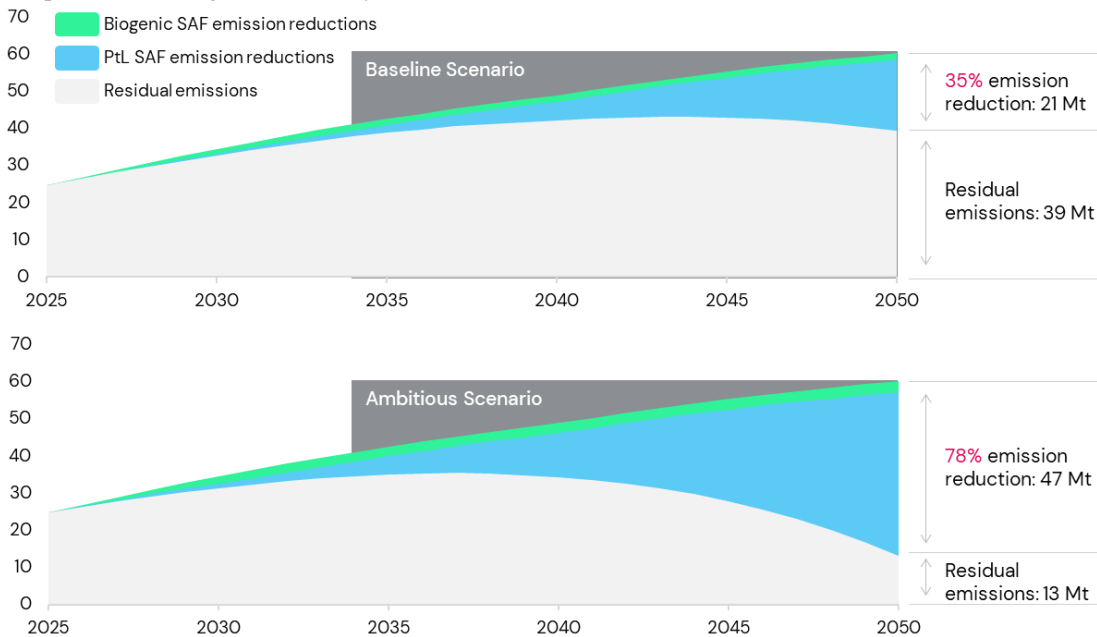
SAF Production, Million Liters



4.1.1 Environmental Benefits

SAF is chemically identical to conventional jet fuel but provides substantially lower lifecycle CO₂ emissions. Key production technologies in the UAE include HEFA, Gasification+FT, PtL, and potentially AtJ, which are expected to achieve emission reductions of well over 80%. PtL could achieve close to zero carbon emissions as production transitions from PSC CO₂ and blue hydrogen, to DAC and green hydrogen. It is estimated that across the industry, a 35% to 78% emissions reduction could be delivered through SAF utilization by 2050, compared to the business-as-usual scenario. This would equate to achieving a 21 Mt to 47 Mt annual emission reductions by 2050 – in excess of the UAE’s pre-COVID-19 aviation emissions of 29 Mt. Due to limited biogenic feedstock availability, the contribution of biogenic SAF to emission reductions would be limited to 3% - 5% by 2050, with the majority of the emission reductions relying on PtL SAF utilization. By 2050, aviation emissions would still increase in the baseline scenario compared to current levels, however in ambitious scenario they would be even lower than the current levels.

The UAE can achieve 35% to 78% emission reduction through SAF utilization by 2050

CO₂ emissions from jet fuel consumption in the UAE (Mt)

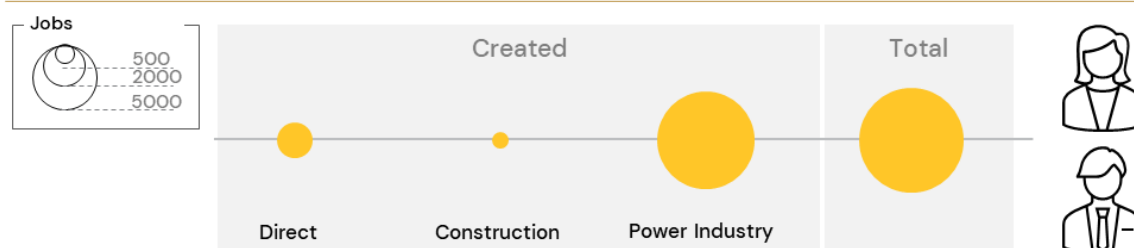
SAF also presents other environmental benefits beyond reduction in CO₂ emissions. The UAE has less than 84,000 km² land area, which makes it a dense country with increased sensitivity for air pollution. Its Particulate Matter (PM) concentrations is already above the WHO guideline values, and increased activities in the airports is expected to add pressure on that. SAF can help reducing the emissions of other non-CO₂ pollutants depending on the number of piston operations in the airports. Considering the high number of non-piston (jet and turboprop aircraft types) operations in the UAE airports due to need for long haul flights, and SAF's ability to be blended up to 50%, hence reduced need for fossil fuel, emissions of CO, SO_x and PM could be reduced up to 11%, 37% and 65% respectively, compared to conventional jet fuel operations⁶².

4.1.2 Economic Benefits

SAF production can also deliver substantial economic benefits to the UAE through investment, employment, and export opportunities. SAF development can serve to create new jobs across the broader value chain while sustaining employment within the aviation industry by ensuring its low carbon growth. Without utilizing SAF, the aviation industry would need to reduce its jet fuel consumption through alternative measures or reduced activity. However, SAF can enable a growing aviation industry to support the UAE's economic decarbonization vision through increased revenue from tourism.

It is estimated that building the SAF facilities required to produce 700 ML SAF by 2030 (baseline scenario) would create up to 18,000 jobs in the UAE by providing employment during the construction and operational stages of the facilities, as well as jobs created across the value chain to facilitate PtL SAF production. By 2050, the ambitious scenario could create and sustain 695,000 to 1,425,000 jobs across the value chain in the process, equal to circa 10% of the population⁶³.

With 700 ML SAF by 2030, up to 18,000 jobs can be created in the UAE



The development of a national SAF industry in the UAE can also retain capital in country, that must currently be spent in others. As described above, CORSIA requires airlines to purchase carbon offsets for a (growing) portion of their emissions from international aviation. The UAE has limited carbon offset projects, which mean that many of the UAE-based airlines will currently look to the international market to purchase sufficient offsets. As the obligation can also be met through SAF use, a domestic SAF industry would allow UAE airlines to channel the capital that would have been spent in the international market to the domestic SAF industry, retaining and further developing the national SAF industry.

⁶² https://nap.nationalacademies.org/login.php?record_id=25548

⁶³ https://www3.weforum.org/docs/WEF_UAE_Power_to_Liquid_Roadmap_2022.pdf

4.2 The UAE SAF Roadmap

This roadmap supports the UAE's 2050 net zero target⁶⁴, alongside with its transformative long-term strategies such as Principles of 50⁶⁵ and Operation 300bn⁶⁶. Although LCAF and other decarbonization measures are considered key enablers for the UAE to decarbonize its aviation industry, this roadmap is focused on the role of SAF in delivering the UAE's long-term targets.

Assessment of the SAF scenarios for the UAE showed that baseline scenario is a feasible and pragmatic target for the UAE with current levels of understanding and technoeconomic dynamics. Therefore, the UAE will aim to produce 700 ML SAF by 2030. 700 ML target is expected to provide substantial environmental and economic benefits. With this target, the UAE is estimated to reduce up to 4.8 Mt CO₂ emissions by 2030 while creating up to 18,000 jobs across the value chain in the process. Delivering this target would require up to five SAF facilities, which translates into one to three additional PtL SAF facilities, beyond the currently planned SBRC's halophytes to SAF and Tadweer's MSW to SAF projects. Tadweer's MSW to SAF project was estimated to deliver the majority of this capacity, although additional facilities may be required if the facility production is meaningfully less than the announced capacity. Prioritizing PtL SAF for export opportunities is expected to provide up to an additional \$1.7bn accumulated export revenue for the UAE by 2030, given half of the target production is allocated for export, for example to the EU. This can be a key non-oil dependent contributor to nation's economy. Inputs for the PtL SAF can be provided through a hybrid approach of utilizing a portion of PSC and blue hydrogen at the early stages, while ensuring high emission reductions and building capacities for DAC and green hydrogen.

This analysis estimates that \$7bn to \$9bn of investment will be required in SAF facilities and the supporting value chain to provide 700 million liters of SAF in the UAE by 2030. This estimate must be considered in the context of three factors:

1. The investment cost to deliver the target 700 million liters of SAF capacity is highly dependent on the pathways utilized, with some (such as HEFA) requiring relatively low capital investment but high feedstock costs, while alternative pathways (such as MSW-FT) require higher capital investment but lower feedstock costs. The profile of feedstock available in the UAE results in a slant in capacity towards facilities and technologies with high capital costs, but these facilities will have commensurately lower operating costs.
2. These facilities will continue to produce fuel for decades after 2030, allowing the investment to be depreciated over many years. Each facility will operate for 20-30 years, and longer with major retrofits. This investment has been calculated to build facilities sufficient for 700 million liters of capacity in 2030, but these same facilities (and investment) will continue to produce 700 ML in 2040 and perhaps even 2050, providing a robust base for the UAE to build on.
3. The unit investment cost is at the higher end of values estimated in other literature as elements of the upstream value chain have been included. For example, the PtL estimate includes the capital cost for the electrolyzers and carbon capture, while alternative calculations may set a different scope and consider hydrogen and carbon to be operational costs. This analysis includes the full scope of investment costs to provide a more complete and pragmatic estimate of the total expected cost

⁶⁴ <https://u.ae/en/information-and-services/environment-and-energy/climate-change/theuaeresponsetoclimatechange/uae-net-zero-2050>

⁶⁵ <https://u.ae/en/about-the-uae/initiatives-of-the-next-50/the-principles-of-the-50>

⁶⁶ <https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/federal-governments-strategies-and-plans/the-uae-industrial-strategy>

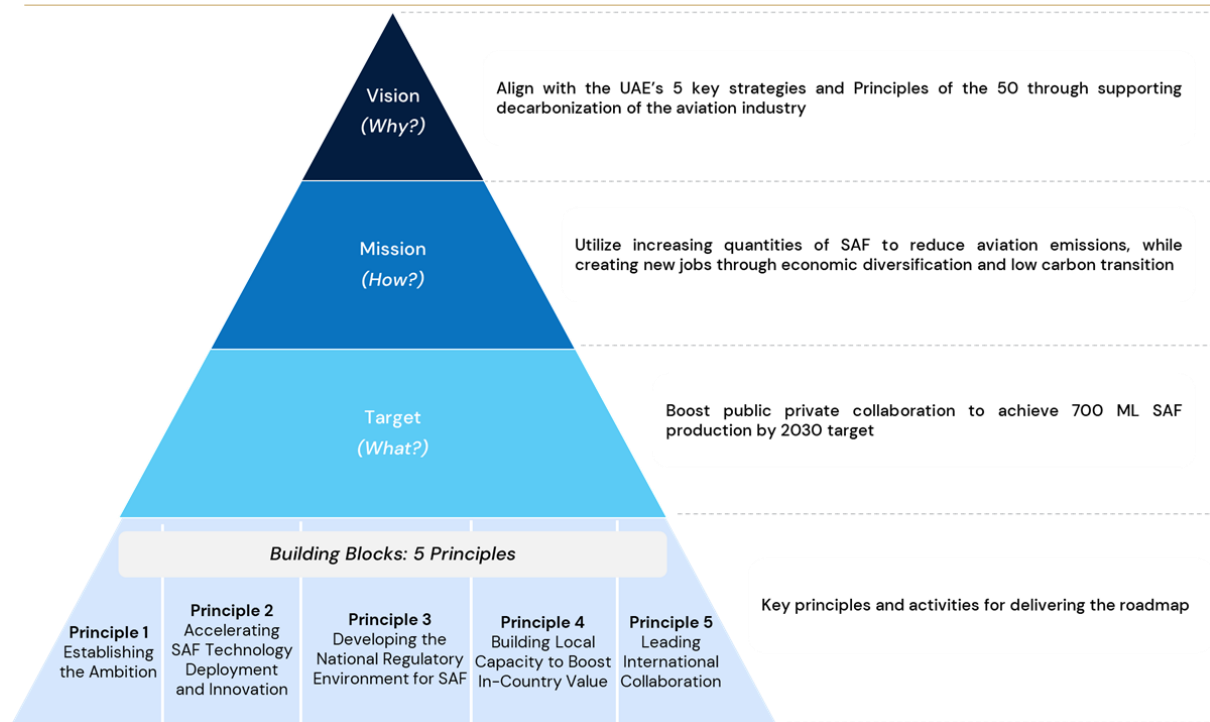
With 700 million liters of SAF by 2030 target, the UAE can both boost low carbon growth of its aviation industry, and can unlock export opportunities



The 700 ML by 2030 target will position the UAE as a regional leader for SAF production and solidify its role within the global SAF industry, and aims to build on 5 principles:

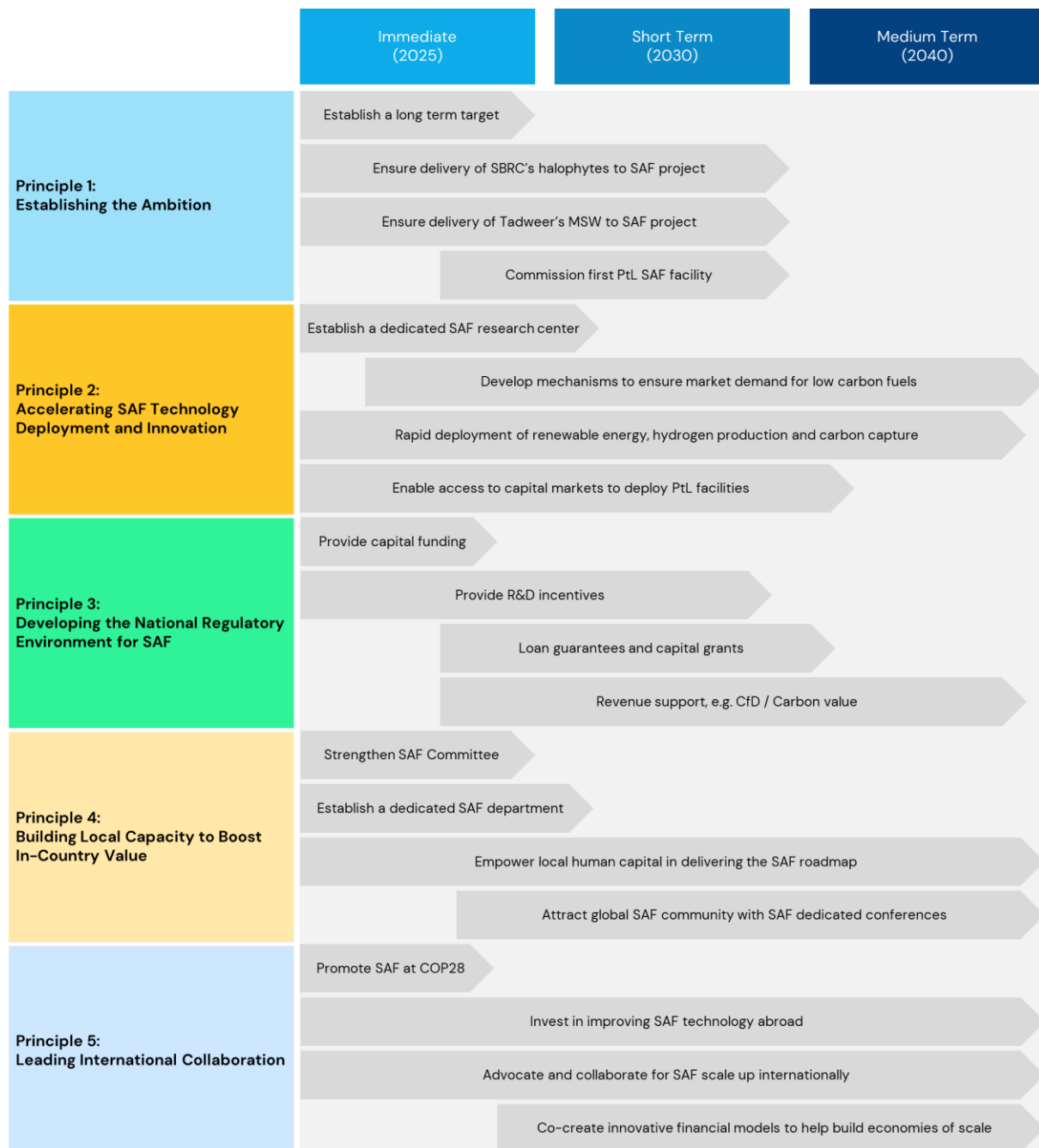
- **Principle 1:** Establishing the Ambition
- **Principle 2:** Accelerating SAF Technology Deployment and Innovation
- **Principle 3:** Developing the National Regulatory Environment for SAF
- **Principle 4:** Building Local Capacity to Boost In-Country Value
- **Principle 5:** Leading International Collaboration

5 Principles will be the building blocks of the UAE SAF Roadmap



4.2.1 Proposed Timeline

Each principle plays a crucial role in delivering the UAE SAF future. They are designed to work in harmony, to ensure all aspects of delivering the roadmap is covered. Establishing the roadmap will also set the scene for establishing a long-term plan and ensuring the delivery of ongoing projects. This is supported by accelerating SAF deployment and innovation, and regulatory environment, which are crucial in deploying advanced technologies, such as PtL. Building local capacity through institutions, increased public private collaboration and empowering local human capital are key contributors to the UAE's economy. Initiatives like participating in the CST SAF Ambassadors program and hosting COP28 will underpin the UAE's leading role in international SAF agenda.





" Achieving the goals of the United Arab Emirates for the next 50 years, and its quest for global leadership in various fields, especially clean energy, in addition to sustainable development ambitions, requires joint work between the various Government agencies, along with the private sector, and redoubled efforts to innovate and implement innovative solutions and optimize the use of modern technology that would accelerate the achievement of the UAE Centennial 2071"

H.E. Engineer Sherif Al Olama

Undersecretary of the Ministry of Energy and Infrastructure for the Energy and Petroleum Sector

5 Delivering the Roadmap

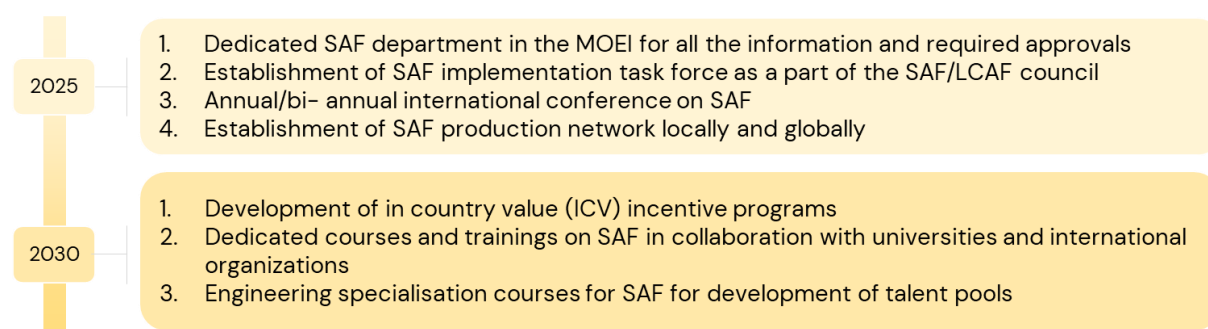
Five principles presented in the previous chapter will serve as key measures to ensure the delivery of 700 ML SAF by 2030 target. This chapter presents detailed insight of how to deliver the roadmap through building a coherent knowledge base, exploring human and financial capital, and by establishing a monitoring and evaluation system. The sections below outline short to medium term strategies which can contribute to the development of a SAF compliance plan while providing a detailed understanding of policy instruments and government support.



Capacity Building

This report highlights the feedstock, technology, economic and employment opportunities for SAF in the UAE. Achieving these opportunities will require a robust governance structure, and skilled workforce. The UAE has a unique head-start with a workforce highly experienced with liquid hydrocarbons, and developing experience producing renewable electricity, low-carbon hydrogen, and carbon capture. Further steps can consolidate and build on these skills and capabilities to ensure the UAE becomes a regional hub for low carbon aviation. Establishing educational courses, engineering specializations, a SAF specific government department as a part of the Assistant Undersecretary for Oil, Gas and Mineral Resources, and SAF conferences are just some of the steps the UAE can take to build its capacity to develop SAF.

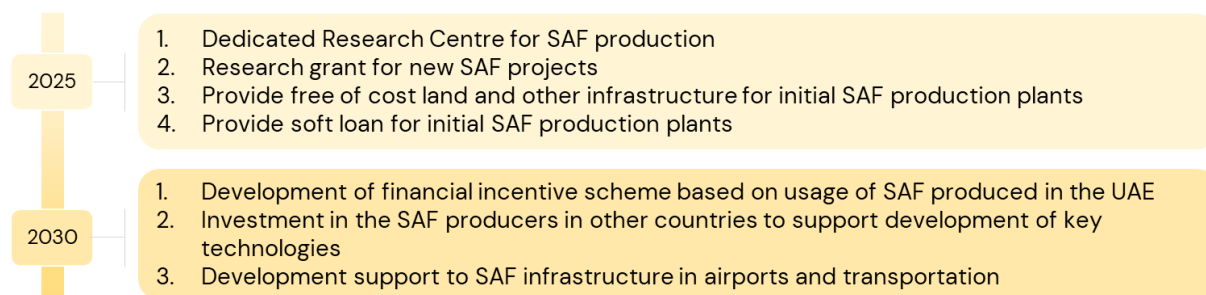
Capacity Building



Financial Support for RD&D and Production

RD&D is a key enabler for SAF scale up in the UAE, which can be boosted with dedicated research efforts. High RD&D, capital expenditure (CAPEX), and feedstock costs are some of the inhibitors preventing widespread SAF development and use. The implementation of innovative SAF fiscal support packages can serve to alleviate some of these barriers to growth. Providing financial support for SAF RD&D and production will enable the UAE to create a SAF ecosystem which supports and attracts sustainable research and industrial activity for the purposes of achieving sustainable aviation.

Financial Support for RD&D and Production

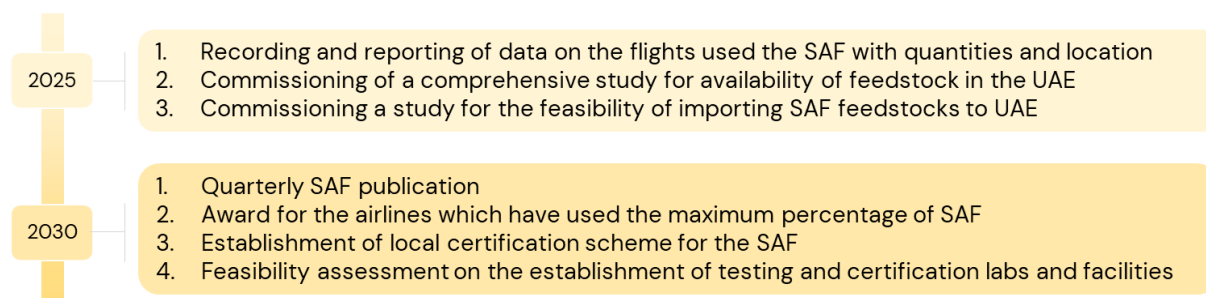


Monitoring and Evaluation

The SAF sector is technologically dynamic and politically responsive. It will be essential to develop robust monitoring and evaluation tools, allowing the roadmap and strategy to adapt as technologies and markets evolve.

A robust system for monitoring the progression of the UAE's SAF industry will be required to ensure that the Roadmap is being successfully implemented. The ability to identify developmental, technological, and funding shortcomings is crucial if targets are to be met. Through a transparent evaluation system, adjustments and updates to the Roadmap can be adequately crafted and subsequently implemented.

Monitoring and Evaluation



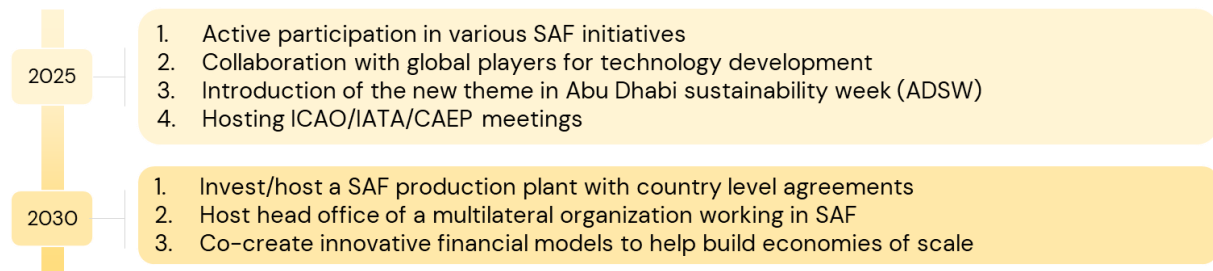
International Cooperation

The UAE's commitment to SAF development, highlighted by its ambitious roadmap, will put the nation as a global leader within the sustainable aviation transition. Slated to host COP28 in 2023, the UAE is uniquely positioned to lead global discourse on SAF production and utilization as part of wider climate change action.

Beyond COP28, by leveraging its world leading, international aviation sector, the UAE can host ICAO, IATA, and CAEP conferences, reinforcing its position as an authoritative voice within the sustainable aviation movement.

As a global educational, financial, and technological hub, the UAE can facilitate the global proliferation of SAF best practice, aid in knowledge transfer, and invest in RD&D. The opportunity to collaborate with private and public sector partners to further SAF development, production, and use will not only benefit the UAE's aviation industry, providing a mechanism to secure sustainable sector growth, but it will also solidify the UAE's unwavering commitment to mitigate the effects of global warming.

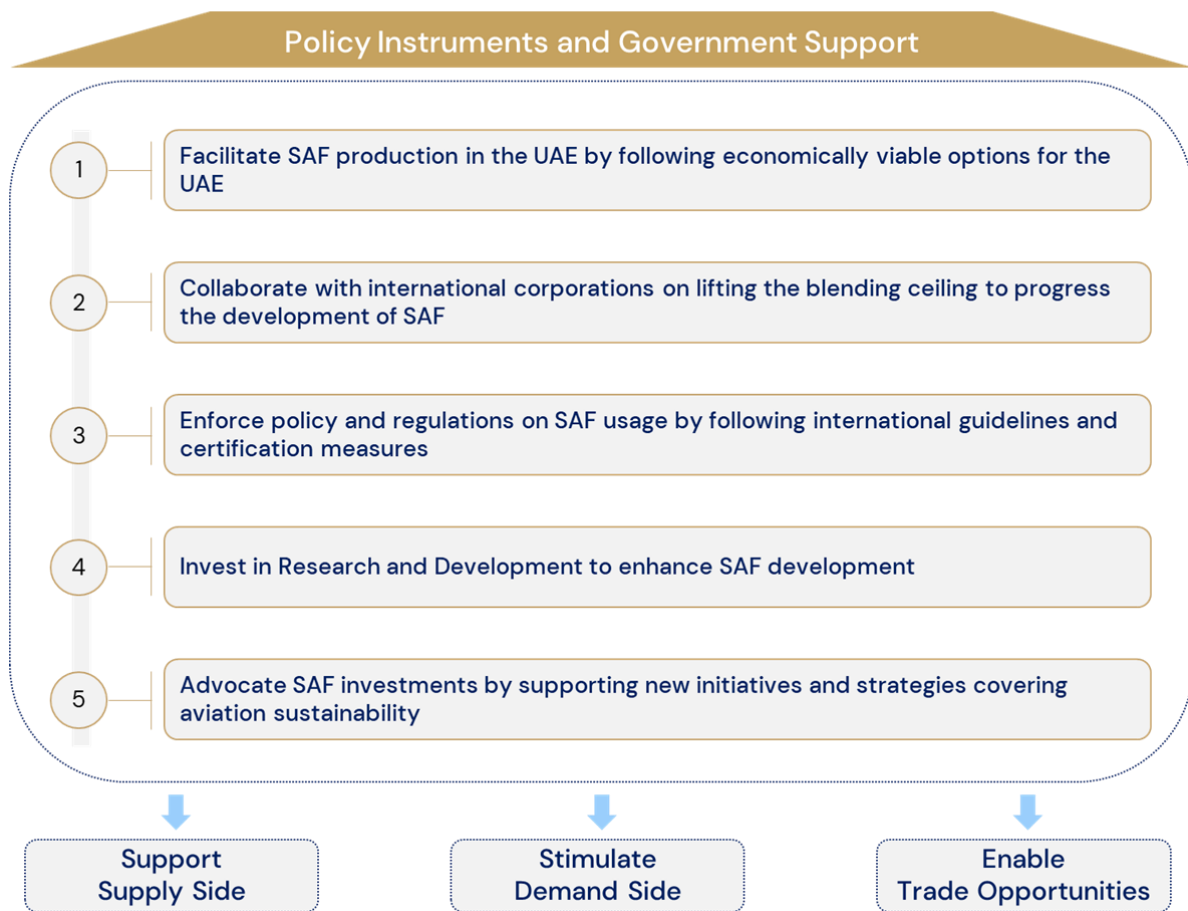
International Collaboration



5.1 Policy Mechanisms and Regulatory Environment

There is a variety of policy instruments which could be utilized to scale up SAF capacities, which can be broadly categorized into supply-side and demand-side measures. Positive incentives are likely to be the most appropriate tools to scale up early stage SAF facilities in the UAE, given the specific feedstock and technology opportunities associated low level of technology maturity in the country, and the. This section provides a top-level overview of global SAF policies applicable to the UAE.

Supply, demand and trade oriented hybrid policies can be used to deliver the UAE's 2030 SAF target

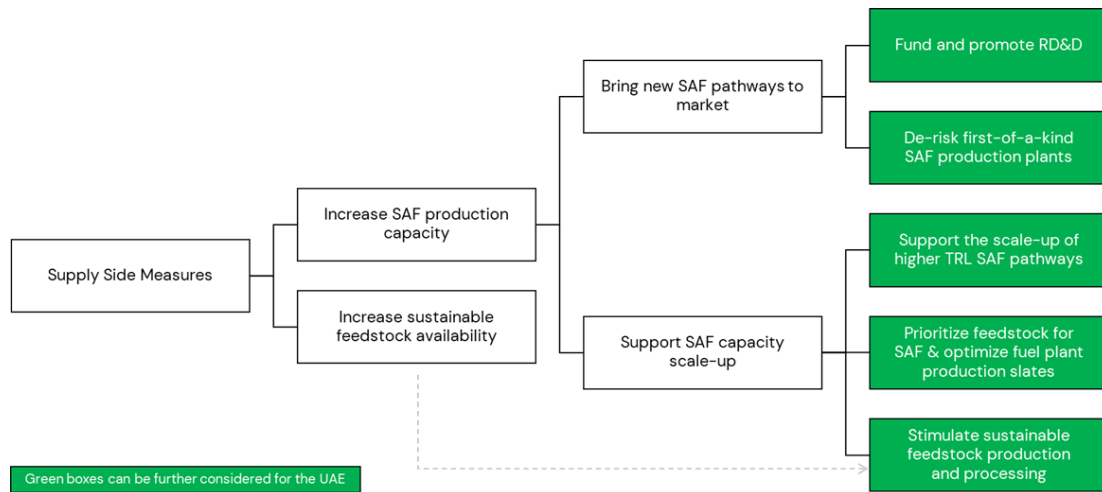


5.1.1 Supply-side Measures to Support SAF Deployment

Supply side measures focus on increasing production capacity and feedstock availability in an effort to catalyze the sustainable supply of SAF. To fund and promote RD&D, dedicated innovation funds or financing packages will be required to support SAF production pathways at a lower TRL. Moreover, creating innovation centers and research institutions, similar to the UAE's SBRC, is essential to accelerate SAF development knowledge.

It is important to de-risk first-of-a-kind (FOAK) SAF production plants by reducing the price gap between SAF and CAF. Launching a government-backed price floor to provide a combination of up-front capital grants, low-interest loans and favorable tax treatment for the building and running first-of-a-kind plants can serve to accomplish this. Furthermore, an initiative aimed at limiting the volatility of SAF feedstock prices and production routes can reduce the price gap between SAF and CAF. Funding and promoting RD&D is essential to enhance the production processes as it increases conversion yields and lowers manufacturing costs. Stimulating sustainable feedstock production and processing can arise through the granting of tax exemptions, investing in comprehensive municipal waste collection infrastructure, facilitating access to public credit, providing training for SAF bio-feedstock producers, and obtaining tax exemptions on the income generated from sustainable crops when used as feedstock. Many of these instruments are well suited for the UAE context, yet mechanisms should be further tailored in line with specific targets to ensure delivery of the 2030 SAF target.

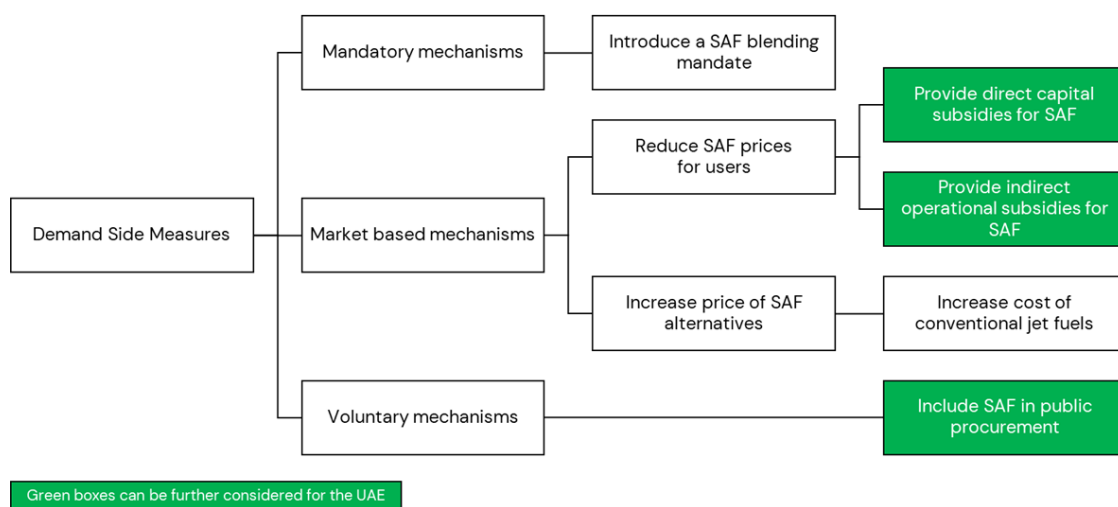
Supply side measures can be utilized to scale up SAF production



5.1.2 Demand-side Measures to Stimulate SAF Uptake

Demand side measures are instruments which stimulate voluntary, mandatory, and market-based demand by setting standards and mandates. In the case of the UAE, voluntary and market-based mechanisms can be enablers for stimulating demand for SAF, and in the process to encourage SAF investment through the creation of the market. Voluntary mechanisms based on utilizing SAF within the public sector by imposing a minimum procurement quantity for government flights can be a useful policy tool to scale up SAF demand. Market-based mechanisms include the reduction of SAF prices for users by providing direct tax incentives. This could provide benefit to off-takers, producers, and blenders alike.

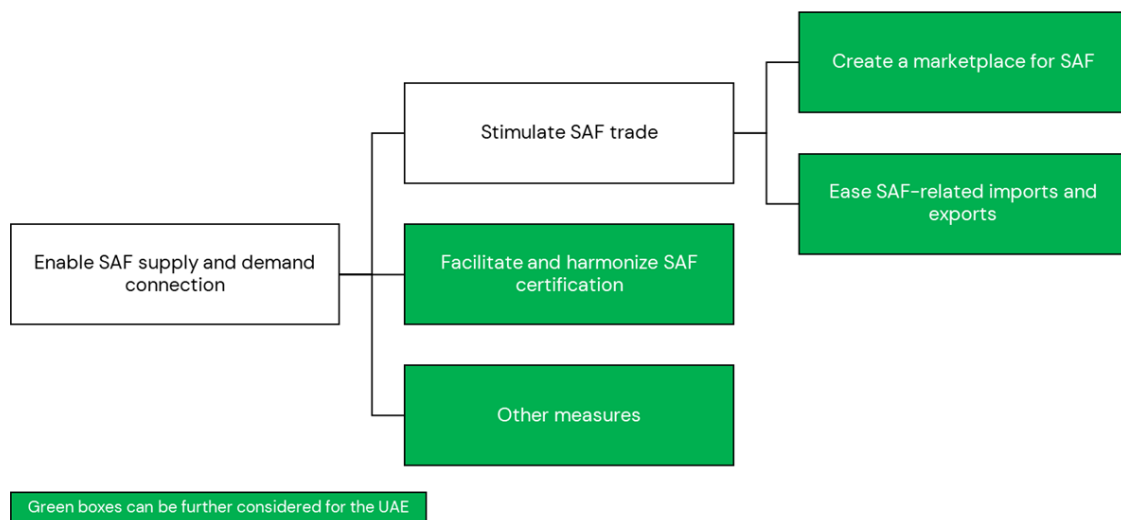
Demand side measures can be utilized to stimulate SAF market



5.1.3 Enabling Measures and Systems to Facilitate SAF Scaling

Enabling measures consists of supply and demand tools which serve to mitigate scaling barriers while simultaneously promoting trade. To stimulate SAF trade, a marketplace for SAF must be created by recognizing/establishing an environmental attribution ownership system for certificates and credits trading. Additionally, adherence to a global accounting mechanism using chain of custody systems such as blockchain is important. To facilitate and harmonize SAF certification, it will be important to adopt feedstock sustainability standards which are robust and globally recognized. Finally, other measures that will support SAF scale up include supporting existing SAF production technologies, establishing a dedicated government entity for SAF to support and monitor the activities necessary for SAF adoption, and creating climate performance labelling for airlines to develop green lead markets.

Enabling measures can be utilized to promote further SAF export



5.2 Institutional Roles

Delivering this roadmap will require a collaborative effort. Strong public private collaboration, cross-ministerial support across the government and state-owned enterprises will be crucial to deliver the targets. Each organization will have a unique role in supporting the 5 Principles, and only with their continuous collaboration the roadmap can be fully delivered.

Stakeholder	Role	Responsibility in Delivering the Roadmap	Principles Supported
Ministry of Energy and Infrastructure	Government	Implement national SAF strategy in collaboration with other stakeholders	1,2,3,4,5
General Civil Aviation Authority (GCAA)	Government	Implement national SAF strategy in collaboration with other stakeholders	1,2,3,4,5
Ministry of Climate Change and Environment	Government	Support delivery of the SAF roadmap	3,4,5
Ministry of Industry and Advanced Technology	Government	Support delivery of the SAF roadmap	2,4,5
Ministry of Economy	Government	Support delivery of the SAF roadmap	2,4,5

Stakeholder	Role	Responsibility in Delivering the Roadmap	Principles Supported
Ministry of State for Foreign Trade	Government	Support delivery of the SAF roadmap	5
Ministry of State for Financial Affairs	Government	Support delivery of the SAF roadmap	2
Ministry of State for International Cooperation	Government	Support delivery of the SAF roadmap	5
Abu Dhabi Future Energy Company (Masdar)	State-owned enterprise (SOE)	Implement national SAF strategy in collaboration with other stakeholders	1,2,3,4,5
Abu Dhabi Waste Management Centre (Tadweer)	SOE	Deliver MSW to SAF Project in collaboration with other stakeholders	1,2,4
Abu Dhabi National Oil Company (ADNOC)	SOE	Support delivery of the SAF roadmap, investigate LCAF opportunities	2,4
Dubai Electricity & Water Authority (DEWA)	SOE	Ensure readiness of SAF supply chain	1,2
Emirates National Oil Company (ENOC)	SOE	Ensure readiness of SAF supply chain	1,2
DP World	SOE	Ensure readiness of SAF supply chain	1,2
Khalifa University (SBRC)	Academic Research Institution	Deliver halophytes to SAF Project in collaboration with other stakeholders and unify national SAF production RD&D	1,2,4,5
Etihad	National flag carrier airline	Support delivery of the SAF roadmap	1,3,4,5
Emirates	National flag carrier airline	Support delivery of the SAF roadmap	1,3,4,5
Boeing	Aircraft OEM	Support delivery of the SAF roadmap	1,4,5
HSBC	Financial institution	Provide innovative financial tools to support SAF projects	2,5
Dubai Airports	Airport	Ensure readiness of the SAF infrastructure in collaboration with other stakeholders	1,2,4,5
Dubai Carbon Centre of Excellence	Local think-tank	Provide SAF research	1,2,3,5

The Role of Regulators and Government

The regulatory sector will play a key role in delivering the 700 ML target, by designing and enforcing policies on SAF development. Through previously mentioned policy measures, regulatory bodies across the UAE government can provide substantial contribution to this target.

The Role of Fuel Suppliers

Fuel suppliers will provide one of the most crucial roles in delivering the UAE's SAF roadmap, if not the most crucial role as producers of the fuel. In collaboration with other stakeholders, commissioning required facilities timely and operating with high availabilities will be key enablers for achieving the 2030 SAF target. If the SAF is delivered to the airport blended, there is no need for extra infrastructure at the airport, since the product would enter the airport already certified as D1655 jet fuel. Therefore, another role of fuel suppliers would be to blend and certify the SAF blended jet-fuel so that it can be delivered to the airport and used by airlines. This can minimize transportation costs, infrastructure, and improve sustainability credentials.

The Role of Airlines and Airports

The core aviation sector should encompass SAF in their process flow and infrastructure to provide a smoother transition for the technology. Although airlines will be the ones to utilize SAF in their flights as a drop-in fuel paying the SAF premium, airports will also play a key role in enabling SAF utilization through fuel infrastructure. Although blended SAF will have the same properties with CAF as a drop-in fuel future development plans of airports and their fuel supply infrastructure should nevertheless take SAF supply into account.

The UAE's airports can absorb the volumes of SAF generated with minimal impact to infrastructure, given the well-developed oil distribution infrastructure, storage capability of the existing fuel farms and high demand for aviation fuel. There is an inherent synergy for SAF within the UAE, a nation state with a strong aviation industry coupled with beneficial conditions for generation of SAF.

The Role of Financial and Research Institutions

While the establishment of a favorable regulatory framework for SAF adoption is key, accelerating the transition will require financial investment by all the players involved. Financial institutions play a key role in facilitating the capital flows required to enable early adoption.⁶⁷

Through continuous research and development, academy has been supporting SAF development in the UAE, especially through Khalifa University's SBRC. Delivering the SEAS project will be key in achieving the UAE's SAF targets. Additional to that, a dedicated center of research excellence can play a key role in unifying SAF RD&D efforts in under a single strategic research agenda and vision.

⁶⁷ Please visit Appendix for detailed assessment of the financial mechanisms to support on SAF implementation in the UAE

" More than at any other point in recent history, fundamental changes to the economic model of resource-rich countries look unavoidable. The future will look very different from the past... first movers – countries that take a proactive approach to this – could do especially well."

Fatih Birol,

Executive Director, International Energy Agency



Dubai

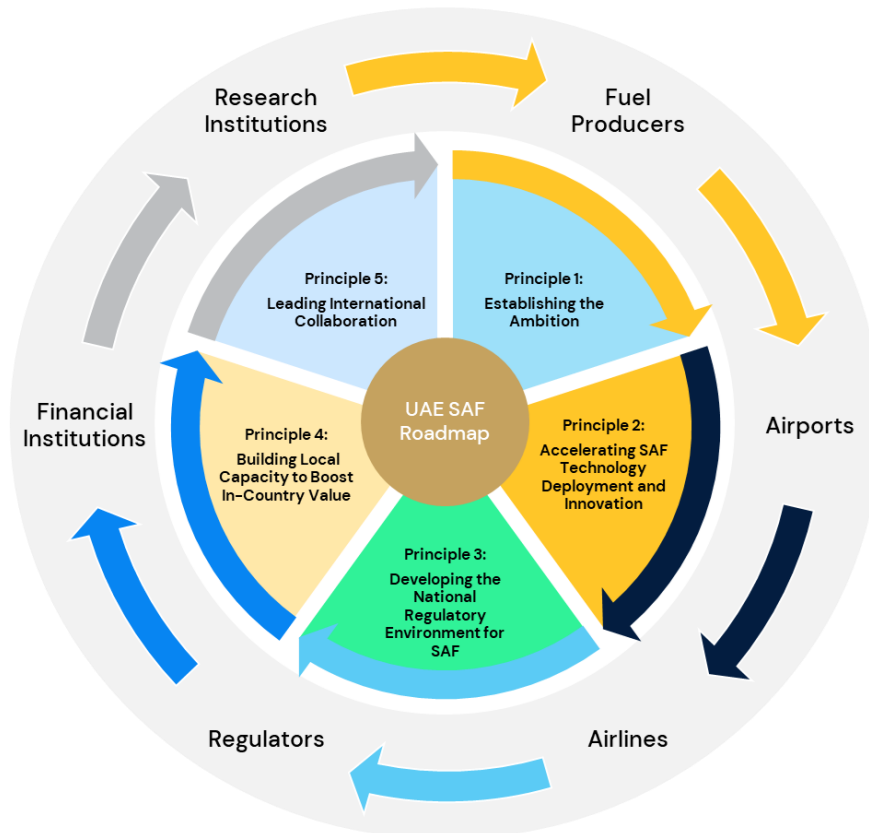
Photo by Fredy George Antony

6 Closing Remarks for Roadmap

Scaling SAF will be an important complement to the UAE's Energy, Economic and Climate goals. Decarbonizing international aviation will be a challenge but the production and subsequent utilization of SAF, guided by the UAE's 5 SAF principles, offers a technically feasible and economically viable means to achieve this ambition.

In pursuing wider climate stewardship and leadership activities the UAE has taken a proactive role in mitigating its footprint through various sustainability initiatives and investments. Supporting the development and deployment of SAF as a key national priority would serve to reinforce the UAE's position as a regional aviation and sustainability leader. Accomplishing this ambition will require that barriers to growth be addressed in order to secure investment and commercialization. The substantial gap between the cost of jet fuel and SAF creates a need for large capital investments in production infrastructure as signaled by the ICAO's Committee on Aviation Environmental Protection. Therefore, it is essential for the UAE to develop an appropriate environment to incubate to industry, with strong support for research and development, immediate support to kick-start the industry, and the development of a supportive policy environment to ensure its long-term success. Seizing this opportunity will grow the UAE's exports, create new jobs and boost investment in science, technology, and higher education. The value of a UAE based SAF industry will continue to grow as the need, importance, and pace of the energy transition becomes increasingly rapid in the quest to mitigate climate change.

Delivering the UAE SAF Roadmap will require strong public private collaboration across aviation industry stakeholders in harmony with 5 Principles



“The civilized, advanced nation we seek to build and the sustainable development that we are keen to achieve both require concerted efforts from all sectors of the community and from all public and private entities and organizations. They require consistent and harmonious work in order to achieve our goals and promote and underpin our nation's status with its distinct role regionally and internationally.”

H.H. Mohammed bin Zayed Al Nahyan

President of the United Arab Emirates and the Ruler of Abu Dhabi



Dubai

Photo by Sahil ibn Sarafudeen

7 Appendix

7.1 Sustainability Criteria for Sustainable Aviation Fuels

To achieve the main goal of emission reductions, SAF must be produced from sustainable feedstocks that significantly reduce GHG emissions on a full life-cycle basis. Therefore, the production must follow strict sustainability criteria for the feedstock, energy inputs and process emission. This should cover the full supply chain and include land-use, waste management and the impact on agricultural feedstocks to avoid incentivizing production of otherwise unsustainable practices or products.

According to the WEF “SAF as a pathway to Net-Zero Aviation” report, a two-step approach is necessary to prioritize feedstocks; first identifying feedstocks that are more sustainable and then quantifying their availability considering further sustainability criteria. The sustainability criteria are currently evolving but usually cover a certain target of GHG emission reductions compared to a fossil fuel baseline. Certifiers like Roundtable on Sustainable Biomaterials (RSB) provide guidance on sustainability criteria of biomass and biomaterial and ISCC provide different certification covering all kinds of bio-based feedstocks and renewables for target markets. When considering biological feedstocks in SAF production, food security and changes in land-use must not be threatened. For example, edible oils and sugars are excluded from being potential feedstocks since more CO₂ is produced than waste and residues-based fuels. Moreover, an important feedstock is the carbon used to produce SAF. In contrast to fossil fuels which is newly introduced to the global carbon cycle, SAF carbon sources should be attained from sustainable alternatives such as Direct Air Capture (DAC), Carbon Capture and Storage (CCS) or Bio-energy Carbon Capture and Storage (BECCS). Those alternatives are especially relevant when considering PtL-Fuels as the question of; where to source the CO₂ from can significantly impact the sustainability of the fuel. Practical availability assessment based on sustainability include conservation measures such as excluding feedstocks produced on land protected for biodiversity and carbon stock protective measures such as unauthorized use of land with high-carbon stock (forests and wetlands). Other criteria to consider include logistics and viability, which emphasize mainly on global feedstock transportation. For example, if a feedstock cannot be transported, the only economic viable option is if the concentration is high enough close to potential production site.

The net climate effect should cover a holistic accounting of all emissions associated with the fuel, including its production methods and feedstock source. It is vital to utilize feedstocks that fulfil the sustainability criteria for SAF to satisfy its purpose. Feedstocks sustaining high GHG reduction while limiting sustainability disputes, should be considered while other cases may require local validation. The list below outlines the existing and upcoming sustainability criteria on SAF adopted by ICAO Council in November 2021. Sustainability criteria for SAF has been defined under the CORSIA, where numerous principles of sustainability were addressed.⁶⁸

1. Greenhouse Gases (GHG)

With respect to greenhouse gas emissions (GHG), under CORSIA, SAF should achieve life cycle emission reductions of at least 10 % compared to a fossil fuel baseline of 89 grams of CO₂ equivalent per megajoule (g CO₂e/MJ). According to EU, to qualify biofuels as renewable

⁶⁸ Retrieved from <https://www.icao.int/environmental-protection/CORSIA/Documents/ICAO%20document%2005%20-%20Sustainability%20Criteria.pdf>

energy sources, fuels must achieve a 65 % greater reduction in emissions against a fossil fuel baseline of 94 g CO_{2e}/MJ.

2. Carbon stock

SAF should not be made from biomass obtained from land with high carbon stock (forest, wetlands, or peatlands).

3. Water

Production of SAF should maintain or enhance water quality and availability.

4. Soil

Soil health should be maintained during agricultural and forestry practices for feedstock production or residue collection.

5. Air

Air pollution emissions should be minimized.

6. Conservation

Production of CORSIA SAF should maintain biodiversity, conservation value and ecosystem services.

7. Waste and Chemicals

Responsible management of waste and use of chemicals should be promoted during SAF production.

8. Human and labor rights

SAF production should respect human and labor rights.

9. Land use rights and land use

Existing land rights and land use rights should be respected.

10. Water use rights

Existing water use rights of local and indigenous communities should be respected.

11. Local and social development

SAF should contribute to social and economic development in regions of poverty.

12. Food security

SAF production should promote food security in food insecure regions.

7.2 Authorization of Use⁶⁹

The General Civil Aviation Authority is responsible for certifying jet engines and airplanes to operate on a fuel that is specified by ASTM. Therefore, any newly developed fuel must meet conventional fuel ASTM specifications and should be approved by ASTM D4054 process to be used in commercial flights. The international protocol for the approval and qualification of SAF involves the following:

- I. Commercial aircraft manufacturers certify that their aircraft will achieve mandated performance and operability aspects when they operate with fuel meeting certain criteria

⁶⁹ Fuel Qualification, Retrieved from https://www.caafi.org/focus_areas/fuel_qualification.html

defined in an internationally recognized specification. If an operator uses fuel that meets this specification, then the aircraft will operate as expected. The most used specification of conventional aviation turbine fuel is ASTM D1655 (Standard Specification for Aviation Turbine Fuels), while other equivalent standards also exist (e.g., DEF STAN 91-091). ASTM D1655 allows for alternative fuels that demonstrate their equivalence to conventional jet fuel, and are listed in ASTM D7566, to be redesignated as D1655 fuel.

- II. New Alternative Aviation Fuel (AAF) must go through ASTM's D4054 Evaluation Process to determine if it is equivalent (either neat or as a blend) to conventional jet fuel. If the fuel is determined to be equivalent, an Annex with the new AAF (including any required blending level) is added to the D7566 Drop-In Fuel Specification. Since the D7566 Drop-In Fuels Specification meets the ASTM Conventional Fuel Specification, the new SAF is approved for use in all existing commercial aircraft.

The certification process is important to ensure a safe and reliable operation of aircraft on alternative aviation fuels.

7.3 Blending of SAF

To advocate for Sustainable Aviation Fuel (SAF) production, the aviation industry agrees that alternative fuels should be blended with fossil jet fuel to the permitted level and used directly in commercial aircraft, engines, pipelines, fuel farms, and all other distribution and storage channels, thus requiring no new, modified, segregated equipment or infrastructure. As a result, the sector has developed rigorous testing requirements to compare the properties of new, alternative jet fuels to petroleum-derived jet fuel, to determine whether a fuel can be considered as "drop-in." This process and the development and management of specifications for alternative aviation fuels are accomplished in the United States by American Society of Testing and Materials International's (ASTM) Committee D02.J0.06 (Emerging Turbine Fuels).⁷⁰ As per ASTM standards, the blending rate is limited to 50% today to ensure full compatibility with aircraft systems and engines of all ages, but in its pure form, SAF already meets all requirements of Jet A/A-1 specification except the aromatics content that makes the blending necessary. Experts expect future aircraft and engine generations to be capable of handling 100% SAF.⁷¹ To further support the transition to producing SAF, several considerations related to the feedstock availability and chosen conversion path are important. The respective feedstock and conversion pathway combinations must achieve regulatory approval through the ASTM since SAF will be utilized as a "drop-in" fuel. This section will address the various SAF pathways, specific opportunities, and challenges depending on feedstock and technology maturity.

7.4 Utilization of SAF

The UAE, which recognizes that the aviation industry is a vital contributor to its economy, is committing to enhance energy transitions as part of efforts to improve its on carbon footprints. The UAE is looking to improve SAF deployment in the aviation sector through investing in the future and strengthening international collaboration to address the challenge of combating CO₂ emissions. This

⁷⁰ Fuel Qualification, Retrieved from https://www.caafti.org/focus_areas/fuel_qualification.html

⁷¹ Retrieved from

<https://www.mckinsey.com/~/media/mckinsey/industries/travel%20transport%20and%20logistics/our%20insights/scaling%20sustainable%20aviation%20fuel%20today%20for%20clean%20skies%20tomorrow/clean-skies-for-tomorrow.pdf>

section will layout the development strategy of SAF utilization in the UAE to support the aviation sector to achieve its emission reduction goals.

7.4.1 Users Monitoring System

Traceability and transparency are important for enabling verification of SAF purchases and sustainability or emissions reduction claims. The transparent accounting method of tracing a batch of fuel through the phases of production, transportation and use is called chain of custody.

There are three main options available for chain of custody:

1. **Physical chain of custody**, where the SAF shall be produced and transported separately i.e., only mixed with the conventional jet fuel near the point of use. This is not feasible due to the small quantity of SAF and requirements for separate infrastructure, would be more costly.
2. **Book and claim** (virtual based on certificates), where the sustainability or environmental attributes are separated from the physical product i.e., SAF. The sustainability attributes are certified in the desired form i.e., tons of CO₂ reduced, kWh of renewable energy used or any other agreed form. The physical SAF is blended with conventional jet fuel for delivery to the airport, while sustainability attributes can be claimed by the operators or users who purchase the SAF.
3. **Mass balance** (mix of physical and book and claim), where a certificate is issued based on the quantity of fuel produced. The SAF can then be blended with conventional jet fuel for delivery to the airport. The fuel supplier can claim up to equivalent amount of SAF for which the certificate is issued.

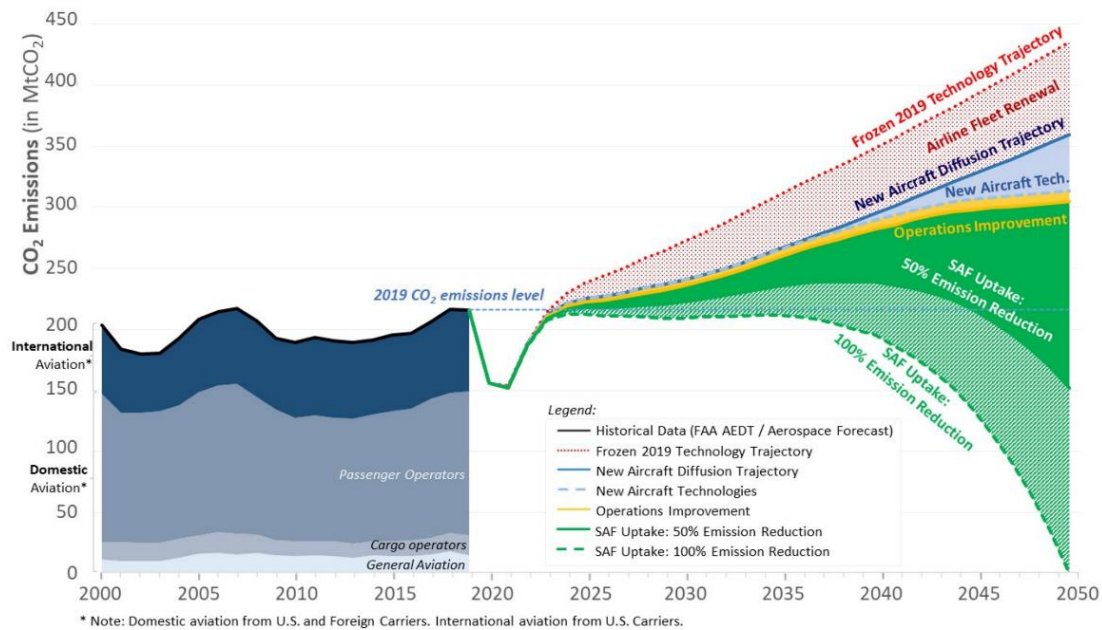
Based on available blockchain technologies in the UAE, it is possible to track the sustainability attributes of the product transparently. By using blockchain technology along with the mass balance model, products can move freely through the supply chain and claims are supported by centrally traded certificates. Preferred method, including a hybrid approach, for the UAE will be further explored.

7.5 International SAF Outlook

In order to align institutional actors and drive activities and goal setting along multilateral consensus work, the global response to address climate change falls under the purview of the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat. The UNFCCC was first established in 1992 and is the parent treaty of the 1997 Kyoto Protocol, its first operationalizing treaty aiming to limit and reduce greenhouse gas (GHG) emissions by industrialized and developing countries (the Kyoto Protocol was later extended upon by the 2012 Doha Amendment)⁷². In 2015, the UNFCCC's Conference of the Parties (COP) adopted the Paris Agreement, which is a legally binding international treaty on climate change. It was adopted by 196 Parties in Paris, on 12 December 2015 and entered into force on 4 November 2016. Its goal is to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels⁷³.

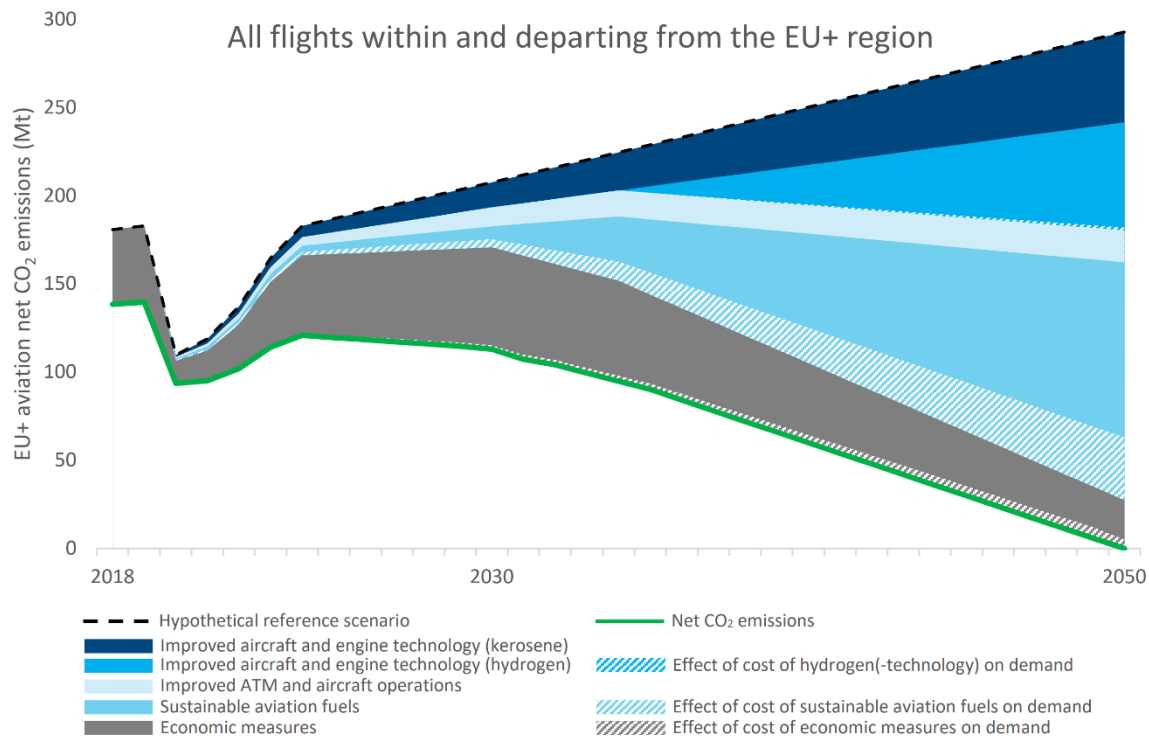
⁷² https://unfccc.int/kyoto_protocol

⁷³ <https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement>



7.5.1 Destination 2050

In the baseline scenario analyzed in the “Destination 2050” plan, 99 Mt CO₂ emissions could be avoided by 2050 via the use of SAF (for both intra-EU+ flights and EU+ originating flights). Their assessment also covers potential emissions reduction due to other basket of measure interventions, such as technology and operational performance improvements, and offsetting via carbon removal projects, in addition to potential reductions due to transport modal shifts impacting future demand (while still forecasting an average compound annual passenger growth rate of 1.4%). Total net emissions in 2030 would have to remain below 13 Mt CO₂ during that year, to positively contribute to European Green Deal targets. In addition, reaching 2050 targets would require SAF production capacity exceeding 32 Mt jet fuel per year, which would account for 83% of total aviation fuel demand as jet fuel during 2050 (at 38 Mt jet fuel /year). This production capacity represents an order of magnitude increase from current production capacity forecast target for 2030 (at roughly 3 Mt jet fuel /year, or 6% of aviation fuel as jet fuel demand for that year), while simultaneously improving overall lifecycle GHG emissions (from 2030 average 72% emissions reduction versus CAF to over 98% in 2050) and more than halving associated average CO₂ abatement costs (from 640 €/t_{CO2} to 312 €/t_{CO2}, 2030 and 2050 values respectively). As with the US action plan, a basket of measures in necessary to achieve the 2050 net zero emissions target for the sector.



7.6 UAE's Climate Change Commitments

Anthropogenic climate change is widely regarded as one of the most pressing issues facing modern society, and the significant and alarming rate with which rapidly escalating effects are experienced as a consequence of its impacts has changed discourse to one stressing the need to avoid at all costs the onset of a worldwide “climate crisis”. Timely, sufficiently encompassing and effective action is needed from global stakeholders across all sectors, as expected climate change impacts are just as widespread. Indeed, the climate emergency must be addressed in the context of its nexus with energy, food and water dimensions, as well as justice, human development and security, or risk both inadequacy of interventions and insufficiency of actions.

The Paris Agreement works on a 5-year cycle of increasingly ambitious climate action carried out by countries. By 2020, countries should have submitted their plans for climate action, known as Nationally Determined Contributions (NDCs).

The UAE is a signatory of the Paris Agreement and submitted its second NDC, with the following major commitments:

1. Reduction of Greenhouse Gas (GHG) emissions by 31% compared to business as usual for the year 2030, with the absolute emissions reduction of about 93.2 million tons⁷⁴ (updated from 23.5% in September 2022).

⁷⁴

<http://wam.ae/en/details/1395303082685#:~:text=In%20its%20updated%20second%20NDC%2C%20the%20UAE%20has%20increased%20its%20greenhouse%20gas%20emission%20reduction%20target%20from%2023.5%20percent%20to%2031%20percent%20by%202030.%20To%20achieve%20this%20goal%2C%20the%20country%20aims%20to%20involve%20five%20priority%20sectors%20%E2%80%93%20electricity%2C%20transport%2C%20industry%2C%20waste%20management%2C%20and%20CCUS.>

2. Increase installed clean power capacity including solar and nuclear to 14 GW
3. Plant 30 million mangrove seedlings to enhance carbon sinks and natural barriers against sea level rise
4. Strengthen climate resilience of priority sectors, including energy, infrastructure, health, and environment, informed by scientific assessment of climate risks

7.7 Role of CORSIA Eligible Fuels

In addition to CORSIA eligible emission units, aircraft operators are expected to reduce their CORSIA offsetting requirements by claiming emissions reductions from the use of CORSIA Eligible Fuels. Such fuels are characterized and regulated by the Annex 16 Volume IV SARP on CORSIA and reflected in five key ICAO Documents, namely:

- CORSIA Eligibility Framework and Requirements for Sustainability Certification Schemes
- CORSIA Approved Sustainability Certification Schemes
- CORSIA Sustainability Criteria for CORSIA Eligible Fuels
- CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels
- CORSIA Methodology for Calculating Actual Life Cycle Emissions Values

Collectively, these documents allow aircraft operators to verify the requirements for a candidate SAF to be considered as a part of the CORSIA implementation, as criteria for sustainability certification schemes (SCS), monitoring, reporting and verification (MRV) and both default actual life cycle emissions of CORSIA eligible fuels are formalized.

Thus, the potential emissions reduction due to SAF use may be estimated for different candidate fuels and amounts employed. To do this, the operator will:

- Use the amounts of CORSIA Eligible Fuels purchased, based on purchase records.
- Use the life-cycle emissions values to determine emissions reduction factors for each CORSIA Eligible Fuel.
- Obtain valid sustainability certification document; and
- Report and claim verified reductions of its emissions from the use of CORSIA Eligible Fuels

The State will calculate the operator's total final offsetting requirements at the end of each compliance period by subtracting the emissions reductions from the use of CORSIA Eligible Fuels from the operator's offsetting requirements during the compliance period.

It is important to note that not all currently explored feedstocks and production pathways have a default life cycle emissions value defined in the ICAO Documents, and that there are other SAF certification schemes across important geographies, such as US (*e.g.*, California's Low Carbon Fuel Standard (LCFS) and EU (*e.g.*, RED II Recycled Carbon Fuels (RCF), and Renewable Fuels of Non-Biological Origin (RFNBO) that need to be considered.

7.8 Aviation Activity and Emissions Growth Forecasting in the UAE

The historical aviation activity was extracted from IATA PaxIS through 2021, and then projected to 2050 using growth expectations from the Boeing Commercial Market Outlook⁷⁵ (CMO). The imminent years (through 2023) were adjusted using a proprietary ICF forecast to capture the pandemic recovery, before reverting to the (pre-pandemic) Boeing CMO forecast. While the CMO forecasts annual growth in MENA of 4.55% from 2018, the pandemic reduces this to a lower average annual growth of 3.41% over 2018-2050. The activity was assessed in capacity (Available Tonne Kilometers, ATK), aggregating cargo and passengers using the standard IATA assumption⁷⁶ that passenger weight is equivalent to 150 Kg, composed of 100 Kg for each passenger and baggage, and 50 Kg for the seat, fittings, and consumables. The analysis estimates that the volume of jet fuel consumed by flights refueled in the UAE will double by 2050, from 7.9 million tonnes in 2019 to 15.9 million tonnes in 2050.

The fuel burn per ATK was projected using analysis conducted by the ICAO for the evaluation of a long-term aspirational goal, detailed in the Technology subgroup report⁷⁷ (Appendix M3). This provides fuel burn in Kg fuel consumed per ATK for four aircraft categories, although given the lack of turboprop and regional jet activity in the UAE, only narrow body (NB) and wide body (WB) data was relevant. Over 2012-2019 the ATK split for flights originating in the UAE has remained steady at 12% NB and 88% WB, and the fuel burn per ATK projection was weighted using the same split through 2050. The central scenario (“medium progress”) was used, which provides a conservative baseline compared to the higher level of ambition underlying this PtL analysis. The central scenario also includes a penetration of advanced concept aircraft (ACA) with a 10% reduction in energy consumption per ATK, and the analysis used the central assumption that these aircraft composed 5% of the UAE fleet by 2040, and 50% by 2050. This resulted in an average annual reduction in fuel burn per ATK of 1.17% between 2019-2050, which is slightly above the global average, as the ICAO projections assume a greater reduction in fuel consumption per ATK for WB compared to other aircraft categories. This may be a conservative assumption for the UAE-based airlines, with the premium business model of Emirates and Etihad combining with the higher growth assumption for the UAE in the CMO (4.55%, vs global 4%) to result in a greater number of new deliveries to the country, keeping the average aircraft age lower than the global fleet and ensuring technology efficiencies are rapidly incorporated into the domestic fleet.

Combining the activity recorded by IATA with the ICAO fuel burn per ATK allowed the estimated historical consumption to be compared to recorded consumption. Over the past 5 years (2015-2019) the actual consumption was 6.3% higher than the estimated consumption. This is likely because the ICAO analysis uses a modern A350-900 as the reference WB aircraft and provided fuel consumption per ATK based on the aircraft design range, and both factors will lead to a lower fuel consumption than reality. To accommodate this, the historical and projected values were adjusted by +6.3%, ensuring the historical calculated values reconciled to the recorded values.

This results in an increase in ATK from 40 billion in 2018 to 117 in 2050 (+192%), which is slightly offset through a reduction of adjusted fuel consumption from 0.027 Kg/ASK in 2018 to 0.019 Kg/ASK in 2050 (-27%), and cumulative operational efficiencies of -6%. The total impact is an increase in fuel consumption from 7.9 Mt in 2019 to 15.9 Mt in 2050, which is almost exactly doubling. This can be

⁷⁵ <https://www.boeing.com/commercial/market/commercial-market-outlook/>

⁷⁶ One column manual according to PSB standards ([iata.org](https://www.iata.org))

⁷⁷ <https://www.icao.int/environmental-protection/Pages/LTAG.aspx>

compared to the historical UN data which records an increase by half (+47%) in just 6 years between 2012-2018 and shows that while this analysis projects a significant increase in fuel consumption, it is meaningfully below the historical growth.

In 2019, the aviation jet fuel consumption is equivalent to 7.7% of primary energy consumed in the UAE. The jet fuel consumption in 2019 is estimated at 7.9 Mt, and assuming 44 MJ/Kg, the energy consumed is 0.35 EJ, increasing to 0.70 EJ in 2050. The BP Statistical Review of World Energy 2021⁷⁸ gives the total 2019 primary energy consumption in the UAE at 4.55 EJ, including 2.6 EJ from natural gas (primarily for electrical generation), 1.9 EJ from Oil (primarily for transportation), and just 0.04 EJ of renewables on an input-equivalent basis.

Therefore, the 2019 jet fuel energy consumption is equivalent to 9x the 2019 primary energy from renewable sources, and the projected 2050 jet fuel energy consumption of 0.70 EJ would be equivalent to 18x the 2019 renewable energy input. Given the intermittency of renewables and the energy losses when converting electrical energy to liquid hydrocarbons, this illustrates the considerable increase in installed renewable capacity that will be required to decarbonize the UAE electrical grid and aviation industry.

The well-to-wake emissions from the UAE jet fuel consumption in 2019 are equivalent to 30.8 Mt CO₂e, using the ICAO fossil fuel baseline of 89 gCO₂e/MJ. This is equivalent to 11% of the UAE emissions from oil, gas, and coal consumption of 270 Mt CO₂e in the same year. If the other UAE sectors follow a linear trajectory to the net zero by 2050 target, the projected baseline aviation fuel emissions will contribute a third of total emissions shortly after 2035, and half of national emissions by 2040 – and considerably more if the aviation industry grows faster or fails to achieve the assumed improvements in technology and operations

7.9 Detailed Assessment of the Financial Instruments

7.9.1 Green Loans

Green Loans refer to loans that have characteristics aligned with the four pillars of the Green Loan Principles. The key pillar is that loans are made available to fully or partially finance/re-finance new or existing eligible Green Projects. The four pillars are:

1. **Pillar 1: Use of Proceeds.** The utilization of the loan proceeds must be for green projects
2. **Pillar 2: Process for Project Evaluation and Selection.** The borrower should communicate to the lender what their environmental sustainability objectives are and how they have assessed the project as being green/sustainable.
3. **Pillar 3: Management of Proceeds.** The borrower should appropriately track the loan proceeds to ensure transparency and integrity in the use of the proceeds.
4. **Pillar 4: Reporting.** The borrower should report on the use of proceeds and the progress of the project to the lender on an annual basis, or until the funds are fully drawn

⁷⁸ <https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-full-report.pdf>

The financing of SAF development and implementation through a green loan mechanism could potentially fall under two categories of use of proceeds: Clean Transportation and Pollution prevention and control, including reduction of air emissions and greenhouse gas control. Specific details will need to be agreed for each particular case.

7.9.2 ESG or Sustainability Linked Loans

Sustainability Linked Loans (SLL) aim to facilitate and support environmentally and socially sustainable economic activity and growth by linking a borrower's cost of capital to ESG/sustainability metrics. The Sustainability Linked Loan Principles are voluntary recommended guidelines for SLLs issued by the global loan market associations in 2019, with a revised new guidance launched in May 2020. The SLL can be made available under Term Loan Facility, Revolving Credit Facility, Hire Purchase, Leasing and Asset Finance, which incentivizes the borrowers to achieve ambitious, pre-determined sustainability performance targets (SPT). The SLL set out a framework, enabling all market participants to clearly understand the following four core components:

1. **Pillar 1: Borrower's overall ESG strategy.** The borrower of a SLL should clearly communicate to its lenders its sustainability objectives, as set out in its ESG strategy, and how these align with its proposed SPTs
2. **Pillar 2: Target setting** – measuring the sustainability of the borrower. The SPTs should be ambitious and meaningful to the borrower's business and should be tied to a sustainability improvement in relation to a predetermined performance target benchmark. Data for the benchmark should be based upon recent performance (6-12 months) and can be internal or external but must be meaningful over the life of the loan. Borrowers are encouraged to seek a third-party opinion on the appropriateness of the SPTs, but this is not always mandatory.
3. **Pillar 3: Reporting.** Borrowers should maintain and make readily available up to date information relating to their SPTs. Such information should be provided to participating institutions at least once a year, and where possible, borrowers should be encouraged to publicly report information relating to their SPTs.
4. **Pillar 4: Review.** The Borrower should seek independent external review of its performance against its SPTs and report to the Lender over the full tenure of the loan. Frequency of review should be at least once a year (agreed on a case-by-case basis).

7.9.3 Debt Issuance: Green Bonds/Sukuks and Sustainability Linked Bonds

For those cases where debt is a preferred option to direct lending from banks, the issuance of bonds can potentially be used to finance SAF development and implementation. Green bonds/sukuk are similar to plain vanilla bonds, with the additional requirements of defining the use of proceeds (similar to the green loans) and demonstrate compliance through verification and reporting. Sustainability Linked Bonds (SLBs), similarly to the SLLs have requirements on the selection of SPTs that should be ambitious and material, as well as on the reporting and verification of the borrower's performance against them.

The table below summarizes key characteristics of ESG/sustainability linked products compared to green products. While it refers to bond issuance, there are clear similarities with the green loans and SLLs.

Key Characteristics of ESG vs. Green Products

	Sustainability Linked	Green: Environmental Objectives
Size	- No size restrictions - Benchmark recommended	- Not flexible - Subject to Projects Identified (= or > than issue size) - Benchmark recommended
Tenor	- Not flexible - Tenor has to be longer than the Sustainable Performance Target deadline year – and has to allow enough time to prove the goals have been reached, information is collected, etc.	- Flexible - Full curve available, depending on markets
Projects	No projects required; however, investors will ask what investments are being made to achieve the set Sustainability Performance Targets	Finances projects that address key environmental objectives
Framework	Not necessary, but recommended	Required
Pros	- No restrictions on Use of Proceeds - Company-level performance on a key sustainability target - Can leverage existing Reporting on the Target Goals, with no material additional work post-issuance - Innovative and new structure	- Strong profiling for environmental projects – can include the full spectrum of efforts that the issuer is undertaking - Best-efforts basis, no financial exposure
Cons	- Tenor is not flexible (has to be longer than Target Goals year) – limits the use of targets unless interim targets can be set - Target is tied to the most material parts of your sustainability activity	- Limits the size of an issuance, given that it must be tied to specific expenditures - Additional, bond-specific reporting required on allocation and impact

7.9.4 Transition Finance

Transition finance means any form of financial support that helps high-carbon companies start to⁷⁹ implement long-term changes to become greener. It bridges the gap between traditional and sustainable financing as businesses begin the journey to net zero.

Since the signing of the Paris Agreement, green finance has gained substantial traction. While new initiatives take root in financial centers around the world, the urgency of climate action requires that ambition moves up a gear. Transition finance has the potential to bring the highest greenhouse gas emitters in from the cold. At the lower bound, the transition finance market today is worth some USD 800 billion. It might be many times that size in the years ahead if a broader set of actors and activities are included.

Deep decarbonization of the global economy will not occur without the highest emitters (both companies and countries) getting on board. Adoption of transition finance principles within banks and other financial institutions must be accompanied by appropriate investment policies.

⁷⁹ <https://www.hsbc.com/insight/topics/why-transition-finance-is-essential>

Adoption of the EU Taxonomy Regulation in June of this year has accelerated discussion about global investment standards. While the EU taxonomy does not directly tackle the issues associated with non-green assets, it suggests that “by establishing ‘brown’ criteria, the Taxonomy would effectively create three performance levels within the Taxonomy structure: substantial contribution (green), significant harm (brown, or perhaps red) and a middle category of neither substantial contribution nor significant harm”.

While the EU taxonomy does not specifically define transition finance, it identifies transitional activities as those “making a substantial contribution to climate change mitigation.” The Taxonomy Regulation identifies three conditions for an activity to be included as a transitional activity: that it (i) has greenhouse gas emission levels that correspond to the best performance in the sector or industry; (ii) does not hamper the development and deployment of low-carbon alternatives; and (iii) does not lead to a lock-in of carbon-intensive assets, considering the economic life of those assets.

We may soon reach the limit of the “use of proceeds” model of green finance mentioned above to drive change in the financial system. Evaluating green activities separately from the performance of the entire firm (or even, the entire country) cannot continue indefinitely. With the right set of standards, transition finance can help fill the gaps in emerging investment taxonomies and leading to more precise boundaries between good, bad, and everything in-between.

7.9.5 Green Trade Finance

Green Trade Finance is a proposition where a trade finance facility (of funded products such as trade loans and receivables finance) is made available to exclusively fund environmentally sustainable trade activities (eg. purchase, supply or trading, which can be evidenced by underlying trade transaction documents) and adhering to the Green Loan Principles (GLP).

The GLP have been developed to promote the integrity and transparency of green finance products by setting the standard for the ‘green’ additionality – the underlying activities funded must provide clear environmental benefits that can be assessed, and where feasible, quantified, measured and reported on. The borrower must demonstrate compliance to the 4 pillars of GLP mentioned earlier.

This type of financial products could be applicable for the following cases (non-exhaustive list):

- Sourcing eco-friendly raw materials
- Procuring eco-friendly machinery/ goods/ services
- Manufacturing eco-friendly products
- Trading eco-friendly commodities
- Services / expenditures to and for green projects

The procurement of SAF could potentially fit under this umbrella. One particular example that could be useful for the industry is Sustainable Supply Chain Finance (SCF), where a financial institution can make early payments or provide financial benefits to certain customer’s suppliers on terms that take

into account the suppliers' sustainability performance. This type of finance mechanism aims to service the client needs of ensuring sustainable sourcing and reducing the carbon footprint within their supply chain (e.g., scope 3 emissions).



Glossary

ADNOC	Abu Dhabi National Oil Company
ADQ	Abu Dhabi Developmental Holding Company
AED	United Arab Emirates Dirham
AAF	Alternative Aviation Fuel
ASK	Available Seat Kilometres
ASTM	American Society for Testing and Materials
ATK	Available Tonne Kilometres
AUH	Abu Dhabi International Airport
BECCS	Bioenergy Carbon Capture and Storage
CAAF	Conference on Aviation Alternative Fuels
CAEP	Committee on Aviation Environmental Protection
CAF	Conventional Aviation Fuel
CAPEX	Capital Expenditure
CCS	Carbon Capture and Storage
CCUS	Carbon Capture, Utilization and Storage
CMO	Boeing Commercial Market Outlook
CO	Carbon Monoxide
CO₂	Carbon Dioxide
COP	Conference of Parties
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
COVID-19	Coronavirus Disease 2019
CST	Clean Skies for Tomorrow
DAC	Direct Air Capture
DEWA	Dubai Electricity & Water Authority
DXB	Dubai International Airport
EJ	Exajoules
EK	Emirates
ENOC	Emirates National Oil Company
ESG	Environment, Social, Governance
EU	European Union
EY	Etihad Airlines
FOAK	First-of-a-kind
FOG	Fats, Oils, and Greases
FT	Fischer Tropsch
GCAA	General Civil Aviation Authority
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product

GHG	Greenhouse Gas
GLP	Green Loan Principles
GW	Gigawatt
H₂	Hydrogen
HEFA	Hydroprocessed Esters and Fatty Acids
HRT	High Demand Rapid Transition Scenario
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ICV	In-country Value
IEM	Integrated Energy Model
IRENA	International Renewable Energy Agency
ISCC	International Sustainability and Carbon Certification
JPDA	Joint Project Development Agreement
LCAF	Lower Carbon Aviation Fuels
LCFS	Low Carbon Fuel Standard
LLT	Low Demand Lagging Transition Scenario
LTAG	Long-term Aspirational Goal
MBM	Market Based Measures
MBT	Medium Demand Balanced Transition Scenario
MDC	Ministerial Development Council
MENA	Middle East and North Africa
MJ	Megajoule
ML	Million Liters
MOEI	Ministry of Energy and Infrastructure
MRV	Monitoring, Reporting and Verification
MSW	Municipal Solid Waste
MT	Million Ton
MW	Megawatt
NB	Narrow Body
NDC	Nationally Determined Contributions
OEM	Original Equipment Manufacturer
PM	Particulate Matter
PSC	Point Source Capture
PtL	Power-to-Liquid
RCF	Recycled Carbon Fuels
RD&D	Research, Development and Demonstration
RED	Renewable Energy Directive
RFNBO	Renewable Fuels of Non-biological Origin
RSB	Roundtable on Sustainable Biomaterials

RWGS	Reverse Water Gas Shift
SAF	Sustainable Aviation Fuels
SARP	Standards and Recommended Practices
SBRC	Sustainable Bioenergy Research Consortium
SCF	Supply Chain Finance
SCS	Sustainability Certification Schemes
SEAS	Seawater Energy and Agriculture System
SLB	Sustainability Linked Bonds
SLL	Sustainability Linked Loans
SOE	State Owned Enterprise
SOx	Sulphur Oxides
SPT	Sustainability Performance Targets
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TAQA	Abu Dhabi National Energy Company
TRL	Technology Readiness Level
UAE	United Arab Emirates
UCO	Used Cooking Oil
UK	United Kingdom
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
USD	United States Dollars
WB	Wide Body
WEF	World Economic Forum
WHO	World Health Organization



Abu Dhabi
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